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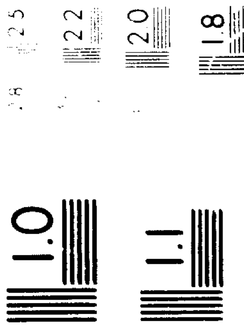

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United Nations Industrial Development Organisation

Elaboration of Integrated Cassava Processing Factory Concept (Project US/INT/80/006) Volume 1: Elaboration of the Concept

Final Report

11709

(1 of 2)

Minster Agriculture Limited

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July 1982

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

ELABORATION OF INTEGRATED CASSAVA PROCESSING CONCEPT

(PROJECT US/INT/80/006)

FINAL REPORT

VOLUME 1

ELABORATION OF THE CONCEPT

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APPENDICES

FINAL REPORT

VOLUME 1: ELABORATION OF THE CONCEPT

1. INTRODUCTION

This final report on UNIDO Project US/INT/80/006 is submitted in accordance with Contract No. T81/73. UNIDO commissioned P-E International Operations Limited (P-EIO) in association with Minster Agriculture Limited (MAL) to execute the contract (Telex of Authorisation, 16 October 1981). The views expressed in this report are those of our two organisations, and do not necessarily reflect those of any member of UNIDO.

The aim of the project is to elaborate and evaluate the concept of setting up a factory or factories to make the range of products which can be derived from cassava in any country whose climate will support its growth.

This necessitates study of the agronomy of the cassava crop and of the procurement system needed to ensure an adequate supply of raw material; research into the markets for products derivable from cassava; the definition of appropriate technology and the outline design of a typical factory; and the evaluation of the concept, both financially and economically.

UNIDO chose Zambia as the country in which the concept was to be tested, and from this study there has emerged a specific project for Zambia, which is described in Volume 2 of this report.

The present Volume 1, however, is intended to stand as a document on its own, and where the findings of the Zambian study are needed to illustrate the elaboration of the global concept, they are repeated in this volume.

The full terms of reference for the project are set out in Appendix 1.

The first stage of the study, a fact-finding tour of Zambia, was carried out in November and December by a team including:

D R Atkinson (P-EIO), Team Leader and Economist
D J Wholey (MAL), Cassava Specialist
T R W Jarman (MAL), Cassava Processing Specialist
J Turnbull (MAL), Farm Management Specialist.

The team was enlarged during the preparation of the interim and draft final reports in January - May 1982 by four P-EIO consultants: K B Freeman and R W Waghorn, project engineers; and C J S Baker and A H Catterall, financial analysts. Support was also provided by P-EIO's Marketing Research Department.

The interim report was sent to UNIDO, Vienna on 27 January 1982 and discussed with Mr H Koenig, Senior Industrial Advisory Officer, Agro-Industries Branch, on 22 March 1982.

The draft final report was sent to UNIDO, Vienna on 5 July and accepted on 13 July 1982.

The team wishes to thank the UNIDO staff in Vienna, the UNDP staff in Lusaka and the many organisations and persons who have helped in this project, for their outstanding co-operation.

The theme of the conceptual study (volume 1) may be described as "If cassava processing is to succeed, the following conditions are necessary", and individual countries' conditions can then be checked against these requirements. In the case of Zambia, (volume 2) the facts on agronomy, markets and locations are precisely established, and a project is positively recommended.

2. SUMMARY OF VOLUME 1

Refer to

2.1 Versatility of Cassava — Chapter 4

All parts of the cassava plant have uses: tubers, as raw and cooked food (after de-toxification), and as a source of starch and derived glucose and dextrins; the leaf, as a source of protein; the stem, as a source of planting material, stockfeed and particle board.

2.2 Markets for Cassava and Derived Products — Chapter 4

These vary very widely: Thailand, for example, exports millions of tonnes of cassava pellets to the EEC and produces 400,000 tonnes of starch; at the other extreme, the proposed factory in Zambia will produce 3-4000 tonnes of starch.

In Zambia, where cassava is a subsistence crop, there is a latent demand for cassava flour, based on marketed chips, and a potential industrial demand for nationally produced starch, glucose and dextrins in place of imports. We foresee no export potential.

2.3 Agronomic Considerations — Chapter 5

Of world output of cassava, 38% is grown in Africa, 36% in Asia and 25% in S. America. — Table 4

Provisional FAO figures of yields per hectare show that these are substantially higher in Asia and S America than in most African countries. Zambia has a particularly low yield. — Table 5

The main influences on growth are temperature (growth ceases at 10°C) and rainfall (1000 - 1500 mm are needed for an annual crop). Soil type must not be saline or sodic; otherwise cassava is tolerant of soil as long as it is not badly drained. — 5.3

	Refer to
African cassava production is particularly affected by virus and bacterial diseases, and pests are encouraged in those countries with long dry seasons.	Appendix 7
Improved varieties are increasingly available, with resistance tc specific pests and diseases.	5.4
Fertiliser recommendations vary with soil and climate; in general, potassium levels are critical to the starch content of cassava.	5.5
It is essential to grow break crops to avoid build-ups of pests and diseases in cassava.	5.6
2.4 Procurement of Cassava	Chapter 6
The processing factory must have a consistently available supply of raw material of the right quality, at a price enabling economic operation.	6.1
The factory can achieve control over availability and quality by having its own plantation, but the capital costs of machinery and the costs of hired labour will make this uneconomic in many cases.	6.2
Cassava roots deteriorate after 24 hours. To avoid the formidable problem of collecting roots over a significant distance it may be advisable to use chips, sun-dried by the farmer. These will not yield the same quality or quantity of starch as do fresh roots, but they do not deteriorate quickly and are adequate for some starches and for all glucose and dextrins. Roots, bought close to the factory, can be used for high quality starch.	6.3
Farmers should be paid a higher price for roots, relative to chips, than a comparison of their starch content warrants.	6.4
Chips must be thoroughly dried, using sun and wind to best advantage. They should be sliced 5 mm thick and 50-80mm long.	6.5 Appendix 5

PE

Refer to

2.5 Considerations of Process Design

Chapter 7

Water used in a starch factory must be of potable quality. Modern processes re-use some water, but consumption is still high: typically, 4300 litres/tonne of starch produced. A dry process needs further research, but it may prove feasible to produce starch of limited use in this way in the future. — 7.2

Effluent from the wet starch process will contain some sugars, which must be treated by a ditch and weir system or a treatment plant. — 7.3

Factories should be as simple as possible and designed with location and operators' skills in mind. — 7.4

It may be possible to incorporate leaf protein processing into cassava plants in the future. This needs more study and perhaps a pilot production and marketing trial. — 7.5

2.6 Outline of Factory

Chapter 8

The processes of converting fresh roots to starch, chips to starch, chips to glucose, and starch to dextrin are described in detail, together with a note on the possibility of converting glucose to potable alcohol.

Layouts of the Zambia factory are shown in Appendices 8 and 9, and list of plant required and of possible suppliers in Appendices 10 and 11. — Appendix 8, Appendix 9, Appendix 10, Appendix 11

Recommendations are made on effluent disposal. — 8.3

2.7 Financial Evaluation

Chapter 9

The starch, glucose and dextrins factory proposed for Zambia will require a capital investment of K3,800 thousand, of which 52.6% will be loan capital and 47.4% equity. An overdraft equal to approximately half the working capital will be needed initially. — Appendix 12, Report 9

	Refer to
Profit after tax (payable only from Year 6 onwards) is calculated to rise from K129,000 in year 1 of production to K504,000 in year 6.	Report 8
The overdraft should be repaid after $2\frac{1}{2}$ years of production and all loan capital after $5\frac{1}{2}$ years. A small dividend can be paid to equity shareholders until year 5; thereafter a dividend of 15-20% should be payable.	Reports 9&10
The IRR on the project is 13.64%.	Report 12
Sensitivity analysis shows that the project is more sensitive to price changes then to volume changes.	Report 13
An analysis of a starch-only factory shows an IRR of only 8.36%.	Appendix 13

3. PROJECT BACKGROUND AND HISTORY

Before the study began Mr Koenig of UNIDO explained its background as follows:

- world interest in cassava is stagnant, if not declining. An imaginative, practical concept is needed to revive that interest.

- many tropical countries grow cassava, but the supply and markets are not organised. Processing plants have been set up in several parts of the world, but they have usually been single-product plants, subject to variations in demand for those single products. Supplies of cassava have been intermittent. Thus factories have shut from time to time because of lack of demand or lack of supply. Farmers, wanting to sell but finding the factory shut, abandon cassava as a cash crop and use it only for subsistence.

- a multi-product cassava processing factory may be able to overcome these difficulties, by altering the mix of derived products according to the state of market demand and thus offering a stable outlet for cassava roots or chips as a cash crop.

- a conceptual study is therefore needed, embracing the markets for products derived from cassava; the agronomic requirements of the crop; the procurement system needed to induce an adequate supply; processing technology; and the financial and economic feasibility of the scheme.

The conceptual study should be made on the basis of markets and supplies being free from artificial constraints or encouragements. The results would, of course, have to be adapted to take account of such constraints or encouragements in any particular country.

4. MARKET CONSIDERATIONS

4.1 The Range of Markets

Given that it is agronomically feasible to grow cassava in a country the starting point of an evaluation of an integrated cassava processing factory concept must be a study of the demand for the crop and the products which can be manufactured from it.

The study of demand in Zambia is briefly described below, and presented more fully in Volume 2, Chapter 8. In summary, Zambia has a small population; virtually no organised market for cassava at present; a potential national demand for marketed cassava in Nshima, bread and beer; a potential national demand for cassava-based starch, glucose and dextrins, based on import substitution; and no export potential, because of great transport distances and a small, high-cost scale of potential output.

At the other end of the scale, Thailand has developed a huge cassava industry, exporting millions of tonnes of cassava pellets to the EEC for animal feed, and processing cassava roots to produce about 400,000 tonnes of starch a year. (Compared to the 4,000 tonnes a year envisaged in Zambia after 5-6 years of the factory's operation).

Clearly, there is a wide range of circumstances in cassava-producing countries, each of which needs individual study. In this volume 1, outlining the integrated cassava processing factory concept, it seems useful to list the various uses to which cassava can be put and to describe the findings of the market study in Zambia.

4.2 Uses of Cassava

As shown in Table 1, cassava is one of the most versatile of plants. After de-toxification of its tubers by soaking and peeling, they can be eaten raw, if young enough; or as is more common, boiled or baked; or dried; or fermented; and mixed with protein relishes of fish, or meat, or leaf protein.

The cassava leaf is a valuable source of protein (see Chapter 7 below) and the stalk, apart from providing cuttings for plant propagation, can be ground into a constituent of animal feed or, if very woody, into a constituent of particle board.

Cassava meal or flour is the basic ingredient of the main staple dish in several parts of Africa, and a useful thickener for many products.

Starches, derivable from cassava, have a wide range of uses, from infant foods to oil well drilling, as illustrated in the table. Their use as a basic material for glucose and dextrins is particularly important.

In evaluating the feasibility of setting up a cassava processing factory it will be necessary to consider, in the content of the individual country studied:

- its present and potential consumption of cassava and each of the products derivable from the plant

- the quantity and cost of imports of the derivable products
- the potential for export of the derivable products.

TABLE 1 - USES OF CASSAVA

Root

Raw (peeled young root or aipim)
Cooked, boiled, or baked for table use (95% of production)
Shredded and mixed with coconut, oil, peanuts, greens, spices
Dried (called kokonte, gaplek, etc., in Africa)
Grated and fermented, added palm oil, fried (called gari in Africa)
Fried slices (French frying, etc)
Residue (fibre or bagasse) from starch extractives
Chipped or sliced for livestock (dairy and beef cattle, goats, pigs, chickens)
Root peel livestock feed
Broken roots
Pellets
Juice (tucupay or cassaripo)

Leaf

Used as a vegetable
Cooked
Soup ingredient
Fortified food supplement
Livestock feed
Ensilage
Dried - Used in animal feed fortification
Leaf meal (feed concentrates)

Stalk (stems)

Cuttings for plant propagation
Grafting material for increased yields
Mixes with leaves as ruminant feed
Dried (used in animal feed concentrate)
Particle board

Chips (raspa or gaplek)

Ground into meal or flour
Extracted for starch
Fermented (fufu) - meat, oil, vegetables, spices and water added animal feeds
Pellets

Meal or Flour

Bakeries, pastries, alimentary pastas (macaroni)
Boiled in soups, sauces, gravies, etc.
Bread extender
Porridge (gruel)
Fortified flour (with wheat, soya, peanut, vitamins, etc)
Improved bread flour (with added calcium stearyl lactate as a conditioner)
Protein enriched flour (fish protein concentrate, soyabean isolate, caseim,etc)
Selected amino acid enriched flour (lysine, tryptophane, methionine, etc)
Fermented (Eba)
Glues
Adhesives

Starch

Baked goods
Desserts - puddings, pie fillings (sago)
Infant foods
Confections (moulding of cast sweets)
Thickening agents (synthetic jellies)
Bodying agents (caramels)
Dusting agents (chewing gum)
Fermented beverages (beer)
Textile sizing and strengthening
Laundry starch
Paper sizing and bonding
Gums (envelopes, postage stamps, gummed tapes)
Dextrins (bonding pigment to paper; preventing glass checking)
Adhesives (cardboard, plywood, and veneer)
Glues and pastes
Blended with peanut flour, nonfat milk solids, vitamins
Enriched with LPC, soy, corn, rice (pasta)
Alcohol
Acetone
Glucose
Oil well drilling

Modified Starches

Pre-cooked soluble starches - "instant" puddings
Thin - boiling starches (confectionery manufacture)
Oxidised starches
Improved starches (ex: added glyceryl monostearate as a binding agent).

Source: Minster Agriculture Limited

4.3 The Market in Zambia

Cassava is almost entirely a subsistence crop in Zambia, grown in the remoter Provinces whose agronomic conditions do not favour the cultivation of maize, the main national staple crop. Cassava is not one of the crops bought by the state agricultural marketing system (Namboard) and has no producer price.

We found a significant latent demand among urban immigrants for cassava flour for use in Nshima, the staple dish in Zambia. Based on this consumer preference, cassava flour can be sold at a premium over maize.

There is a potential demand for cassava flour in bread-making and brewing, as a partial substitute for imported wheat and malted barley.

Starch, glucose and dextrins are all imported into Zambia, and users in the growing foodstuffs, textile and paper industries would welcome a national supplier, provided their quality requirements were met. They would be willing to pay a premium over current import prices to avoid delays and difficulties caused by having to apply for foreign exchange.

The results of the market survey are shown in Table 2, followed by the projection of the market and of estimated factory sales up to 1991 in Table 3.

TABLE 2

Estimated potential for marketed cassava products in Zambia in 1981.

Product	Application	Present Potential (Tonnes/year)	Present Delivered Price + 10% (a) (K/tonne)	Reason for using cassava
Starch	Textiles	300	900	Import Replacement
	Food - biscuits, Blancmanges, Puddings,etc.	500 +	850	Import Replacement
Glucose	Food - biscuits, Puddings,etc.	1,400	1,050	Import Replacement
	Pharmaceuticals	30	1,200	Import Replacement
Dextrins	Glue for paper	150	1,800	Import Replacement
	Pharmaceuticals	5	1,800	Import Replacement
	TOTAL ABOVE	2,400 approx		
			Estimated Acceptable Price	
Cassava Flour	Nshima	40 - 45,000	Breakfast Meal + 7% (= [illegible] + 35%	(i) Urban immigrant demand (ii) Quality improvement
	Blends with wheat flour	7-8,000(10%)	Roll price	(i) Replace imported wheat (ii) Release maize for other uses
	Chibuku & mosi beer	3,000 (10%)	Roller meal price	Release maize for other uses
	Stockfeed	12,500 (10%)	Roller meal price less 10%	Release maize but added protein required
	Potable alcohol (liquor blending)	litres 750,000	55n/litre	Import Replacement

(a) Users of starch and derived products, now imported, would be willing to pay at least a 10% premium for local supplies.

Table 3 - Estimated demand in Zambia for starch, glucose, and dextrins

Year	Volume change from previous Year (%)	Annual demand (values at 1981 prices (a)) Starch		Glucose		Dextrins		Total
		Tonnes	K'000	Tonnes	K'000	Tonnes	K'000	K'000
1981	10	800	640	1430	1573	155	263	2475
1982	10	880	704	1575	1733	170	289	2725
1983	9	960	768	1700	1870	185	315	2950
1984	8	1035	828	1835	2020	200	340	3190
1985	7	1110	888	1960	2155	215	365	3215
1986	6	1175	940	2075	2283	230	390	3615
1987	5	1235	988	2180	2400	240	405	3795
1988	5	1300	1040	2290	2520	250	425	3985
1989	5	1365	1092	2400	2640	265	450	4180
1990	5	1435	1148	2520	2770	280	475	4395
1991	5	1510	1208	2650	2915	290	495	4620

(a) 1981 import prices + 10% premium less K100/tonne for delivery. (Net price for starch, K800/tonne; glucose, K1100/tonne; dextrins, K1700/tonnes).

5. AGRONOMIC REQUIREMENTS OF THE CASSAVA CROP

5.1 Background Information on Cassava

Cassava is the name used in the English speaking regions of Africa, the Caribbean and Australia to describe the plant refered to by botanists as Manihot esculenta (Crantz). The crop is also known as 'tapioca' in India and anglophone South East Asia, 'manioc' in French, 'yuca' in Spanish and 'mandioca' in Portuguese. Local names for the crop defy collation.

The plant is a member of the family 'Euphorbiaceae and is indigenous to tropical America, although it is currently grown in most tropical and many sub-tropical countries of the world. The plant is a short-lived perennial shrub with enlarged starch-rich roots. There are probably thousands of cultivars in existence which range in height from 1m to 5m, and vary from unbranched to heavily branched with stems green, brown, grey to light grey in colour. The leaves vary from small simple or three lobed in seedlings and young plants to large palmate leaves with nine to eleven lobes during the period of maximum growth rate. Fruit usually forms when the plant is in excess of one year old, especially in areas with short rainy season where the crop is usually grown as a biennial, over two rainy seasons. The fruit is a three-seeded capsule which opens explosively to disperse the seeds.

The roots of cassava develop from the stem cuttings during the second and third weeks after planting. Under good conditions nine or more fibrous roots become root-tubers during the second and third months of growth by a process of secondary thickening and starch deposition. The diameter of root-tubers increases with age until maturity which varies with variety but normally occurs after 5-15 months of growing conditions. Both the dry matter and starch content of root-tubers increase becoming fibrous and in some cases hollow. An advantage that the cassava crop offers the farmer is the lack of a fixed harvest date allowing great operational flexibility and enabling the farmer to store the crop in the ground.

The root-tubers form the primary product of the cassava crop. The usual size is 25-40cm in length and 5-15cm in diameter. The thickness of the peel and the ease with which it can be removed from the flesh of the root is a varietal characteristic. Peeling losses can vary between 10-20% of the fresh root.

At the core of the root-tuber there is a concentration of xylem vessels which become lignified with age. In over-mature roots these lignified vessels render the roots undesirably fibrous and are removed in some hand processes.

The cassava plant contains toxic principles which release hydrocyanic acid (HCN) under certain conditions. The cyanogenic glycocides linamarin and lotaustralin are distributed throughout the cassava plant, but the concentration varies greatly between varieties and also with climatic, edaphic and cultural conditions. Toxicity of cassava and its products is associated primarily with free HCN that is formed when the cyanogenic glycocides have been hydrolysed. This is effected by a hydrolytic enzyme Linamarase which is present in all the plant tissue together with the cyanogenic glycocides.

In active healthy tissue of the growing plant the enzyme and glycocide substrate do not come into contact, however on mechanical damage, eg after harvesting, contact occurs and hydrolysis takes place releasing HCN.

It is well established that HCN itself is one of the most powerful mammalian poisons known, large doses causing acute poisoning usually resulting in death. The lethal dose of HCN for an adult male is reported to be 50-60mg. A guide to acute toxicity is as follows:

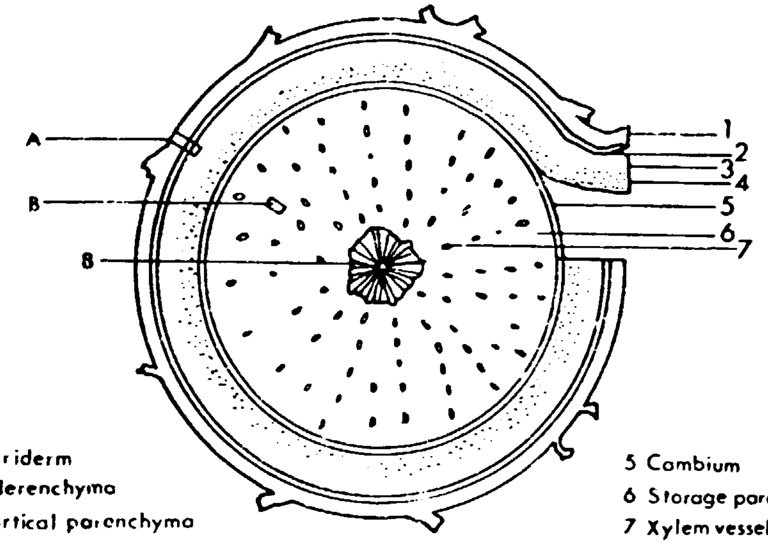
Innocuous	:	Less than 50mg HCN per kg of fresh peeled tuber (FPT)
Moderately poisonous	:	50-100mg HCN per kg of FPT
Dangerously Poisonous	:	Over 100mg HCN per kg of FPT

The habitual ingestion of small quantities of HCN, too small to produce acute symptoms can result in chronic effects including malfunction of the thyroid resulting in goitre in serious cases, and atoxic neuropathy causing lesions of the skin, mucous membranes, nerves and spinal cord. Both conditions are caused by indirect effects of HCN entering the bloodstream via the alimentary tract.

The peel fraction of cassava root-tubers contains substantially higher concentrations of cynaogenic glycocides than the flesh. The ratio of glycocide in peel to flesh varies between 5 to 10 : 1. Traditional users appear to be aware of the danger as peeling is practised as a preliminary to cooking.

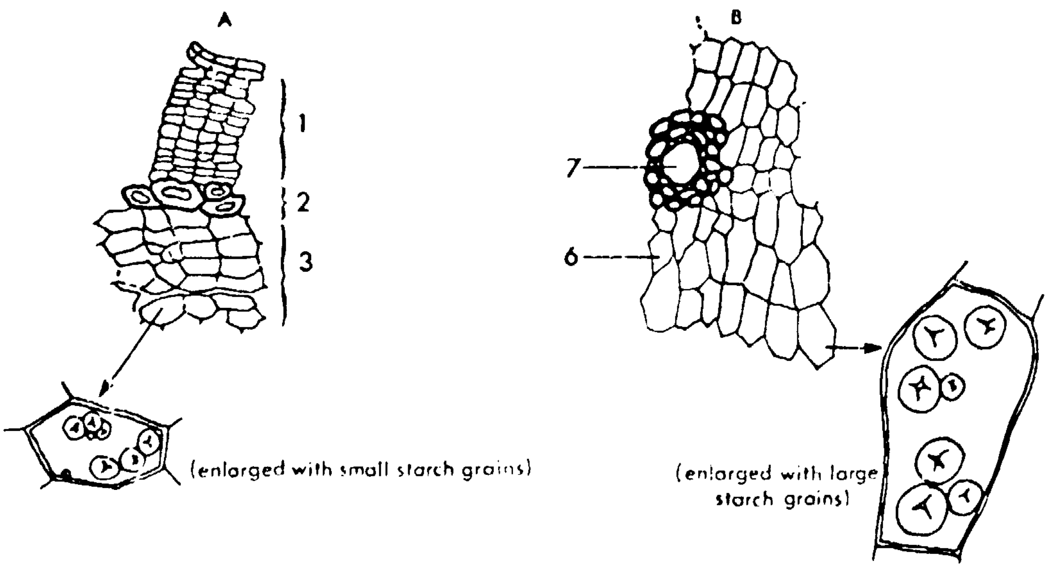
Previously, cassava variations with root-tubers containing small amounts of HCN were classified botanically as Manihot dulcis (or M. palmata) and those with large amounts of HCN, Manihot esculenta (M.utilissima). Currently all cassavas, sweet or bitter, are referred to as Manihot esculenta.

DIAGRAM OF TRANSVERSE SECTION OF CASSAVA STORAGE ROOT



peel
1 Periderm
2 Sclerenchyma
3 Cortical parenchyma
4 Phloem
(1 to 4 = peel)

5 Cambium
6 Storage parenchyma
7 Xylem vessel
8 Xylem vessels & fibres
flesh



SOURCE : Hunt, Wholey & Cock (1977)

5.2 Global Distribution of Cassava

Thought to have originated in the area of today's border between Brazil and Paraguay, cassava has been disseminated across the globe. In the western hemisphere the crop is grown from Northern Argentina to Florida State in the USA; from sea level to 4,000m in the Andes. Introduced into West Africa by the Portuguese, the crop has spread through the continent from the sub Sahel to South Africa. Today a high proportion of the continent's indigenous population depends on the crop for their diet, particularly in the coastal Western African countries. Although only reaching South East Asia some 150 years ago, the crop is a very important human food in Indonesia and South India and an important industrial crop in Thailand (its number one export crop in 1978). Recently the crop has been recognised as having potential in Northern Australia and Papua New Guinea - principally for ethanol production. To sum up, cassava is present in almost every tropical and sub-tropical country where the climate allows its growth. Table 4 shows the quantities of cassava produced in the various parts of the world as presented by the Food and Agriculture Organisation of the United Nations.

Table 4: Production of Cassava by Selected Countries in 1980 (a)

	Production Tonnes (x 1000)	
Africa		
Zaire	12,500	
Nigeria	11,000	
Tanzania	4,600	
Mozambique	2,800	
Ghana	2,250	
Angola	1,850	
Madagascar	1,450	
Uganda	1,300	
Other African countries	9,023	(b)
TOTAL:	46,773	
Asia		
Thailand	13,500	
Indonesia	13,300	
India	6,500	
China	3,174	
Vietnam	4,000	
Philippines	1,900	
Other countries	1,185	
TOTAL:	43,559	
South America		
Brazil	24,554	
Colombia	2,640	
Paraguay	1,950	
Other countries	1,412	
TOTAL:	30,556	
Central American & Caribbean		
TOTAL:	1,024	
Oceania		
TOTAL:	222	
WORLD TOTAL:	122,134	

Source: FAO Production Year Book 1980
(a) Figures mainly provisional
(b) of which Zambia, 177.

5.3 Growth Requirements

Temperature. Cassava growth is favoured by a warm moist climate with temperatures in the range 25-29°C. Temperatures lower than 25°C will reduce growth which, in general, ceases at 10°C. Research suggests that the base temperature for cassava germination is 13°C, and that emergence is retarded below 18°C. As it is the temperature of the growth medium that is the critical factor, the soil temperature in the 5-10cm zone should be used to delineate conditions favourable for establishment. Once the crop has emerged, both the soil temperature and air temperature play an important role. Whereas growth ceases at 10°C, the crop will survive lower temperatures and light frost but will defoliate under these conditions. Short duration severe frosts (ie below -3°C) kill exposed green tissue but growth is supported from woody tissue when temperatures rise. Longer term exposure to severe frost will kill all above-ground growth. Based on a 13°C base temperature for germination, Austalian research workers recommend planting to be done in areas with daily mean temperatures in excess of this figure. However more recent reports recommend 18°C as the low-level temperature boundary for cassava cultivation due to reduced percentage emergence and retarded early growth rate at below this temperature. As indicated above cassava is commercially grown at high altitude in the Andes, therefore it is to be expected that there exists a large varietal effect and some varieties may be tolerant to temperatures much lower than the 18°C suggested by the Australian cassava workers. Research at CIAT has proved that varieties tolerant of low temperatures exist. Temperatures in excess of 29°C are reported to affect yields adversely but little reliable information is available to confirm this figure.

Rainfall. Cassava thrives in areas receiving 1,000 - 1,500mm of rainfall, distributed evenly throughout the growing season. Physiological experiments indicate that different varieties have varying maturity patterns with some reaching a production peak after nine months of growing conditions whereas other varieties require in excess of twelve months. Therefore the practicability of producing cassava depends upon the interaction between variety and rainfall pattern. In the situation where only eight rainy months occur per year, a short season variety can be grown within the calendar year whereas a long season variety would not be feasible. Nevertheless cassava grows successfully in areas receiving as little as 500mm per annum, although the duration of the crop is extended in these areas, so that the crop takes up the moisture provided by two years' rain. This, coupled with the crop's ability to survive periods of drought within the growing season, renders the crop very useful to growers in regions with short rainy seasons and/or periods of uncertain rainfall. The effect of different rainfall patterns on cassava production is discussed in detail in Appendix 2.

Soil. Cassava will grow in a wide range of soil types from stiff marine clays through to almost pure sands. However the crop is intolerant of poorly drained soils. The crop is adapted to a wide range of soil pH and is especially tolerant to acid soils, producing good crops at pH 4.5. Nevertheless saline soils and sodic soils are not tolerated and result in stunted growth. Much of this wide adaptability of cassava is related to variety and care should be taken because all casssava varieties do not show this tolerance. Cassava is frequently the last crop grown in the shifting cultivation system practised in the forest zones of West and Central Africa and, as such, has earned the reputation for being well adapted to soils of low fertility. Recent research has identified a number of features that may be associated with cassava's special adaptation to poor soils including acid soils and soils with high free-aluminium content. Cassava appears able to maintain relative yields under low nitrogen, potassium and calcium conditions and capable of regulating its growth under low nutrient supply conditions. The crop can continue root bulking under severe lack of phosphorus which renders it extremely valuable for soils with very low phosphorus content. It has been suggested that the crop's ability to yield under apparently limiting phosphorus conditions is related to a soil mycorrhiza which forms a relationship with the roots of the cassava plant.

Experiments show that some cassava varieities respond to fertile soils, by producing stem and leaf out of proportion with root-tuber growth. The phenomenon appears to be related to variety as some 'more efficient' varieties appear to respond in terms of increased total (recoverable) biological yield with proportion in stem and leaves remaining constant to the proportion of tubers. Thus the 'harvest index' remains constant regardless of fertility. Cassava can tolerate sandy soil of extremely low fertility especially if the feeder roots can penetrate to 40-60cm and exploit the lower soil profile for nutrients (and moisture). Deep cultivation to facilitate root penetration frequently leads to increased yield.

On heavy soils where drainage is a problem and in areas where heavy rainfall is experienced causing short-duration waterlogging, cassava is usually grown on mounds or ridges to ensure that the root-tuber zone is relatively well aerated. Cassava does not thrive however in basin sites and chronically poor-drained areas, and growth will be retarded in spite of ridging.

Photoperiod. Experiments both in growth chambers and in the field indicate that the partitioning of dry matter between the roots and the above ground parts of the cassava plant is influenced by changes in day length. Thus harvest index is improved by growing the same variety closer to the equator, ie under short days. Colombian experiments indicate however that different varieties show different response to day length in terms of flowering response, therefore overall generalisations for all cassava varieties may be premature and further experimentation will be required to confirm this. Identification of day-neutral varieties, which do not respond to changes in photoperiod will pave the way to the availability of varieties with broad adaptation to changes in latitude.

Yields. National average yields as computed by FAO are presented in Table 5. They should be taken as rough approximations, since it is difficult to measure accurately the acreage of this crop, which is grown on scattered plots in most of the countries producing it. Moreover, in countries where the crop is harvested over more than one year - like Zambia - records of production are subject to wide margins of error.

Farm yields vary with location and are dependent on the interaction between variety, climate and soil with the effects of age at harvesting, disease, pests and management factors superimposed.

Table 5: National Average Yields of Cassava in 1980 (a)

	Tonnes/ha
Africa	
Zaire	6.65
Nigeria	9.17
Tanzania	4.89
Mozambique	4.67
Ghana	9.78
Angola	14.23
Madagascar	6.59
Uganda	3.42
Zambia	3.19
REGIONAL AVERAGE	6.41
Asia	
Thailand	13.30
Indonesia	9.37
India	17.57
China	13.06
Vietnam	8.33
Philippines	10.27
REGIONAL AVERAGE	11.34
South America	
Brazil	11.94
Colombia	10.95
Paraguay	10.83
REGIONAL AVERAGE	11.71
Central America and Caribbean	
REGIONAL AVERAGE	6.39
Oceania	
REGIONAL AVERAGE	11.07
WORLD AVERAGE	8.77

Source: FAO Production Year Book 1980
(a) Figures mainly provisional.

The world average is about 8¾ tonnes per hectare but the theoretical limit to yield has been calculated to be 90 tonnes per hectare per year. Experimental yields of 80 tonnes per hectare have been obtained from plants grown under near optimum conditions at CIAT. However the occurrence of debilitating diseases and devastating pests, together with poor agronomic practices and infertile soils, are responsible for relatively low farm yields in African major production areas. Virus and bacterial diseases particularly reduce root yields. Important pests in Africa include mealy bugs and green spider mite. These pests are currently spreading to new areas where severe yield reductions result. Pests and diseases, and means of combating them, are described in Appendix 7.

5.4 Varieties

There is a wide range of cassava varieties, and a global collection does not exist, although many countries have national collections and import improved varieties from elsewhere. Varieties vary in terms of adaptation to different climatic and soil conditions, and the performance of reputedly high yielding types introduced into a new area has frequently lead to disappointment.

As a result of research activities centred on the International Agricultural Research Centres in Africa (ZITA) and South America (CIAT), coupled with national research programmes, improved varieties are becoming increasingly available. These varieties have resistance to specific pests and diseases and should be selected in appropriate circumstances. From the point of view of the processor the content and quality of starch in the cassava roots is of paramount importance, and this factor is increasingly receiving attention from plant improvement scientists.

Yields quoted in published material may be misleading in that they reflect the yields attained from small plots sited on uniform land which received better than average attention. In many cases extended areas of the same variety may result in significantly lower yields than those obtained from small plots. Information on field-scale plantings should be sought before embarking on cassava production ventures. Where these are not available, the setting up of a pilot-scale production unit is to be encouraged to qualify the results from small-plot experiments.

Care in interpreting all results should be stressed, and where processing is the objective all yield figures should be converted to, and interpreted as:

- unit weight of starch, per unit area, per unit time.

5.5 Fertilisers

It is technically very difficult to sustain yields of any crop over extended time periods without supplementing the naturally occuring elements in the soil which support plant growth. This is very true for cassava which is efficient at obtaining its nutritional needs from even poor soils.

It is not possible to make over-the-board fertiliser recommendations for cassava. These will vary with specific site conditions eg soils and climate. Attention must however, be drawn to the importance of potassium as a nutrient in cassava production. Potassium levels are critical if starch content of roots is to be maintained, and adequate fertilisation with potassium fertilisers is usually required to achieve high yields. Nitrogen and phosphorous, together with a range of minor elements may be required in individual circumstances. Whereas some nitrogen is required to balance additional potassium, too much of this element is thought to encourage the production of stem and leaf without parallel root production. It is becoming increasingly apparent that cassava can obtain its phosphorous needs through the agency of a symbiotic relationship with a soil Mycorhiza. However until further research has been carried out it is safe to assume that cassava needs phosphorus and its fertiliser programme should include this element until direct evidence is available to show otherwise.

Where the scale of cassava production operations is large enough to warrant them, field trials should be carried out to decide site-specific fertiliser requirements. Fertiliser costs are sufficiently high to render these trials financially worthwhile.

5.6 Rotation Crops for Cassava

It is sound agronomic practice to grow a series of crops on the same area to avoid build-ups of pests and diseases, most of which are specific to particular crops. This is the case with cassava.

In addition, the slow growth of cassava during its initial stages and the wide planting distance makes the crop a poor protector of the soil from the erosion standpoint. On sloping fields with soils of poor physical structure, growing cassava can result in severe erosion. This effect is compounded by the extensive soil disturbance, unavoidable during cassava harvesting operations. In this case rotating cassava with a fibrous rooted crop, which requires little soil disturbance, assists in the stabilisation of the upper soil profile.

Small farmers traditionally follow a succession of crops, usually related to the gradual depletion of the soil's fertility. Other farmers practise mixed cropping where rows of crops are intercropped between rows of unrelated crop species.

Unfortunately the move towards mechanisation has tended to an abandonment of sequential and mixed cropping.

Many agro-industrial ventures have neglected the agricultural implications of monoculture, and have developed only sufficient land to cater for the raw material requirements of the factory. This makes no allowance for rotation or break crops, resulting in pest and disease build-up, and/or serious soil erosion which cause low yields and the eventual failure of the venture.

The possible break/rotation crops for use with cassava depend on a list of priorities which include climate, soils and food and industrial requirements of each area. Some which may be considered eg maize or groundnuts would involve the agro-industrial venture in the large-scale production of crops in which it had little direct interest. This complicates the agricultural inputs by adding to the list of machinery, to provide planters and harvesters etc, plus the provision of seed, fertilisers and chemicals. Additional buildings for the storage and processing of rotation crops previous to sale may also be required.

Where cassava is the sole product required of the agricultural component of an agro-industrial venture the use of leguminous cover crops/pasture crops is attractive as they require little in terms of additional inputs other than the expanded land area needed to effect a rotation programme.

Leaf meal could be produced using this rotation system, and incorporated into cassava products to increase their protein content. Alternatively the rotation crop could be grazed to provide some economic return. As stated previously the climatic conditions, length of dry season, and soil conditions must be considered carefully before any decision on rotation-crop policy is decided.

Nevertheless the importance of break crops between cassava crops cannot be over-emphasised and the difficulty in selecting an economically or logistically attractive break crop must not be used as an excuse for not following a rotational policy.

6. PROCUREMENT OF CASSAVA

Factories intended to make products derived from cassava have failed in several tropical countries because the procurement of raw materials has not been properly organised.

Among the factors which must be considered in organising a reliable supply of cassava the following are the most important:

- the source of production: should this be farmers or a plantation, or a combination of both?
- the costs of production of cassava by farmers and by plantation methods.
- the material to be used by the factory: should this be perishable cassava roots or less perishable chips?
- the prices to be paid for roots and/or chips
- the quality standards required of roots and/or chips
- the training of buyers to assess/grade roots and/or chips against required quality standards
- the scheduling of collection and transport of roots and/or chips.

Each factor is considered below.

6.1 Source of Production

From the integrated cassava processing factory's point of view the key requirements of the supply of raw material are that it should be consistently available, of the right quality, and priced at a level enabling the factory to operate economically.

The advantages of supplying the factory from its own plantation are those of control over the availability and quality of material. The disadvantages from the factory's viewpoint are that the costs of machinery and hired labour may well lead to a cost per kg of raw material which is higher than the price at which the factory can buy from farmers; and that the plantation must grow break crops, in which the factory has no interest.

From the national viewpoint, moreover, there may well be a policy to encourage cassava as a cash crop for small farmers, which would be defeated by the factory relying entirely on its own plantation.

In each country where an integrated cassava processing factory is being considered it will be necessary to take these factors into account. In the case of Zambia, where cassava is at present almost entirely a subsistence crop, the recommendation is that farmers should be motivated to grow it also as a cash crop, and that the decision to set up a starch, glucose and dextrins factory should not be taken until supplies from farmers are assured. A small plantation should be set up as a supply source of healthy planting stock for distribution to farmers rather than as a major source of tuber supply to the factory.

6.2 Costs of Production

Appendix 3 shows that there is great variation in the production systems which farmers may use in growing cassava. The labour inputs, however, are approximately 77-78 man-days/ha, of which weeding accounts for 30 days and lifting and trimming roots for 19. These figures exclude land preparation.

Appendix 4 shows the mechanisation requirements of a cassava plantation sufficient to provide 40 tonnes of cassava roots a day for 280 days a year. These requirements vary according to the rainfall system: all-year round rainfall permits machinery to be used continually, and numbers of machines needed are therefore lower than those required when planting and harvesting are restricted to certain periods of the year.

The following figures summarise the fob costs, UK port, of the machinery estimated to be required under all-year round, long bi-modal and long unimodal rainfall systems, and the capital costs per hectare. Under short bi-modal and unimodal systems the costs would be higher in total than under those illustrated.

Estimated machinery costs under three rainfall systems

	All-year round	Long bi-modal	Long unimodal
Assumed yield of roots in Africa (t/ha)	18	12	18
Hectarage required (a)	622	934	622
Fob costs, UK port, of machinery required (b) (£000)	131.3	290.8	243.9
Machinery capital costs per hectare (b) (£)	211.17	311.36	390.09

(a) Before allowing for hectarage needed for break crops.

(b) Before allowing for spare parts.

After increasing these costs by 15-20% to allow for spare parts and adding cif charges it is clear that machinery capital costs per hectare under fairly favourable, long unimodal rainfall conditions, could be of the order of £700 per hectare in a location distant from a port; and under less favourable conditions they would be higher.

These costs, together with the price of hired labour, must be closely calculated in evaluating a plantation.

6.3 Choice of Raw Material

Cassava roots begin to deteriorate only 24 hours after harvesting, and it is essential that they are received for processing at the factory before this occurs. This creates formidable logistical problems if the factory relies entirely on fresh roots for its raw material, and has to draw them from an area not immediately adjacent.

Cassava chips, sun-dried by the farmer, are much less perishable than roots. Their yield of starch will not be as high in quality or quantity as that of fresh roots; but it should be adequate for many applications in which starch is used as such, and certainly adequate as a material base for glucose and dextrins.

It may be that, as proposed for Zambia, the factory should rely on cassava chips as its main raw material, but buy in roots from the immediate vicinity for the production of high quality starch.

6.4 Prices of Roots and Chips

Prices will naturally vary from country to country. Any proposed factory will have to calculate what it can afford to pay, working back from the prices which it can get for its products in the market, and judging also the level whichis needed to give the farmer an incentive.

The yield of starch from fresh roots is only 30% of that from dried chips, and it could be argued that farmers should be offered only this percentage of the chip price. However, they incur at least as much cost in producing roots as in soaking, peeling and drying them into chips, and a price based on starch yield would be a disincentive to sell fresh roots.

It will be more effective to offer 50% of the chip price for fresh roots, and to attempt to charge a higher market price for starch made from roots than for the chip-based product.

6.5 Quality Standards.

For both roots and chips the quality requirements are that they should be:

- free from foreign matter (sand, dirt, insects)
- free from mould or bacterial deterioration
- white in colour
- derived from plants of the right maturity.

The fundamental requirement of fresh roots, however, is that they should indeed be fresh. In contrast, the most important requirement of chips is that they should be thoroughly dry.

The drying of chips, right through to the centre, is essential if they are not to rot. Effective drying by sun and wind depends on chip design and on methods of drying, both described in detail in Appendix 5.

6.6 Training of Buyers

In countries where cassava has previously been only a subsistence crop, or where only fresh roots have been used in starch factories, it will be necessary to train buyers in the assessment and, possibly, grading of chips.

We recommend that fairly simple criteria can be applied in the early years of projects based on chips. These should be:

- white in colour, with no peel present
- dry to the touch (tending to rattle when shaken)
- able to pass through a 50 mm screen
- free from foreign matter.

6.7 Transport Scheduling

This is particularly important in the case of roots, and Appendix 3 contains a special note on planning transport methods in dry and wet weather.

The logistical problems of collecting fresh roots were referred to in 6.3 above. It is essential to keep in mind that roots must be processed within 24 hours of harvesting: and that (Appendix 3) it takes 19 man-days to harvest one hectare of roots.

It is therefore a matter for careful organisation when scheduling collection of fresh roots. It may be necessary to go to 5 farms once a day for 5 days, to collect 1 tonne of roots from each, rather than to arrange to collect 5 tonnes from each on successive days. In the latter case, unless the necessary labour is deployed, a proportion of the roots would certainly be over one day old.

7. THE FACTORY CONCEPT: CONSIDERATIONS OF PROCESS DESIGN

A typical analysis of the constituents of fresh cassava root is as follows:

25%	starch & other carbohydrates
2%	cellulose
3%	protein
5%	others
65%	water
100%	

The amounts vary considerably according to such factors as method of analysis, stage of maturity, growing conditions and many others. However the analysis does demonstrate that the main constituent of cassava roots, other than water, is starch, and other carbohydrates. Therefore in designing a factory process, the main technology used and the equipment required will be that used in the starch industry. There are a number of different uses for cassava starch and indeed other parts of the plant. A list of the uses of cassava was given in Chapter 4. It can be seen from this that there are considerable opportunities for the processing of cassava, and that these are mainly starch products. The choice of product to make will be dependent upon:

(a) Availability of raw material
ie root, leaf
stalk
chips

(b) Market size or requirements for products

(c) The shelf life or storability of the product.

The availability of raw materials for a cassava factory is a key issue, as discussed in Chapter 6.

Market requirements have been discussed in Chapter 4, in general and with specific reference to Zambia. Each country, region or area where a processing factory is proposed, should be analysed individually.

The shelf life or storability of the product is perhaps the most important single factor which requires attention at the planting stage. Cassava is a perishable root as soon as it has been harvested, similarly the leaf and stem will also deteriorate rapidly if a process of some kind is not carried out to arrest the spoilage, preserve the product or alter it so that the resultant product will store.

Because the fresh roots and leaves are so perishable, the location of processing facilities often has to be near the production area. A factory sited near to cassaa production could process to an intermediate stage, eg starch, flour or even chips. The product from this rural factory would have a much longer shelf life and could then be transported to other processing facilities or form the raw material for existing factories.

Chapter 6, on procurement, emphasises the need for the introduction of a vertically integrated system of cassava production and processing. This concept therefore requires that the producer makes a product which will keep and can be easily transported to a processing installation or market. A dried chip has been determined as being the most suitable way of doing this. This chip is mainly composed of starch and is the easiest way of storing the commodity until the starch can be extracted.

The cassava processing concept is therefore designed around a starch extraction process. The possibility of deriving some products during the production of starch is considered, as well as the use of dried chips as a raw material. The modification of starches is not considered in detail since the process for doing this uses standard manufacturers' machinery. Information and plans can therefore be obtained from them.

A flow diagram showing a processing concept is shown in Figure 2. It is unlikely that this would ever be built since the demand for the whole range of products or the raw material supply to viably supply each product line would not be available. However, the figure does show the process for each product and therefore a process flow line to suit the product demanded can be planned.

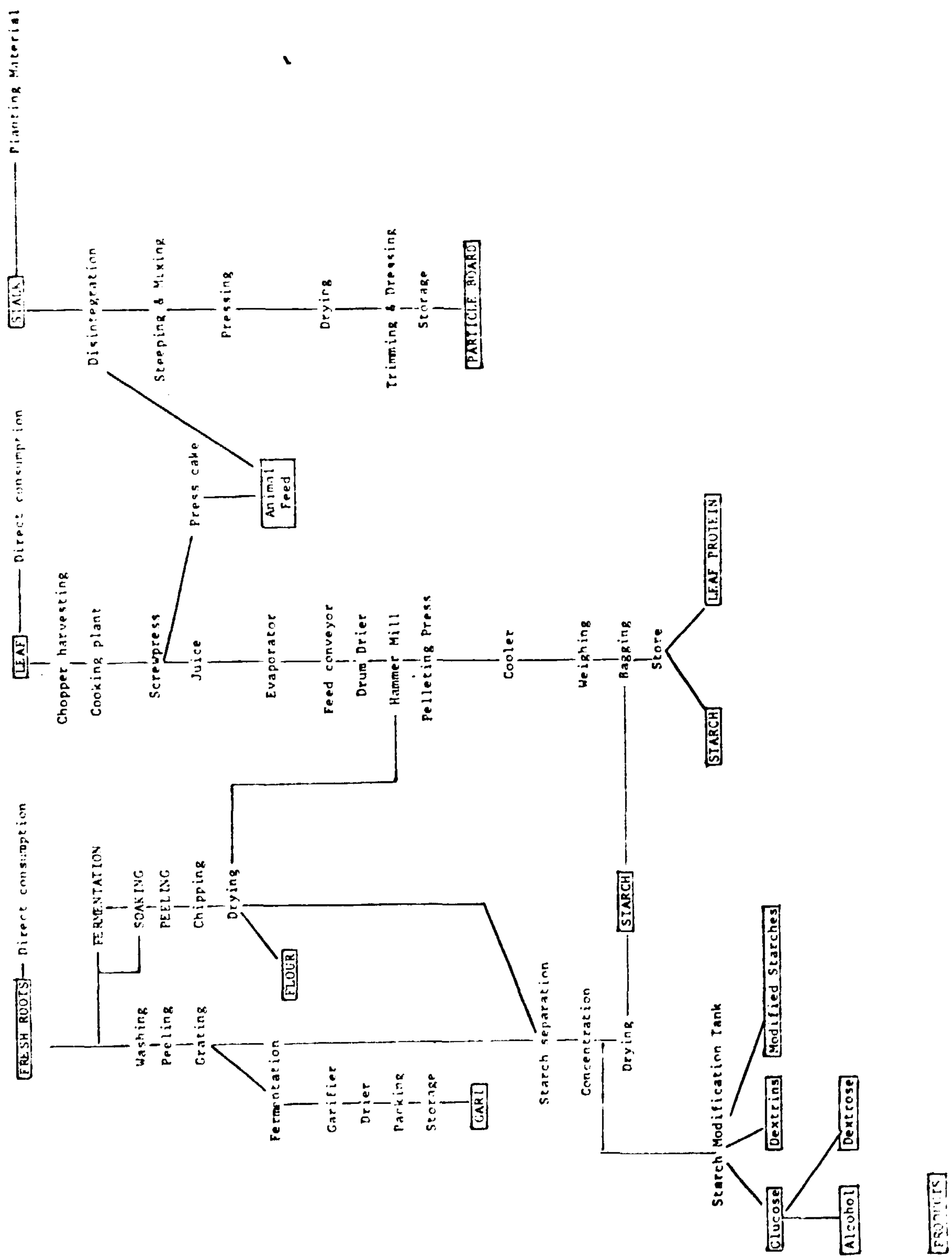
Other considerations which must be taken into account when planning a cassava processing concept of this type are:

- Chip quality, and fresh root availability
- Availability and quality of water for processing
- Market requirements on quality and facilities in the country for further processing
- Effluent disposal standards
- Level of technology required in the process.

A brief discussion expanding the above factors follows.

Figure 2

Cassava: A Comprehensive Processing Concept



7.1 Chip Quality and Root Availability

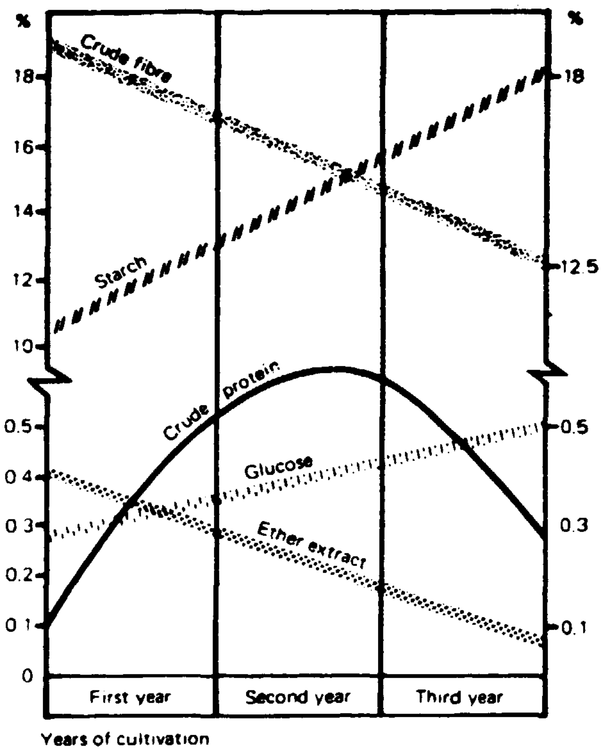
The use of sun dried producer prepared chips is a new processing concept in Africa. In some countries the drying of sections of the root is already practised. (This was seen in Zambia, see Volume 2). In most cases cassava is processed by the producer or villager into a staple product such as gari or flour directly from the fresh root or after a soaking and fermentation stage. Since the "Chip" has been suggested in this report as a means of prolonging the life of the raw material for further processing, it is important that it be properly dried throughout otherwise some deterioration from moulds and bacteria will occur on any damp surfaces. For this reason a discussion on chip geometry has been included to demonstrate that the size of chip exposed for drying is important. Any chips which have incurred mould growth or which have deteriorated because they are wet, will be rejected for processing into starch or other products because the resultant products will also be poor in quality.

Fresh root availability and methods of production have also been discussed. It is important to emphasise that any capital investment in plant and machinery for cassava processing must be run for as long as possible to be economic. Plants awaiting raw material for processing are inherently a poor investment. Thus it is important to ensure that fresh roots are available in sufficient quantity and quality to ensure maximum plant utilisation. Quality is an important consideration and is related to stage of maturity at harvest; variety; growing conditions; and speed of processing after harvest.

An example of the changes which take place in a cassava root over a three year period is graphically shown in the accompanying diagram. From this it can be seen that maximum starch production can be achieved by leaving the root to mature. However, from the production and processing point of view, this may not be ideal.

Figure 3

Trend of the nutrient content in cassava tubers during 3 year growing period



7.2 Water Quality and Quantity

The traditional method of extracting starch from cassava is a wet process designed to wash out starch granules from a pulp and to sediment out these granules from the suspension. In small rural factories, up to one tonne per day this is still done on settling tables or in tanks. Settling tables have a very slow flow of starch milk (starch in suspension in water) over a series of inclined trays. The starch particles precipitate out of suspension onto the tables. Varying quality according to granule size can be achieved since the larger or heavier starch granules will separate out first. In modern processing factories, capacity 1 tonne per day plus, the settling out is speeded up by the application of centrifugal force. Centrifugal separators remove the starch granules, and here, varying speeds can be used to obtain differing quality. It is important for quality reasons that the starch be removed from the starch milk as soon as possible since a starchy milk is a good media for the growth of moulds. The centrifugal separation process is therefore efficient and effective at removing starch from the water.

The quality of the water is therefore important, since it will be in contact with the starch and must be of potable quality. It should be potable from the point of view of being free from bacteria or mould spores and it must also be of good chemical quality. Free ions of copper or iodine will affect the colour of the starch.

In the dextrin process steam is required for heating the starch. Where boilers are required, suitable water quality in terms of level of salts of calcium (ie hardness) is also important.

Since the centrifugal process is a wet one of continuous washing and extraction, the quantity of water required is large. A typical example would be a water consumption of 4,300 litres for every tonne of starch produced (ie a 4.3:1 ratio). Some water can be re-used on the modern processes which is reflected in the above figure. Older processes required as much as 16,000 litres/tonne of starch.

In view of this high water demand and since cassava is often grown in areas of the world with low or very seasonal rainfall, we have investigated the possibility of extracting starch using a flour sifting technique rather than a wet process. A dry technique would be feasible depending on the quality and use of the resultant starch. A dried chip would have a starch content of approximately 85% and, depending on the stage of maturity of the parent root, the fibre contained in the chip could be sifted out. This starch product could then be used for dextrin manufacture or even glucose manufacture. Its quality would be poor for food uses since the proteins and fat still bound up with the starch might affect its viscosity and heating properties. Similarly the product may have some application in textile sizing but its boiling qualities would be variable.

The above demonstrates the importance of considering the end product from a cassava factory since a dry process would be cheaper in both capital terms and in use of water, especially if the water needs to be treated before use.

Further research work on the dry processing of cassava starch needs to be done. Some work is already quite advanced on potato starch and this may be applicable for cassava.

7.3 Effluent Disposal Standards

The extraction of constituents of cassava can never be 100% efficient, and depending on the sophistication and thus capital cost of the factory, the efficiency of extraction will vary. In the wet process some product will be lost as soluble sugars in the waste waters, and these sugars provide nutrients to bacteria and microorganisms which ferment and often produce the odours associated with starch or agricultural processing plants. The starch water will need to be treated as it leaves the factory. This can either be a simple ditch and weir system allowing some precipitation of suspended solids, or it may be a more complete effluent treatment plant to ensure organic matter is digested in a more controlled manner. Much will also depend on the disposal of by-products such as the fibre extraction. If this is dried and sold for animal feeds, then there will be mainly a liquid effluent disposal problem. Whatever manner it is dealt with, the disposal of effluent willneed to be considered in the light of the local and government legislation, the quality of the effluent being disposed of and the resources available in the vicinity of the factory, eg rivers, streams.

7.4 Level of Technology Required in the Process

The level of technology required will be dependent upon scale of operation and the market requirement. One other consideration will be location of the factory. Sophisticated factories in remote areas are often difficult to service both technically and managerially. Factories should be simple and appropriate to both location and skill of operators using the plant. The location of the processing facility may also be determined by its proximity to the growing area, which may cause the location to be in a more remote area. In these instances a simple "extension of raw material life" type process is the most appropriate and shipping to further processors in an industrially developed region of the country would save the cost of the factory providing its own infrastructure and service industry.

7.5 Leaf Processing

In Zaire, as an example, it is estimated that in rural areas 60% of the diet is derived from the cassava plant and that leaves are plucked from cassava every two months. The leaves are normally boiled and used as a spinach. They are high in nutrients and therefore have a good food value.

Comparison of Nutritional value of Cassava Root and Leaf

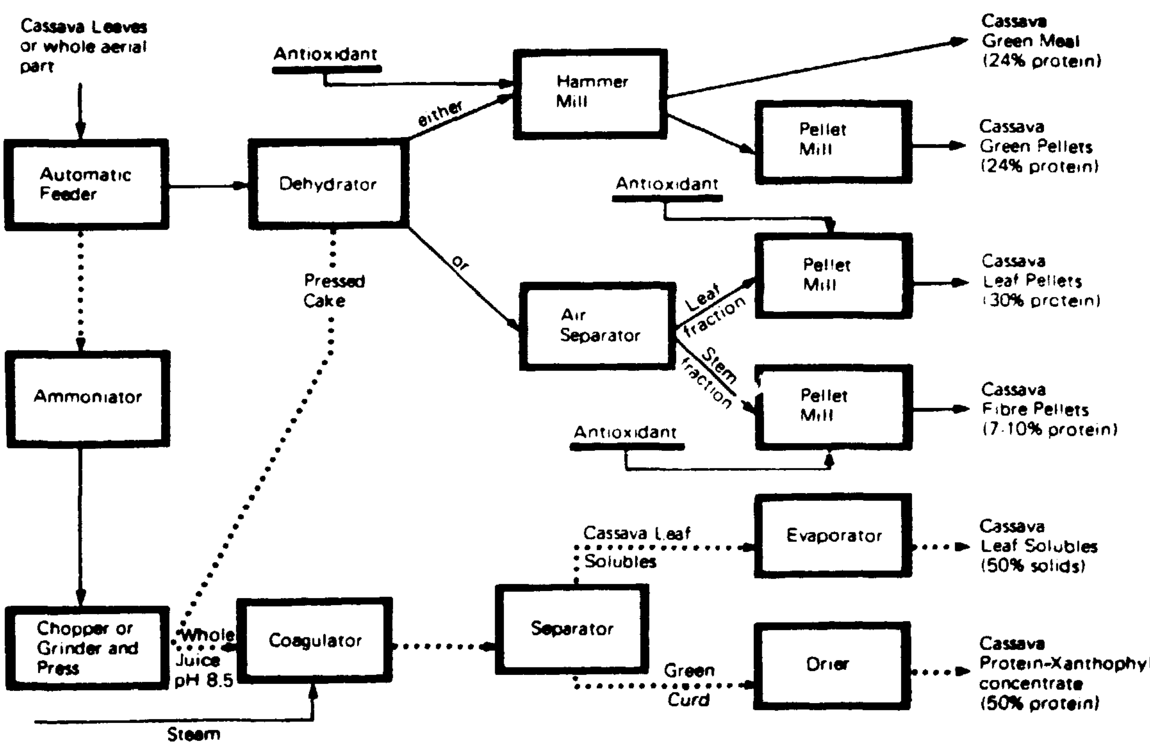
Food Composition	Units/ 100 gms	Raw Root	Raw Leaf	Potato
Food energy	Calorie	135	60	82
Moisture	Percent	65.6	81.0	77.7
Protein	gms	1.0	6.9	1.7
Fat	gms	0.2	1.3	0.1
Carbohydrate	gms	32.4	9.2	18.9
Fibre	gms	1.0	2.1	0.6
Ash	gms	0.9	1.6	0.9

Source: Leung, Butrum and Chang, 1972.

The biological value of leaf protein is between 44-59 due to the low levels of methionine (an essential amino acid in the protein). If the leaf is supplemented by this at 2 gm/kg, then the biological value of cassava leaf is raised to that of fish or meat. Thus provided people on a cassava-based diet supplement their diet with protein from legumes or fish, then a well balanced ration should be achieved. Leaf protein extraction from cassava is not generally recommended since the crop is normally grown for its roots and cassava is not a plant with a large leaf area. Experiments have shown that some defoliation every two months has little or no effect on root yield, however any off-take greater than this will seriously depress root yield. Other more leafy crops are therefore recommended for leaf protein extraction on a large scale.

Figure 3a

The commercial potential of the utilisation of the aerial part of cassava (modification of the PRO-XAN process)



The possibility of integrating a leaf protein extraction plant into a cassava processing plant would be a logical concept, especially where cassava is produced on an estate basis. To elaborate this concept further in the case of estate cassava production, the alternative crop to cassava grown in the rotation could be a leafy crop. Such a crop as alfalfa (lucerne) or even a grass cover would be a useful break crop to cassava since a legume would restore some fertility back to the soil or a grass crop could be ploughed back into the soil, providing during its life an opportunity to treat broad leaf weeds which may be a problem in cassava and to provide a break from cassava diseases. The break crop may also provide grazing or feed for livestock but more relevantly the crop could be used for leaf protein extraction. Thus a possible concept would be a cassava factory producing gari or cassava flour and a leaf protein extraction factory, using some common plant producing leaf protein. These products could be mixed to form a nutritionally balanced meal for both human and animal feeding or could be sold separately.

Since the dried products would store well, the possibility exists of using the same factory to produce leaf protein in the wet or rainy season (a period of maximum leaf growth) and cassava flour/gari in the dry season (the period most suitable for root harvest). The products could then be mixed at a convenient time of the year. In this way a factory could be operational 12 months of the year. Much of the equipment used in such a factory is common to both processes providing a saving on capital. (A flow diagram of a leaf protein process is given in Figure 3a).

On further investigation of this concept, the consultants have found very little relevant research work and indeed leaf protein itself is still a somewhat untried product. It would appear that marketing a balanced meal of this type or even leaf protein, is the present constraint. In Nigeria, where the enrichment of gari would appear to be an obvious market opportunity for the urban poor, the concept of leaf protein is still in the experimental stage. Some feeding trials have been done but there has been no attempt at marketing on a larger scale.

In conclusion, therefore, we would suggest that a leaf protein cassava flour complex be looked at in more detail and perhaps a pilot production and marketing trial set up. The technology for both processes is available and could be engineered and therefore such a factory may find a new market opportunity.

8. OUTLINE OF INTEGRATED CASSAVA PROCESSING FACTORY

In this chapter we describe the integrated cassava processing factory and its procurement system as proposed for Zambia. In other countries the circumstances of raw material supply and market demand will vary; but an operation on the scale proposed will probably be applicable to a number of other countries, and to regions in countries of larger population.

Layouts of the proposed Zambian factory are shown as Appendices 8 and 9 and a list of machinery required is given in Appendix 10. Appendix 11.1 gives details of manufacturers able to undertake turnkey projects, and Appendix 11.2 shows those with experience of supplying some of the machinery required.

8.1 Procurement Supply

The factory proposed in this report is a new concept for the African situation since the major source of raw material is cassava chips and not fresh roots. We believe that, if a sufficiently well organised marketing system can be arranged which would not only ensure adequate quantity but would also ensure a quality chip suitable for processing, then the processing of cassava on a commercial scale becomes a very real possibility.

An outline of the proposed factory and associated collection system is shown in figure 4. The recommended system of procurement of chips is described in volume 2 which is designed to ensure that the chips are purchased during the dry season and stored at the factory for later processing. In the case of Zambia this could conveniently be done through the national crop buying organisation (NAMBOARD).

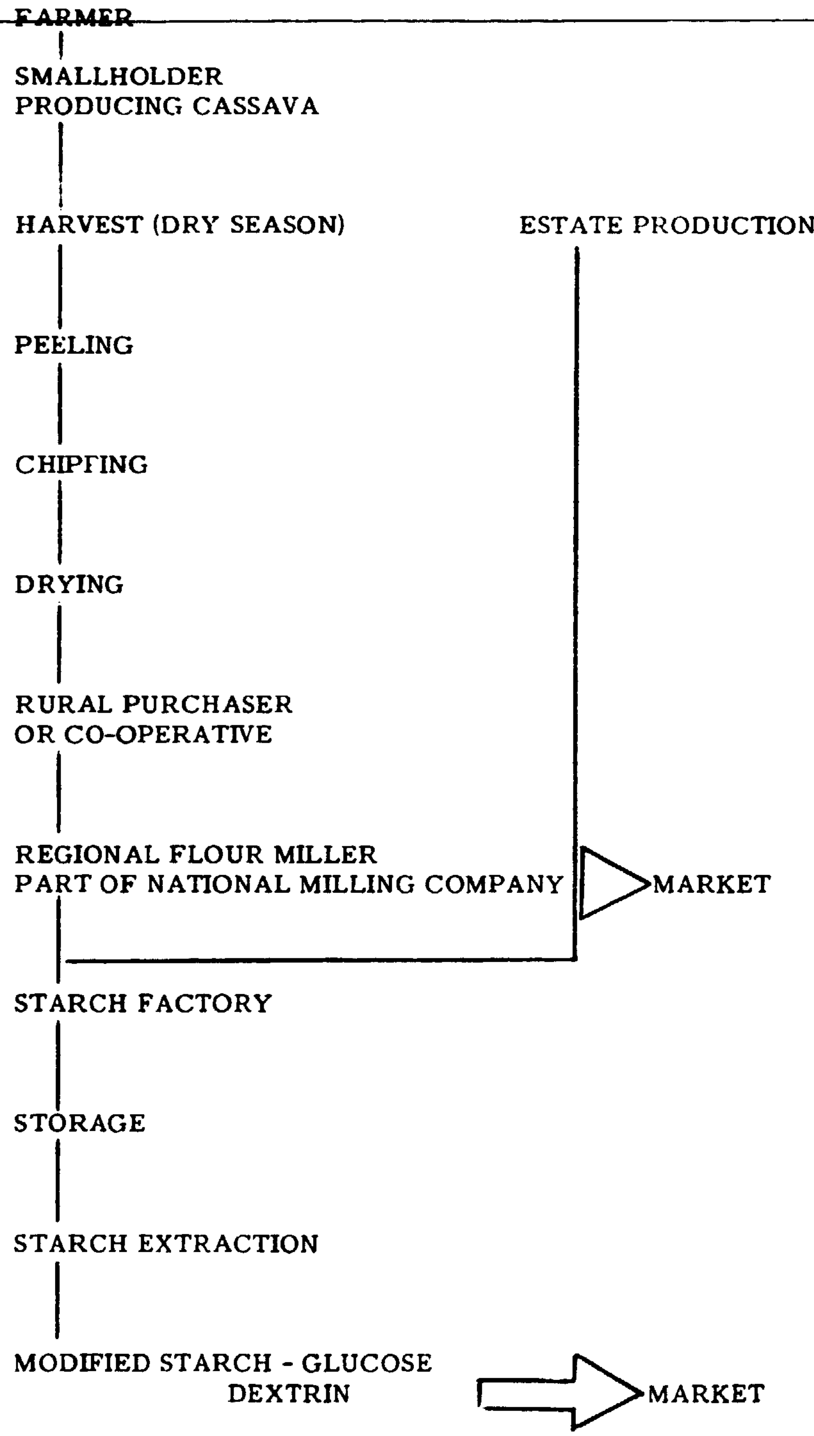
It is proposed that a considerable quantity of chips collected be processed into flour through the existing maize mills. The product would be used in the national dish, Nshima, or could be stored or substituted for maize as a reserve. It is therefore proposed that the cassava starch factory only process that quantity of chips which will be surplus to demand for flour production. However a flour production line has been provided in the process to allow the factory to produce flour since the factory's location may be in an area where there is currently no national mill.

Since the factory would purchase chips from the government marketing system it would not have to have a large purchasing force of its own. In some countries however this team may be crucial to ensure adequate supply of chips to a factory.

The factory would not be built in the Zambian situation until the system of production, buying and milling of chips was well established.

Figure 4 - PROPOSED FACTORY & ASSOCIATED COLLECTION SYSTEM

PE



8.2 The Starch Process

The concept of starch extraction from sun dried chips is uncommon. Standard designs and equipment are not generally available from companies specialising in starch processing. Normally starch from chips would not be recommended since the quality of the resultant produce can never be as good as starch drived directly from the fresh roots. There is therefore little experience on the quality and uses of starch produced from chips. However for industrial purposes (textile sizing and glues) and as the raw material for glucose manufacture the product should be of adequate quality.

It is proposed that the factory described in this report should also have the capability of processing some fresh roots for the production of high grade starch.

8.2.1 Starch from Fresh Roots

The extraction of starch from fresh roots will be done on standard equipment designed for the extraction of starch from potatoes. The process relies on the use of centrifugal force to separate the starch granules from a water suspension.

Fresh roots will be supplied daily to the factory from surrounding smallholders and possibly from a small plantation set up on the Government research station just outside the town of Kasama. This small plantation is advised for the supply of new planting material for the Zambian farmers and which will, when harvesting planting material, also supply roots to the factory at Kasama. We would recommend that any starch or cassava processing scheme have some facility or system of promoting the use of high yielding varieties in the area which assists the farmers in obtaining higher yields of roots per unit area of their land. This normally means that some research or trials area needs to be established to provide information on the most suitable varieties of cassava for a given region. Once the variety has been determined then the regular supply of clean planting material to the farmers assists in controlling disease levels in the region. It also provides a centre for agricultural extension and demonstration for small holders. The resultant roots are available for any nearby processing facility.

The rated capacity of the starch factory is planned at an output of 1¼ tonnes starch per hour. This scale is too large for the processing of fresh roots and is designed mainly for chip processing. To supply such a line with fresh cassava roots would require approximately six tonnes of roots per hour (Approx 50 tonnes/roots/day on an 8 hr processing day). This is a considerable undertaking since the average yield of cassava is often below 10 tonnes per hectare and therefore the physical harvesting of 5 hectares per day all the year round is the logistic problem most commonly cited in the poor performance of cassava plants already in existence. This output may be possible from an estate or plantation, but the problems discussed in Chapter 6 above make this uneconomic in Zambia.

It is therefore proposed that only 5 tonnes/day will be processed at the factory for a maximum of 150 days during the dry season, when the quality of roots is at its best. The fresh roots will be from 18 months to two years old. This will mean that the starch level will be high, but the roots may have become rather woody and fibrous.

We calculate that the extraction of starch from these roots will take $1\frac{3}{4}$ hours per day. This process would be carried out as the last process of the day before cleaning down. The remainder of the day would be spent on washing and peeling and rasping of the roots. Since the peeling can now be done by hand (due to lower throughput) considerable savings can be made on the amount of root actually processed. Mechanical peelers presently marketed have been designed for potato and therefore losses of up to 25% of the root have been recorded when peeling a root the shape of cassava.

The process flow line to the point of starch extraction is therefore as shown in Figure 5.

The material balance and water requirements are shown in Figure 6 showing the whole starch process from fresh roots.

Much of the machinery for this stage of the process can be locally made out of mild steel. There is a well established ability in Zambia to produce on-farm milling equipment and these fabricators could readily assemble the conveyors, washers and rasping machines to a specified design.

Figure 5

PE

PROCESS FLOW LINE FOR PREPARATION OF FRESH ROOTS FOR STARCH EXTRACTION

FRESH ROOTS	5 tonne/day
WEIGHING	Platform Scale & Tared Buckets.
WASHING	Rotary Tumble Washer (recycled water)
STORAGE	Open Silo
PEELING	By Hand
WASHING	Rotary Tumble Washer (Raw/Fresh Water)
CHOPPER	Size Reduction Slicer
DISINTEGRATOR	Rotating Rasp of Local Manufacture.
SLURRY TANK STORAGE RESIDENCE TIME MAX 12 HOURS	Stainless Steel Vat with Facility for Dosing with Sulphur Dioxide (SO_2)

Figure 6

PE

TYPICAL MATERIAL BALANCE SHEET FOR CASSAVA STARCH PLANT

1 TONNE FRESH ROOTS
350 KG DRY MATTER (DM)
650 KG WATER

WASHING AND PEELING
310 KG DM
750 KG WATER

RASPING
310 KG DM
2950 KG WATER

EXTRACTION
310 KG DM
6450 KG WATER

REFINING
220 KG DM
370 KG WATER

DRYING
220 KG DM
30 KG WATER

Root Preparation to Slurry

Root slurry is the term used in this report for the disintegrated root material which is awaiting starch extraction. In some cases it is referred to as starch milk.

Since storage for a maximum of 12 hours will be required it will be necessary to introduce Sulphur Dioxide (SO^2) as a preservative for the starch. This prevents fermentation by bacteria from occuring and preserves the colour of the slurry. There will be a tendency for browning to occur due to enzyme action and this is prevented by the addition of SO^2. The chemical will tend to have a bleaching effect.

The maximum holding time of 12 hours assumes that the processing day will be a total of 16 hours (2 shifts of 8 hours). Two hours will be required for start up and cleaning down, approximately ½ hour start up and 1¾ hours cleaning down at the end of each day. The roots will arrive and be stored from the previous day's harvest and will therefore be available for immediate processing as the factory starts in the morning. The roots will then be washed and await peeling which would take some time (estimated that 1 tonne could be peeled by hand in one hour using 10 women). Women have been found to be more adept at removing the peel with a knife than men. Piece work rates could be considered for this task, especially since the harvest is only for a certain period of the year.

Following peeling the roots would need to be further washed to remove pieces of peel and dirt. The design of the washer would be similar to that used before peeling and would consist of an inclined perforated drum. The drum rotates in a bath of water and the roots travel from the higher end and are retrieved at the bottom by a conveyor. Brushes may also be fixed to the side of the drum to have a further cleaning effect. Raw or clean water would be introduced in the second wash but could be circulated and used for the roots prior to peeling, the first wash removing soil and sand adhering to the roots. Some drying out of the roots will occur whilst they are in storage overnight which should facilitate the removal of adhering soil if the roots are forked into the washing machine.

Following washing it is necessary to break up the roots and release the starch. Starch is contained in the cells of the plant as granules. To obtain the maximum starch it is necessary to break each cell and this is done by rasping. In the process shown a size reduction known as chopping is shown which will cut the roots down into small pieces ready to be pushed against a rasping drum. Large pieces will tend to bridge or not be in contact with the rasp effectively. The rasp or disintegrator can be a simple machine such as a roughened drum rotating at speed against a quantity of the roots. This will have the effect of grating the root material and breaking it up into a fine slurry. The root being high in water content should provide some liquid to form a slurry which will flow into the slurry tank. Additional water to assist the process is added over the rasp to increase the extraction of starch from the plant tissue.

Before the slurry enters the tank a simple sieve may be incorporated to extract large pieces of fibre and root material which has not been disintegrated.

Starch is composed of complex chains of sugar molecules which are insoluble in the quantities of water forming the slurry. However some of the sugars will not be complexed into starch chains or molecules and will become soluble in water. These soluble sugars will be lost in the waste water. The amount of loss is related to the stage of maturity of the roots. High soluble sugars in the waste water can also lead to effluent disposal problems since these sugars provide nutrients to bacteria and other organisms. The effluent may then begin to ferment.

It is recommended that the slurry tank be constructed of stainless steel or some other non-ferrous metal. The reaction of iron with starch will cause discolourisation of the starch. Cleaning of the equipment will also be facilitated if this vessel is constructed on stainless steel.

Fibre Extraction from Slurry

The starch at the slurry stage is in suspension in water and the final process for the extraction is by centrifugal force. This process separates suspended solids from a liquid. Since the liquid will also contain other impurities such as fibre these need to be removed first. The slurry is therefore passed through sieves to remove the larger fibre particles. Further amounts of water are added at this stage to assist the flow. Sulphur dioxide water is also added to maintain starch quality.

The fibre which results from these sieving operations is then pressed to remove excess water. The press consists of a rotating drum slung on an endless belt. The fibre is pressed between the drum and the belt. The press reduces the moisture content of the fibre from 93% to 78% approximately. The fibre should have a moisture content of 12%. This is usually achieved by sun drying since the installation of a drier for the fibre cannot be justified on cost. The drier used for the starch is not suitable for fibre so there would be no advantage in attempting to use the drier for two functions. Fibre is sold as an animal feed. In Zambia this could substitute in the ration for maize.

Starch Extraction from Slurry

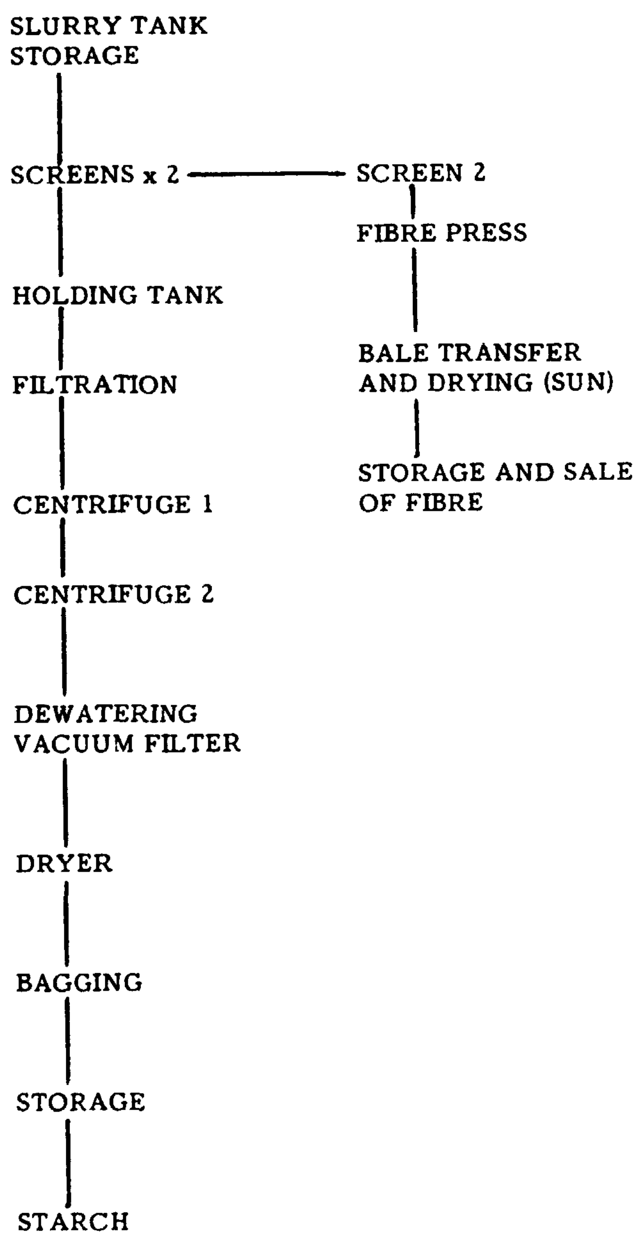
The press water or starch milk with the fibre extracted will now contain soluble sugars, starch in suspension, protein, fat and other foreign matter in suspension or solution. A further filtration is carried out using a much finer mesh which removes more pulp. This can be incorporated in the fibre. The main e.traction process then follows. The starch milk is centrifugal twice to remove the starch. This considerably reduces the water content. A further dewatering is done through a rotating vacuum filter before the wet starch is passed to a drier for the reduction of moisture content from 40% to 12%.

At a moisture content of 12% the starch will be stable and will store for considerable periods. In this state it may be bagged or kept in bulk for sale. Drier temperatures are important since the high temperatures will cause gelatinisation. A temperature above 70°C will cause gelatinisation resulting in an insoluble starch product. The lower temperatures are achieved by using a flash drier. These types of driers reduce the residence time of the particles in the drier, thus ensuring that high temperatures around each particle are not achieved. Steam is used to heat the drier and therefore a boiler must be provided for the factory. In the Zambia situation this will run on coal brought by rail to the factory. Steam generation may be an important consideration in other installations in Africa with regard to fuel and water availability and cost.

Dry root starch from the drier would be packaged in 25 kg paper sacks with polythene liners. This would be stored awaiting transport to the consumer.

The conversion of chip slurry to starch follows the same flow line and this is the reason for processing root starch for only 1¼ hours per day. The rest of the day the plant is used for chip processing.

PROCESS FLOW LINE FOR STARCH EXTRACTION FROM SLURRY (CONTINUED FROM FIG 5)



8.2.2 Starch from Chips

Chip Storage

The cassava chips would be purchased by the factory from the National NAMBOARD marketing system. This organisation should co-ordinate the buying and processing of the chips into flour. It should therefore be aware of the location and quantity of any excess chips in the region of the factory.

Since chips are only produced in the dry season purchases and storage will need to be provided to enable starch processing to continue for the full 240 days per year. The total chip requirement over the first production year is estimated at 3300 tonnes. Assuming 24 weeks are during the rainy season then the minimum storage would be 1,650 tonnes. To allow a working store of chips we recommend a storage capacity of 2,000 tonnes. These would need to be kept under cover in an A frame building in bulk on the floor.

We recommend that the use of solar heated convection be tried in such a building. This system means that the roof of the store would be double skinned. The outside surface exposed to the sun would be painted black. The sun will heat the air between the roof (the space between roofs being approximately 10 cm). The heated air would be ducted down to the floor and allowed to rise through the stored chips via ducts. This system would have no running costs but would ensure that dry air is passing through the chips and maintaining them in a dry state whilst they are in storage. This is a further concept so far untried with cassava but has been experimentally tried with grain. Since cassava chips may tend to be hygroscopic the circulation of air through the bulk of the chips should be attempted.

The size of the storage capacity would need to be 3,600m^3. (1.8m^3/tonne chips). The dimensions of such a building to accommodate this would be 10m eaves height, 15m standard span x 25m long. (Floor area for storage only 750 sq.metres at a stack height of 5 metres). Standard A frame building should be used where possible.

Chips arriving at the factory by lorry would first be check weighed over a weigh bridge. This would be possible in the Zambian situation if the chips were purchased in bulk from NAMBOARD. However, in a rural situation where control of chip quality is difficult delivery should be in sacks so that each could be checked for quality and the absence of foreign matter such as sand and stones. Bags or lorry loads could then be dumped at the foot of an elevator which would enable one to achieve a heap of chips to a height of approximately 5 metres.

Whilst the chips are in store the solar heated air could be blown through them.

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Chips to Slurry

The dry chips would be taken out of storage using a tractor mounted bucket or shovel. These would be dumped in a sleeping or chip preparation area. This area would simply be a separate floor near the process area which has a drain or gutter and where the chips can be soaked with water. This should preferably be done about 8 hours before processing, and could conveniently be done whilst the fresh roots are being processed at the end of each day. The moisture content of chips in store would be approximately 12%. Any moisture content higher than this would not inhibit mould growth and deterioration of the chips. The soaking would increase the moisture content to about 40% which will soften the chips and make them considerably easier for processing. The 8 hour delay enables the chips to absorb the water. (21 tonnes to be soaked per 14 hour process period). Floor area required approximately 76 square metres at a 0.5 metre depth of chips.

The soaked chips are then pushed manually to the reception pit of a bucket elevator. This conveyor conveys them to a rasping machine similar to that for roots. Further water will be sprayed into the machine during the rasping process. The rasping of chips has the same effect as on the roots, that of breaking the plant cells and releasing the starch.

Some losses of loose starch and other particulars will occur in this washing process. For this reason water is reused by recirculating it to the rasp in a screed and hydrocyclone, and effectively remove sand and other particles from the water.

The rasped chips are milled to a fine pulp by the rasps and together with the added water now form a slurry. This is then pumped to a holding tank or slurry tank where it will be processed for starch. Agitation is needed on this tank to keep the starch in suspension and to ensure an even flow of slurry to the next process.

At this stage the slurry from the chips is the same as that for roots. The onward processing to starch is therefore as described.

Figure 7

PE

CHIPS TO SLURRY

CHIPS	-	2000 ton ventilated store with solar drying floor
SOAKING AREA	-	moved by mechanical shovel to floor with central guttering
SOAKING	-	8 hour soaking. Water is hosed over the chips which are sread out on the floor (76 sq.m).
ELEVATOR	-	Bucket type - hand fed by pushing chips into reception pit
RASPING	-	Water addition. Rotating rasps to release starch
SLURRY TANK	-	Starch milk

8.2.3. Chips to Glucose

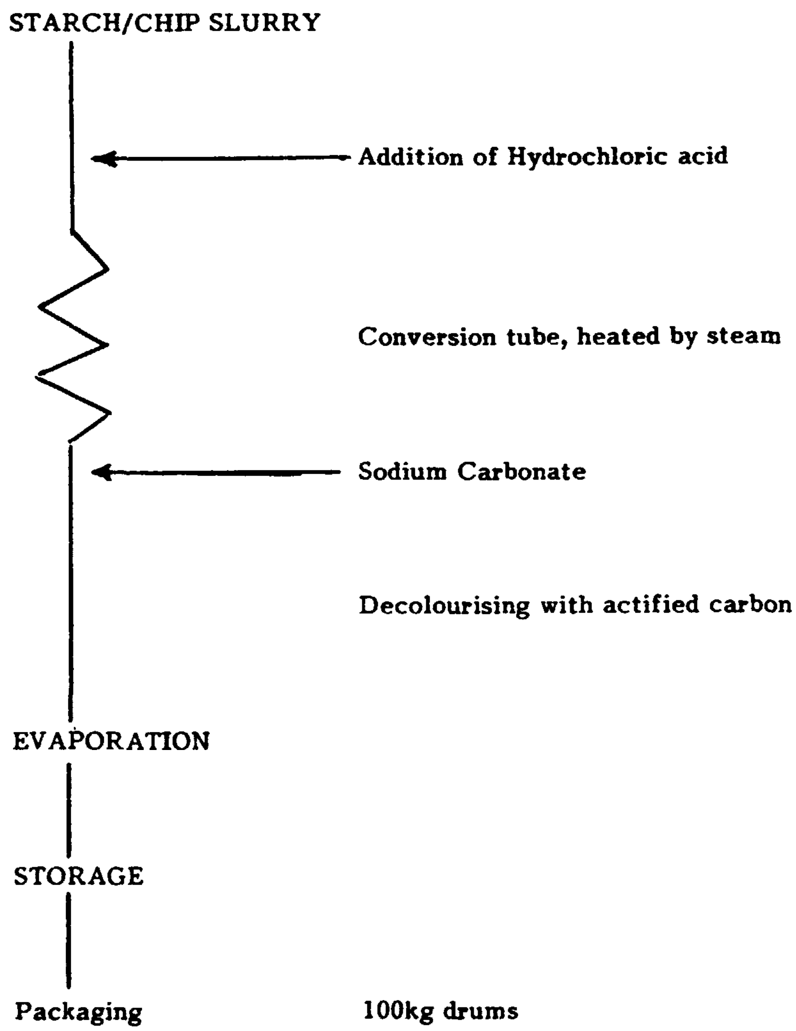
Over half the world's starch production is estimated to be converted to glucose. This is done by the action of acids, or enzymes or a combination of the two. The action of these agents is to break down the long starch molecule into its consistent elements, the starch molecule being mostly composed of glucose and simple sugar units. 100% pure glucose is know chemically as dextrose. The production of Dextrose is more elaborate and costly than only going part of the way to Dextrose. Thus the concentration of the glycose syrup, which is the Dextrose process, is known as the Dextrose Equivalent. For example a D E of 50 means that there has been a 50% conversion to pure Dextrose. Pure Dextrose has a powerful reducing property and can be measured and in this way the D E value can be applied to glucose syrups. The other 50% of the syrup referred to in the example will be composed of short chain sugars such as Dextrins. In most applications the presence of Dextrins in the syrup is not important and may be even advantageous.

The most widely used glucose (known as confectioners glucose) has a DE value of approximately 42% and a moisture content of 16-20%. This is produced by the acid process and is the easiest process.

It is recommended, to avoid expenditure on capital equipment to produce a product too refined for the market, that only an acid hydrolysis plant be installed. These plants are in themselves expensive and are little more expensive if the raw material is dry starch rather than slurry. Because of this we have considered in the economics of the cassava concept the possibility of only producing starch in the factory described. Glucose could be produced elsewhere, perhaps Lusaka (in the case of Zambia), where there is likely to be better facilities for food processing than in say Kasama. This may be even more relevant in a case such as Zambia where glucose is required as a brewing substrate in substitution for malt. In this instance the conversion of starch to glucose, indeed even the conversion of cassava flour to glucose would best be done on the brewing premises. This would save considerably on packaging and transport costs and would mean a simplified process could be installed producing a glucose to the DE value required by the Brewer. The brewing industry requires a DE value of approximately 55-56 and in the case of Zambia is the largest consumer of sugars, or malt in the country.

Figure 8

CHIPS TO GLUCOSE DIAGRAM



The acid used in the conversion is hydrochloric acid, although sulphuric and oxalic are used in some parts of the world. The acid conversion process is much quicker and also less costly since less conversion vats are required. The acid is later neutralised with sodium carbonate. These chemicals are normally readily available.

Chips for glucose extraction will be stored, soaked and rasped into a slurry the same way as described for starch manufacture. Starch from the slurry tank is then preheated with steam before being pumped to the converter. Hydrochloric acid is metered into the stream and as the temperature rises the starch begins to gelatinise. Temperature of conversion being approximately 80°C. The residual time for the conversion to take place is achieved by running the heated, acidified slurry through a spiral tube. Directly after acid conversion the syrup is neutralised with sodium carbonate. The syrup is then cooled to approximately 50°C and then decolourised by passing the syrup through an activated carbon filter.

Finally the syrup is concentrated by evaporating the water off the liquid under vacuum. The resultant syrup is then held in heated containers to aid flow before being filled into 100 kg metal drums. The syrup will have a light yellow colour which should be acceptable for most standards. If the market demands however this can be removed by ion exchange methods.

The conversion of starch to glucose is a standard process used all over the world. Maize starch is now the most common raw material for the manufacture of glucose syrups. The advantage of maize being that the starch is often the by product of the vegetable oil industry and therefore the raw material is obtained cheaply and syrup manufacture is often associated with the same factory. In the Zambia situation however where maize is in short supply for human needs the use of cassava is far more appropriate. Further design and process considerations must be made when a future plant is purchased since such factors as syrup concentration or DE value to be produced will affect the cost of the plant. The concentration will be dependent upon market requirements as will the scale or throughput of the factory. Suffice it to say therefore that for the purposes of this report glucose syrups manufacture is both possible and relevant in the Zambia situation. The more precise details of the plant should be planned at the detailed design stage where standard glucose plant and technology can be used.

Properties and uses of glucose syrups are described in Appendix 6.

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8.2.4. Starch to Dextrin

Dextrin is the term used from the products obtained by treating starch in a number of ways. They may be prepared by a wet or dry process either by acid or enzymes or under carefully controlled heating conditions. Once again standard equipment is available for Dextrin manufacture and therefore careful planning considering the markets and the quality of product required is essential. Both batch and continuous processes are available and unless the quantities required are very large we would recommend a batch process. The batch process is also most easily accomplished using the dry process.

The starch with a 12 percent moisture is filled into a reactor. This is a closed vacuum pressure vessel holding 1 tonne of starch. The reactor also contains a high speed mixing paddle and is surrounded by a jacket for heating and cooling the vessel. After filling hydrochloric acid is added in a measured quantity. This is normally done through a metering pump which measures the quantity of acid introduced. The vessel is then heated and a vacuum applied to remove any moisture in the starch. Once dry the reaction is allowed to take place under the action of acid and heat. Finally water is added to bring the moisture up to 12 percent again ready for sale. The product can then be cooled. The Dextrin is removed from the bottom of the vessel and conveyed for packaging in 25 kilo bags.

The total reactor time for yellow Dextrins is 6 hours, white Dextrins take less time. Under the proposed factory therefore two processes could be carried out each day on a 16 hour day. If the Dextrin is stored in bulk after processing packaging could continue whilst waiting for the next batch to react.

Figure 9

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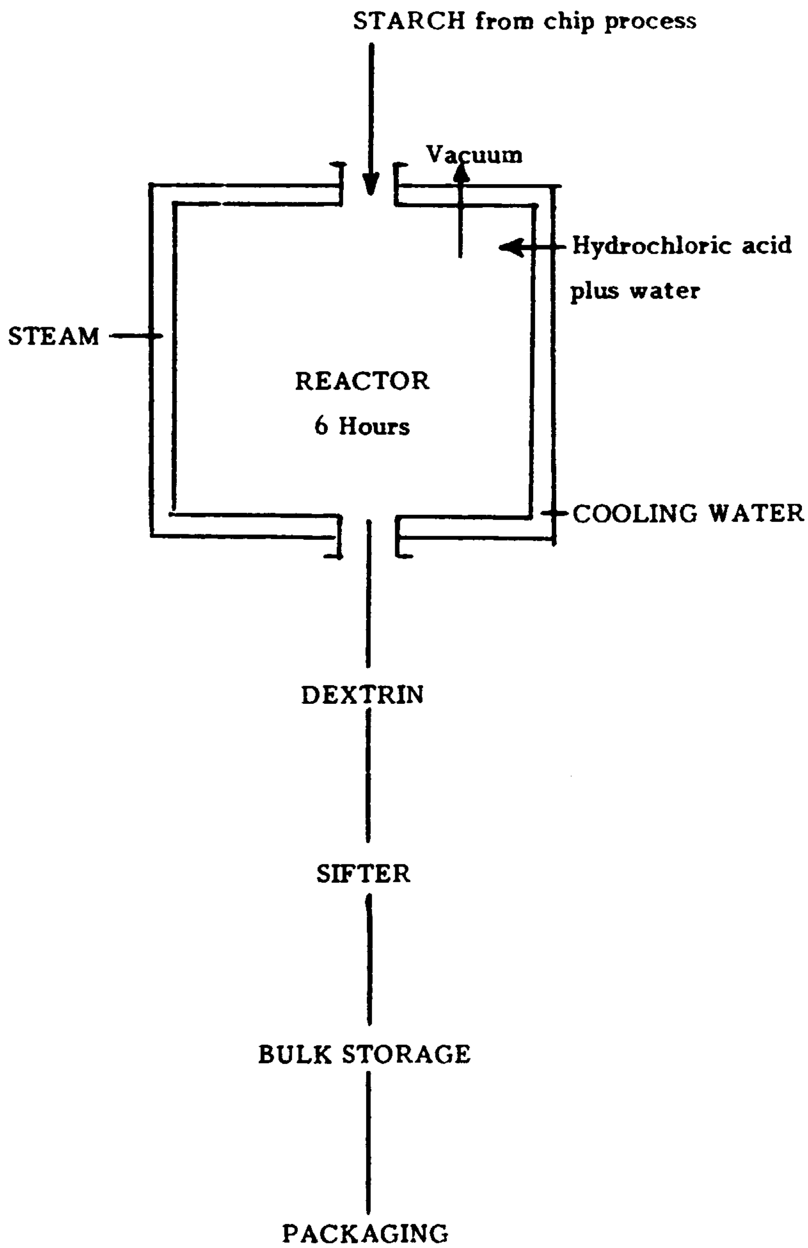
STARCH TO DEXTRIN



8.2.5 Potable Alcohol

Alcohol for drinking purposes or industrial uses can be made from cassava via glucose. Considerable attention is currently focussed upon alcohol or 'Gasohol' production from cassava for use in combustion engines as a fuel. At present alcohol can be more economically made from sugar cane since sugar is:

- normally produced on a plantation scale
- the waste material bagasse provides a fuel source for the alcohol fermentation process
- there is already a greater amount of fermentable sugar available in cane sugar so that little conversion needs to be undertaken from complex carbohydrates eg starch to sugar before fermentation begins.

The route from cassava to alcohol on an industrial scale is via glucose. The preparation of glucose has already been described in this report. Alcohol production is the process of converting this glucose by fermentation an distillation to alcohol. Thus a factory concept could plan for an alcohol production facility down stream from its glucose line.

8.3 Effluent Disposal

From the discussion on the processing aspects of the factory concept it can be seen that considerable quantities of water are used in the process. Where possible this is recirculated and reused. The final waste water will contain suspended solids of soil, sand and carbohydrates plus other organic matter from the process. There will also be dissolved sugars present in the water. The resultant waste is likely to have a BOD value (Biological Oxygen Demand) higher than would be permissable for discharge into local rivers and streams without some form of pretreatment.

In the tropics, especially the area around Kasama, the most convenient means of reducing the organic matter in the water is to discharge into a lagoon. This allows suspended solids to precipitate out and with high evaporation rates the bulk can also be considerably reduced. Provided the lagoon is large enough to allow a residence time of approximately one week then this method of treatment should be satisfactory. Overflow over a wier would tend to discharge relatively clean water if this residence time is allowed. Thus a lagoon for 5 days discharge of water waste from the factory would need to contain 670,000 litres of water.

9. FINANCIAL EVALUATION

It is not practicable to construct hypothetical financial evaluations of the possible projects in different countries. We show in this chapter the financial evaluation of the Zambian project.

The main points of the financial evaluation of the starch, glucose and dextrins factory are set out below, including, in 9.1.6, a sensitivity analysis. The model can be used for a very rapid re-evaluation of the project at any time. If the project proceeds, actual results can be fed into the model to provide an instant picture of their implications on the factory's financial performance.

We also made a financial evaluation of a factory making starch only and supplying this to outside manufacturers of glucose and dextrins. The results of this evaluation, showing a much lower IRR than the multi-product factory, are shown in 9.2 below.

9.1 Financial Statements

The financial evaluation of the project has been done using a computer model the print out from which is attached as Appendix 12 Reports 1-12. The model logic for individual items is described in the notes attached as Reports 1A-12A, explaining the basis on which figures have been calculated.

In overall terms the model matrix is divided into two elements. Year C shown in the first two columns represents the construction period of 18 months. Year CP1 represents cost build ups in the first 12 months of project development and construction. This compression is possible since it is assumed all initial development will be done out of equity capital and has the advantage of enabling us to show more periods in the operations phase. Year CP2 represents the final six months of installation and trial runs. Thereafter ie years P1 onwards, operational years are shown in six monthly intervals (P1 = July-December, P2 = January-June). This format enables the model to demonstrate the effect of the seasonal raw material purchasing pattern on stocks and cash flow. For the same reason it is assumed that the project will have a financial year July 1st - June 30th so that year opening coincides with the major buying season.

The overall financial performance of the project is good as shown in the following summaries.

9.1.1 Profit and Loss (Report 8)

The project achieves a profit in its first year and as sales increase generates substantial cash flows to enable it to repay all borrowed capital by the end of operational year 6 period 1.

By year 6 period 2 the project is at optimal practical volume and the half year's results show the following:-

	K'000
Sales	2,088
Less raw materials	612
Gross added value	1,476
Less other variable costs	410
Contribution	1,065
Less fixed costs	597
Profit before tax	468
Tax at 50%	210
Nett Profit	258

Thus, allowing for a reasonable retention of funds for future years, a dividend of K 150-200,000 could be declared for the half year, representing an annual dividend of 15-20% on the equity capital of K2,000,000. Such a distribution would only be possible from about year 5 onwards.

9.1.2 Balance Sheet and Capital Funding (Report 9)

The project will require initial capitalisation as follows (see Yr.C P2).

	K'000	K'000
Sources of funds		
Equity capital		2,000
Term loan capital (75% P & M)		1,800
Total funds		3,800
Application		
Fixed Assets		
Land	25	
Factory buildings	500	
Housing	250	
Plant and machinery	2,400	
Vehicles	70	3,245

	K'000	K'000
Pre-production Working Capital		
Stocks	36	
Debtors	31	
Cash in hand	194	261
Pre-production expenses		294
		3,800

NB Pre-production trial runs are expected to bring in sales equal to approximately 50% of the raw materials used.

The basis of the capitalisation is the assumption that term loan financing will be available to a maximum of 75% of the cost of plant and machinery. The remainder is to be funded from fixed capital with short term overdrafts used to fund the substantial initial working capital requirements until self generated funds are available to take over.

The project's funds flow is more than adequate to service this capital profile and the project becomes totally self financing by the end of year 6 *period 1 at which time the position is as follows.*

	K'000	K'000
Sources of funds		
Fixed capital		2,000
Revenue Reserves	2,104	
Less surplus cash	816	1,288
Nett capital employed		3,288
Applications of Funds		
Nett fixed assets		1,848
Current assets		
Stocks	1,003	
Debtors	482	
Cash in hand	96	
	1,581	
Less current liabilities	141	
		1,440
Total Nett Assets		3,288

NB
The cash surpluses represent additional funds flow not immediately needed in the business.

Working capital requirements are substantial and grow from an initial requirement Yr.1 P1 of K842,000 to a level K1,441,000 by Yr.5 P2 levelling off thereafter. Initially K400,000 has been financed by an overdraft facility. This represents less than 50% of the total requirement and can normally be expected to be available. The overdraft is paid off by the end of year three period 1.

Term lending of K1,800,000 is equal to 75% of the cost of plant and machinery. The moratorium is three years from disbursement in Year C period 2, and repayments, at six monthly rests, take place during the following three years. The term loan is divided between two headings to enable loans of different terms to be built into the model should this prove necessary in future.

The model takes a conservative view of capitalisation which could be reduced by using a short term overdraft on a revolving basis to fund raw material stock peaks.

9.1.3 Funds Flow Statements (Report 10)

The project sustains a surplus cash position throughout its life. Funds need to be retained to finance the relatively short term loan repayment cycle, where in certain years the annual cash flow goes into deficit.

Given this debt servicing level then distributions to risk capital will be minimal for the first five years of the project. Thereafter however good dividends can be paid. Cumulative surpluses are available sufficient for a small dividend of 5% per annum from year 2 onwards, building up from an annual cumulative surplus in Yr.2 P1 of K132,000 to one of K476,000 in Yr.4 P2.

9.1.4 Financial Ratios (Report 12)

The project's performance indicates the importance of achieving good throughput. Fixed expenses are high and this in the early stages represent 53% of sales value dropping to 29% once higher throughput is achieved. This pattern is confirmed by the percentage of profit after tax to sales and it should be noted that given the high tax level of 45% the profit percentage is almost halved once tax becomes payable.

The profit on capital employed is good, achieving a level of 20.3% in terms of gross capital employed and a very creditable 30.9% on nett capital employed. This assumes substantial internal funding and early term loan repayments which mean that risk capital has to wait a considerable period before appreciable dividends can be paid.

The high capitalisation of the project is demonstrated by the fact that once established, capital is only turned over once a year and apart from the relatively high fixed capital investment, the current ratio of 11.2 to 1 indicates the high levels of stock and retained cash holdings needed to finance the crop purchases.

The overall capitalisation is conservative in development banking terms with term loans representing initially some 50% of capital employed. Debt service is reasonable dropping substantially during the major repayment period Yrs.3 P2 - Yr.6 P1. The term loan is repaid in a relatively short period which could be extended if this became necessary.

9.1.5 Internal Rate of Return (Report 12)

The internal rate of return of the project is an overall 13.64%. This is marginally above the cost of term loan capital at 13.5% and it is this debt service burden, coupled with a high risk capital component which accounts for the difference between the fully operational return on capital employed and the overall internal rate of return.

Given the importance to peasant agriculture of opening new markets for their crops by local processing perhaps more reasonable interest rates could be considered, at levels more in line with lending to the agricultural sector rather than the industrial sector.

9.1.6 Sensitivity Analysis (Report 13)

We have calculated in the sensitivity analysis the effect on cumulative funds flow and on profit after tax of changes in volume of sales (sales factor) and selling prices (price factor). The range calculated is 0 to -15% in 5% stages.

In overall terms it will be seen that the project is much more sensitive to price fluctuations than to volume fluctuations. This is particularly marked in the schedules showing effect on cumulative cash flow. In the case of price variations a drop of five percent results in a periodic maximum cash shortfall of K126,630 whilst a drop of 10% in sales volume only shows a periodic cash shortfall of K36,070. Profits after tax are not as dramatically affected since the major cash shortfalls occur due to heavy debt servicing.

It would probably be possible to reschedule the debt service to enable the factory to continue should such adverse conditions arise as follows:

- in terms of price sensitivity a price drop of 5% could be easily accommodated by loan repayment scheduling. More than this would require a major rethink of the project.

- in terms of sales volume a drop of 10% could be easily accommodated and one of as high as 15% could possibly still yield a fundable project but investment return would be very low.

9.2 Factory for Cassava Starch Only

We have modelled the factory on the basis of the cassava factory producing and selling starch only. The basis of the model is that overall output and sales will be the same, and that capitalisation will be on a similar basis as follows:

	Multiple Product		Starch Only	
	K'000	%	K'000	%
Share Capital	2,000	52.6	1,700	58.6
Term Loan	1,800	47.4	1,200	41.4
	3,800	100.0	2,900	100.0

The marginal difference in structure is caused by rounding up figures, and gives the more conservative view of lower loan capital content. The overdraft has been retained on the same basis since this is tied to working capital which has not altered significantly. Fixed asset cost has been reduced by K900,000, the cost of the glucose and dextrin plant.

The term loan conditions and repayment has been retained on the same basis as the multiple product factory. The reports 1-12 for this option are shown in Appendix 13.

In overall terms the project's internal rate of return is reduced to 8.36%. It does not offer a very attractive proposition to risk investors and would require loan capital to be made available with longer grace periods.

9.2.1 Profit & Loss Account (Report 8)

The factory does not achieve profit break even until year 2 period 1. Subsequent profitability is at a very low level and dividends to equity capital are unlikely to be forthcoming until the 7th year of the project after all debt servicing has been completed.

9.2.2 Balance Sheets (Report 8)

The initial capitalisation of the factory at the end of the construction period is as follows:

	K'000
Sources of funds	
Equity	1,700
Term loans	1,200
	2,900

	K'000
Applications	
Fixed assets	2,345
Working capital	102
Cash	161
Pre-production expenses	292
	2,900

As set up the project has sufficient capital to start operations. Applying the same conditions, repayments are too burdensome as described in the funds flow statement comments below.

9.2.3 Funds Flow Statement (Report 10)

The factory initially has sufficient capital injections to meet its needs. However from year 2 onwards cumulative cash deficits build up to a maximum of K194,000 and are not paid off until the end of year 6.

This arises due to applying the same loan terms as the multi-product factory and the situation could be alleviated by providing longer grace periods. These will need to be of the order of six months' extra grace period on the overdraft and a full year's extra grace period on the term loan.

9.2.4 Key Financial Ratios (Report 11)

Contribution is reduced from 51% to 41%. Fixed costs as a percentage of sales are initially higher but level off at the same figure. This is due to fixed costs being reduced by the plant maintenance charges. Profit on sales is marginally lower in line with the lower contribution. Given the overall reduced profitability and cash flow all other key ratios also demonstrate a poorer performance from the starch only factory.

TERMS OF REFERENCE FOR CONSULTING SERVICES

Elaboration of an Integrated Cassava Processing Factory concept for the production of a variety of marketable cassava products supported by relevant economic calculations.

Responsibilities and Duties of the Contractor.

A. With regard to the field study work to be carried out in Zambia the contractor is expected to carry out the following activities:

a) Assess the existing situation in the agricultural cassava production sector with regard to the variety, quantity and quality of cassava tubers presently produced;

b) Assess and evaluate the organisational aspects and managerial situation in the agricultural cassava production sector and the marketing proceedings presently applied;

c) Study the planting, growing, harvesting and post-harvesting techniques presently applied;

d) Assess the infrastructural situation and comment on its suitability and/or requirements;

e) Study the present utilisation of cassava tubers in view of direct consumption, village-scale processing small-scale processing and industrial-scale processing and comment on its suitability;

f) Assess the domestic market situation and specify the cassava products presently available, with regard to variety, quality, quantity and price structure;

g) Evaluate the domestic market potential for cassava products and specify types, quality and quantity of cassava products expected to be in demand and outline their most practical price structure and development trends;

h) Evaluate the opportunities that exist in the country for exports of cassava products. Specify these products with regard to quality and quantity and estimate the expected export benefit derived therefrom;

i) Based on the assessments, evaluations and otherwise studies as mentioned above, specify the types, quantity and quality of the marketable products to be produced by the cassava processing factory to be defined and estimate the quantity and quality of the cassava tuber raw materials required for this purpose;

j) Comment on the present situation in the agricultural cassava production sector and based on the assessments mentioned under the paragraph a) to e) above define the action to be taken in order to make available the required cassava tuber raw materials as estimated under para i) above. Estimate the average cassava raw material costs;

k) Estimate the costs involved in the up-dating of the agricultural cassava production sector and outline the expected man power, equipment and other requirements;

l) Assess wages and salaries commonly paid in the country under review and the water and power costs.

B. With regard to the elaboration of the cassava processing factory concept, the contractor is expected to carry out the following activities.

a) Define the most suitable processing technology for the production of each of the cassava products to be produced and prepare relevant quantified process and product flow diagrams;

b) Integrate the different product and process flow diagrams in one overall process and product flow that characterises the processing technology of the cassava processing factory to be defined. By doing so, due consideration has to be given to the utilisation of the by-products and residues of one process by the other in order to guarantee the optimum utilisation of the cassava tuber raw material;

c) Based on the quantified flow diagrams specify the required equipment by using relevant equipment items from known processes that are available in the market;

d) Outline the engineering design in principle for such equipment that may not be available in the market and has to be newly developed in connection with the cassava processing factory concept to be defined;

e) Prepare principal factory lay-out plans and specify the pipings, fittings, motors and other electrical and mechanical installations that are required for the appropriate function of the cassava processing factory to be defined;

f) Outline the type and size of the required factory buildings that meets with the conditions that exist in the country under review and specify the type of building material most suitably to be used;

g) Specify the service requirements - if any - of the cassava processing factory such as for example repair and maintenance workshops, laboratory, storage facilities, spare-part stocks, steam boiler, main water pumps, etc. as well as the administrative facilities;

h) Specify the techno-economic data of the cassava processing factory such as manpower requirements, energy, steam, and water consumption figures and define the throughput capacity (raw material) and the production capacity (products);

i) Based on the results of the studies mentioned under A) above, outline those measures in details that need to be taken inorder to secure the required raw material supply to the factory, the production concept of which has been defined;

j) Elaborate a suitable practical management plan for the integrated cassava processing factory concept starting with cassava production controls and raw material provisioning and ending with marketing operations thereby covering the entire production process of the cassava processing factory.

C) With regard to the economic and financial calculations to be prepared in support of the proposed cassava processing factory concept, the contractor is expected to carry out the following activities.

a) Estimate the investment costs for the entire cassava processing factory as outlined and defined (para B above);

b) Based on the raw material cost assessment (para A,j) above and the specifications prepared (para B,h) above estimate the expected operating costs;

c) On this basis (para C,b) above define the cassava raw material price limits and comment on the incentives derived therefrom fro the cassava production sector/farmers;

d) Prepare a plant investment and schedule of construction layout over one or more stages consisting of fixed assets (equipment, land, buildings, others), preliminary expenses (planning services, start-up expenses, others) working capital, interest and total investment cost over a reasonable period;

e) Estimate the required working capital, depreciation, replacement and residual values as well as annual income and capital structure if considered appropriate and prepare relevant cash flow calculations;

f) On this basis and by obtaining all other relevant data prepare a comprehensive economic feasibility analysis as a basis for investment considerations.

THE EFFECT OF RAINFALL DISTRIBUTION ON CASSAVA PRODUCTION

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The key to a successful cassava processing operation is to make available the required amounts of roots of the right quality over as much of the year as possible.

In order to achieve this it is fundamentally important to understand the relationship between cassava's growth cycle and the various patterns of rainfall distribution which occur in the tropics.

Growth Cycle

Cassava requires some 9-10 months of growing conditions before root yields are maximised, and starch content has reached acceptable levels. Whereas cassava does not have a definite point at which it must be harvested as, for example, some cereals, the flexibility inherent in being able to store the crop in the ground is to a certain degree offset by a deterioration in root quality and increase in fibre contents.

Rainfall Distribution Patterns

The relationships which exist between cassava production and the climate can best be described by relating the growth cycle of the crop to examples of the various patterns of rainfall distribution which occur in the tropics. Five alternatives are described:

- Year-round rainfall
- Long unimodal rainy season
- Long bimodal rainy season
- Short unidodal rainy season
- Short bimodal rainy season.

The rainfall distribution patterns are shown in Figure 1 together with the planting and harvesting operations which are feasible to undertake within these rainfall patterns. Each rainfall pattern is then described in more detail.

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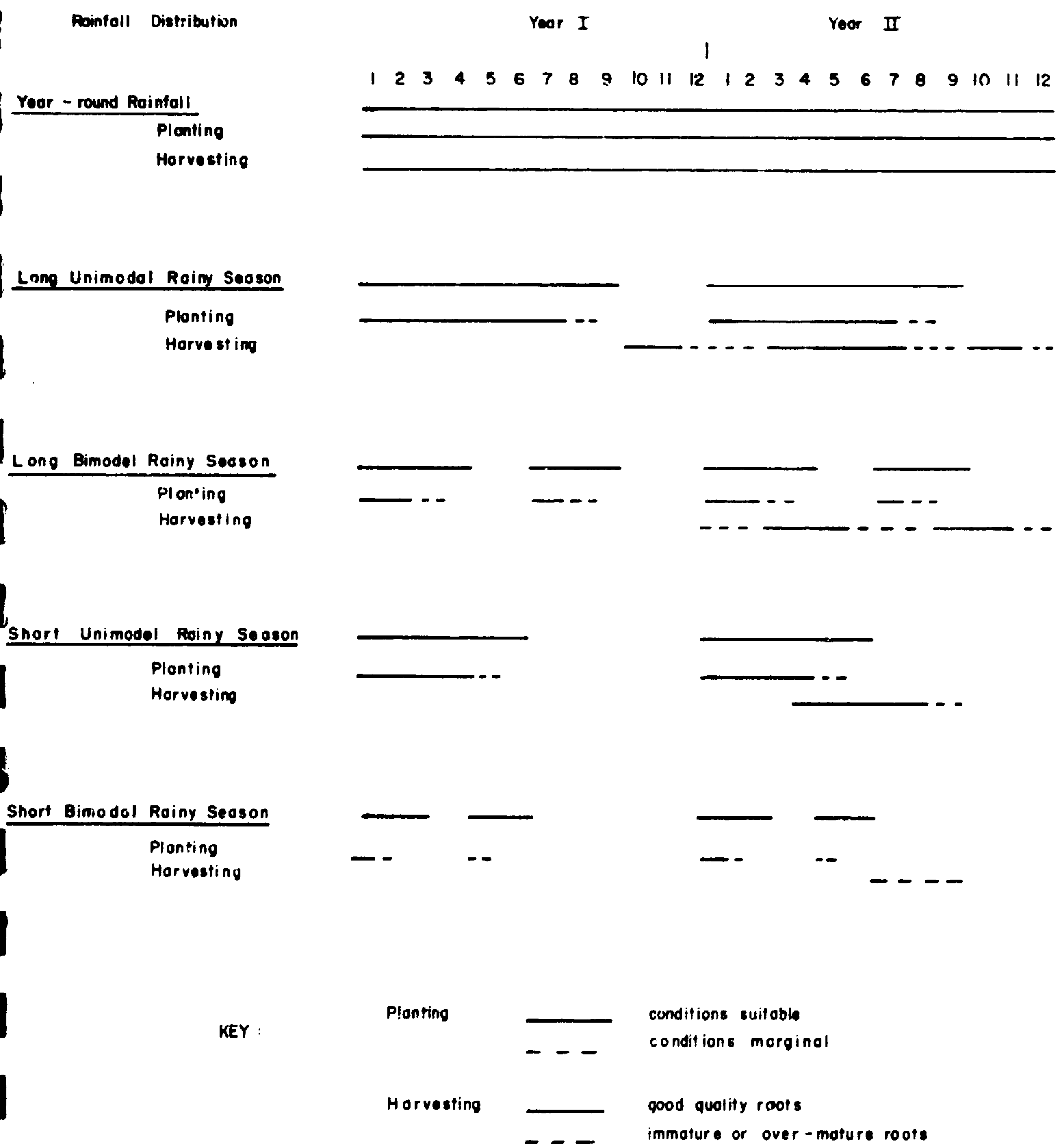
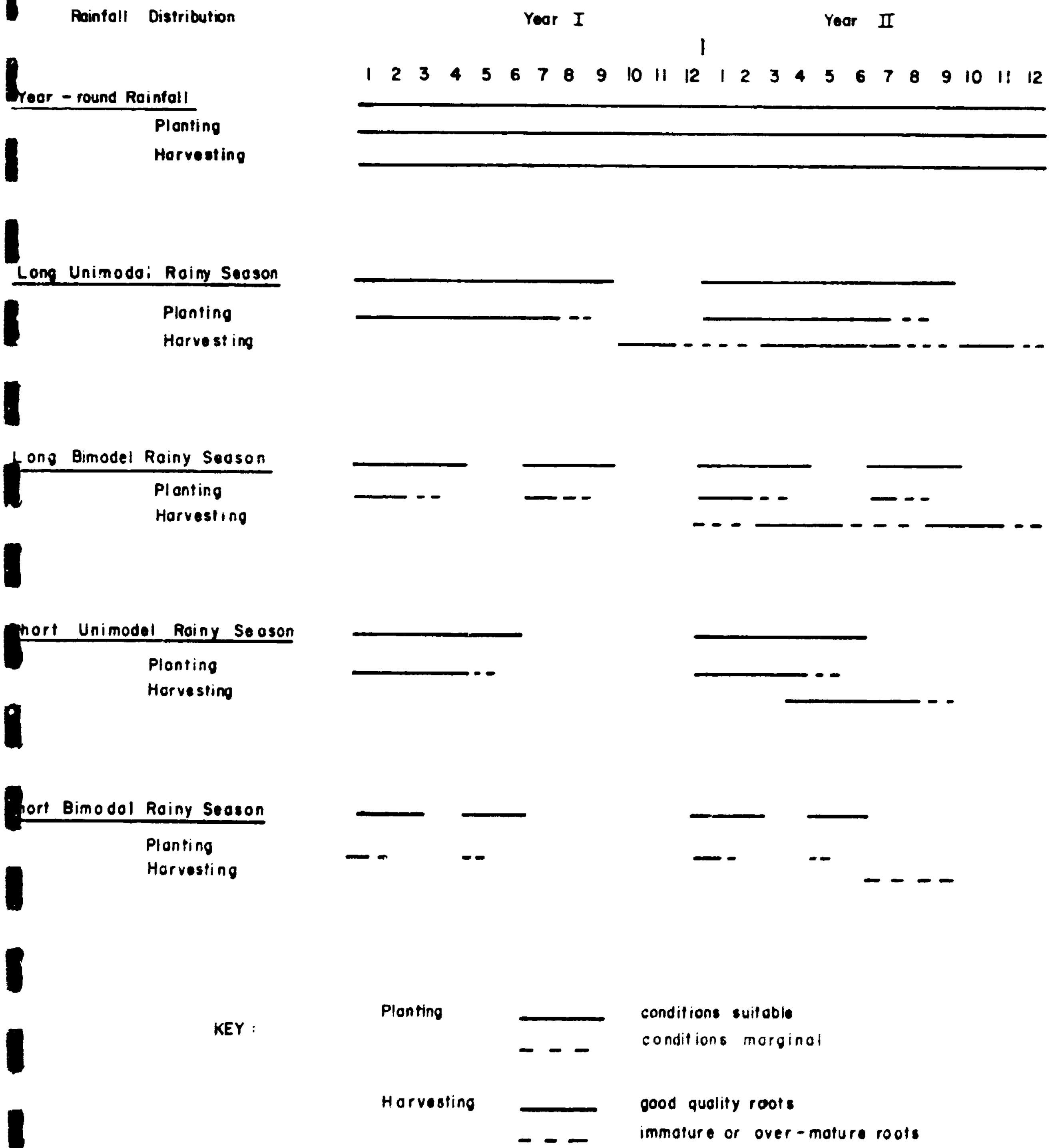

Rainfall Distribution
Year I
Year II
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
Year - round Rainfall
Planting
Harvesting
Long Unimodal Rainy Season
Planting
Harvesting
Long Bimodal Rainy Season
Planting
Harvesting
Short Unimodal Rainy Season
Planting
Harvesting
Short Bimodal Rainy Season
Planting
Harvesting
KEY :
Planting
conditions suitable
conditions marginal
Harvesting
good quality roots
immature or over-mature roots

Figure 1 - Cassava Fresh Root Production

Timing of operations and availability of fresh roots as related to rainfall distribution.



Note:

The premises upon which this figure has been prepared are presented on the following page.

Premises used in the calculation of Figure 1.

1. Cassava requires 9 months of effective rain after planting to produce roots of acceptable quality for processing.

2. Cassava requires 2 months of effective rainfall after planting to establish it sufficiently to be able to withstand drought.

3. In areas where frost is likely to occur during the dry season, 3 months of effective rainfall will be required to establish the cassava and enable some reserves to be laid down.

4. It is assumed that after a long rainy season, residual soil moisture is sufficient to support growth for one month during the dry season. After a short rainy season, half a month's growth is anticipated.

5. It is assumed that harvesting after the first two months of the dry season may be difficult due to hard soil.

6. The model has been prepared on the assumption that a cassava variety which matures after nine months of growth is planted.

Year-Round Rainfall

Examples of this type of climate exist close to the Equator, namely; Peninsular Malaysia, Sumatra, Kalimantan (Indonesia), Mindanao (Philippines) and Papua New Guinea in Asia; the West African coastal strip, Congo and Zaire in Africa; and northern Brazil and the Guiana's in South America.

Year-round rainfall permits land preparation, planting, growth of the crop and harvesting to go on throughout the year. This situation is the nearest to the ideal for cassava production but is not without problems.

Periods of unremitting rainfall occur during which field operations are almost impossible due to water logged soil conditions. The operation of tractors, cultivation equipment and mechanical harvesters is not only difficult during such periods, but can be physically damaging to soil structure. Even where roots can be harvested by hand, their transportation to the factory involves tractor-drawn trailers and/or trucks which become bogged-down, cause compaction to fields and damage to farm roads. In most circumstances the harvesting of roots from waterlogged soil increases the amount of soil adhering to the roots, resulting in high soil tare and problems with the washing and disposal of soil in the processing factory.

It is realistic to expect that a cassava processing factory which relies entirely on fresh roots as its source of raw material will face many occasions during the year when fresh root supply breaks down due to wet field conditions.

Long Unimodal Rainfall Pattern

Adjacent to the areas which receive year-round rainfall are those which have one short dry season per year. This pattern of rainfall distribution permits planting to go on except during the dry season and the final months of the rainy season. However the rainfall pattern will permit harvesting to go on all year round.

Nevertheless the remarks relating to waterlogged soil in areas with year-round rainfall are equally valid for these areas.

During a dry season there are 4-5 months during which planting operations are suspended due to dry soil conditions preventing germination, or due to the danger of drought killing newly emerging plantlets. Even though sufficient area may be planted up during the early part of the rainy season to supply enough roots for the year-round operation of the processing factory, the difficulty in matching harvest date with maturity period results in the harvesting of either immature or overmature roots. This has an impact on starch recovery rate in starch factories. Where a range of varieties is available with different maturity periods ie varieties which have optimum harvest dates at 7,9, and 11 months after planting it is possible to overcome the maturity problem to a certain extent, by planting an appropriate mixture of varieties.

Long Bimodal Rainfall Pattern

Moving further away from the Equator the areas receiving a long unimodal rainfall pattern merge into those where the rainy season is broken by a dry spell. This complicates the production of cassava, since the occurrence of two dry seasons per year further limits the period during which soil moisture conditions are favourable for the planting and establishment of the crop. Only 3-5 months of planting season occur, which has a serious impact on the availability of quality fresh roots for processing. Using a standard nine-month variety, mature roots would only be available during six months of the year, even though factory operations could continue during the other six months of the yield using immature or overmature roots. Once again by planting a selection of varieties with different maturity characteristics this problem can be partially overcome.

Short Unimodal Rainfall Pattern

Areas receiving this pattern of rainfall distribution, such as Zambia, are marginal for cassava production for industrial purposes as the annual rainy season is of insufficient length to satisfy the growth requirements of the cassava crop. This makes the production of a crop of cassava, from planting to harvesting within one year very difficult. Areas receiving 6-7 months of effective rain are marginal for the production of cassava for orocessing purposes. In areas with a unimodal rainfall pattern with less than 6 months of rainfall there is insufficient moisture to complete the growth cycle within the calendar year and it becomes necessary to leave the crop to survive the dry season and grow on through the rainy season of the following year. Although harvesting after one rainy season is practised by some farmers, both the yield and starch content of the roots are depressed through the crop being harvested prematurely.

From the processors' point of view the production of cassava in such areas is far from ideal. The crop has to occupy the land for two years before yields of roots with satisfactory starch content are available. Also, due to difficulties of harvesting roots from dry soil, the harvesting operations are hindered and may be eventually stopped by hard soil conditions after the residual moisture from the rainy season has gone from the soil. This factor varies with the physical properties of the soil. Nevertheless, because of the short planting period (4-5 months) and the long dry season, it is impossible to organise the production of roots of processing quality for more than 5 months of the year and there are 6 months of the year when it is difficult to obtain roots of even marginal quality.

Cassava processing factories set up in areas with this type of rainfall distribution can expect to experience fresh root supply problems for extended periods, especially during the last part of the dry season and the first part of the rainy season.

This is the reason for basing the Zambia factory project on dried cassava chips, rather than roots, as the major raw material for starch.

Short Bimodal Rainy Season

Much of the sub-Sahel region and Southern Africa fall into this rainfall distribution belt. There is insufficient rainfall to produce a crop of roots of processing quality, even when the crop is grown over a two year period to include four rainy seasons (two per year). The resulting crop is then only available for a short period each year.

Because of the two short rainy seasons followed by a long dry season the planting of the cassava crop must be carried out with the first rains of the first rainy season to ensure its establishment before it experiences the rigours of drought. The impact of this restricted planting season is the difficulty in spreading the period of availability of mature roots over an extended period.

Availability of fresh roots for processing related to rainfall distrubution (months/year)

	Good Quality Roots	Poor Quality Roots	Total
Year round rainfall	12	-	12
Long unimodal rainy season	7	5	12
Long bimodal rainy season	6	6	12
Short unimodal rainy season	5	1	6
Short bimodal rainy season	-	3	3

Thus roots for processing are very limited both in quantity and quality for much of the year.

The establishment of a processing industry based on the supply of fresh cassava roots must be regarded as extremely marginal in areas with this rainfall distribution.

The periods of fresh root availability for the cifferent rainfall distribution patterns are shown above.

Cassava Production under Irrigation

The previous discussion has dealt with the problems associated with fitting cassava productionfor processing into natural patterns of rainfall distribution. An alternative is the modification of the environment by irrigating during dry periods. Inthis way it is technically feasible to produce cassava throughout most of the year. However it is a question of economics, and there are few - if any - circumstances where the cost of the provision of irrigation facilities can be borne by such a low value crop as cassava.

Nevertheless there are circumstances when cassava can be grown under irrigation which are economically justifiable. Such a circumstance exists when surplus water from an existing irrigation scheme is available from time to time during the year. It is often possible to predict the periods during which surplus water is available, and plantings of cassava can be timed to coincide with these periods. Therefore by using natural rainfall supplemented by periods of irrigation it is possible to extend the planting period and therefore the production period over much of the year.

This opportunity is particularly worthwhile in areas where the topography is level, allowing the application of water by surface flooding techniques. These do not involve heavy infrastructure costs, so making it economically more attractive. The costs of irrigation are therefore composed basically of water costs and the cost of providing earth channels to direct the water on to the crop.

This opportunity of using cassava to "mop-up" surplus water from existing irrigation schemes is particularly valid for ethanol factories, where a mix of sugar cane and cassava are used as fermentables.

The lack of a critical period such as flowering, coupled with a degree of drought tolerance make cassava an ideal candidate to mop up surplus water, as providing the crop is established there is no necessity to have water available at critical times and periods without irrigation will not cause the total loss of the crop.

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COSTS OF PRODUCING CASSAVA

It has been shown in Chapter 5 that cassava production is tied in with the rainfall distribution pattern and a range of production alternatives occurs. The extremes are continuous production of cassava with all the various field operations underway at all times; and a specific, restricted period of the year during which certain operations, such as planting, must be carried out.

There is no simple formula for calculating labour, machinery and material inputs on a global scale. Each producer must decide which production system is most relevant to his circumstances and build up the economics of production using the various inputs on a piecemeal basis. The following table provides estimates of labour inputs for various operations involved in cassava production.

Labour Inputs in Cassava Production

	Man Days/ha
Planting by hand	9.0
Fertiliser application by hand	4.0
Replacing missing plants	1.5
Weed control (3 rounds)	30.0
Selection of planting material for next crop	3.0
Removal of tops before harvest	9.0
Lifting root clumps	10.3
Removal of trimming roots	9.0
Loading	1.5
Total	77-78

Transportation of planting material to the field and preparation of cuttings must also be catered for. The time needed for these operations will vary widely in different locations and circumstances.

No land preparation figures are included in the above table as this would in most cases be done by hired tractor.

In addition to the above list of operations material inputs are required at all levels of cassava production. At the most primitive hand tools are required in the form of knives for preparation of planting material, clearing tops before harvesting and trimming roots, and hoes for soil preparation, weeding and harvesting. Where cash is available for the full range of material inputs required to maximise yields the following additional list is relevant;

- insecticide/fungicide treatment for cuttings
- fertilisers
- herbicides, both pre-emergence & post emergence
- crop protection sprays (rarely justifiable)
- machinery and equipment for a range of operations.

During the early years of establishing a cassava production unit, the purchase of planting material is usually necessary. In areas where only small amounts are available this may involve quite a substantial financial provision.

Transportation of fresh roots from field to factory.

This subject is of vital importance in the context of cassava processing. The economics of transporting a low value, bulky crop such as cassava must be carefully calculated before selecting a production area and siting a factory. The difficulties in transporting roots along un-made roads during wet periods are discussed elsewhere. The selection of the type of transport equipment, comparing fast-moving lorries which can easily become stuck during periods of wet weather, to slow moving tractors and trailers must be carefully made. Provision of sufficient equipment to satisfy both field operations and transport requirements is stressed, particularly in tractor numbers. The distance between the production area and the factory involves not only increased fuel and equipment running costs, but also may require additional units of equipment due to protracted running time.

MECHANISED CASSAVA PRODUCTION

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Traditionally cassava has been a crop grown on a small scale under labour intensive, small farmer conditions. It is only in comparatively recent times that interest in cassava for processing on a large scale has lead to its development as a plantation crop.

Mechanisation of cassava production is therefore in its early stages; many large plantations are still heavily dependent on manual labour for such operations as planting, weeding and harvesting.

Machinery is now available to plant cassava and to bring the tubers to the surface at harvest time, but no automatic planter or full system harvester has yet been developed. Consequently there is a labour requirement in both of the mechanised operations. Land preparation and chemical weed control systems have been adapted from existing and developing technology.

Machinery requirements for mechanised cassava production can be classified into two groups:

1. Those which are cassava specific.
2. Those which have an application in the culture of other crops in the rotation.

Equipment falling into group one would be:

a) Ridger (may have application with break crops)
b) Cassava planter - multi-row
c) Cassava stem pulveriser
d) Cassava digger/lifter
e) Cassava tuber bulk handling facilities.

Equipment in group two would be:

a) Subsoiler or chisel ripping plough
b) Plough or disc ploughing harrow
c) Field crop sprayer
d) Fertiliser distributor
e) Tipping trailers.

Tractors would of course be required as prime movers for the equipment.

There would be also a need for equipment for estate maintenance eg grader, grass cutter, loader for gravel and perhaps a ditcher.

Break crop specific equipment such as planters, combine harvesters may be required but are not considered here as they would be costed against the applicable enterprise.

Five areas have been classified according to rainfall distribution.

Areas of year round rainfall, areas where there is a long unimodal rainy season and areas which have a long bimodal rainy season are capable of production for a sufficient period each year to warrant mechanisation of the crop.

Climatic areas with short unimodal rainy seasons and short bimodal rainy seasons are generally not suitable for large scale cassava plantations, and it is unlikely that cassava enterprises in such areas could support mechanisation costs.

Mechanisation requirements for plantations in areas one to three are discussed below. The choice of break crop to be grown will affect the need for machinery. No allowance has been made for break crop specific equipment.

Root Production - Under Year Round Rainfall Conditions

For agronomic reasons continuous cassava culture is not recommended and a rotation which embodies principles of good husbandry should be selected. Cassava yields tend to diminish in the third successive crop, therefore the rotation would probably be two years cassava and one or two years break crop depending on the choice of crop.

To provide raw material (cassava tubers) for processing at the rate of 40 tonnes per day for 280 days per year under year round rainfall conditions an area of approximately 622 ha of cassava would be necessary if one assumes a yield of 18 tonnes/ha.

For a one year break crop rotation, an estate of approximately 933 ha would be required, and 1,244 ha would be required if the two year cassava, two year break crop were to be selected. The areas quoted are net cultivable land, total estate area including roads, drains, firebreaks, unusable land and buildings would be 15-20 percent more.

It is assumed that land clearing has been carried out to leave the land in a suitable condition for mechanised operations, ie free of stumps and obstructions.

Land preparation operations are influenced by soil type and condition, therefore local conditions may make it necessary to modify the number and type of operations suggested here.

Under year round rainfall conditions there maybe a considerable loss of working days due to wet field conditions. Machinery capacity must therefore be increased by 20 percent to allow flexibility and to even out raw material supply.

This surplus capacity can be used to plant only under suitable conditions, and to harvest roots in addition to those required for input at the factory. The additional roots may be chipped, sun dried and then stored until required to keep the factory running on days when fresh roots are not available.

Field Operations

1. a. Chisel plough
   b. Cross Chisel plough if necessary
2. a. Disc Ploughing Harrow pass
   b. Second disc ploughing harrow pass if necessary
3. Fertiliser application
4. Ridge
5. Plant
6. Herbicide spray/hand weed
7. Herbicide spray/hand weed
8. Hand weed if necessary
9. Pulverise stems
10. Harvest
11. Transport.

Year Round Rainfall

Machinery Requirements and indicative FOB prices UK port

	No required	FOB per unit (£)	Total (£)
Chisel ripping plough	2	1,950	3,900
Disc ploughing harrow	2	3,500	7,000
Fertiliser distributor	1	575	575
Ridger	1	730	730
Planter	2	1,750	3,500
Crop sprayer	1	1,440	1,440
Knapsack sprayers	10	40	400
Cassava stem pulveriser	1	4,000	4,000
Cassava harvester	3	2,800	8,400
Loader handler	1	2,200	2,200
Boxes	100	18	1,800
Trailers - 8 tonne tandem axle	3	1,800	5,400
Water tanker	1	3,500	3,500
Tractors, 78 hp 4 x 4	6	10,500	63,000
Tractors, 78 hp 2 wheel drive	3	8,500	25,500
	Total		131,345

Machinery capital cost = £211.17 per Ha.

In addition, spares and workshop equipment will be required. Local conditions will influence level of stocks and standard of facilities which must be provided.

Long Bimodal Rainfall System

It is assumed that yields achievable under long bimodal rainfall conditions are approximately 12 tonnes/ha in Africa.

934 ha of cassava would be necessary to produce sufficient fresh roots to supply a factory with the equivalent of 40 tonnes of fresh roots per day.

Quality roots can be harvested for only 6 months of the year so equipment specified is capable of harvesting the total area in 6 months. Roots surplus to requirements would be sun dried and used to provide raw material for the factory during the rest of the year.

Long Bimodal Rainfall System

Machinery requirements and indicative FOB prices UK port

	No required	FOB per unit (£)	Total (£)
Chisel ripping plough	2	1,950	3,900
Disc ploughing harrow	2	3,500	7,000
Fertiliser distributor	2	575	1,150
Ridger	4	730	2,920
Planter	10	1,750	17,500
Crop spayer	1	1,440	1,440
Knapsack sprayers	15	40	600
Stem pulveriser	3	4,000	12,000
Cassava harvester	7	2,800	19,600
Loader/handler	2	2,200	4,400
Boxes	200	18	3,600
Trailers	4	1,800	7,200
Water tanker	1	3,500	3,500
Tractors 78 hp 4 x 4	18	10,500	189,000
Tractors 78 hp 2 wheel drive	2	8,500	17,000
	Total		290,810

Machinery capital cost = £311.36 per Ha.

In addition, spares and workshop equipment will be required. Local conditions will influence level of stocks and standard of facilities to be provided.

Long Unimodal Rainfall

It is assumed that yields under long unimodal rainfall patterns will be similar to those achieved under year round rainfall.

Due to constraints on operations imposed by the rainfall pattern, less time is available for the various operations and good quality roots will probably be available for only 7 months each year.

The equipment list provides for the harvest of all roots during the seven month period. Roots surplus to the factory daily requirement would be chipped and dried to provide raw material for the factory for the remainder of the year.

Long Unimodal Rainfall

Machinery requirements and indicative FOB prices UK port

	No required	FOB per unit (£)	Total (£)
Chisel ripping plough	2	1,950	3,900
Disc ploughing harrow	2	3,500	7,000
Fertiliser distributor	1	575	575
Ridger	2	730	1,460
Planter	3	1,750	3,500
Crop sprayer	1	1,440	1,440
Knapsack sprayers	10	40	400
Stem pulveriser	2	4,000	8,000
Cassava harvester	4	2,800	11,200
Loader handler	2	2,200	4,400
Boxes	100	18	1,800
Trailers - 8 tonne tandem axle	4	1,800	7,200
Water tanker	1	3,500	3,500
Tractors 78 hp 4 x 4	14	10,500	147,000
Tractors 78 hp 2 wheel drive	5	8,500	42,500
	Total		243,875

Machinery capital cost = £392.09 per Ha.

In addition, spares and workshop equipment will be required. Local conditions will influence level of stocks and standard of facilities to be provided.

CHIP DESIGN AND QUALITY

PE

The fundamental food processing concept, that quality of product is directly related to the quality of raw material, is especially true of cassava processing. The finest quality starches can only be made from fresh roots which are harvested and processed at a time and in a manner controlled and directed by the factory. A sun dried cassava chip of unknown origin and age is inevitably going to result in starch of poorer quality. The factory which relies on the supply of dried chips as its raw material will therefore be most concerned that its supply is of the highest quality possible. This will be inherently difficult if the supply is from smallholders and is reliant upon the weather. The factory's main criteria for buying chips will be that they are:

- thoroughly dry
- free from foreign matter (sand, dirt, insects)
- free from mould or bacterial deterioration
- white in colour
- derived from plants of the right maturity.

Chip Design and Drying

To ensure that a chip is dried in the shortest possible time by the natural means of sun and wind, the geometry of the chips must allow the maximum exposure to these drying forces. A large section of root which is exposed to sun drying will quickly dry on the outside but will seldom become dry through to the centre before deterioration from micro-organisms has taken place. This deterioration will not take place if the moisture content is below 12 percent moisture, ie below the level to support the micro-organisms. Therefore the size of the chip is important to ensure thorough drying - the smaller the better since this will dry throughout far quicker. On the other hand if a chip is too small, not only will it be blown away or crumble into a dust but it will also be more likely to become mixed with dust, soil or sand.

The vectors which cause drying are wind and sun. The wind is possibly the more important of the two. In order to increase the effect of these vectors several factors need to be considered:

- geometry of chip, ie shape and size
- loading depth, ie depth of pile exposed for drying
- air temperature
- windspeed
- solar radiation
- moisture content of the fresh root.

The recommended geometry of the chip is 5mm wide by 50-80mm long. These can be made from simple chipping machines which chop the root. The machines are often made in the country from locally available materials.

The loading depth is important if the sun and wind are to reach each chip. The maximum depth recommended is 10kg/sq. metre. This density will vary depending on whether the chips are being dried on trays or on the ground.

Air temperature and windspeed are factors which ensure that the air surrounding the chip is dry enough to evaporate moisture from the chip surface. The effect of drying is considerably increased if the chip is raised off the ground to allow air circulation around it. The system in Zambia of woven matting held off the ground is effective and should be encouraged. In some countries inclined trays are used which angle the chips towards the sun, thereby increasing solar radiation and increasing the effect of the wind. These are often expensive to erect and have been mainly used for experimental purposes. If trays or woven mats can be easily and cheaply made locally then considerable increases in drying can be achieved. The quicker the drying the less deterioration can occur with the quality of chip.

PROPERTIES AND USES OF

Type glucose	Properties
Acid-converted	High viscosity, moderately sweet
Acid-enzyme dual (63 DE)	Increased moisture holding, higher sweetness, less flavour masking, higher fermentability, and lower viscosity.
High maltose (43 DE)	Controlled moisture absorption in candy. Low dextrose content reduces danger of crystallisation. Improved colour stability and taste.
High fermentable (70 DE)	Increased percentage of fermentable sugars up to 80% plus.
Acid-enzyme Extra high DE (70-72 DE)	Increased sweetness, reduced content of high sugars, less flavour masking, reduced viscosity.
Liquid glucose (95 DE)	Contains 80-90% dextrose pl s higher sugars. Can be considered commercial liquid dextrose.
High maltose Extra high DE (52 DE)	Increased maltose content. Reduced hygroscopicity in sugar boilings.
High maltose Low DE (36 DE)	Reduced humectant properties. Increased viscosity and body.

SOURCE: STARCH PRODUCTION TECHNOLOGY. Radley 1976.

GLUCOSE SYRUPS

Use
This is the original 'glucose'. It is limited in its properties (43 because the composition is predetermined by the degree of hydrolysis. Used in sugar confectionary, mixed syrups, and chewing gum.
This was the first technological breakthrough in glucose production. Substituted for acid-converted glucose at higher levels Has taken over most of the market in preserves, catsup, fruits, marshmallows, bar candy, etc. because of better humectant properties and increased sweetness. Also because of higher fermentability, widely used in brewing.
The first product in a proliferation of new glucose products starting about 1959. This and subsequent products were obtained by manipulation of the carbohydrate composition by use of specific enzyme systems. Used primarily for hard candy at increased levels up to 50% DE. In jams and jellies, can use at maximum allowed by the US Food and Drugs Administration plus added dextrose. In ice cream, can be used at higher levels up to about 40%.
Will replace up to 100% of sugars in bread and rolls. First syrup to be widely accepted by the baking industry.
Replaces conventional "Dual" in fruit juices and concentrates. Possible future application in canned fruits and pickles.
Used in pickles, although limited by relatively low solids. Used in baking to replace crystalline dextrose.
Can be used in ice cream at levels to 50%. Used in confectionery, especially hard types, at higher levels.
Not available at present. Indicated use in dried cream substitutes. Possible use in ice cream and dried juice powders.

PE

PESTS AND DISEASES OF CASSAVA IN ZAMBIA

PE

INTRODUCTION

Although a countrywide survey of the pest and disease situation has not been carried out, sufficient circumstantial evidence is available through reports and observation to suggest that a number of serious pests and diseases are present in Zambia. These must be seen to be responsible for significant yield losses and pose a serious threat to increased production. A better understanding of pests and diseases by the extension services could lead to an improvement of the current situation.

PESTS

The protracted dry season renders cassava prone to insect pests which thrive under dry conditions. A number of these colonise the cassava to draw their food requirements from the plant.

Scale Insects

Severe infestations by this pest were observed during the consultants' visit to Zambia, particularly at Misamfu Research Station, Kasama, in Northern Province. The insects resembled **Aonidomytilus albus** but proper identification should be carried out by a competent entomologist.

Heavy scale populations cover the stem and lateral buds. Sucking activities weaken the plant, cause defoliation and death to the stem apex, and may even kill young plants. Although wind dispersal is known to occur the pest is usually transmitted from crop to crop on infested cuttings. The scale population increases during dry periods: therefore crops of cassava planted late in the rainy season, thereby entering the dry season in an immature stage of development, are particularly prone to severe damage.

Some natural parasitism of the scale occurs, particularly by the coccinellid **Chilocorus distigma.** Avoidance of infested plants for use as planting material is the best method available to subsistence farmers. Applications of systemic insecticides to plants which will be used for planting material is recommended for those situations where cash is available. As a last resort, infested cuttings can be dipped in insecticide but even after killing the scales, the performance of the cutting may be poor.

Mealybugs. This important pest has been reported in Northern Zambia and again is favoured by the dry season. High mealybug infestations are reported to cause severe problems to the cassava plant. Initially attacking the terminal area of the shoots, the insects invade older parts of the shoot, petioles and leaves when population pressure becomes severe. The damage to the plant is done in two ways; by sucking sap and by introducing an unidentified substance into the plant during sap-sucking which causes stunting of the shoot. Heavy populations result in gross distortion of the shoot apex, die-back and in severe cases death of the plant. The causative organism **Phenacoccus Manioti** is believed to have been introduced to Africa from S. America.

PE

The insect pest is dispersed on infested planting material or by wind. Control by chemical methods through the dipping of cuttings is the only sure method of combatting the pest. No natural predators are known which are effective at low-level mealybug populations. Farmers can reduce potential damage by the pest by planting early in the rainy season to ensure that the crop is well established and thus better equipped to withstand an attack during the dry season.

Termites. These insect pests attack cuttings, young plants and even root-tubers in extreme cases. The severity of the attack is related to the length of the drought, and plants established late in the rainy season are particularly prone to attack. Wilted shoots and dead plants are the symptoms of termite attack. The tubers of apparently healthy plants may be found to have been hollowed out by termites on harvesting. Very high losses are reported when cuttings are planted into termite infested soils during dry periods. Insecticide treatment to cuttings by dipping or dusting has been shown to be an effective method of protection.

Whiteflies. Although not considered to be an economic pest of cassava per se, the whitefly **Bemisia tabaci** (and other **Bemisia spp**) have been observed on cassava in Zambia. The importance of this pest is related to its suggested role as vector of African Mosaic Disease.

DISEASES

Cassava Mosaic Disease. This is the major disease of cassava in Africa and is endemic throughout the continent, Zambia included. Believed to be caused by a virus (or a complex of viruses) transmitted by the whitefly (**Bemisia** spp), the disease causes considerable losses. Depending on the severity of infection the symptoms vary from mild yellowish mottling of leaves to severe leaf distortion and yellow areas. Leaves are reduced in size by severe infections and root yields may be reduced by as much as 80 percent depending on the cultivar grown. Differing degrees of resistance to the disease are known, and the use of those showing high degrees of resistance is a recommended method of combatting the disease. Recent research indicates that roguing infected plants may hold promise as a means of preventing the serious build-up of the disease in clean plantations.

Cassava Bacterial Blight. This disease is reported in the Northern Province and is caused by **Xanthomonas Manihotis.** The organism causes water-soaked angular spots on leaves which may develop into more serious symptons including blight, wilt, defoliation and stem die-back. Exudation of gum from leaf veins, petioles and immature stem may also occur. As the disease is caused by a vascular pathogen, it can move throughout the plant even to the roots. Similarly the disease is passed from year to year by the use of infected planting material cut from plants with the disease. Infection from diseased plants to healthy plants within a crop is by rain splash or on contaminated hand tools, clothing etc. Varieties showing high levels of resistance to the disease are known and are recommended in countries where available. Cuttings from healthy plants should be used as planting material where possible.

Methods are available for the production of disease-free cuttings from diseased plants, and can be used where otherwise healthy material is not available.*

FROST DAMAGE

Although frosts are predictable during most years in many parts of Zambia, especially the Central and Southern Plateau areas, occasional frosts may occur all over the country. Mild frost affects cassava by causing bronzing of the leaves. As the severity of the frost increases its effects on the plant increase from leaf scorch, defoliation, stem-tip, die-back, to total death of above-ground parts of the plant. Providing the soil does not freeze the cassava plant will survive air frosts of -10^{o}C. Even though all the above-ground parts of the plant will be killed, growth is resumed from buds on the stem base or planting piece below soil level.

Frosted cassava which has been defoliated and the green-portions of the stem killed resemble those severely attacked by cassava bacterial blight or **Phoma** spp. Some reports of these diseases in Zambia may have been caused by frost.

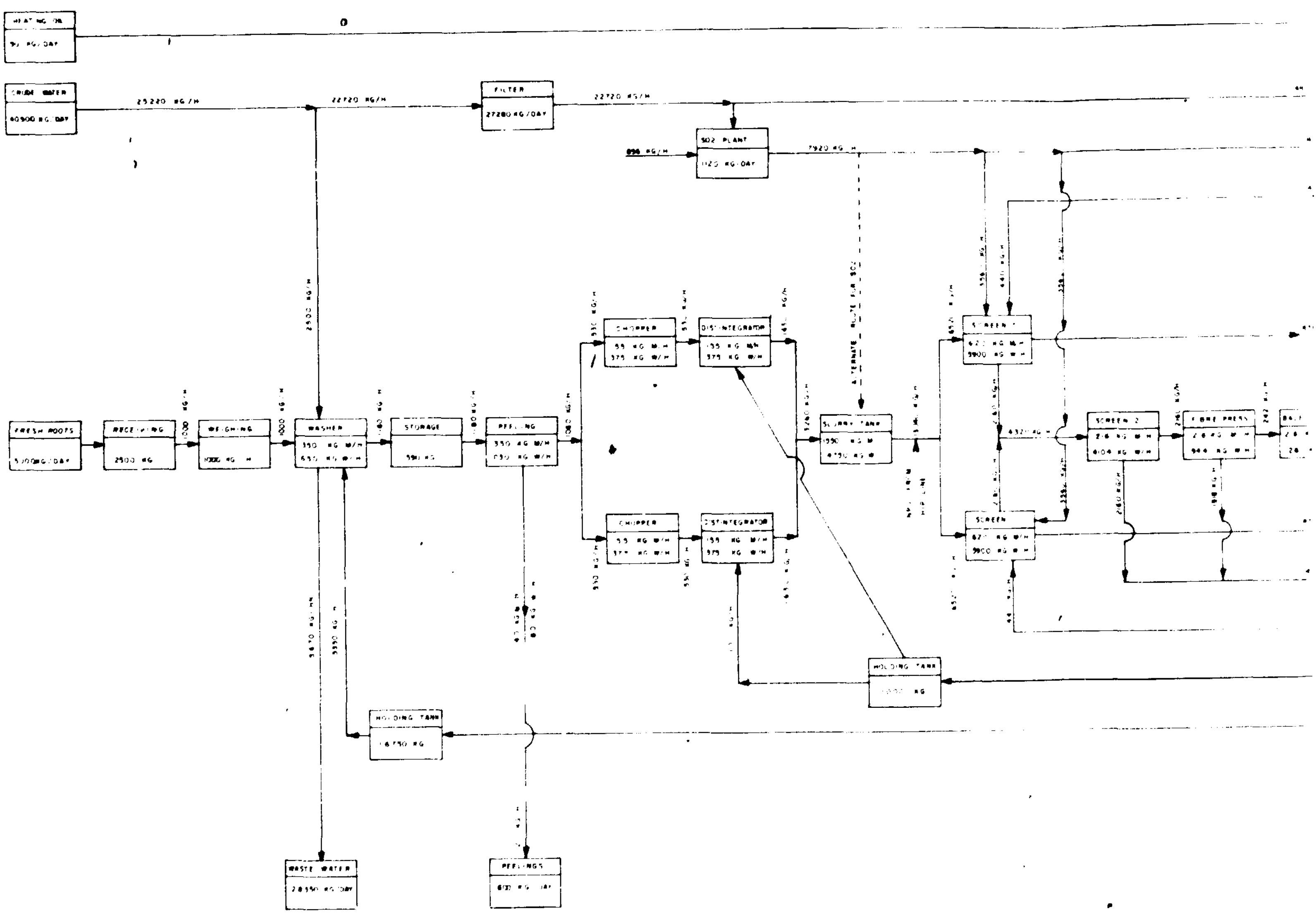
OTHER PESTS AND DISEASES

Pests and diseases other than those described above may occur in Zambia, but no reports are available.

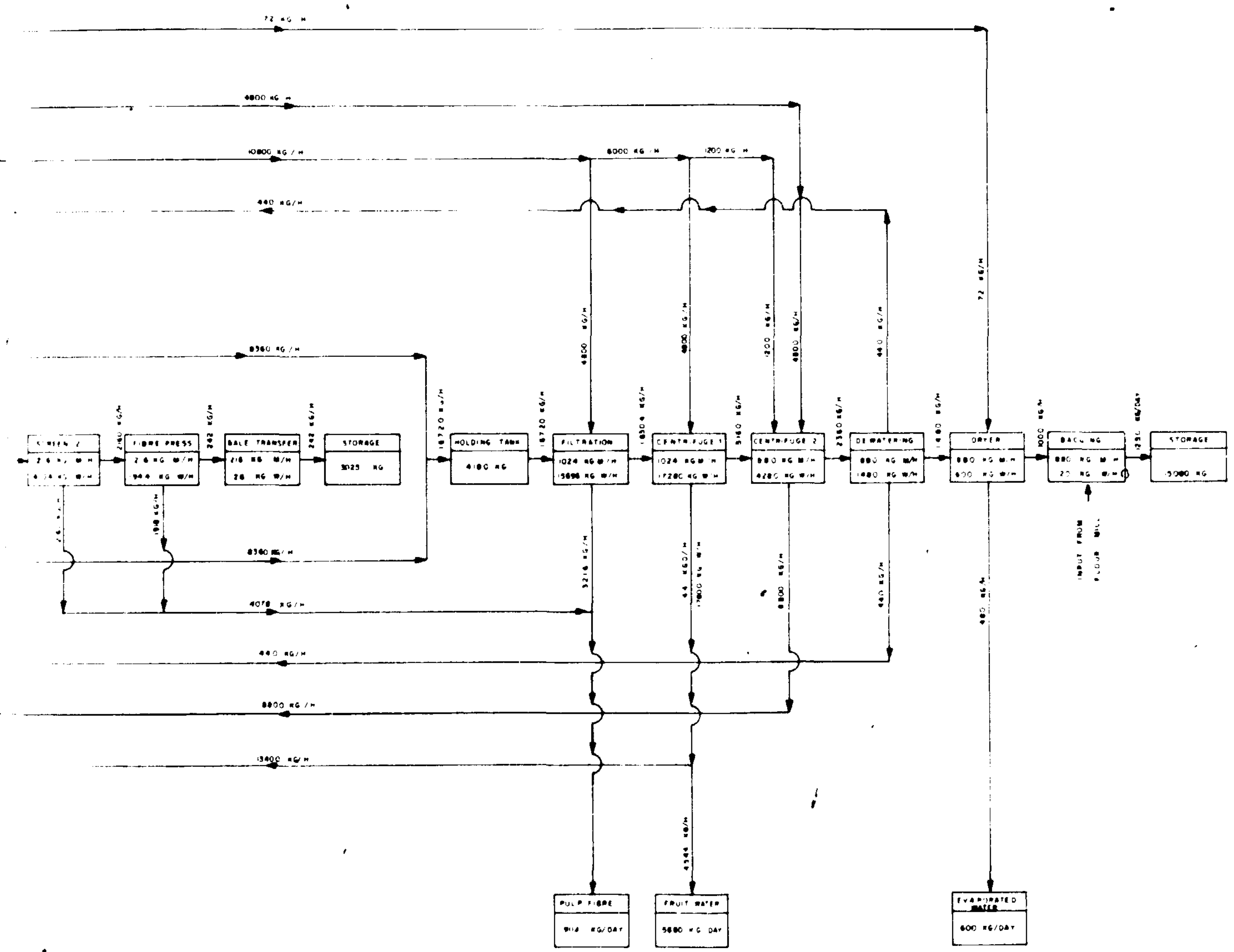
They may occur in neighbouring countries and can be expected to spread into Zambia. One such example is the pest 'green spider mite'. This pest was introduced by accident from the Americas to Uganda and is spreading to many parts of Central West and East Africa. The mite is particularly severe in areas with long dry seasons and its activities in the growing point and developing leaves at the stem apex, cause a severe reduction in leaf size. This results in poorer yields. The Zambian authorities should be on the lookout for the appearance of this pest.

***Footnote:**

Ref: 'The International Exchange and Testing of Cassava Germ Plasma in Africa' edited Eugene Terry & Reginald Macintyre; pub'd 1975 by International Development Research Centre.


HEATING OIL
CRUDE WATER
40900 KG/DAY
25220 KG/H
22720 KG/H
FILTER
27280 KG/DAY
22720 KG/H
SO2 PLANT
7920 KG/H
FRESH ROOTS
RECEIVING
2500 KG
WEIGHING
WASHER
STORAGE
PEELING
CHOPPER
DISINTEGRATOR
CHOPPER
DISINTEGRATOR
ALTERNATE ROUTE FOR SO2
SLURRY TANK
SCREEN 1
SCREEN 2
FIBRE PRESS
SCREEN
HOLDING TANK
HOLDING TANK
WASTE WATER
PEELINGS

SECTION 1



W DRY MATTER

W WATER

THROUGHPUT BASED ON ROOT INPUT OVER 5HRS AND CONVERSION AFTER SLURRY TANK IN 1 1/4 HRS TO GIVE STARCH OUTPUT OF 1 TONNE/HR

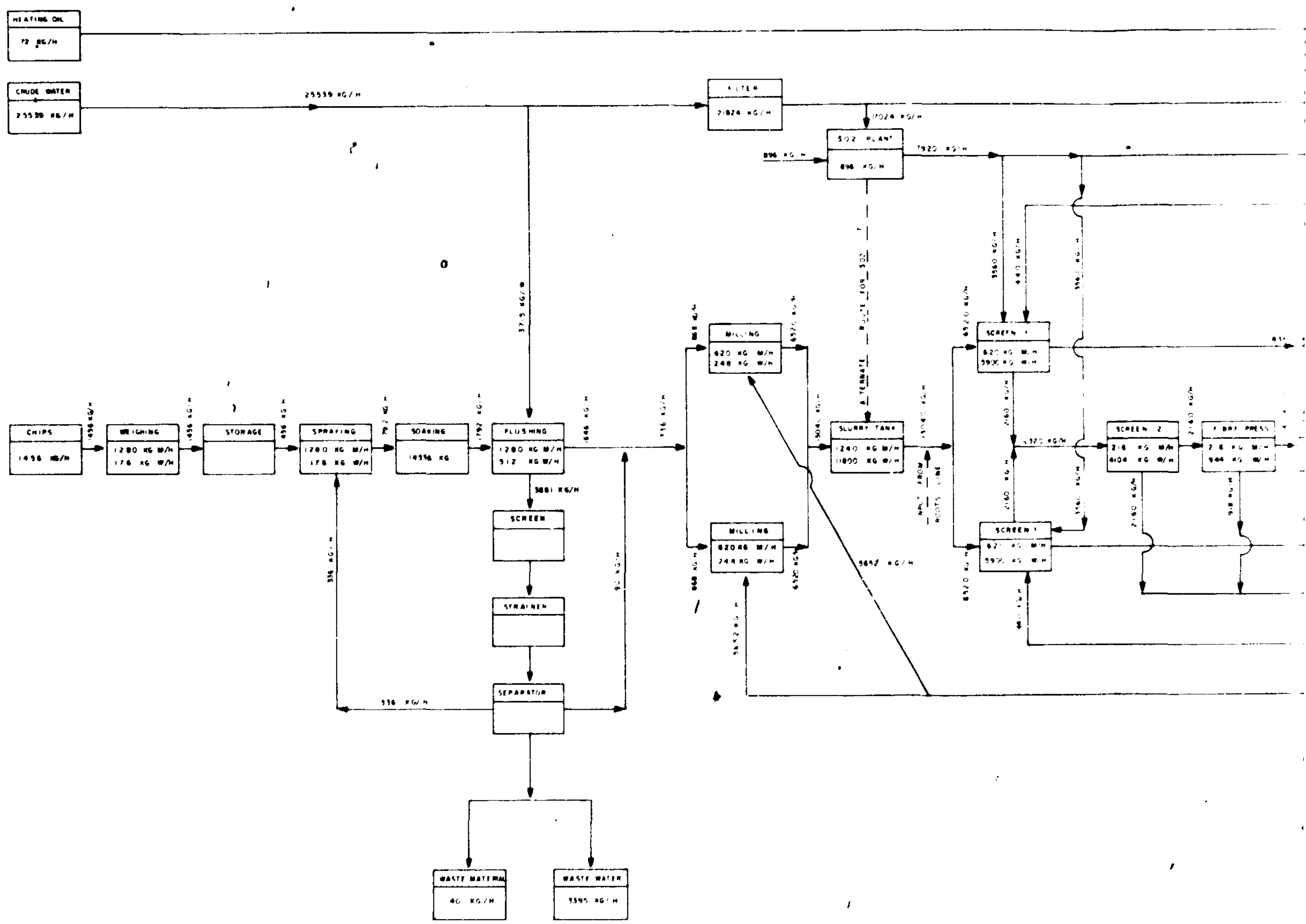
CLIENT: UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

TITLE: TYPICAL FLOW DIAGRAM FOR CASSAVA STARCH PLANT EXTRACTED FROM ROOTS

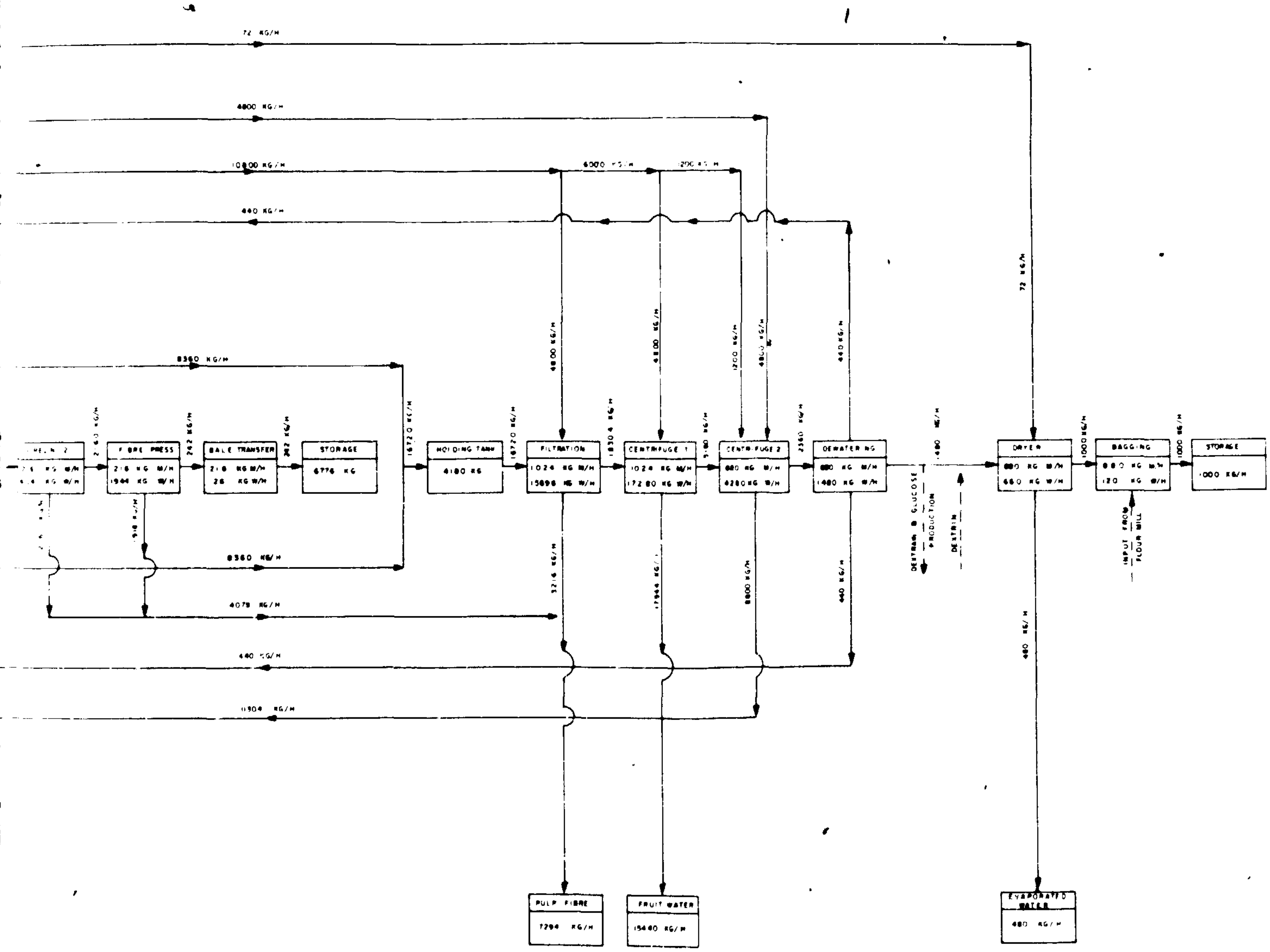
SCALE	DRAWN R W W	DATE MARCH 82
JOB 0290851	DRAWING 1	REVISION

The P E Consulting Group

SECTION 2


HEATING OIL
72 KG/H
CRUDE WATER
25539 KG/H
FILTER
SO2 PLANT
896 KG/H
CHIPS
1456 KG/H
WEIGHING
STORAGE
SPRAYING
SOAKING
FLUSHING
SCREEN
STRAINER
SEPARATOR
336 KG/H
WASTE MATERIAL
WASTE WATER
MILLING
SLURRY TANK
SCREEN 1
SCREEN 2

SECTION 1



M - DRY MATTER
W - WATER

CLIENT: UNITED NATIONS INDUSTRIES DEVELOPMENT ORGANISATION

TITLE: TYPICAL FLOW DIAGRAM FOR CASSAVA STARCH PLANT EXTRACTED FROM CHIPS

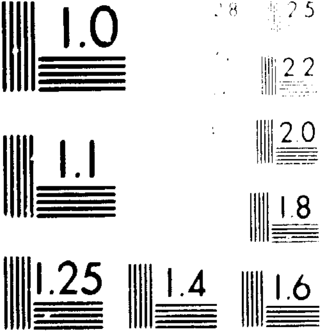
SCALE	DRAWN	DATE
—	R W W	MARCH 82
JOB 0290851	DRAWING 2	REVISION

The P E Consulting Group

SECTION 2

C-947

82.11.15


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5

LIST OF MACHINERY REQUIRED FOR PROPOSED FACTORY

PE

A. STARCH EXTRACTION - Fresh Roots and Chips

2 x Conveyor/Elevator
1 x Washer
2 x Chopper
2 x Rasping Machine
2 x Elevator
2 x Hopper
2 x Dosage Screw
1 x Disintegrator
1 x Pump
2 x Slurry Tank with paddle
1 x Starch Separator
1 x Pump
1 x Starch Separator
1 x Cyclone for sand extraction
1 x Separator
1 x Pump
1 x Separator
1 x Pump
1 x Vacuum Filter with feed tank
1 x Screw conveyor
1 x Flash drier
1 x Screen/Sieve
1 x Starch Bulk Silo
1 x Bagging Machine
1 x Sewing Machine
1 x Conveyor

B. GLUCOSE PRODUCTION

1 x Pump
1 x Balance Tank/Starch Suspension Tank
1 x Acid Tank
1 x Vacuum Filter with feed tank
1 x Pump
1 x Water Tank
1 x Flow Meter
1 x Pump
1 x Water Heater
1 x Plate Heat Exchanger
1 x Centrifugal Heat Exchanger
1 x Monopump and Filter
1 x Temperature Recorder
1 x Plate Heat Exchanger (cooler)
1 x Expansion Chamber
1 x pH Meter
1 x Caustic Tank
1 x Pump
1 x Filter/Clarifier
1 x Holding Tank
1 x Filling Machine
1 x Drum Filling & Weighing Machine

C. DEXTRIN PRODUCTION

1 x Conveyor Elevator
1 x Reactor Vessel
1 x Pump
1 x Acid Tank
1 x Pump
1 x Water
1 x Conveyor
1 x Sifter
1 x Conveyor
1 x Bulk Store/Bin
1 x Bagging Machine
1 x Sack Sewing

D. UTILITIES REQUIRED

1 x Boiler
1 x Sulphur Dioxide Plant
1 x Hydrochloric Acid Plant
1 x Caustic Soda Mixing Plant
1 x Effluent Treatment Plant (Civil engineering)
Process Piping
Process Control Systems
Utility Piping
Electrical Works and Cable
Building Materials
Spare parts, workshop and store.

1. DETAILS OF MACHINERY MANUFACTURERS ABLE TO PROVIDE TURNKEY FACTORIES

	NAME & ADDRESS OF COMPANY	COMMENTS
1.	ALFA LAVAL AB POSTFACK S14700 TUMBA, SWEDEN	Complete starch plants from cassava using centrifugal process. Fresh roots to starch only.
2.	HOVEX ENGINEERING LIMITED AE - KADE 35a P O BOX 105 VEENDAM, HOLLAND	Complete engineering design and installation of starch factories.
3.	KOMATSUGAWA CHEMICAL ENGINEERING COMPANY LIMITED 5F TMM BUILDING NO. 10-5, 1-CHOME IWAMOTO-CHO CHIYODA-KU TOKYO,101, JAPAN	Consulting engineering and project preparation.
4.	NIVOBA POSTBUS 40 9640 VEENDAM, HOLLAND	Compact containerised starch plants. Considerable experience of cassava processing especially from dried chips. Also glucose and dextrin plants.
5.	NEWELL DUNFORD ENGINEERING LTD NEWELL DUNFORD HOUSE PORTSMOUTH ROAD SURBITON SURREY UK	Complete gari manufacturing plants on turnkey basis. Little experience of starch production.
6.	PROJECTS DEVELOPMENT INSTITUTE (PRODA) 3 INDEPENDENCE LAYOUT P O BOX 609 ENUGU, NIGERIA	Design and fabrication of equipment for processing raw cassava into gari.
7.	SALZGITTER INDUSTRIEBAU GmbH POSTFACH 411169 3320 SALZGITTER 41 F R GERMANY	Complete starch glucose and dextrin plants from fresh cassava.
8.	STARCOSA GmbH POSTFACH 5105 AM ALLEN BALMHOF 5 D 3300 BRAUNSCHWEIG F R GERMANY	*Cassava flour plants and complete* starch plants.
9.	UBERSEE-TECHNIK RODINGSMARKT 29 2000 HAMBURG 11 F R GERMANY	Planning and erection of industrial plant, specialising in equipment for the production of starch, and starch derivatives.

2. LIST OF MANUFACTURERS WITH EXPERIENCE OF THE SUPPLY OF SOME MACHINERY

	NAME & ADDRESS OF COMPANY	COMMENTS
1.	ANHYDRO A/S OSTMARKEN 8 DK-2860 SOBORG-COPENHAGEN DENMARK	Flash driers for starch drying only.
2.	A P V MITCHELL 30 THORNTON ROAD THORNTON HEATH SURREY UK	Driers for starch and complete design engineering for glucose factories
3.	BERNAUER SECADORES INDUSTRIAIS LTDA CIAXA POSTAL 3748 SAO PAULO BRAZIL, S AMERICA	Manufacture and installation of driers. Flash fluid bed, rotary conveyor and bin dryers.
4.	BRITISH ARKADY CO LTD ARKADY SOYA MILLS OLD TRAFFORD MANCHESTER M16 ONJ UK	Mixers for dough making using cassava flour.
5.	BUELL LTD GEORGE STREET PARADE BIRMINGHAM B3 1QQ UK	Thermal drying of freshly harvested raw roots for pellet production.
6.	BUHLER-MAIG 19 STATION ROAD NEW BARNET HERTFORDSHIRE UK (Also HQ in Germany)	Pelletising of chips for feed and milling of dried chips
7.	NOVO INDUSTRI A/S NOVO ALLE DK 2880 BAGSVAERD DENMARK	Enzymes for hydrolysis of starch to modified products. Have process know-how especially ethanol and alcohol production.
8.	ROSIN ENGINEERING COMPANY 35/37 WILLIAM ROAD LONDON NW1 3ER UK	Drier manufacturers with experience of starch production from cassava.
9.	RONCAGLIA SpA MILLING ENGINEERING WORKS P O BOX 519 41100 MODENA ITALY	Flour milling and sifting machinery. Some experience of tapioca industry.
10.	WESTFALIA SEPARATOR AG D 4740 OELDE/WEST F WERNER-BABIG STR W GERMANY	Separators and decanters for starch separation

BUDGET COSTINGS ERECTED IN ZAMBIA IN STERLING

A.	STARCH EXTRATION (see list)	579,000
B	GLUCOSE PRODUCTION	512,000
C.	DEXTRIN PRODUCTION	200,000
D.	UTILITIES (Part included in buildings)	268,000
E.	BUILDINGS & CIVILS & HOUSING	412,000
		1,971,000

FINANCIAL REPORTS MULTIPRODUCT FACTORY

REPORT ... SCENARIO ...

CASSAVA FACTORY (THROUGHPUT)

		YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
QUANTITY (TONNES)																
ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
YIELD RSL TO RST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
ROOT SLURRY	T	0.0	155.2	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7
YIELD R TO RSL	%	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260
ROOTS INPUT	T	0.0	60.1	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6
CHIP STARCH SOLD	T	33	33	207	252	297	342	387	432	477	522	567	612	612	612	612
YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
CHIP SLURRY	T	364.5	364.5	2156	2625	3094	3562	4031	4500	4969	5437	5906	6375	6375	6375	6375
YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
CHIPS INPUT CST	T	52.1	52.1	308.0	375.0	442.0	508.9	575.9	642.9	709.8	776.8	843.7	910.7	910.7	910.7	910.7
GLUCOSE SOLD	T	133	133	800	800	850	900	950	1000	1050	1100	1150	1200	1200	1200	1200
YIELD CST TO G	%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
CHIP STARCH G	T	133.0	133.0	800.0	800.0	850.0	900.0	950.0	1000	1050	1100	1150	1200	1200	1200	1200
YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
CHIP SLURRY G	T	1385	1385	8333	8333	8854	9375	9896	10417	10937	11458	11979	12500	12500	12500	12500
YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
CHIPS INPUT G	T	197.9	197.9	1190	1190	1265	1339	1414	1488	1562	1637	1711	1786	1786	1786	1786
DEXTRIN SOLD	T	13	13	80	80	85	90	95	100	105	110	115	120	120	120	120
YIELD CST TO D	%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
CHIP STARCH D	T	13.0	13.0	80.0	80.0	85.0	90.0	95.0	100.0	105.0	110.0	115.0	120.0	120.0	120.0	120.0
YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
CHIP SLURRY D	T	135.4	135.4	833.3	833.3	885.4	937.5	989.6	1042	1094	1146	1198	1250	1250	1250	1250
YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
CHIPS INPUT D	T	19.3	19.3	119.0	119.0	126.5	133.9	141.4	148.8	156.2	163.7	171.1	178.6	178.6	178.6	178.6
TOTAL CHIPS INPUT	T	269.3	269.3	1616	1685	1833	1982	2131	2280	2429	2577	2726	2875	2875	2875	2875
TOTAL STARCH PROD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
TOTAL STARCH SOLD	T	33.0	48.0	300.0	345.0	390.0	435.0	480.0	525.0	570.0	615.0	660.0	705.0	705.0	705.0	705.0
TOTAL CHIP SLURRY		1885	1885	11323	11792	12833	13875	14917	15958	17000	18042	19083	20125	20125	20125	20125
TOTAL CHIP STARCH	T	181.0	181.0	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932

Report 1A

The model is primarily "driven" by the sales forecast. The quantity sales for each product may be seen in rows 3,9, 14, and 19.

Given the sales forecast this section of the model takes the sales forecast and calculates the tonnage of cassava roots and chips required to produce that quantity, using the conversion factors shown in each subsection. These conversion factors are based on the technical data described in technical section of the report.

It will be noted that over and above basic raw materials the model also calculates throughput of the two main stages of the factory ie slurry production and starch production. This is used in report three to assess the factory loading.

It will be noted that sales are apparently made during the construction period. This is done to generate costs for trial runs and chip purchases in season. By the simple device of valuing such sales at zero price, one months costs are automatically written off to developmental expenses in Period Yr.C 1. A further months chip stocks are raised as stock in the working capital routine. In period Yr.C 2 a further one month's sales are also raised to boost the cost loads on trial runs. The sales are however allowed to stand as revenue earning on the basis that having generated approximately three months' production resources they will produce one month's (ie 33⅓%) saleable product. Note that root starch production is only generated in period Yr C P2. since roots must be procured fresh. (ie purchased and processed at the same time). Sales are valued at 50% to give a realistic saleable product outturn. This is expected to be higher than the chip starch outturn since root starch will be produced in the final trial month period.

REPORT 2 :
SCENARIO 1

CASSAVA FACTORY:VALUE OF INPUTS/OUTPUTS

			YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
30	VALUE:INPUTS																
2	XXXXXXXXXXXXXXXXXX																
310	ROOT PRICE	N/T	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
32	ROOTS CONSUMED		0	6	37	37	37	37	37	37	37	37	37	37	37	37	37
330	CHIP PRICE	N/T	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
34	CHIPS CONSUMED		54	54	324	337	367	396	426	456	486	515	545	575	575	575	575
35	TOTAL DIR MATERIALS		54	60	361	374	404	434	463	[illegible]	523	553	582	612	612	612	612
36	VALUE:OUTPUTS																
2	XXXXXXXXXXXXXXXXXX																
370	RST PRICE	N/T	0	400	800	800	800	800	800	800	800	800	800	800	800	800	800
30	ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
38	ROOT STARCH		0	6	74	74	74	74	74	74	74	74	74	74	74	74	74
390	CST PRICE	N/T	0	800	800	800	800	800	800	800	800	800	800	800	800	800	800
90	CHIP STARCH SOLD	T	35	35	207	252	297	342	387	432	477	522	567	612	612	612	612
40	CHIP STARCH		0	28	166	202	238	274	310	346	382	418	454	490	490	490	490
410	GLUCOSE PRICE	N/T	0	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
140	GLUCOSE SOLD	T	133	133	800	800	850	900	950	1000	1050	1100	1150	1200	1200	1200	1200
42	CHIP GLUCOSE		0	146	880	880	935	990	1045	1100	1155	1210	1265	1320	1320	1320	1320
430	DEXTRIN PRICE	N/T	0	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
190	DEXTRIN SOLD	T	13	13	80	80	85	90	95	100	105	110	115	120	120	120	120
44	CHIP DEXTRIN		0	22	136	136	145	153	162	170	179	187	196	204	204	204	204
45	TOTAL SALES		0	202	1256	1292	1392	1491	1591	[illegible]	1790	[illegible]	[illegible]	2088	2088	2088	2088

Report 2A

This report takes the physical quantities in report 1 and converts them to purchases and sales values using agreed prices. Note that the root starch price changes as explained in Appendix 1A and that glucose sales prices have been uplifted by the drum costs. Drum costs are to be recharged to customers and the model approach, showing a higher sale price on the one side, and a materials cost in the variable expenses, ensures that adequate stocks are generated in the working capital routines.

REPORT 3 : [illegible] OPERATING LINES
SCENARIO 1

		YRCP1	YRCP2	YRIP1	YRIP2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
50 PROCESSOR TO RSL																
5 ROOT SLURRY	T	0.0	[illegible]	[illegible]	958.7	958.7	[illegible]	[illegible]	[illegible]	958.7	958.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
510 PROCESS RATE/HOUR		13.0	13.0	13.0	13.0	13.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
52 HOURS REQUIRED		0	12	75	75	75	75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	75	75
530 HOURS PER SHIFT		7	[illegible]	[illegible]	7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	[illegible]
540 SHIFTS PER WEEK		10	10	10	10	[illegible]	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
55 WEEKS REQUIRED		0.0	0.2	1.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.7	0.7
560 WEEKS PER PERIOD		24	24	24	24	24	[illegible]	24	24	24	24	24	24	24	24	24
57 PROCESSOR:RSL TO RST																
30 ROOT STARCH SOLD	T	0	15	93	[illegible]	[illegible]	[illegible]	[illegible]	93	93	93	[illegible]	93	[illegible]	93	93
520 PROCESS RATE/HOUR		1.0	1.0	1.0	[illegible]	1.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0
59 HOURS REQUIRED		0	15	93	93	93	93	93	93	93	93	93	93	[illegible]	93	93
530 HOURS PER SHIFT		7	7	7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
540 SHIFTS PER WEEK		10	10	10	10	10	10	10	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
60 WEEKS REQUIRED		0.0	0.2	1.3	1.3	1.3	1.3	1.3	[illegible]	0.8	0.8	[illegible]	[illegible]	[illegible]	0.8	0.8
560 WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
61 PROCESSOR:IC TO CSL																
28 TOTAL CHIP SLURRY	T	1890	1885	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15958	17000	18042	19083	20125	[illegible]	[illegible]	20125
620 PROCESS RATE/HOUR		13.0	13.0	13.0	13.0	[illegible]	13.0	13.0	[illegible]	13.0	13.0	[illegible]	[illegible]	[illegible]	13.0	13.0
63 HOURS REQUIRED		145	145	871	907	[illegible]	[illegible]	1147	1228	1309	1388	[illegible]	[illegible]	[illegible]	1548	1548
530 HOURS PER SHIFT		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
540 SHIFTS PER WEEK		10	10	10	[illegible]	[illegible]	10	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15
64 WEEKS REQUIRED		2.1	2.1	12.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13.8	13.8
560 WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
65 PROCESSOR:CSL TO CST																
29 TOTAL CHIP STARCH	T	181.0	181.0	1087	[illegible]	[illegible]	1332	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1932	1932
660 PROCESS RATE/HOUR		[illegible]	1.0	1.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0	[illegible]	[illegible]	[illegible]	[illegible]	1.0	[illegible]
67 HOURS REQUIRED		181	181	1087	1132	[illegible]	1332	1432	1532	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1932
530 HOURS PER SHIFT		7	7	7	[illegible]	[illegible]	7	7	7	[illegible]	[illegible]	8	8	[illegible]	[illegible]	[illegible]
540 SHIFTS PER WEEK		10	10	10	10	10	10	[illegible]	10	[illegible]	[illegible]	[illegible]	15	[illegible]	[illegible]	[illegible]
68 WEEKS REQUIRED		2.6	2.6	15.5	[illegible]	[illegible]	19.0	[illegible]	21.9	14.5	15.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
560 WEEKS PER PERIOD		24	[illegible]	[illegible]	[illegible]	[illegible]	24	24	[illegible]	24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24
69 PROCESSOR:CST TO G																
140 GLUCOSE SOLD		133	133	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1200
700 PROCESS RATE/HOUR		1.0	1.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0	[illegible]	[illegible]	[illegible]	[illegible]	1.0	1.0
71 HOURS REQUIRED		133	133	[illegible]	[illegible]	[illegible]	[illegible]	950	[illegible]	1050	[illegible]	[illegible]	1200	[illegible]	1200	1200
530 HOURS PER SHIFT		7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
540 SHIFTS PER WEEK		[illegible]	10	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
72 WEEKS REQUIRED		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
560 WEEKS PER PERIOD		24	24	24	[illegible]	24	[illegible]	[illegible]	24	[illegible]	24	[illegible]	24	[illegible]	[illegible]	[illegible]
73 PROCESSOR:CST TO D																
140 DEXTRIN SOLD		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
740 PROCESS RATE/HOUR		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
75 HOURS REQUIRED		[illegible]	81	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
530 HOURS PER SHIFT		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
540 SHIFTS PER WEEK		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
76 WEEKS REQUIRED		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
560 WEEKS PER PERIOD		[illegible]	24	[illegible]	[illegible]	[illegible]	24	[illegible]	24	[illegible]	24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Report 3A

This routine is included to enable us to judge the factory load factors. The dextrin and glucose lines are separate to the main stream and have adequate capacity to process their offtake from the main line.

The critical process is slurry to starch by a small margin and to this must be added the element of the utilisation by the root starch production. Thus, maximum load is the sum of rows 60 and 68. This is reached in year 3 P2 after which the third shift is brought in.

Maximum capacity is conservatively set by assuming that the 1.25 tonne line has a practical operating optimum of 1 tonne per hour.

Shift hours are assumed to be as follows:

2 shift working = gross 16 hours

less changeover, start up and closedown = nett 14 hours.

3 shift working = gross 24 hours

less changeover etc = nett 22½ hours

(NB - the print out rounds up to 8 hours per shift but the model calculates on the actual of 7½ hours).

REPORT 4.3 CASSAVA FACTORY OTHER VARIABLE COSTS
SCENARIO 1

Code	Item	Unit	YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
30	ELECTRICITY																
25	TOTAL STARCH PROD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
310	UNITS PER TONNE		250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
320	RATE PER UNIT		0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
33	ELECTRICITY-VARIABLE		2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
34	WATER																
25	TOTAL STARCH PROD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
350	LT.000 PER TONNE		4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
360	RATE PER 000LITRE		2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30
37	WATER-VARIABLE		2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
38	FUEL																
25	TOTAL STARCH PROD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
890	LITRES PER TONNE		132	132	132	132	132	132	132	132	132	132	132	132	132	132	132
900	RATE PER LITRE		0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
91	FUEL		12	13	31	84	91	98	105	112	118	125	132	139	139	139	139
42	CHEMICALS																
140	GLUCOSE SOLD	T	133	133	300	300	850	900	950	1000	1050	1100	1150	1200	1200	1200	1200
930	EST.KGS PER TONNE		30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
940	COST PER KG.		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
95	CHEMICALS		2	2	12	12	13	14	14	15	16	17	17	18	18	18	18
100	PACKING MATERIALS																
26	TOTAL STARCH SOLD	T	35.0	35.0	300.0	345.0	390.0	435.0	480.0	525.0	570.0	615.0	660.0	705.0	705.0	705.0	705.0
1010	BAG UNIT WEIGHT	KG	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
1020	BAG UNIT COST		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
103	TOTAL BAG COST		1	2	12	14	15	17	19	21	23	25	26	28	28	28	28
140	GLUCOSE SOLD	T	133	133	300	900	850	900	950	1000	1050	1100	1150	1200	1200	1200	1200
1040	DRUM UNIT WEIGHT	KG	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
1050	DRUM UNIT COST		15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
106	TOTAL DRUMS COST		20	20	120	120	128	135	143	150	158	165	173	180	180	180	180
170	DEXTRIN SOLD	T	13	13	80	80	85	90	95	100	105	110	115	120	120	120	120
1070	BAG UNIT WEIGHT	KG	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
1080	BAG UNIT COST		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
109	TOTAL BAGS COST		1	1	3	3	3	4	4	4	4	4	5	5	5	5	5
110	PACKING MATERIALS		22	22	135	137	147	156	166	175	185	194	204	213	213	213	213

Report 4A

In expressing the variable costs and given that quantity figures, especially of electricity and water are so high the units per tonne and prices are equal to 000's units where appropriate.

Note that drum costs are generated by the programme. This is a contra in the profit and loss account with the inflated sales price. This ensures stock of drums are created for the working capital requirements.

REPORT 5 :
SCENARIO 1

CASSAVA FACTORY:FIXED ASSET MAINT/DEPR

			YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
115	FIXED ASSET COST																
1160	LAND		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
1170	FACTORY BUILD		375	500	500	500	500	500	500	500	500	500	500	500	500	500	500
1180	PLANT & EQUIP		600	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400
1190	VEHICLES		70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
1200	HOUSING		38	250	250	250	250	250	250	250	250	250	250	250	250	250	250
122	TOTAL COST		1258	3245	3245	3245	3245	3245	3245	3245	3245	3245	3245	3245	3245	3245	3245
1230	LAND	MNT/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1240	FACTORY BUILD	MNT/RT	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5
1250	PLANT	MNT/RT	0.0	0.0	10.0	10.0	12.5	12.5	15.0	15.0	17.5	17.5	20.0	20.0	20.0	20.0	20.0
1260	VEHICLES	MNT/RT	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
1270	HOUSING	MNT/RT	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5
128	MAINTENANCE		7	7	146	146	176	176	206	206	236	236	266	266	266	266	266
1290	LAND	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1300	FACTORY BUILD	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1310	PLANT	DEP/RT	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10
1320	VEHICLES	DEP/RT	0	0	20	20	20	20	20	20	20	20	20	20	20	20	20
1330	HOUSING	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
134	DEPRECIATION		0	0	127	127	127	127	127	127	127	127	127	127	127	127	127
135	TOTAL CUM DEP		0	0	127	254	381	508	635	762	889	1016	1143	1270	1397	1524	1651
141	NET FIXED ASSETS		1258	3245	3118	2991	2864	2737	2610	2483	2356	2229	2102	1975	1848	1721	1594

Report 5A

This routine assembles the maintenance and depreciation costs on fixed assets. Note that no depreciation costs are raised in the construction period and that only maintenance of vehicles is charged in this period.

After due thought it has been assumed that given a reasonable maintenance expenditure buildings should not be depreciated. In the case of plant and machinery it is assumed that the initial cost will include a supply of spares and that maintenance cost will rise progressively over the first five years levelling off at 20% per annum from year five onwards.

REPORT [illegible]
SCENARIO 1

CASSAVA FACTORY/WORKING CAPITAL

		YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
1401 ROOT WEIGHT	T	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	[illegible]	[illegible]
[illegible] ROOT PRICE	[illegible]	100	[illegible]	[illegible]	[illegible]	[illegible]	100	100	100	[illegible]	[illegible]	[illegible]	[illegible]	100	[illegible]	[illegible]
[illegible] ROOT VALUE		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] CHIP WEIGHT	T	269	[illegible]	[illegible]	[illegible]	[illegible]	330	[illegible]	306	[illegible]	[illegible]	[illegible]	479	2575	[illegible]	[illegible]
1350 CHIP PRICE	[illegible]	200	[illegible]	[illegible]	200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	200	[illegible]	[illegible]
148 CHIP VALUE		54	9	324	[illegible]	[illegible]	[illegible]	426	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
110 PACKING MATERIALS		22	12	136	[illegible]	147	155	166	[illegible]	[illegible]	194	[illegible]	213	213	[illegible]	[illegible]
1430 STOCK PERIOD %		50.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	50.0	[illegible]	[illegible]	[illegible]	50.0	50.0	[illegible]	[illegible]
144 PACKING MATS VALUE		11	11	68	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] TOTAL SALES		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2088	[illegible]	[illegible]
[illegible] STOCK WEEKS HALF YR		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	4	[illegible]	[illegible]
[illegible] FINISHED GOODS VALUE		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	321	[illegible]	[illegible]
154 TOTAL STOCKS		[illegible]	[illegible]	385	324	654	574	754	[illegible]	534	474	[illegible]	524	1005	[illegible]	[illegible]
[illegible] DEBTOR WEEKS HALF YR		0	4	[illegible]	[illegible]	[illegible]	[illegible]	6	3	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] DEBTORS/PREPAYMENTS		0	21	[illegible]	298	[illegible]	344	[illegible]	390	413	[illegible]	[illegible]	482	[illegible]	[illegible]	[illegible]
[illegible] CASH PERIOD HALF YR		0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] CASH		54	[illegible]	[illegible]	124	55	[illegible]	66	[illegible]	5	465	36	148	75	[illegible]	[illegible]
[illegible] TOTAL CUR ASSETS		54	[illegible]	[illegible]	374	404	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	612	612	[illegible]	[illegible]
[illegible] CREDITORS WEEKS HALF YR		0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] CREDITORS/ACCRUALS		[illegible]	[illegible]	[illegible]	[illegible]	47	[illegible]	[illegible]	[illegible]	[illegible]	123	134	141	141	141	141

Report 6A

The working capital requirements of agro-industrial units are frequently complicated by the need for seasonal buying of raw materials. The model is constructed to cope with the particular problems of the cassava market.

Period 1 July to December the majority of cassava has to be acquired. For period 2 January - June supplies will only be available in June when the buying season begins. The effect on working capital is one of high stocks and low cash holdings at end period 1 and the reverse at end period 2. As can be seen the model has been constructed to incorporate this important cash flow feature.

Other working capital requirements have been estimated on the following basis:

- packing materials at three months usage
- finished goods stocks at four weeks sales
- debtors at six weeks sales
- creditors at six weeks materials purchases

Debtors and finished goods stocks are the most significant items. These are relatively conservatively estimated since stocks are valued at full market value rather than at cost and debtors could be reduced by insisting on earlier payment. It is in fact not unknown, in developing countries, for producers of important industrial inputs to insist on payment in advance.

Since purchases are to be through NAMBOARD we assume that some credit will be available.

[illegible] SCENARIO 1 [illegible]

	YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
1140 CORPORATE TAX RATE %	0	0	0	0	0	0	0	0	0	0	0	0	45	[illegible]	[illegible]
1110 S-T DEBT INT RATE %	0	0	12	12	12	12	12	12	12	12	12	12	12	12	12
1120 M-T DEBT INT RATE %	0.00	5.75	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50
1130 L-T DEBT INT RATE %	0.00	5.75	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50
1620 SHORT-TERM DEBT	0	0	400	300	200	100	0	0	0	0	0	0	0	0	0
1630 CAPITAL	1650	350	0	0	0	0	0	0	0	0	0	0	0	0	0
1640 MEDIUM-TERM DEBT	0	900	0	0	0	0	0	0	0	0	0	0	0	0	0
1650 MEDIUM-TERM DEBT	0	0	0	0	0	0	0	150	150	150	150	150	150	0	0
1660 MEDIUM-TERM DEBT	0	900	900	900	900	900	900	750	600	450	300	150	0	0	0
1670 LONG-TERM DEBT	0	900	0	0	0	0	0	0	0	0	0	0	0	0	0
1680 LONG-TERM DEBT	0	0	0	0	0	0	0	150	150	150	150	150	150	0	0
1690 LONG-TERM DEBT	0	900	900	900	900	900	900	750	600	450	300	150	0	0	0

Report 7A

This section of the model is the one through which the capitalisation, debt service and tax charges are entered and/or calculated into the main financial statements.

Interest charges have been assessed on the basis of rates currently been asked in Zambia. The term loan is set at 75% of plant and machinery which is the amount that the Development Bank of Zambia has indicated it would be prepared to lend. The loan is split into two to enable the model to accommodate two sorts of term loan financing should this be necessary in the future.

Debt service has been set at three years moratorium and three years repayment in six monthly rests. The Development Bank of Zambia has indicated to us the length of moratorium period they were willing to grant, whilst repayment has been set to enable the earliest practical repayment period.

It is assumed that the project will enjoy a tax holiday for the first five years' operations.

REPORT [illegible] SCENARIO 1

[illegible] PROFIT STATEMENTS

	YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
KWACHA THOUSAND															
SALES REVENUE:															
ROOT STARCH	0	6	74	74	74	74	74	74	74	74	74	74	74	74	74
CHIP STARCH	0	18	166	202	238	274	310	346	382	418	454	490	490	490	490
CHIP GLUCOSE	0	146	880	880	935	990	1045	1100	1155	1210	1265	1320	1320	1320	1320
CHIP DEXTRIN	0	22	136	136	145	153	162	170	179	187	195	204	204	204	204
TOTAL SALES	0	202	1256	1292	1392	1491	1591	1690	1790	1889	1989	2088	2088	2088	2088
RAW MATERIALS:															
ROOTS CONSUMED	0	6	37	37	37	37	37	37	37	37	37	37	37	37	37
CHIPS CONSUMED	54	54	324	337	367	396	426	456	486	515	545	575	575	575	575
TOTAL RAW MATERIALS	54	60	361	374	404	434	463	493	523	553	582	612	612	612	612
GROSS ADDED VALUE	(54)	143	895	918	988	1057	1127	1197	1267	1336	1406	1476	1476	1476	1476
ELECTRICITY-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
WATER-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
FUEL	12	13	81	84	91	98	105	112	118	125	132	139	139	139	139
CHEMICALS	2	2	12	12	13	14	14	15	16	17	17	18	18	18	18
PACKING MATERIALS	22	22	135	137	147	155	166	175	185	194	204	213	213	213	213
OTHER VARIABLE COSTS	40	42	252	257	[illegible]	[illegible]	315	334	[illegible]	[illegible]	[illegible]	410	410	410	410
CONTRIBUTION	(94)	101	[illegible]	661	711	762	812	863	914	964	1015	1066	1066	1066	1066
LABOUR & STAFF	53	[illegible]	117	117	117	117	117	117	156	156	156	156	156	156	156
ELECTRICITY-FIXED	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2
WATER-FIXED	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MAINTENANCE	7	7	146	146	176	176	206	206	236	236	266	266	266	266	266
MISCELLANEOUS	50	[illegible]	59	59	59	59	59	59	59	59	59	59	59	59	59
DEPRECIATION	0	0	127	127	127	127	[illegible]	127	127	127	127	127	127	127	127
TOTAL FIXED COSTS	133	[illegible]	442	442	472	472	502	502	567	567	597	597	597	597	597
PROFIT BEFORE INTEREST & TAX	(227)	[illegible]	201	219	239	289	310	361	346	[illegible]	418	468	468	468	468
INTEREST:															
SHORT-TERM DEBT	0	0	24	24	18	12	6	0	0	0	0	0	0	0	0
MEDIUM-TERM DEBT	0	30	61	61	61	61	61	61	61	41	30	20	10	0	0
LONG-TERM DEBT	0	30	61	61	61	61	61	61	61	41	30	20	10	0	0
TOTAL INTEREST	0	[illegible]	[illegible]	146	140	134	128	122	[illegible]	81	[illegible]	41	20	0	0
PROFIT BEFORE TAX	(227)	[illegible]	[illegible]	73	99	156	183	239	245	[illegible]	357	428	448	468	468
TAXATION	0	0		0	0	0	0	0	0	0	0	0	202	211	211
PROFIT AFTER TAX	(227)	[illegible]	[illegible]	73	99	156	183	237	245	316	357	428	246	[illegible]	[illegible]

Report 8A

The variable elements of the profit statement have been entered from the previously described reports where they are calculated. In terms of the fixed expenses the following have been estimated at fixed annual levels:

- electricity
- water
- miscellaneous.

Depreciation and annual maintenance are calculated as described in report 5.

The major item is staff and labour which has been estimated in accordance with the following table for operating periods:

	Basic Single Shift			Increment 2 Shifts		Increment 3 Shifts	
	No	Rate K	Total K	No	Total K	No	Total K
Management	5	9,000	45,000	-		1	9,000
Lab.Technician	1	3,960	3,960	-			
Foremen	2	5,280	10,560	1	5,280	1	5,280
Mechanics	2	4,300	8,600	1	4,300	1	4,300
Admin/Clerks	7	3,300	23,100	1	3,300	1	3,300
Drivers	3	3,000	9,000	-		1	3,000
Guards	4	2,410	9,640	1	2,410	1	2,410
Operatives	12	2,665	31,980	12	31,980	12	31,980
Labourers/ Groundsmen	20	1,645	32,900	4	6,580	4	6,580
	56		174,740	20	53,850	22	65,850
Add 7½% shift allowance					4,038		4,263 *
Total			174,740		57,888		70,113

* NB Management does not receive shift allowance.

per period

2 shifts $= \frac{175,000 + 58,000}{2} = 116,500$

3 shifts $= \frac{175,000 + 58,000 + 70,000}{2} = 151,500$

[illegible]ort 8A

The [illegible]able elements of the profit statement have been entered from the [illegible]usly desc[illegible] reports where they are calculated. In terms of the fixed e[illegible]s the follow[illegible]ve been estimated at fixed annual levels:

- [illegible]tricity
- w[illegible]
- misc[illegible]neous.

Depreciation and a[illegible] maintenance are calculated as descr[illegible] in report 5.

The major item is sta[illegible] labour which has been estim[illegible] in accordance with the following table for oper[illegible] periods:

	Bas[illegible]	[illegible]le Shift		[illegible]nent 2 Shifts		Increment 3 Shifts	
	No	Rate K	Total K	[illegible]	Total K	No	Total K
Management	5	9,000	[illegible]000	-		1	9,000
Lab.Technician	1	3,960	[illegible]60	-			
Foremen	2	5,280	10[illegible]	1	5,280	1	5,280
Mechanics	2	4,300	8,[illegible]	1	4,300	1	4,300
Admin/Clerks	7	3,300	23,1[illegible]	1	3,300	1	3,300
Drivers	3	3,000	9[illegible]	-		1	3,000
Guards	4	2,410	[illegible]	1	2,410	1	2,410
Operatives	12	2,665	[illegible]80	12	31,980	12	31,980
Labourers/ Groundsmen	20	1,645	[illegible],900	4	6,580	4	6,580
	56		174,740	20	[illegible]3,850	22	65,850
Add 7½ shift allowance					[illegible]038		4,263 *
Total			174,740		57,888		70,113

* NB [illegible]nagement does not receive shift allowance.

p[illegible]eriod

2 shifts $= \frac{175,000 + 58,000}{2} = 116,500$

3 shifts $= \frac{175,000 + 58,000 + 70,000}{2} = 151,500$

In building up the construction period the cost levels for the majority of items are either generated within the model or set at levels commensurate with operating period costs. The major item not described by the schedules is again labour and sta*f which has been estimated as follows using the above annual salary rates:

- In the first six months staff will build up to the following levels.

	No		Rate K	Total K
Management	3	x	9000/2	13,500
Foreman	1	x	5280/2	2,640
Mechanics	1	x	4300/2	2,150
Clerical	2	x	3300/2	3,300
Drivers	1	x	3000/2	1,500
Guards	2	x	2410/2	2,410
Operatives	-		-	-
Labourers	4	x	1645/2	3,290
		Total		28,790

- In the second six months staff will build up to the following levels.

	No		Rate K	Total K
Management	4	x	9000/2	18,000
Foreman	1	x	5280/2	2,640
Mechanics	1	x	4300/2	2,150
Clerical	4	x	3300/2	6,600
Drivers	3	x	3000/2	4,500
Guards	3	x	2410/2	3,615
Operatives	-		-	-
Labourers	8	x	1645/2	6,580
		Total		44,085

Total labour and staff period Yr C P1 72,875
say 73,000.

In the final six months of construction the full staffing will be engaged. However given the low output load this is expected only to be at a one shift level and in the case of operatives and factory labour, they will only be engaged during the last three months when trial runs take place. The staffing level is calculated as follows.

	No		Rate K	Total K
Management	5	x	9000/2	22,500
Foremen	2	x	5280/2	5,280
Lab.Technician	1	x	3960/2	1,980
Mechanics	2	x	4300/2	4,300
Clerical	7	x	3300/2	11,550
Guards	4	x	2410/2	4,820
Operatives	12	x	2665/4	7,995
Labourers/ Groundsmen	12	x	1645/2	9,870
Labourers/ Groundsmen	8	x	1645/4	3,290
				71,585
Say				72,000

REPORT 9 : CASSAVA FACTORY BALANCE SHEETS

SCENARIO 1

KWACHA THOUSAND	YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
NET FIXED ASSETS	1255	3243	[illegible]	2991	[illegible]	[illegible]	[illegible]	2483	[illegible]	[illegible]	[illegible]	[illegible]	1848	1721	1594
CURRENT ASSETS:															
TOTAL STOCKS	[illegible]	36	[illegible]	324	[illegible]	[illegible]	[illegible]	424	354	474	[illegible]	504	1003	524	1003
DEBTORS/PREPAYMENTS	0	31	[illegible]	[illegible]	[illegible]	[illegible]	307	390	413	436	457	462	462	482	462
CASH	54	54	[illegible]	324	[illegible]	[illegible]	96	426	75	486	[illegible]	545	96	575	96
TOTAL CURRENT ASSETS	119	121	[illegible]	[illegible]	[illegible]	[illegible]	1157	1240	1343	[illegible]	[illegible]	1551	1551	1581	1581
CURRENT LIABILITIES:															
CREDITORS/ACCRUALS	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	134	141	141	141	141
SHORT-TERM DEBT	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0	0
TOTAL CURRENT LIABILITIES	0	0	483	[illegible]	[illegible]	[illegible]	107	114	[illegible]	128	134	141	141	141	141
NET CURRENT ASSETS	[illegible]	121	[illegible]	[illegible]	[illegible]	980	1050	[illegible]	[illegible]	[illegible]	[illegible]	1410	1440	1440	1440
SURPLUS CASH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL NET ASSETS	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4352	[illegible]
FINANCED BY:															
CAPITAL	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2000	[illegible]	2000	[illegible]	[illegible]
RESERVES	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1430	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL EQUITY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3430	[illegible]	4104	4352	[illegible]
MEDIUM-TERM DEBT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	500	150	0	0	0
LONG-TERM DEBT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	500	150	0	0	0
CAPITAL EMPLOYED	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4158	4104	4352	4619

Report 9A

The model constructs the balance sheets largely from data already calculated in previous reports. One item however requires particular mention, namely cash surplus. This item is made necessary as a balancing item since the cash in hand figure is already fixed on the basis of the working capital requirement.

This form of presentation has the major advantage of demonstrating clearly the surplus cash flow build up and available for possible equity distributions. It must agree with the cumulative surplus cash flow shown in report 10, funds flow statement, and thus gives a clear audit check that the model logic is working. Finally in any one year this figure represents accumulated reserves not immediately required in the business and therefore enables us to refine capital employment, and thus the relevant ratios, to a figure representing the capital actually used in the business in the year in question.

REPORT 10 : SCENARIO I

CASSAVA FACTORY FUNDS FLOW STATEMENTS

	YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
KWACHA THOUSAND															
SOURCES OF FUNDS:															
PROFIT AFTER TAX	(1227)	(670)	58	73	99	156	183	239	246	316	337	428	246	258	258
DEPRECIATION	0	0	127	127	127	127	127	127	127	127	127	127	127	127	127
M-T & L-T DEBT INT	0	61	122	122	122	122	122	122	101	81	81	41	20	0	0
CASH GENERATED FROM OPERATIONS	(1227)	(609)	304	321	348	404	431	488	473	524	545	595	394	385	385
CAPITAL	1650	350	0	0	0	0	0	0	0	0	0	0	0	0	0
MEDIUM-TERM DEBT	0	400	0	0	0	0	0	0	0	0	0	0	0	0	0
LONG-TERM DEBT	0	900	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL SOURCES OF FUNDS	1423	2744	304	321	348	404	431	488	473	524	545	595	394	385	385
APPLICATIONS OF FUNDS:															
FIXED INVESTMENT	1266	1908	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
WORKING CAPITAL	119	2	179	107	179	145	176	45	46	46	46	46	30	0	0
DEBT REPAYMENT:															
MEDIUM-TERM DEBT	0	0	0	0	0	0	0	150	150	150	150	150	150	0	0
LONG-TERM DEBT	0	0	0	0	0	0	0	150	150	150	150	150	150	0	0
TOTAL DEBT REPAYMENT	0	0	0	0	0	0	0	300	300	300	300	300	300	0	
INTEREST:															
MEDIUM-TERM DEBT	0	30	61	61	61	51	61	61	51	41	[illegible]	[illegible]	[illegible]	0	0
LONG-TERM DEBT	0	30	61	61	61	61	61	61	51	41	[illegible]	[illegible]	[illegible]	0	0
M-T & L-T DEBT INT	0	61	122	122	122	122	122	122	101	81	81	41	20	0	0
TOTAL DEBT SERVICE	0	61	122	122	122	122	122	422	401	381	381	341	320	0	0
TOTAL APPLICATIONS OF FUNDS	1427	2980	401	230	301	268	317	466	497	427	455	387	350	0	0
SURPLUS CASH BALANCES:															
PERIOD	4	[illegible]	[illegible]	91	47	137	114	20	(24)	97	88	207	44	385	385
CUMULATIVE	4	[illegible]	44	85	132	269	382	403	[illegible]	476	564	[illegible]	[illegible]	[illegible]	1566

Report 10A

This statement is computed by the model from the data in previous reports. It should be noted that term loan interest is included in both inflows and outflows to give a total debt service on which the debt service ratio can be computed.

REPORT [illegible] [illegible] FINANCIAL RATIOS

SCENARIO 1

		YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
230	CONTRIBUTION MARGIN%	0	50	51	51	51	51	51	51	51	51	51	51	51	51	51
231	FIXED COST/SALES%	0	55	35	34	34	32	32	30	32	30	30	29	29	29	29
232	PROFIT AFT TAX/SALES%	0	(30)	4	[illegible]	7	10	11	14	14	17	15	20	12	12	11
233	PR AFT S-T INT/SALES%	0	(3)	14	15	16	17	19	21	19	21	21	22	22	22	22
234	PROFIT/CAP EMPLOYED%	(31.9)	(6.6)	4.8	10.2	11.1	12.8	14.3	16.6	17.9	18.7	20.2	21.3	22.8	21.5	20.3
235	SALES/CAP EMPLOYED	0.0	0.1	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
236	CURRENT RATIO	0.0	0.0	1.8	2.4	3.0	5.4	11.1	10.9	11.1	10.9	11.1	11.0	11.2	11.2	11.2
237	DEBT/CAP EMPLOYED%	[illegible]	51	51	50	48	46	44	37	30	23	15	7	0	0	0
238	DEBT SERVICE COVER	0.0	(1.1)	2.0	2.6	2.9	3.3	3.5	1.2	1.2	1.4	1.5	1.7	1.2	0.0	0.0
239	PROFIT/NET CAP EMPL	(31.9)	(6.7)	4.9	10.5	11.6	13.3	15.6	16.4	19.3	21.3	23.5	26.1	28.5	29.6	30.9

REPORT 11: CASSAVA FACTORY: KEY FINANCIAL RATIOS

Report 11A

We have extracted certain key financial ratios to give an overview measurement of the project. The majority of the ratios are self explanatory and need no further comment as to their derivation. In the two profit/capital employed ratios we wish to clarify the basis of calculation as follows:

> These ratios have in the first instance been calculated as annual rates of return rather than six monthly rates. This has been done on the basis of adding the previous periods profit (loss) to that of the period being assessed, except in the first period where it has been necessary to multiply the current period profit or loss by two since no previous period exists.
>
> The difference between the profit/capital employed ratio (234) and the profit/net capital employed ratio (239) is that, in the latter case, the surplus cash figure in the balance sheet has been deducted from the capital employed to give the net figure.

REPORT 12 [illegible]
SCENARIO 1

	YR1	YR2	YR3	YR4	YR5	YR6	YR7	YR8	YR9	YR10
NET CASH FLOW	3600 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
DISCOUNT [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D. C. F.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
N. P. V.	[illegible]									

Report 12

The model calculates the NPV against a given rate of return. It will be noted that the cash flow expressed in six monthly periods in the main model has been consolidated to annual figures for this calculation and that whilst the print out shows only the first 15 periods, after which the annual results are the same, the model does hold a full 20 periods enabling ten years project life to be discounted.

In compiling the report we have established the IRR that yields an NPV as near as possible to zero by using a separate Finesse routine available as part of the package.

The final years cash flow has been adjusted to include the recovery of working capital together with the disposal of fixed assets as follows:

Land	100%
Buildings	50%
Plant	5%
Vehicles	10%
Working Capital	100%.

-15.00 PERCENT CHANGE IN SALES FACTOR												
0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
0.85	0.85	0.85	0.85	0.85	0.85	0.85						
RESULTS IN PROFIT AFTER TAX												
(212.64)	(82.10)	(40.67)	(26.37)	(7.33)	41.71	60.75	109.79	108.08	171.37	204.66	267.95	158.51
169.65	169.65	169.65	169.65	169.65	169.65	169.65						
-10.00 PERCENT CHANGE IN SALES FACTOR												
0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
0.90	0.90	0.90	0.90	0.90	0.90	0.90						
RESULTS IN PROFIT AFTER TAX												
(217.33)	(77.07)	(8.49)	4.65	28.22	79.79	101.36	152.93	153.76	219.58	255.40	321.22	187.81
198.95	198.95	198.95	198.95	198.95	198.95	198.95						
-5.00 PERCENT CHANGE IN SALES FACTOR												
0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
0.95	0.95	0.95	0.95	0.95	0.95	0.95						
RESULTS IN PROFIT AFTER TAX												
(222.02)	(72.03)	23.68	39.67	63.77	117.87	141.98	196.08	199.43	267.79	306.14	374.49	217.11
228.25	228.25	228.25	228.25	228.25	228.25	228.25						
0.00 PERCENT CHANGE IN SALES FACTOR												
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00						
RESULTS IN PROFIT AFTER TAX												
(226.71)	(57.00)	35.86	72.69	99.32	153.96	182.59	239.23	245.11	316.00	356.88	427.77	246.41
257.55	257.55	257.55	257.55	257.55	257.55	257.55						

-15.00 PERCENT CHANGE IN SALES FACTOR												
0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
0.85	0.85	0.85	0.85	0.85	0.85	0.85						
RESULTS IN CUMULATIVE												
78.48	157.08	66.16	16.78	(30.96)	(1.41)	5.01	(97.36)	(243.61)	(284.40)	(334.07)	(278.28)	(318.07)
(21.42)	275.22	571.87	868.51	1165.16	1461.80	1758.45						
-10.00 PERCENT CHANGE IN SALES FACTOR												
0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
0.90	0.90	0.90	0.90	0.90	0.90	0.90						
RESULTS IN CUMULATIVE												
57.86	151.39	58.69	39.39	23.23	38.56	130.82	69.29	(36.07)	(30.95)	(34.66)	72.09	60.12
386.06	712.01	1037.96	1363.90	1689.85	2015.79	2341.74						
-5.00 PERCENT CHANGE IN SALES FACTOR												
0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
0.95	0.95	0.95	0.95	0.95	0.95	0.95						
RESULTS IN CUMULATIVE												
57.24	145.70	51.22	62.00	77.43	178.53	256.62	235.93	171.47	222.49	264.74	422.47	438.30
793.55	1148.80	1504.04	1859.29	2214.54	2569.78	2925.03						
0.00 PERCENT CHANGE IN SALES FACTOR												
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00						
RESULTS IN CUMULATIVE												
46.62	140.01	43.75	84.61	131.62	268.51	382.42	402.58	379.01	475.94	564.15	772.84	816.49
1201.04	1585.58	1970.13	2354.68	2739.22	3123.77	3508.32						

RESULTS OF SENSITIVITY RUNS

-15.00 PERCENT CHANGE IN PRICE FACTOR

0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
0.85	0.85	0.85	0.85	0.85	0.85	0.85						

RESULTS IN PROFIT AFTER TAX

(226.71)	(97.36)	(132.54)	(121.11)	(109.40)	(67.69)	(35.98)	(14.27)	(23.31)	32.65	53.61	114.57	74.15
85.29	85.29	85.29	85.29	85.29	85.29	85.29						

-10.00 PERCENT CHANGE IN PRICE FACTOR

0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
0.90	0.90	0.90	0.90	0.90	0.90	0.90						

RESULTS IN PROFIT AFTER TAX

(226.71)	(87.24)	(69.74)	(56.51)	(39.83)	6.86	23.54	70.23	66.16	127.10	158.03	218.97	131.57
142.71	142.71	142.71	142.71	142.71	142.71	142.71						

-5.00 PERCENT CHANGE IN PRICE FACTOR

0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
0.95	0.95	0.95	0.95	0.95	0.95	0.95						

RESULTS IN PROFIT AFTER TAX

(226.71)	(77.12)	(8.94)	8.09	29.75	81.41	103.07	154.73	150.64	221.55	257.46	323.37	188.99
200.13	200.13	200.13	200.13	200.13	200.13	200.13						

0.00 PERCENT CHANGE IN PRICE FACTOR

1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00						

RESULTS IN PROFIT AFTER TAX

(226.71)	(67.00)	30.86	72.69	97.32	150.96	182.59	239.23	245.11	316.00	356.88	427.77	246.41
257.55	257.55	257.55	257.55	257.55	257.55	257.55						

-15.00 PERCENT CHANGE IN PRICE FACTOR

0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
0.85	0.85	0.85	0.85	0.85	0.85	0.85						

RESULTS IN CUMULATIVE

46.62	116.65	(102.55)	(253.42)	(409.38)	(490.41)	(609.33)	(836.93)	(1123.18)	(1303.86)	(1508.19)	(1606.96)	(1735.57)
(1523.28)	(1310.99)	(1098.71)	(886.42)	(674.13)	(461.85)	(249.56)						

-10.00 PERCENT CHANGE IN PRICE FACTOR

0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
0.90	0.90	0.90	0.90	0.90	0.90	0.90						

RESULTS IN CUMULATIVE

46.62	124.44	(53.78)	(140.74)	(229.05)	(237.44)	(276.74)	(423.76)	(622.45)	(710.60)	(817.41)	(313.69)	(884.88)
(615.18)	(345.47)	(75.76)	193.95	463.65	733.35	1003.07						

-5.00 PERCENT CHANGE IN PRICE FACTOR

0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
0.95	0.95	0.95	0.95	0.95	0.95	0.95						

RESULTS IN CUMULATIVE

46.62	132.22	(5.02)	(28.07)	(48.71)	15.53	31.84	(10.59)	(121.72)	(117.33)	(126.63)	(20.42)	(34.20)
292.93	620.06	947.18	1274.31	1601.44	1928.57	2255.69						

0.00 PERCENT CHANGE IN PRICE FACTOR

1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00	1.00	1.00	1.00						

RESULTS IN CUMULATIVE

46.62	140.01	43.75	34.61	131.62	268.51	382.42	402.58	379.01	475.94	564.15	772.84	816.49
1201.04	1585.58	1970.13	2354.68	2739.22	3123.77	3508.32						

FINANCIAL REPORTS FOR CASSAVA STARCH FACTORY ONLY

REPORT 1 : FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY:THROUGHPUT

No.	QUANTITY:TONNES	Unit	YRCP1	YRCP2	R1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
3D	ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
4D	YIELD RSL TO RST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
5	ROOT SLURRY	T	0.0	156.2	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7
6D	YIELD R TO RSL	%	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260
7	ROOTS INPUT	T	0.0	60.1	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6
8																	
9D	CHIP STARCH SOLD	T	181	181	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
10D	YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
11	CHIP SLURRY	T	1885	1885	11323	11792	12833	13875	14917	15958	17000	18042	19083	20125	20125	20125	20125
12D	YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
13	CHIPS INPUT CST	T	269.3	269.3	1618	1685	1833	1982	2131	2290	2429	2577	2726	2875	2875	2875	2875
8																	
14D	GLUCOSE SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15D	YIELD CST TO G	%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
16	CHIP STARCH G	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10D	YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
17	CHIP SLURRY G	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12D	YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
18	CHIPS INPUT G	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8																	
19D	DEXTRIN SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20D	YIELD CST TO D	%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
21	CHIP STARCH D	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10D	YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
22	CHIP SLURRY D	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12D	YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
23	CHIPS INPUT D	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8																	
24	TOTAL CHIPS INPUT	T	[illegible]	269.3	1618	1685	1833	1982	2131	2280	2429	2577	2726	2875	2875	2875	2875
5																	
25	TOTAL STARCH PROD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
8																	
26	TOTAL STARCH SOLD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	[illegible]	1925	2025	2025	2025	2025
9																	
28	TOTAL CHIP SLURRY	T	1885	1885	11323	11792	12833	13875	14917	15958	17000	[illegible]	19083	20125	20125	20125	20125
8																	
29	TOTAL CHIP STARCH	T	181.0	181.0	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
27																	

REPORT 2 : CASSAVA FACTORY:VALUE OF INPUTS/OUTPUTS
FACTORY FOR CASSAVA STARCH ONLY

			YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
30	VALUE:INPUTS																
2																	
31D	ROOT PRICE	K/T	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
32	ROOTS CONSUMED		0	6	37	37	37	37	37	37	37	37	37	37	37	37	37
8																	
33D	CHIP PRICE	K/T	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
34	CHIPS CONSUMED		54	54	324	337	367	396	426	456	486	515	545	575	575	575	575
8																	
35	TOTAL DIR MATERIALS		54	60	361	374	404	434	463	493	523	553	582	612	612	612	612
27																	
36	VALUE:OUTPUTS																
2																	
37D	RST PRICE	K/T	0	409	800	800	800	800	800	800	800	800	800	800	800	800	800
3D	ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
38	ROOT STARCH		0	6	74	74	74	74	74	74	74	74	74	74	74	74	74
8																	
39D	CST PRICE	K/T	0	800	800	800	800	800	800	800	800	800	800	800	800	800	800
9D	CHIP STARCH SOLD	T	181	181	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
40	CHIP STARCH		0	145	870	906	986	1066	1146	1226	1306	1386	1466	1546	1546	1546	1546
8																	
41D	GLUCOSE PRICE	K/T	0	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
14D	GLUCOSE SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	CHIP GLUCOSE		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8																	
43D	DEXTRIN PRICE	K/T	0	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
19D	DEXTRIN SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	CHIP DEXTRIN		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8																	
45	TOTAL SALES		0	151	944	980	1060	1140	1220	1300	1380	1460	1540	1620	1620	1620	1620
27																	

REPORT 3 : FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY : OPERATING TIMES

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
50 PROCESS:R TO RSL																
5 ROOT SLURRY	T	0.0	156.2	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7
510 PROCESS RATE/HOUR		13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
52 HOURS REQUIRED		0	12	75	75	75	75	75	75	75	75	75	75	75	75	75
530 HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
540 SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
55 WEEKS REQUIRED		0.0	0.2	1.1	1.1	1.1	1.1	1.1	1.1	0.7	0.7	0.7	0.7	0.7	0.7	0.7
560 WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
57 PROCESS:RSL TO RST																
30 ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
580 PROCESS RATE/HOUR		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
59 HOURS REQUIRED		0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
530 HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
540 SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
60 WEEKS REQUIRED		0.0	0.2	1.3	1.3	1.3	1.3	1.3	1.3	0.8	0.8	0.8	0.8	0.8	0.8	0.8
560 WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
61 PROCESS:C TO CSL																
28 TOTAL CHIP SLURRY	T	1885	1885	11323	11792	12833	13875	14917	15958	17000	18042	19083	20125	20125	20125	20125
620 PROCESS RATE/HOUR		13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
63 HOURS REQUIRED		145	145	871	907	987	1067	1147	1228	1308	1388	1468	1548	1548	1548	1548
530 HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
540 SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
64 WEEKS REQUIRED		2.1	2.1	12.4	13.0	14.1	15.2	16.4	17.5	11.6	12.3	13.0	13.8	13.8	13.8	13.8
560 WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
65 PROCESS:CSL TO CST																
29 TOTAL CHIP STARCH	T	181.0	181.0	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
660 PROCESS RATE/HOUR		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
67 HOURS REQUIRED		181	181	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
530 HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
540 SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
68 WEEKS REQUIRED		2.6	2.6	15.5	16.2	17.6	19.0	20.5	21.9	14.5	15.4	16.3	17.2	17.2	17.2	17.2
560 WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
69 PROCESS:CST TO G																
140 GLUCOSE SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
700 PROCESS RATE/HOUR		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
71 HOURS REQUIRED		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
530 HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
540 SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
72 WEEKS REQUIRED		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
560 WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
73 PROCESS:CST TO D																
190 DEXTRIN SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
740 PROCESS RATE/HOUR		0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
75 HOURS REQUIRED		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
530 HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	6
540 SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
76 WEEKS REQUIRED		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
560 WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24

REPORT 4 1 CASSAVA FACTORY:OTHER VARIABLE COSTS

FACTORY FOR CASSAVA STARCH ONLY

			YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
80	ELECTRICTY																
25	TOTAL STARCH PROD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
810	UNITS PER TONNE		250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
820	RATE PER UNIT		0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
83	ELECTRICITY-VARIABLE		2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
84	WATER																
25	TOTAL STARCH PROD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
850	LT.000 PER TONNE		4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
860	RATE PER 000LITRS		2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30
87	WATER-VARIABLE		2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
88	FUEL																
25	TOTAL STARCH PROD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
890	LITRES PER TONNE		132	132	132	132	132	132	132	132	132	132	132	132	132	132	132
900	RATE PER LITRE		0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
91	FUEL		12	13	81	84	91	98	105	112	118	125	132	139	139	139	139
92	CHEMICALS																
140	GLUCOSE SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
930	EST.KGS PER TONNE		30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
940	COST PER KG.		0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
95	CHEMICALS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	PACKING MATERIALS																
26	TOTAL STARCH SOLD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
1010	BAG UNIT WEIGHT	KG	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
1020	BAG UNIT COST		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
103	TOTAL BAG COST $		7	8	47	49	53	57	61	65	69	73	77	81	81	81	81
140	GLUCOSE SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1040	DRUM UNIT WEIGHT	KG	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
1050	DRUM UNIT COST		15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
106	TOTAL DRUMS COST		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
190	DEXTRIN SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1070	BAG UNIT WEIGHT	KG	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
1080	BAG UNIT COST		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
109	TOTAL BAGS COST		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	PACKING MATERIALS		7	8	47	49	53	57	61	65	69	73	77	81	81	81	81

REPORT 5.1
FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY:FIXED ASSET MAINT DEPR

			YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
115	FIXED ASSET COST																
2	XXXXXXXXXXXXXXXXXX																
1160	LAND		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
1170	FACTORY BUILDINGS		375	500	500	500	500	500	500	500	500	500	500	500	500	500	500
1180	PLANT & EQUIPMENT		600	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
1190	VEHICLES		70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
1200	HOUSING		183	250	250	250	250	250	250	250	250	250	250	250	250	250	250
121																	
122	TOTAL COST		1258	2345	2345	2345	2345	2345	2345	2345	2345	2345	2345	2345	2345	2345	2345
6																	
5																	
1230	LAND	MNT/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1240	FACTORY BUILD	MNT/RT	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5
1250	PLANT	MNT/RT	0.0	0.0	10.0	10.0	12.5	12.5	15.0	15.0	17.5	17.5	20.0	20.0	20.0	20.0	20.0
1260	VEHICLES	MNT/RT	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
1270	HOUSING	MNT/RT	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5
8																	
128	MAINTENANCE		7	7	101	101	120	120	138	138	157	157	176	176	176	176	176
27																	
8																	
3																	
1290	LAND	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1300	FACTORY BUILD	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1310	PLANT	DEP/RT	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10
1320	VEHICLES	DEP/RT	0	0	20	20	20	20	20	20	20	20	20	20	20	20	20
1330	HOUSING	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8																	
134	DEPRECIATION		0	0	82	82	82	82	82	82	82	82	82	82	82	82	82
27																	
8																	
135	TOTAL CUM DEP		0	0	82	164	246	328	410	472	574	656	738	820	902	984	1066
121																	
8																	
141	NET FIXED ASSETS		1258	2345	2263	2181	2099	2017	1935	1853	1771	1689	1607	1525	1443	1361	1279
27																	

REPORT [illegible] CASSAVA FACTORY:WORKING CAPITAL

[illegible] FOR CASSAVA STARCH ONLY

		YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
[illegible] WEIGHT	T	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
[illegible] PRICE	K/T	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
[illegible] VALUE		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
[illegible] WEIGHT	T	269	45	1619	281	1833	336	2131	380	2429	430	2726	479	2875	479	2875
[illegible] PRICE	K/T	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
[illegible] VALUE		54	9	324	56	367	66	425	76	486	86	545	96	575	96	575
[illegible] MATERIALS		7	8	47	49	53	57	61	65	69	73	77	81	81	81	81
[illegible] PERIOD %		50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
[illegible] MATS VALUE		4	4	24	25	27	29	31	33	35	37	39	41	41	41	41
[illegible]		0	151	944	900	1060	1140	1220	1300	1380	1460	1540	1620	1620	1620	1620
[illegible] WEEKS HLF YR		0	2	4	4	4	4	4	4	4	4	4	4	4	4	4
[illegible] GOODS VALUE		0	12	140	151	163	175	188	200	212	225	237	249	249	249	249
[illegible]		58	25	493	232	557	270	640	309	733	348	821	386	865	386	865
[illegible] WEEKS HLF YR		0	4	5	5	6	6	6	6	6	6	6	6	6	6	6
[illegible] PREPAYMENTS		0	23	218	226	245	263	282	300	318	337	355	374	374	374	374
CASH [illegible] HLF YR		0	0	2	2	2	2	2	2	2	2	2	2	2	2	2
[illegible]		54	54	9	324	56	367	66	426	76	486	86	545	96	575	96
[illegible] MATERIALS		54	60	361	374	404	434	463	493	523	553	582	612	612	612	612
[illegible] WEEKS HF [illegible]		0	0	5	6	6	6	6	6	6	6	6	6	6	6	6
[illegible] /ACCRUALS		0	0	53	66	93	100	107	114	121	128	134	141	141	141	141

REPORT 7 :   CASSAVA FACTORY:TAX/INT/DEBT/CAP
FACTORY FOR CASSAVA STARCH ONLY

		YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
1140D	CORPORATE TAX RATE %	0	0	0	0	0	0	0	0	0	0	0	0	45	45	45
1110D	S-T DEBT INT RATE %	0	0	12	12	12	12	12	12	12	12	12	12	12	12	12
1120D	M-T DEBT INT RATE %	0.00	6.75	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50
1130D	L-T DEBT INT RATE %	0.00	6.75	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50
1620D	SHORT-TERM DEBT	0	0	400	300	200	100	0	0	0	0	0	0	0	0	0
1630D	CAPITAL	1600	100	0	0	0	0	0	0	0	0	0	0	0	0	0
1640D	MEDIUM-TERM DEBT	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0
1650D	MEDIUM-TERM DEBT	0	0	0	0	0	0	0	100	100	100	100	100	100	0	0
1660D	MEDIUM-TERM DEBT	0	600	600	600	600	600	600	500	400	300	200	100	0	0	0
1670D	LONG-TERM DEBT	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0
1680D	LONG-TERM DEBT	0	0	0	0	0	0	0	100	100	100	100	100	100	0	0
1690D	LONG-TERM DEBT	0	600	600	600	600	600	600	500	400	300	200	100	0	0	0

REPORT 8 : FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY:PROFIT STATEMENTS

		YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
170	KWACHA THOUSAND															
1	XXXXXXXXXXXXXXXXXXX															
171	SALES REVENUE:															
38	ROOT STARCH	0	6	74	74	74	74	74	74	74	74	74	74	74	74	74
40	CHIP STARCH	0	145	370	906	986	1066	1146	1226	1306	1386	1466	1546	1546	1546	1546
42	CHIP GLUCOSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	CHIP DEXTRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121																
45	TOTAL SALES	0	151	944	980	1060	1140	1220	1300	1380	1460	1540	1620	1620	1620	1620
172	RAW MATERIALS:															
32	ROOTS CONSUMED	0	6	37	37	37	37	37	37	37	37	37	37	37	37	37
34	CHIPS CONSUMED	54	54	324	337	367	396	426	456	486	515	545	575	575	575	575
121																
35	TOTAL DIR MATERIALS	54	60	361	374	404	434	463	493	523	553	582	612	612	612	612
121																
173	GROSS ADDED VALUE	(54)	91	583	606	656	706	757	807	857	907	958	1008	1008	1008	1008
83	ELECTRICITY-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
87	WATER-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
91	FUEL	12	13	81	84	91	98	105	112	118	125	132	139	139	139	139
95	CHEMICALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	PACKING MATERIALS	7	8	47	49	53	57	61	65	69	73	77	81	81	81	81
121																
174	OTHER VARIABLE COSTS	23	25	152	157	170	183	196	209	222	235	247	260	260	260	260
121																
175	CONTRIBUTION	(77)	66	432	448	486	523	561	598	635	673	710	747	747	747	747
1760	LABOUR & STAFF	73	72	117	117	117	117	117	117	152	152	152	152	152	152	152
1770	ELECTRICITY-FIXED	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1780	WATER-FIXED	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
128	MAINTENANCE	7	7	101	101	120	120	138	138	157	157	176	176	176	176	176
1790	MISCELLANEOUS	50	25	50	50	50	50	50	50	50	50	50	50	50	50	50
134	DEPRECIATION	0	0	82	82	82	82	82	82	82	82	82	82	82	82	82
121																
180	TOTAL FIXED COSTS	133	107	352	352	371	371	390	390	443	443	462	462	462	462	462
121																
191	PROFIT BEFORE															
182	INTEREST & TAX	(210)	(41)	79	96	115	152	171	208	192	229	248	285	285	285	285
183	INTEREST:															
184	SHORT-TERM DEBT	0	0	24	24	18	12	6	0	0	0	0	0	0	0	0
185	MEDIUM-TERM DEBT	0	20	41	41	41	41	41	41	34	27	20	14	7	0	0
186	LONG-TERM DEBT	0	20	41	41	41	41	41	41	34	27	20	14	7	0	0
121																
187	TOTAL INTEREST	0	41	105	105	99	93	87	81	68	54	41	27	14	0	0
121																
188	PROFIT BEFORE TAX	(210)	(82)	(26)	(9)	16	59	84	127	124	175	207	258	272	285	285
189	TAXATION	0	0	0	0	0	0	0	0	0	0	0	0	122	128	128
121																
190	PROFIT AFTER TAX	(210)	(82)	(26)	(9)	16	59	84	127	124	175	207	258	149	157	157
27	====================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

REPORT 9 : CASSAVA FACTORY:BALANCE SHEETS

FACTORY FOR CASSAVA STARCH ONLY

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
170	KWACHA THOUSAND															
2	XXXXXXXXXXXXXXXXXX															
141	NET FIXED ASSETS	1258	2345	2263	2181	2099	2017	1935	1853	1771	1689	1607	1525	1443	1361	1279
8																
191	CURRENT ASSETS:															
154	TOTAL STOCKS	58	25	493	232	557	270	645	309	733	346	821	386	865	386	865
156	DEBTORS/PREPAYMENTS	0	23	218	226	245	263	282	300	318	337	355	374	374	374	374
158	CASH	54	54	9	324	56	367	64	426	76	486	86	545	96	575	96
121																
192	TOTAL CURRENT ASSETS	112	102	720	782	858	900	992	1035	1127	1170	1262	1305	1335	1335	1335
8																
193	CURRENT LIABILITIES:															
161	CREDITORS/ACCRUALS	0	0	83	86	93	100	107	114	121	128	134	141	141	141	141
162D	SHORT-TERM DEBT	0	0	400	300	200	100	0	0	0	0	0	0	0	0	0
121																
194	TOTAL CURRENT															
195	LIABILITIES	0	0	483	386	293	200	107	114	121	128	134	141	141	141	141
121																
196	NET CURRENT ASSETS	112	102	236	395	564	700	886	921	1007	1043	1128	1164	1194	1194	1194
8																
197	SURPLUS CASH	21	161	83	(2)	(74)	(68)	(88)	(115)	(194)	(172)	(168)	(64)	(62)	177	416
8																
121																
198	TOTAL NET ASSETS	1390	2608	2583	2574	2590	2649	2733	2660	2584	2559	2567	2625	2575	2731	2888
27																
8																
199	FINANCED BY:															
200	CAPITAL	1600	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
201	RESERVES	(210)	(292)	(317)	(326)	(310)	(251)	(167)	(40)	84	259	467	725	875	1031	1188
121																
202	TOTAL EQUITY	1390	1408	1383	1374	1390	1449	1533	1660	1784	1959	2167	2425	2575	2731	2888
8																
166D	MEDIUM-TERM DEBT	0	600	600	600	600	600	600	500	400	300	200	100	0	0	0
169D	LONG-TERM DEBT	0	600	600	600	600	600	600	500	400	300	200	100	0	0	0
121																
205	CAPITAL EMPLOYED	1390	2608	2583	2574	2590	2649	2733	2660	2584	2559	2567	2625	2575	2731	2888
27																
8																

REPORT 10 : CASSAVA FACTORY:FUNDS FLOW STATEMENTS

FACTORY FOR CASSAVA STARCH ONLY

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
170	KWACHA THOUSAND															
2	xxxxxxxxxxxxxxxxxx															
206	SOURCES OF FUNDS:															
190	PROFIT AFTER TAX	(210)	(82)	(26)	(9)	16	59	84	127	124	175	207	258	149	157	157
134	DEPRECIATION	0	0	82	82	82	82	82	82	82	82	82	82	82	82	82
207	M-T & L-T DEBT INT	0	41	81	81	81	81	81	81	68	54	41	27	14	0	0
121	------------------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
208	CASH GENERATED FROM															
209	OPERATIONS	(210)	(41)	137	154	179	222	247	290	274	311	330	367	245	239	239
9																
1630	CAPITAL	1600	100	0	0	0	0	0	0	0	0	0	0	0	0	0
1640	MEDIUM-TERM DEBT	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0
1670	LONG-TERM DEBT	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0
121	------------------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
213	TOTAL SOURCES OF															
214	FUNDS	1390	1259	137	154	179	222	247	290	274	311	330	367	245	239	239
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
8																
215	APPLICATIONS OF															
216	FUNDS:															
217	FIXED INVESTMENT	1258	1088	0	0	0	0	0	0	0	0	0	0	0	0	0
218	WORKING CAPITAL	112	(10)	134	159	169	136	185	36	85	36	85	36	30	(0)	0
3																
219	DEBT REPAYMENT:															
1650	MEDIUM-TERM DEBT	0	0	0	0	0	0	0	100	100	100	100	100	100	0	0
1680	LONG-TERM DEBT	0	0	0	0	0	0	0	100	100	100	100	100	100	0	0
121	------------------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
222	TOTAL DEBT REPAYMENT	0	0	0	0	0	0	0	200	200	200	200	200	200	0	0
8																
183	INTEREST:															
185	MEDIUM-TERM DEBT	0	20	41	41	41	41	41	41	34	27	20	14	7	0	0
186	LONG-TERM DEBT	0	20	41	41	41	41	41	41	34	27	20	14	7	0	0
121	------------------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
207	M-T & L-T DEBT INT	0	41	81	81	81	81	81	81	68	54	41	27	14	0	0
121	------------------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
223	TOTAL DEBT SERVICE	0	41	81	81	81	81	81	281	268	254	241	227	214	0	0
121	------------------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------
224	TOTAL APPLICATIONS															
225	OF FUNDS	1369	1118	215	240	250	217	266	317	353	290	326	263	243	(0)	0
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
226	SURPLUS CASH															
227	BALANCES:															
228	PERIOD	21	141	(78)	(86)	(71)	5	(20)	(27)	(79)	21	4	104	2	239	239
229	CUMULATIVE	21	161	83	(2)	(74)	(68)	(88)	(115)	(194)	(172)	(168)	(64)	(62)	177	416
27	==================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

REPORT 11 : FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY:KEY FINANCIAL RATIOS

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
230 8	CONTRIBUTION MARGIN%	0	44	46	46	46	46	46	46	46	46	46	46	46	46	46
231 8	FIXED COST/SALES%	0	71	37	36	35	33	32	30	32	30	30	29	29	29	29
232 8	PROFIT AFT TAX/SALE%	0	(54)	(3)	(1)	1	5	7	10	9	12	13	16	9	10	10
233 8	PR AFT S-T INT/SALE%	0	(27)	6	7	9	12	14	16	14	16	16	18	18	18	18
234 8	PROFIT/CAP EMPLOYED%	(30.2)	(9.6)	0.5	5.0	6.5	8.9	11.2	14.0	15.5	16.5	18.6	20.3	22.2	20.9	19.8
235 8	SALES/CAP EMPLOYED	0.0	0.1	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
236 8	CURRENT RATIO	0.0	0.0	1.5	2.0	2.9	4.5	9.3	9.1	9.3	9.2	9.4	9.2	9.4	9.4	9.4
237 8	DEBT/CAP EMPLOYED%	0	46	46	47	46	45	44	38	31	23	16	8	0	0	0
238 8	DEBT SERVICE COVER	0.0	(1.9)	1.7	1.9	2.2	2.7	3.0	1.0	1.0	1.2	1.4	1.6	1.1	0.0	0.0
239 8	PROFIT/NET CAP EMPLD	(30.7)	(10.3)	0.6	5.0	6.3	8.7	10.8	13.4	14.4	15.4	17.4	19.8	21.6	22.3	23.1
27	====================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

REPORT 12 : RATE OF RETURN ANALYSIS
FACTORY FOR CASSAVA STARCH ONLY

		YR1	YR2	YR3	YR4	YR5	YR6	YR7	YR8	YR9	YR10
8 242	NET CASH FLOW	(2900)	(1.6)	96.2	315.8	463.9	575.9	454.1	477.8	477.8	2153
8 2430	DISCOUNT PERCENTAGE	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36
8 245	D. C. F.	(2900)	(1.5)	81.9	248.2	336.4	385.5	280.5	272.4	251.4	1045
8 246	N. P. V.	0.2									

United Nations Industrial Development Organisation

Elaboration of Integrated Cassava Processing Factory Concept (Project US/INT/80/006) Volume 2: Cassava Processing Factory Project in Zambia

Final Report

11709
(2 of 2)

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July 1982

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

ELABORATION OF INTEGRATED CASSAVA PROCESSING FACTORY CONCEPT

FINAL REPORT

VOLUME 2

CASSAVA PROCESSING FACTORY PROJECT IN ZAMBIA

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Registered in England No. 1228758 Employment Agencies Act 1973

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5. FACTORY PLAN

6. FACTORY PLAN

7. LIST OF MACHINERY REQUIRED FOR PROPOSED FACTORY

8. DETAILS OF MACHINERY MANUFACTURERS ABLE TO PROVIDE TURNKEY FACTORIES

9. FINANCIAL REPORTS MULTI-PRODUCT FACTORY

10. FINANCIAL REPORTS FOR CASSAVA STARCH FACTORY ONLY.

-	Nil
°C	Degrees Centigrade
CU	Co-operative Union
FAO	Food & Agricultural Organisation of the United Nations
FPT	Fresh peeled tuber
IRDP	Integrated Rural Development Programme
ha	Hectare
HCN	Hydrocyanic acid
KVA	Kilowatts
K	Kwacha
Kg	Kilogramme
ml	Millilitre
mm	Millimetres
MAWD	Ministry of Agriculture & Water Development
MAL	Minster Agriculture Limited
n	Ngwee (= 1/100 of 1 Kwacha)
NCDP	National Council for Development Planning
NIEC	National Import & Export Corporation
Namboard	National Agricultural Marketing Board
P-EIO	P-E International Operations Limited
NP	Northern Province
NWP	North Western Province
ton	Metric Tonne (1000 kg or 2205 lbs)
TCZ	Tropical convergence zone
ZIMCO	Zambia Industrial and Mining Corporation Limited

FINAL REPORT

VOLUME 2: CASSAVA PROCESSING FACTORY PROJECT IN ZAMBIA

1. INTRODUCTION

This final report on UNIDO Project US/INT/80/006 is submitted in accordance with Contract No. T81/73. UNIDO commissioned P-E International Operations Limited (P-EIO) in association with Minster Agriculture Limited (MAL) to execute the contract (Telex of Authorisation, 16 October 1981). The views expressed in this report are those of our two organisations, and do not necessarily reflect those of any member of UNIDO.

The aim of the project is to elaborate and evaluate the concept of setting up a factory to make the range of products which can be derived from cassava. This necessitates study of the agronomy of the crop and of the procurement system necessary to ensure an adequate supply of raw material; research into the markets for the factory's products; the definition of appropriate technology and the outline design of the factory; and the evaluation of the concept, both financially and economically.

UNIDO chose Zambia as the country in which the concept was to be tested, and from this testing there has emerged a project, specifically for Zambia, which is described in the present Volume 2 of the report. The concept as a whole is discussed in Volume 1.

The full terms of reference for the study are set out in Appendix 1.

The first stage of the work was a fact-finding tour of Zambia in November and December 1981. The field work team included:

- D R Atkinson (P-EIO), team leader and economist
- D J Wholey (MAL), cassava specialist
- T R W Jarman (MAL), cassava processing specialist
- J Turnbull (MAL), farm management specialist.

The organisations and persons contacted in Zambia are listed in Appendix 2. We are grateful to them all for their outstanding co-operation.

The team was enlarged during the preparation of the interim and draft final reports in January - May 1982 by four P-EIO consultants: K B Freeman and R W Waghorn, project engineers, and C J S Baker and A H Catterall, financial analysts. Support was also provided by P-EIO's Marketing Research Department and Drawing Office.

The interim report was sent to UNIDO Vienna on 27 January 1982 and discussed with Mr H Koenig, Senior Industrial Advisory Officer, Agro-Industrial Branch, on 22 March 1982.

The draft final report was sent to UNIDO, Vienna on 5 July and accepted on 13 July 1982.

	Refer to

2. SUMMARY OF VOLUME 2

2.1 Background Data — Chapter 4

Zambia's population of almost 6 million rises at 3.2% pa. Average population density is very low, but urbanisation has concentrated over 40% of the people in towns. Many have come from the 4 outlying Provinces which grow and rely on, cassava as the main staple.

Maize, heavily subsidised by the State, is the staple outside the 4 cassava-producing Provinces. There is a large, latent demand for cassava in the national dish, Nshima, among urban immigrants.

2.2 Cassava Agronomy — Chapter 5

Cassava needs 1000-1500mm of rainfall, well distributed over the year, to yield a mature crop within a year; ceases to grow below 10^{0}C; and is severely hampered by frost. Zambia's rainfall is below that needed for an annual crop, and temperatures fall below minimum requirements for part of the year. Pests and diseases are encouraged by the long, dry season.

Cassava is therefore harvested at 12-18 months (sweet varieties) or at 2-3 years (bitter varieties), and yields are below average for Africa.

Agronomic methods can be improved: planting material is poor, plant population per ridge is too high, ridges are too far apart, weeding is inadequate and, where fertilisers are used at all, they are the wrong ones. — Chapter 6

2.3 Utilisation — Chapter 7

Cassava is grown almost entirely as a subsistence crop for use in Nshima. Leaves are eaten as a protein-rich relish in cassava-producing Provinces. Beer is made from cassava peel in 2 Provinces.

2.4 Market Potential — Chapter 8

Unlike other major staples, cassava does not have a producer price and there is virtually no organised market. — 8.1

In Zambia there is a latent demand for marketed cassava flour in the urban areas for Nshima and in the baking and brewing industries as a substitute for maize and imported wheat and barley. This could have amounted to about 50-55000 tons in 1981. 8.2.1

There is a well-defined demand in Zambia for starch, glucose and dextrins, all imported, which could be made from cassava. This totalled about 2400 tonnes in 1981, and is increasing. Users in the foodstuffs, textiles, paper and pharmaceutical industries would welcome a national source of supply, provided their quality requirements were met, and would pay a Kwacha premium of at least 10% over import prices. 8.2.2

We do not see an export potential for cassava-based products: world markets are over-supplied, and Zambia's land-locked position makes for high transport costs. 8.2.3

2.5 Proposed Project

Chapter 9

We propose a project with the following features:

- to stimulate cassava production the Government announces a producer price for the crop in Northern Province.
- because of the cassava roots' perishability, the producer price is for dried chips rather than roots
- Namboard and Co-operative Unions buy the dried roots during the maize buying season (June - October/November) and channel them to Indeco's hammer mills
- Indeco mills process the roots to cassava flour, and sell the flour in urban areas for Nshima making and bread and beer production
- Namboard and Co-operative Union buyers are trained before the 1983-4 buying season in the quality specifications for dried chips
- MAWD's extension workers are trained to advise cassava growers on agronomic practices
- if, after two years, cassava production has responded to these incentives sufficiently, a factory is set up to make starch, glucose and dextrins from this crop.

PE

2.6 Proposed Factory

Chapter 10

This should be located at Kasama, which is in the best cassava growing area and has good communications and facilities.

Most of the factory's production will be derived from dried chips, but a minor amount of locally-produced roots will be bought direct by the factory for processing into high-grade starch.

The factory will rapidly build up to 2-shift working, employing about 77 people, and go on to 3 shifts after 3 years, employing almost 100 people.

2.7 Implementation Scheduling

Chapter 11

The producer price for chips should be announced late in 1982 for the 1983-4 buying season.

Training of Namboard/CU chip buyers must be completed in 1982, to ensure that farmers responding to the incentives to grow cassava find the market available.

The project should be briefly re-appraised in August/September 1985. Provided supplies have increased sufficiently, and the market is still favourable, contract procedures should begin in October 1985. Key staff will be engaged during 1986 and increased to one-shift level in January-May 1987. The plant should be commissioned in May 1987 and after trial runs, begin commercial production in July 1987. Two-shift working should be achieved before the end of 1987.

2.8 Financial Evaluation

Chapter 12

The starch, glucose and dextrins factory will require a capital investment of K3,800 thousand, of which 52.6% will be loan capital and 47.4% equity. An overdraft equal to approximately half the working capital will be needed initially. Report 9

Profit after tax (payable only from Year 6 onwards) is calculated to rise from K129,000 in year 1 of production to K504,000 in year 6. Report 8

The overdraft should be repaid after 2½ years of production and all loan capital after 5½ years. A small dividend can be paid to equity shareholders until year 5; thereafter a dividend of 15-20% should be payable. Reports 9-10

The IRR on the project is 13.64%. Report 12

Sensitivity analysis shows that the project is more sensitive to price changes then to volume changes. Report 13

An analysis of a starch-only factory shows an IRR of only 8.36%. Appendix 10

2.9 Economic Evaluation

Chapter 13

The economic evaluation shows that foreign exchange outgoings from the starch, glucose and dextrins factory project will be more than recouped after 2 years of production by import savings, and that net import savings after 6 years of production will be K9½ million.

Other economic benefits are the direct employment of about 100 people and the opportunity to some thousands of farmers to earn cash from cassava.

3. PROJECT BACKGROUND AND HISTORY

Before the study began Mr Koenig of UNIDO explained its background as follows:

- world interest in cassava is stagnant, if not declining. An imaginative, practical concept is needed to revive that interest.

- many tropical countries grow cassava, but the supply and markets are not organised. Processing plants have been set up in several parts of the world, but they have usually been single-product plants, subject to variations in demand for those single products. Supplies of cassava have been intermittent. Thus factories have shut from time to time because of lack of demand or lack of supply. Farmers, wanting to sell but finding the factory shut, abandon cassava as a cash crop and use it only for subsistence.

- a multi-product cassava processing factory may be able to overcome these difficulties, by altering the mix of derived products according to the state of market demand and thus offering a stable outlet for cassava roots or chips as a cash crop.

- a conceptual study is therefore needed, embracing the markets for products derived from cassava; the agronomic requirements of the crop; the procurement system needed to induce an adequate supply; processing technology; and the financial and economic feasibility of the scheme.

The conceptual study should be made on the basis of markets and supplies being free from artificial constraints or encouragements. The results would, of course, have to be adapted to take account of such constraints or encouragements in any particular country.

The special circumstances which have to be considered in the case of Zambia are discussed in Chapter 4 below.

4. KEY FACTS ABOUT ZAMBIA

Before considering the agronomy, markets and processing of cassava in Zambia it is necessary to draw attention to a number of important facts: some general, like population and area; others institutional, like the state agricultural marketing system and the subsidisation of maize, which affect the prospects for cassava.

4.1 General

4.1.1 The first important fact affecting the prospects for cassava in Zambia is that the climate is too cold and dry for it to be an annual crop. It is normally harvested after 1-2 years of growth. This is explained in more detail in Chapter 5.3 below.

4.1.2 Zambia's area of 750,000 Km^2 is as large as France and the Federal German Republic combined, but the population is less than 6 million.

Urbanisation is growing strongly. Copperbelt, Lusaka and Central Provinces, where the mines and most industries are located, now have 43% of the population, having drawn many migrants from outlying Provinces (see Table 1 and Map 1). Cassava is grown almost entirely in four of the outlying Provinces.

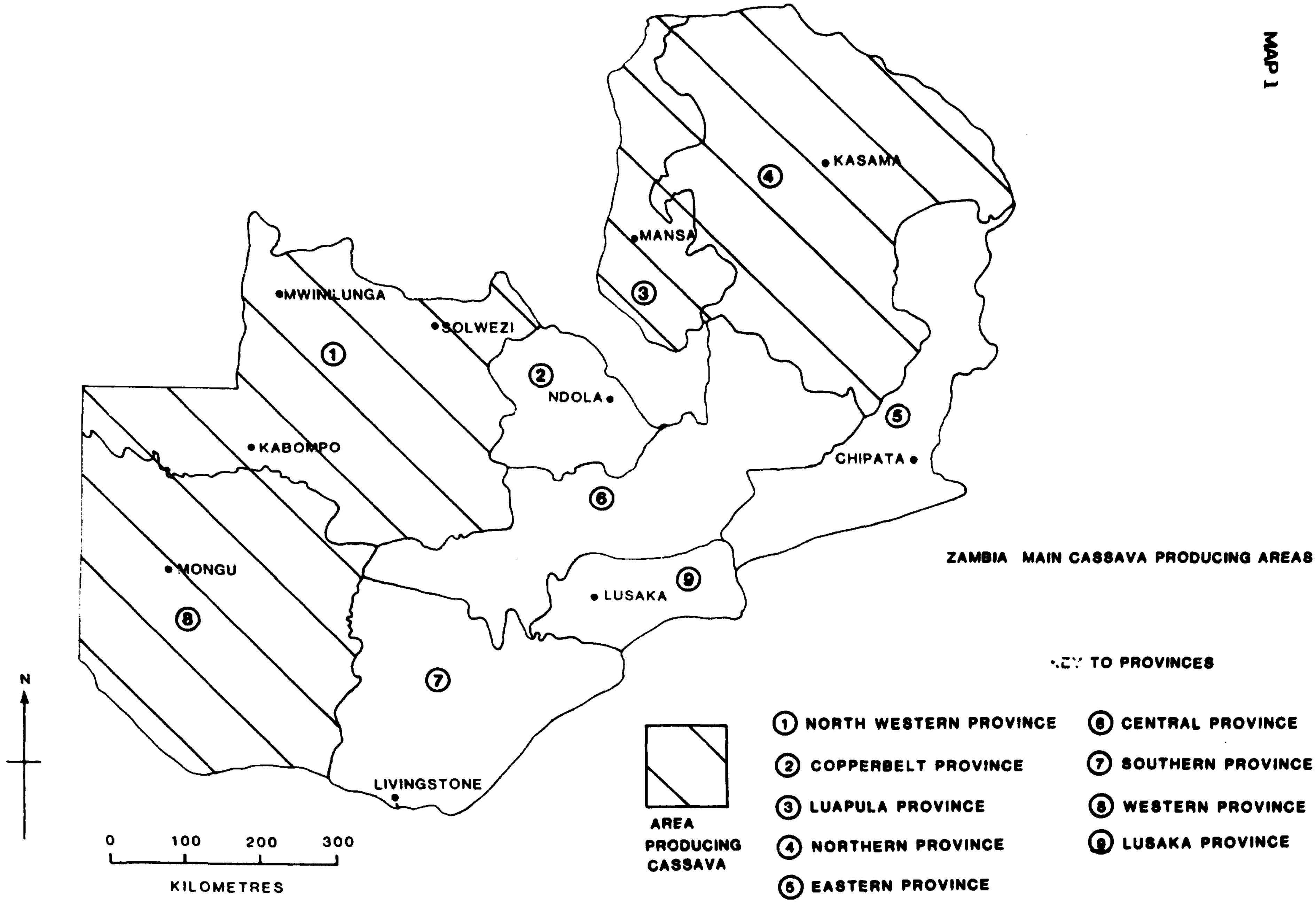
TABLE 1

Population Shifts in Zambia

	1969	1980	Growth Numbers	Growth % pa
	Thousands			
Copperbelt	816	1,249	433	3.9
Lusaka	354	694	340	6.3
Central	359	514	155	3.3
Sub-total	1,529	2,457	928	4.7
Northern	545	678	133	2.0
Western	410	488	78	1.6
Luapula	336	413	77	1.9
North-Western	232	302	70	2.4
Southern	496	686	190	3.0
Eastern	510	656	146	2.3
TOTAL ZAMBIA	4,047	5,680	1,623	3.1

Source: 1980 Census of Population and Housing, Preliminary Report.

MAP 1


ZAMBIA MAIN CASSAVA PRODUCING AREAS
MWINILUNGA
SOLWEZI
NDOLA
KASAMA
MANSA
KABOMPO
MONGU
CHIPATA
LUSAKA
LIVINGSTONE
1
2
3
4
5
6
7
8
9
N
0
100
200
300
KILOMETRES
AREA PRODUCING CASSAVA
TO PROVINCES
1 NORTH WESTERN PROVINCE
2 COPPERBELT PROVINCE
3 LUAPULA PROVINCE
4 NORTHERN PROVINCE
5 EASTERN PROVINCE
6 CENTRAL PROVINCE
7 SOUTHERN PROVINCE
8 WESTERN PROVINCE
9 LUSAKA PROVINCE

There is a well-defined potential market for cassava based starch and its derivatives in Zambian industry and a latent demand for cassava flour among urbanised consumers; but the factor of distance between the cassava-producing areas and the markets is one which must be given due importance in evaluating the project.

4.1.3 Shortage of foreign exchange is a constant problem. Zambia depends on copper for over 90% of its export income, and production has fallen from about 700,000 tons a year in the early 1970s to 580-610,000 tons in 1979 and 1980. This shortage of foreign exchange is an encouragement to cassava processing, since all starch, glucose, dextrins and potable alcohol are imported, and industrial users will pay a premium for home supplies of the right quality. On the other hand, lack of foreign exchange has led to a shortage of transport equipment - locomotives, wagons and road vehicles of all kinds - which, though easing in the last year, makes the collection and distribution of produce difficult. In particular, it makes exporting exceptionally difficult.

4.1.4 Electrical energy is abundant: Zambia exports 15% of its output. Water for well-sited industrial plants is also abundant.

4.2 Institutional

4.2.1 Central Planning. The National Council for Development Planning (NCDP), which is responsible directly to the President, plays a leading and increasing role in the planning of the economy. The Director-General was of the greatest assistance to our team, permitting unrestricted travel and thus enabling the agronomists to visit all four cassava-growing Provinces in a short space of time. At the verbal presentation to the NCDP and other interested organisations it was indicated that the NCDP was in favour of the proposed factory project.

4.2.2 Ministerial licensing of industrial projects. All industrial enterprises must be licensed by the Minister of Commerce and Industry under the Industrial Development Act of 1977.

A new enterprise can qualify for "priority" status if it meets four out of six criteria:

- maximum utilisation of domestic raw materials
- production of intermediate goods for use by other industries
- diversification of industrial structure
- creation of substantial opportunities for permanent employment
- improvement of domestic industrial skills
- promoting industrial development in rural areas.

We are confident that the factory proposal in Chapter 9 below meets all six criteria, and as a priority enterprise should qualify for the following benefits:

- preferential treatment over granting and processing of import licences

- rebates on customs duty payable on capital equipment, raw materials and other intermediate goods
- relief from sales tax, selective employment tax and corporation tax.

These concessions are granted for five years. The Ministry of Commerce and Industry may then extend them if the business is still expanding and a longer concessionary period would be nationally beneficial.

4.2.3 State ownership of industry and distribution. Zambia has a mixed economy, but the State has a majority share in manufacturing companies which account for 75% of the country's industrial output and it controls the import and export trade and large-scale retailing.

Zambia Industrial and Mining Corporation Limited (ZIMCO) is the holding company for the Government's stake in mining, manufacturing and trading. Indeco Limited, responsible to ZIMCO, has a majority holding in 34 industrial concerns, including milling, brewing, baking, textile, drink and pharmaceutical companies. Most of the potential industrial consumption of cassava products depends on Indeco subsidiaries' demand, and it is likely that the proposed cassava processing factory would come under Indeco control.

Another ZIMCO subsidiary, National Import and Export Corporation (NIEC) is responsible for large-scale retailing in Zambia through some of its own subsidiaries, and the expansion of the retail market for cassava flour will depend largely on NIEC policy.

4.2.4 State agricultural price support, input supply and marketing arrangements. Zambia has a system of agricultural price support, input supply and marketing, which will have an important bearing on the proposed venture. The system is operated by the National Agricultural Marketing Board (Namboard) and the Provincial Co-operative Unions. The latter are taking an increasing part, while Namboard's territorial field of operation is being diminished.

Agricultural price support. The main features of the price support scheme are as follows:

- each year the Ministry of Agriculture and Water Development (MAWD) declares a producer price for crops: maize, the principal staple and 18 other crops; but not cassava. (See Appendix 3 for crops and volumes). We strongly recommend that cassava is included in the list.
- Namboard or the Provincial Co-operative Union buys in these crops* at their depots, paying the fixed producer price. The largest depots are open all the year round, but most are open only from June to October, the maize buying season.
- Farmers are not paid cash on the spot, but are issued with credit notes. There is delay in cashing these notes, partly due to transport problems, which often results in farmers not being able to buy seed and fertiliser in time to achieve optimum or even good yields of maize.

* Footnote: Excluding cotton, tea, coffee, sugar and tobacco, which are bought by specialist state bodies.

Input Supply. Namboard and increasingly the Co-operative Unions, are responsible for transporting fertilisers and seeds to their depots for farmers to buy them before planting time. Fertilisers are mainly imported, and have been heavily subsidised.

Marketing. Namboard and the Unions sell maize and the other supported crops at controlled prices. Maize goes mainly to the millers (about 92% of the total) and to the brewers (about 8%).

Extent of Maize Subsidies. It will be noted from Appendix 3 that maize accounts for the great majority of agricultural crops bought from Zambian farmers. The following figures of subsidies to Namboard and the Provincial Co-operative Unions refer to all crops; but most of them relate to maize.

Summarised Extract from Government of Zambia's Estimates of Revenue and Expenditure 1/1/81 - 31/12/81.

	1980 Total Authorised Expenditure	**1981 Estimate**	
	(Million Kwacha)		
Namboard			
Maize handling costs (a)	28.9	24.9	
Maize price differential (b)	74.9	15.0	
Fertiliser handling costs (a)	15.8	10.4	
Fertiliser price differential (b)	27.6	27.5	
1978 deficit	23.8	-	(c)
Co-operative Unions	11.5	25.9	(d)
	182.5	103.7	

(a) Reflects costs of collection and distribution within Zambia.
(b) Reflects difference between costs of imports and sales of imported product to Zambian users.
(c) Namboard's overall deficit is always voted some years in arrears by supplementary estimate. The 1979 deficit will be similarly dealt with in the 1982 estimates.
(d) Reflects the devolvement of buying and marketing responsibility from Namboard to the CUs.

These figures illustrate several important points:

- Maize production is unreliable, though the crop is the major staple. The very high charge for maize price differential reflects the cost of importing 3.2 million bags in 1980 to supplement the small marketed crop of 3.7 million bags in 1979-80.

- If only 80% of the K182.5 million in 1980 is attributed to maize, this represents a national cost of K21.2 per 90 kg bag, in subsidies.

- Compared with K21.2 per 90 kg bag in subsidies, Namboard and the Co-operative Unions were paying 13.50 per 90 kg bag, to the producer, and selling at K13.50 per bag, plus K0.25 as a nominal rail transport charge and K0.19 for the sack.

- In practice, therefore, Namboard and the Unions are buying, administering and distributing maize free of charge, with Government paying the cost from its revenues.

- The true cost of a 90 kg bag of maize in 1980 was about K35 compared with K13.50.

5. CASSAVA'S AGRONOMIC REQUIREMENTS AND ZAMBIA'S ENVIRONMENTAL SUITABILITY FOR THE CROP

Before describing the current status of cassava in Zambia in Chapter 6 we summarise in the present chapter the nature and the agronomic requirements of the plant and then discuss Zambia's environmental suitability for growing it. A general and much fuller account of cassava's agronomic requirement is given in Volume 1, Chapter 5.

5.1 Background Information on Cassava

Cassava is a short-lived, perennial shrub with enlarged starch-rich roots. Very many cultivars exist, ranging in height from 1 to 5 metres.

The roots of cassava develop from the stem cuttings during the second and third weeks after planting. Under good conditions nine or more fibrous roots become root-tubers during the second and third months of growth by a process of secondary thickening and starch deposition. The diameter of root-tubers increases with age until maturity which varies with variety but normally occurs after 5-15 months of growing conditions. Both the dry matter and starch content of root-tubers increase becoming fibrous and in some cases hollow. An advantage that the cassava crop offers the farmer is the lack of a fixed harvest date allowing great operational flexibility and enabling the farmer to store the crop in the ground.

The root-tubers form the primary product of the cassava crop. The usual size is 25-40cm in length and 5-15cm in diameter. The thickness of the peel and the ease with which it can be removed from the flesh of the root is a varietal characteristic. Peeling losses can vary between 10-20% of the fresh root.

At the core of the root-tuber there is a concentration of xylem vessels which become lignified with age. In over-mature roots these lignified vessels render the roots undesirably fibrous and are removed in some hand processes.

The cassava plant contains toxic principles which release hydrocyanic acid (HCN) under certain conditions. The cyanogenic glycocides linamarin and lotaustralin are distributed throughout the cassava plant, but the concentration varies greatly between varieties and also with climatic, edaphic and cultural conditions. Toxicity of cassava and its products is associated primarily with free HCN that is formed when the cyanogenic glycocides have been hydrolysed. This is effected by a hydrolytic enzyme Linamarase which is present in all the plant tissue together with the cyanogenic glycocides. In active healthy tissue of the growing plant the enzyme and glycocide substrate do not come into contact, however on mechanical damage, eg after harvesting, contact occurs and hydrolysis takes place releasing HCN.

It is well established that HCN itself is one of the most powerful mammalian poisons known, large doses causing acute poisoning usually resulting in death. The lethal dose of HCN for an adult male is reported to be 50-60mg. A guide to acute toxicity is as follows:

Innocuous	:	Less than 50mg HCN per kg of fresh peeled tuber (FPT)
Moderately poisonous	:	50-100mg HCN per kg of FPT
Dangerously Poisonous	:	Over 100mg HCN per kg of FPT

The habitual ingestion of small quantities of HCN, too small to produce acute symptoms can result in chronic effects including malfunction of the thyroid resulting in goitre in serious cases, and atoxic neuropathy causing lesions of the skin, mucous membranes, nerves and spinal cord. Both conditions are caused by indirect effects of HCN entering the bloodstream via the alimentary tract.

The peel fraction of cassava root-tubers contains substantially higher concentrations of cynaogenic glycocides than the flesh. The ratio of glycocide in peel to flesh varies between 5 to 10 : 1. Traditional users appear to be aware of the danger as peeling is practised as a preliminary to cooking.

Cassava variations with root-tubers containing small amounts of HCN are normally called sweet, and those with large amounts, bitter.

FAO estimates world production at 117 million tonnes of roots in 1979 (Africa 45 mn.t, Asia 41 mn.t and S America 30 mn.t). Yields per hectare averaged 11 tonnes in Asa, 11½ tonnes in S America and 6½ tonnes in Africa.

Farm yields vary with location and are dependent on the interaction between variety, climate and soil with the effects of age at harvesting, diseases, pests and management factors superimposed.

The world average is 8.75 tonnes per hectare but the theoretical limit to yield has been calculated to be 90 tonnes per hectare per year. Experimental yields of 80 tonnes per hectare have been obtained from plants grown under near optimum conditions at CIAT. However the occurrence of debilitating diseases and devastating pests, together with poor agronomic practices and infertile soils, are responsible for relatively low farm yields in African major production areas. Virus and bacterial diseases particularly reduce root yields. Important pests in Africa include mealy bugs and green spider mite. These pests are currently spreading to new areas where severe yield reductions result. Appendix 4 describes the pests and diseases attacking cassava in Zambia, and the action recommended to combat them.

5.2 Growth Requirements

Temperature. Cassava growth is favoured by a warm moist climate with temperatures in the range 25-29°C. Temperatures lower than 25°C will reduce growth which, in general, ceases at 10°C. Research suggests that the base temperature for cassava germination is 13°C, and that emergence is retarded below 18°C. As it is the temperature of the growth medium that is the critical factor, the soil temperature in the 5-10cm zone should be used to delineate conditions favourable for establishment. Once the crop has emerged, both the soil temperature and air temperature play an important role. Whereas growth ceases at 10°C, the crop will survive lower temperatures and light frost but will defoliate under these conditions. Short duration severe frosts (ie below -3°C) kill exposed green tissue but growth is supported from woody tissue when temperatures rise. Longer term exposure to severe frost will kill all above-ground growth. Based on a 13°C base temperature for germination, Austalian research workers recommend planting to be done in areas with daily mean temperatures in excess of this figure. However more recent reports recommend 18°C as the low-level temperature boundary for cassava cultivation due to reduced percentage emergence and retarded early growth rate at below this temperature. As indicated above cassava is commercially grown at high altitude in the Andes, therefore it is to be expected that there exists a large varietal effect and some varieties may be tolerant to temperatures much lower than the 18°C suggested by the Australian cassava workers. Research at CIAT has proved that varieties tolerant of low temperatures exist. Temperatures in excess of 29°C are reported to affect yields adversely but little reliable information is available to confirm this figure.

Rainfall. Cassava thrives in areas receiving 1,000 - 1,500mm of rainfall, distributed evenly throughout the growing season. Physiological experiments indicate that different varieties have varying maturity patterns with some reaching a production peak after nine months of growing conditions whereas other varieties require in excess of twelve months. Therefore the practicability of producing cassava depends upon the interaction between variety and rainfall pattern. In the situation where only eight rainy months occur per year, a short season variety can be grown within the calendar year whereas a long season variety would not be feasible. Nevertheless cassava grows successfully in areas receiving as little as 500mm per annum, although the duration of the crop is extended in these areas, so that the crop takes up the moisture provided by two years' rain. This, coupled with the crop's ability to survive periods of drought within the growing season, renders the crop very useful to growers in regions with short rainy seasons and/or periods of uncertain rainfall.

Soil. Cassava will grow in a wide range of soil types from stiff marine clays through to almost pure sands. However the crop is intolerant of poorly drained soils. The crop is adapted to a wide range of soil pH and is especially tolerant to acid soils, producing good crops at pH 4.5. Nevertheless saline soils and sodic soils are not tolerated and result in stunted growth. Much of this wide adaptability of cassava is related to variety and care should be taken because all casssava varieties do not show this tolerance. Cassava is frequently the last crop grown in the shifting cultivation system practised in the forest zones of West and Central Africa and, as such, has earned the reputation for being well adapted to soils of low fertility. Recent research has identified a number of features that may be associated with cassava's special adaptation to poor soils including acid soils and soils with high free-aluminium content. Cassava appears able to maintain relative yields under low nitrogen, potassium and calcium conditions and capable of regulating its growth under low nutrient supply conditions. The crop can continue root bulking under severe lack of phosphorus which renders it extremely valuable for soils with very low phosphorus content. It has been suggested that the crop's ability to yield under apparently limiting phosphorus conditions is related to a soil mycorrhiza which forms a relationship with the roots of the cassava plant.

Experiments show that some cassava varieities respond to fertile soils, by producing stem and leaf out of proportion with root-tuber growth. The phenomenon appears to be related to variety as some 'more efficient' varieties appear to respond in terms of increased total (recoverable) biological yield with proportion in stem and leaves remaining constant to the proportion of tubers. Thus the 'harvest index' remains constant regardless of fertility. Cassava can tolerate sandy soil of extremely low fertility especially if the feeder roots can penetrate to 40-60cm and exploit the lower soil profile for nutrients (and moisture). Deep cultivation to facilitate root penetration frequently leads to increased yield.

On heavy soils where drainage is a problem and in areas where heavy rainfall is experienced causing short-duration waterlogging, cassava is usually grown on mounds or ridges to ensure that the root-tuber zone is relatively well aerated. Cassava does not thrive however in basin sites and chronically poor-drained areas, and growth will be retarded in spite of ridging.

Photoperiod. Experiments both in growth chambers and in the field indicate that the partitioning of dry matter between the roots and the above ground parts of the cassava plant is influenced by changes in day length. Thus harvest index is improved by growing the same variety closer to the equator, ie under short days. Colombian experiments indicate however that different varieties show different response to day length in terms of flowering response, therefore overall generalisations for all cassava varieties may be premature and further experimentation will be required to confirm this. Identification of day-neutral varieties, which do not respond to changes in photoperiod will pave the way to the availability of varieties with broad adaptation to changes in latitude.

5.3 Zambia's Environmental Suitability for Cassava Production

Based on reports and maps collected during the field survey, the environment of Zambia was reviewed for the overall suitability for cassava production. There is a fundamental difference between environmental suitability for subsistence cassava production and commercial cassava production to supply a processing factory. This difference is discussed under the major topics.

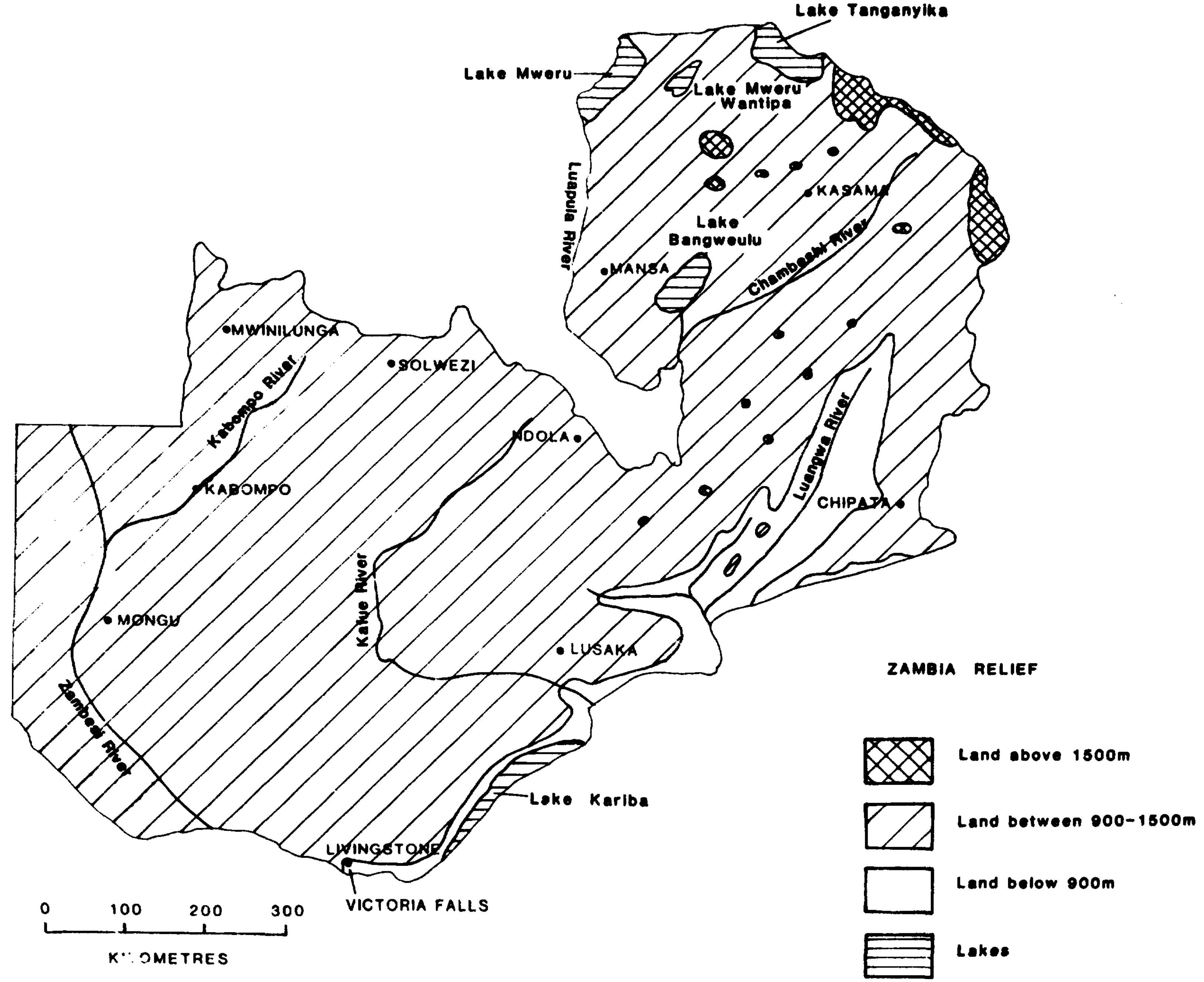
PE

Zambia lies in the tropical latitudes between approximately 8° and 18° south of the Equator and is composed mostly of gently undulating plateau with the land surface at between 900-1500m above sea level (Map 2). The monotony of the plateaux, made up of shallow basins with lakes, swamps and grassy plains is broken by isolated hills and ranges, and river valleys and gorges.

Climate. Zambia's climate is tempered by its plateau situation, so that the majority of the country enjoys mainly pleasant weather. The river valleys at altitudes down to 300m are considerably warmer but these represent a small proportion of Zambia's land area. The most striking feature of the Zambian climate is the division into two seasons, the rainy season and the dry season.

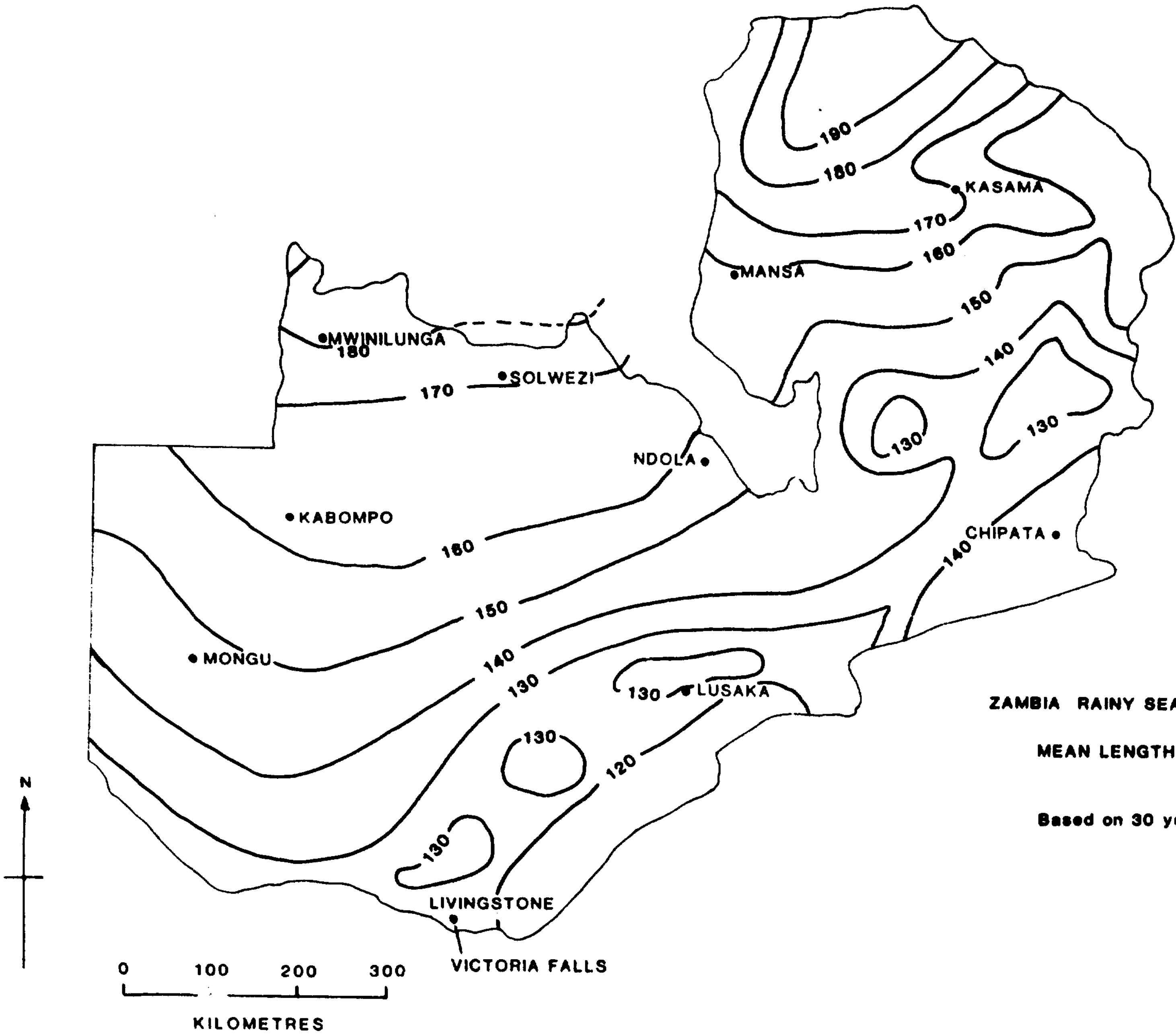
Rainfall. This is the climatological element of primary importance to tropical agriculture. In general the year can be divided into a dry season and wet season, however in effect the variability in terms of duration of the rainy season and the amounts of rain falling within the rainy season, can be great, ie unreliable. In general the rainy season extends from November to March inclusive, and occurs as a result of the southward migration of the tropical convergence zone (TCZ). As the zone crosses the northern boundaries of Zambia in December, the rains begin earlier in the north than in the south of the country. The TCZ migrates northwards during February and March of the following year causing the rains to cease earlier in the south than the north. This effect is responsible for the rainy season extending for some 60-70 days longer in the north than in the south (Map 3).

From the point of view of cassava production, the rainy season is too short to produce a crop within one calendar year. As explained in Section 5.1 above, the development of storage roots does not occur until during the second and third months after planting. Similarly, in order to produce yields of commercially acceptable roots, a further period of some six months of growing condition is required to enable the roots to increase in both size and starch content, ie a total growing season of 240-270 days. No areas of Zambia receive a rainy season of sufficient length within one year to support cassava's growth cycle. Due to this, it is the general practice to grow the crop over two or more years (see Section 6.3). The cumulative effects of two or more rainy seasons are required to bring the crop to maturity. Cassava's ability to withstand the long intervening dry season is pre-requisite for the success of this method of production.


Lake Tanganyika
Lake Mweru
Lake Mweru Wantipa
Luapula River
KASAMA
Lake Bangweulu
Chambeshi River
MANSA
MWINILUNGA
SOLWEZI
Kabompo River
NDOLA
KABOMPO
Luangwa River
CHIPATA
Kafue River
MONGU
LUSAKA
Zambezi River
Lake Kariba
LIVINGSTONE
VICTORIA FALLS
N
0
100
200
300
ZAMBIA RELIEF
Land above 1500m
Land between 900-1500m
Land below 900m
Lakes

MAP 2

MAP 3



ZAMBIA RAINY SEASON

MEAN LENGTH IN DAYS

Based on 30 years data 1940–1970

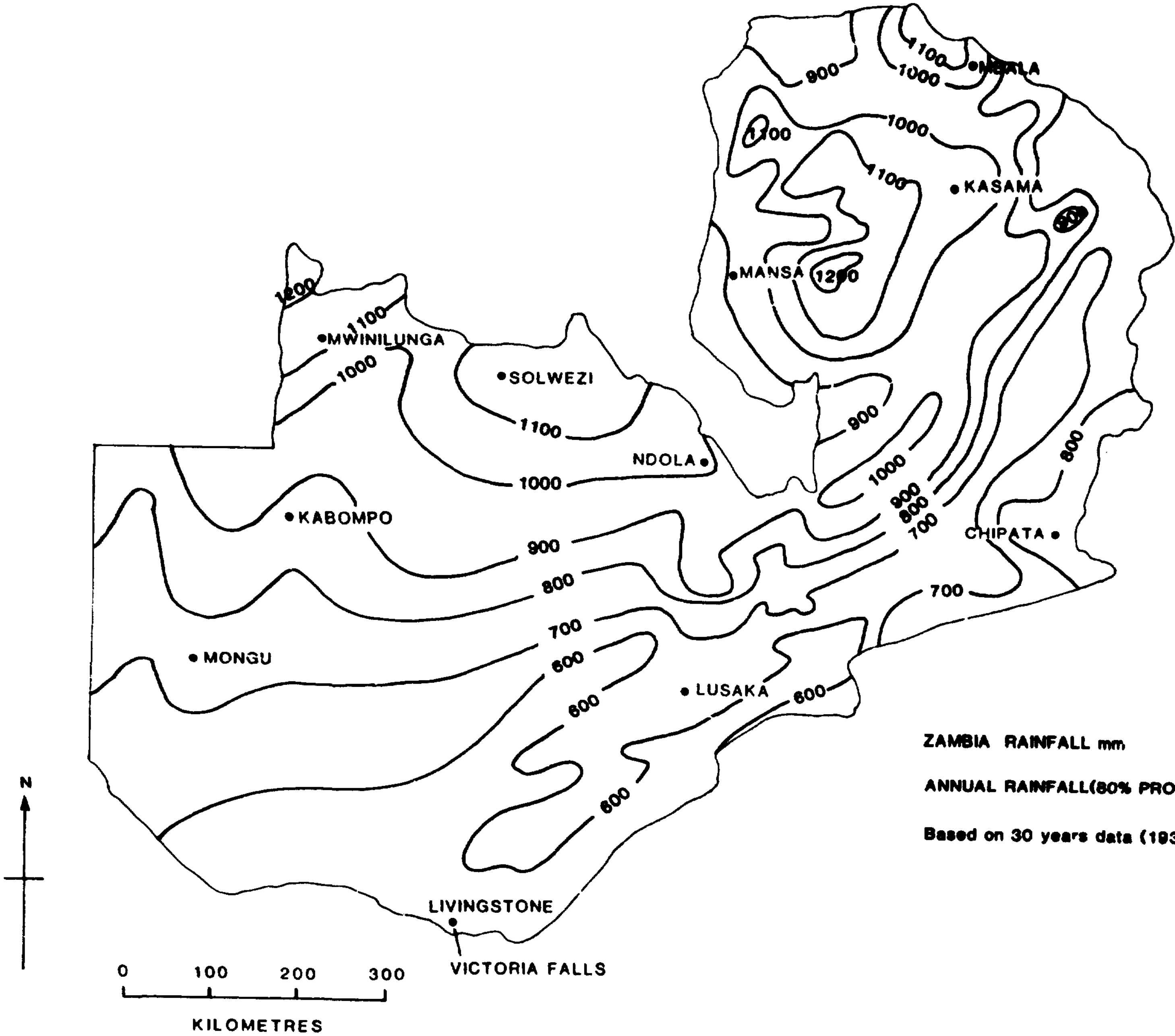
The mean annual rainfall is shown in Map 4. Since rainfall is scant during the dry season the quantities shown on the map can be regarded as representing the rainfall received during the rainy season. Although the actual amount of rainfall required per month to support growth varies with temperature, windspeed, soil type, stage of canopy development of the crop and other factors, in excess of 100m of rainfall per month is a reasonable estimate of cassava's rainfall requirements during its germination and growth phase. Residual moisture in the soil profile can support growth, but this depends on soil type, and the depth to which the cassava roots have been able to penetrate. In some circumstances up to one month's growth can be supported on residual moisture.

On this basis it is possible to demonstrate the potential months of growth given that the cassava is planted at the beginning of the first month with 'effective' rainfall. In order to compare the climate's ability to support cassava growth (or otherwise), four stations in the north, north-west, south and south-east are compared.

Table 4: Comparison of Monthly Rainfall and Ability to Support Cassava Growth at Four Stations in Zambia Mean Monthly Rainfall (1931-60) mm

	Station			
	Mwinilunga (NW)	**Mbala (N)**	**Livingstone (S)**	**Chipata (SE)**
July	0	0	0	0
August	1	2	0	1
September	15	5	2	1
October	92 (P)	22	26	9
November	196 (*)	117 (P)	92 (P)	94 (P)
December	261 (*)	221 (*)	164 (*)	208 (*)
January	225 (*)	217 (*)	186 (*)	256 (*)
February	222 (*)	210 (*)	175 (*)	236 (*)
March	227 (*)	238 (*)	101 (*)	164 (*)
April	95 (*)	104 (*)	28 (*) (?)	45 (*) (?)
May	8 (*) (?)	21 (*) (?)	5	5
June	1	1	1	1
TOTAL:	1,342	1,157	781	1,020

Source: Climate of Zambia (1971)
(P) = Month during which crop planted
(*) = Indicats growth month for cassava
(?) = Indicates possibility of curtailed growth



ZAMBIA RAINFALL mm

ANNUAL RAINFALL(80% PROBABILITY)

Based on 30 years data (1931-1960)

Mwinilunga is on average capable of supporting cassasva growth for a period of 6-7 months per calendar year (Table 4). In the north, Mbala is capable of producing cassava over a period of 5-6 months. Further south, the growing season is much shorter and is only capable of supporting cassava growth for 4-5 months.

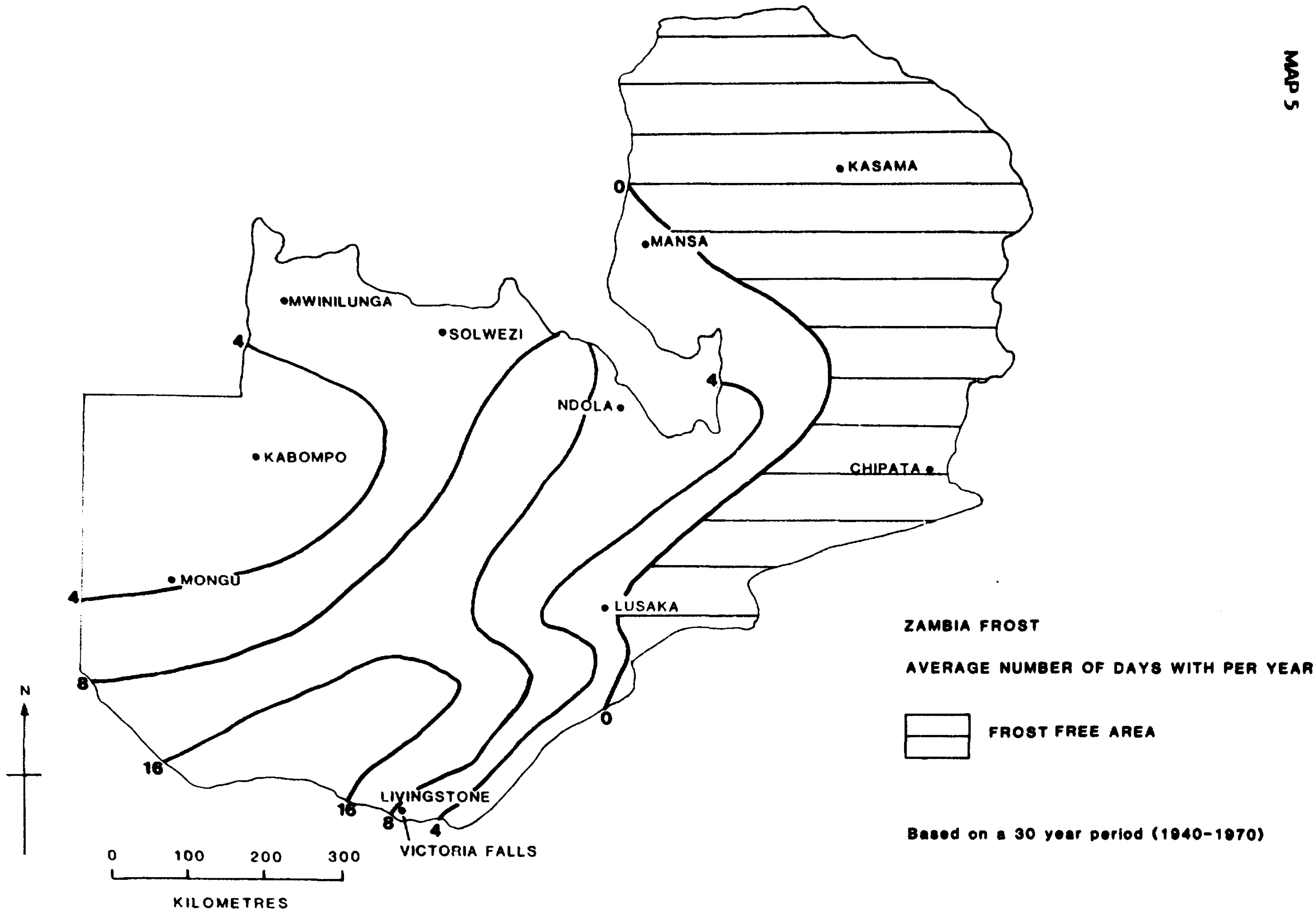
It may be possible in some years to produce a crop of immature roots in the extreme north of the country, however research in Malaysia has shown that root starch content does not reach acceptable levels for processing until 44 weeks. The only method whereby the growing season could be extended sufficiently is by irrigation. It is not normally economically justifiable to irrigate cassava unless surplus water is available from an existing irrigation scheme at low cost.

Temperature. Temperatures are equable in most of Zambia considering its tropical latitudes. This is partly due to the elevation of the land and partly due to the cooling effect of rainfall and the shading from clouds during the potentially hottest time of year as the overhead sun travels south of the equator.

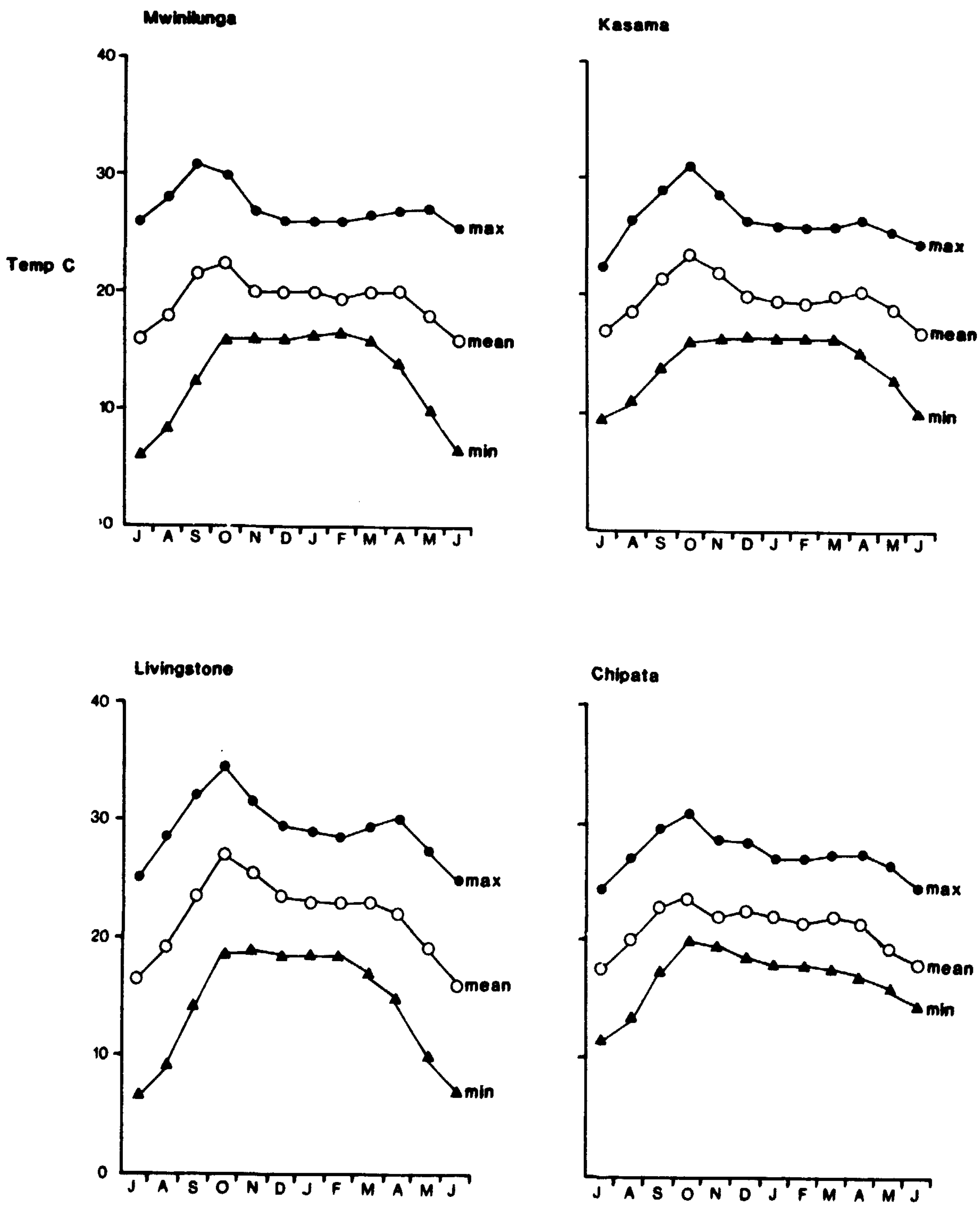
The chart following Map 5 shows the monthly mean daily minimum, the monthly mean, and the monthly mean daily maximum temperatures at four stations in Zambia. As discussed above, research findings indicate that cassava growth is retarded when the ambient temperature falls below 18^{o}C. The mean monthly temperature at most stations in Zambia approaches, or falls below, this critical temperature for the period May-August. For some parts of the day the temperature rises sufficiently to permit growth, however it is expected that growth will be retarded for most of this period and as a result, productivity affected.

During the dry season absolute minimum temperatures fall to below freezing point in many parts of Zambia. Map 5 shows that almost three-quarters of Zambia receives at least one frost per year. From time to time frost occurs in the frost-'free' area, these being unpredictable in severity and frequency.

MAP 5


KASAMA
MANSA
MWINILUNGA
SOLWEZI
NDOLA
KABOMPO
CHIPATA
MONGU
LUSAKA
LIVINGSTONE
VICTORIA FALLS
0
4
8
16
N
0 100 200 300
KILOMETRES
ZAMBIA FROST
AVERAGE NUMBER OF DAYS WITH PER YEAR
FROST FREE AREA
Based on a 30 year period (1940-1970)

Temperatures at four stations in Zambia



SOURCE : The Climate of Zambia (1971)

Mild frost kills the leaves and green parts of the cassava plant. Severe frost, ie below -4^{o}C causes death of the above-ground parts of the plant. Whereas the plant can regrow from underground portions of the stem, productivity is reduced by the plant having to regrow a complete canopy each year. It is therefore inadvisable to grow cassava in areas affected by severe frost. In the following section it is described how current cassava production in Zambia is concentrated in the areas of low frost incidence.

Soils. The soils of Zambia in common with all soils, owe their origin to the action of environmental influences (both physical and biological) on the parent material. There are a number of parent materials in Zambia each giving rise to a range of soils depending on the nature and degree of environmental influence superimposed. The parent materials include:

- granite
- sandstone
- limestone
- deep sands
- alluvium
- peat.

These parent materials are weathered by the rainfall and high temperature to produce mineral fragments which eventually become incorporated in soil. Rain falling on the soil and passing through it can move clay particles and chemical compounds from surface layers to lower layers or out of the soil altogether. This is known as leaching, and is more prevalent in the north of Zambia where rainfall is higher.

Three climatic soil zones can be recognised in Zambia:

- North of the 1,000mm isohyet
- Between the 1,000 and 750mm isohyet
- South of the 750mm isohyet.

The area north of the 1,000mm isohyet, including the northern parts of the North-Western and Northern provinces, has deeply weathered and strongly leached soils. Even over limestone they are strongly acid with low contents of calcium and magnesium, and the clay minerals have low exchange capacities rendering the soil with a poor ability to hold nutrients. Leaching has removed clay from the upper layers of soil so that the topsoils are generally sandy over a more loamy or clayey subsoil.

In the zone receiving between 1,000 and 750mm of annual rainfall, soils are affected less by weathering and leaching and are therefore less acid in reaction with more available nutrients. Leaching is still strong enough to transport clays from topsoil to subsoil, producing lighter textured surface layers. South of the 750mm isohyet, ie mainly in the river valleys of the south, the excess of rainfall over evaporation is small. This results in little or no leaching, with only very porous soils, eg sands, showing any leaching effects. Loam and clay soils are almost uniform in texture down the profile and generally have a deposit of lime at some depth in the profile. Some soils accumulate soluble salts and sodium where they are present in the parent material.

Topography influences soil formation and examples of the effects of this factor can be observed in Zambia. The major topographic effect is its influence on drainage, which in turn affects the degree and nature of weathering on soils. Weathering proceeds most rapidly in well drained soils in high rainfall areas. Soils which are wet for most of the year due to being situated in a basin site are usually grey (or black) in colour due to the absence of oxidised iron, (which imparts the red and yellow colours to freer draining soils). Where grey soils dry out for part of the year, some red/yellow mottles are present due to limited oxidation. Under continuously wet conditions organic matter decomposes slowly and accumulates to form peat, as found in basin sites, referred to locally as 'dambos', in the wetter northern parts of Zambia.

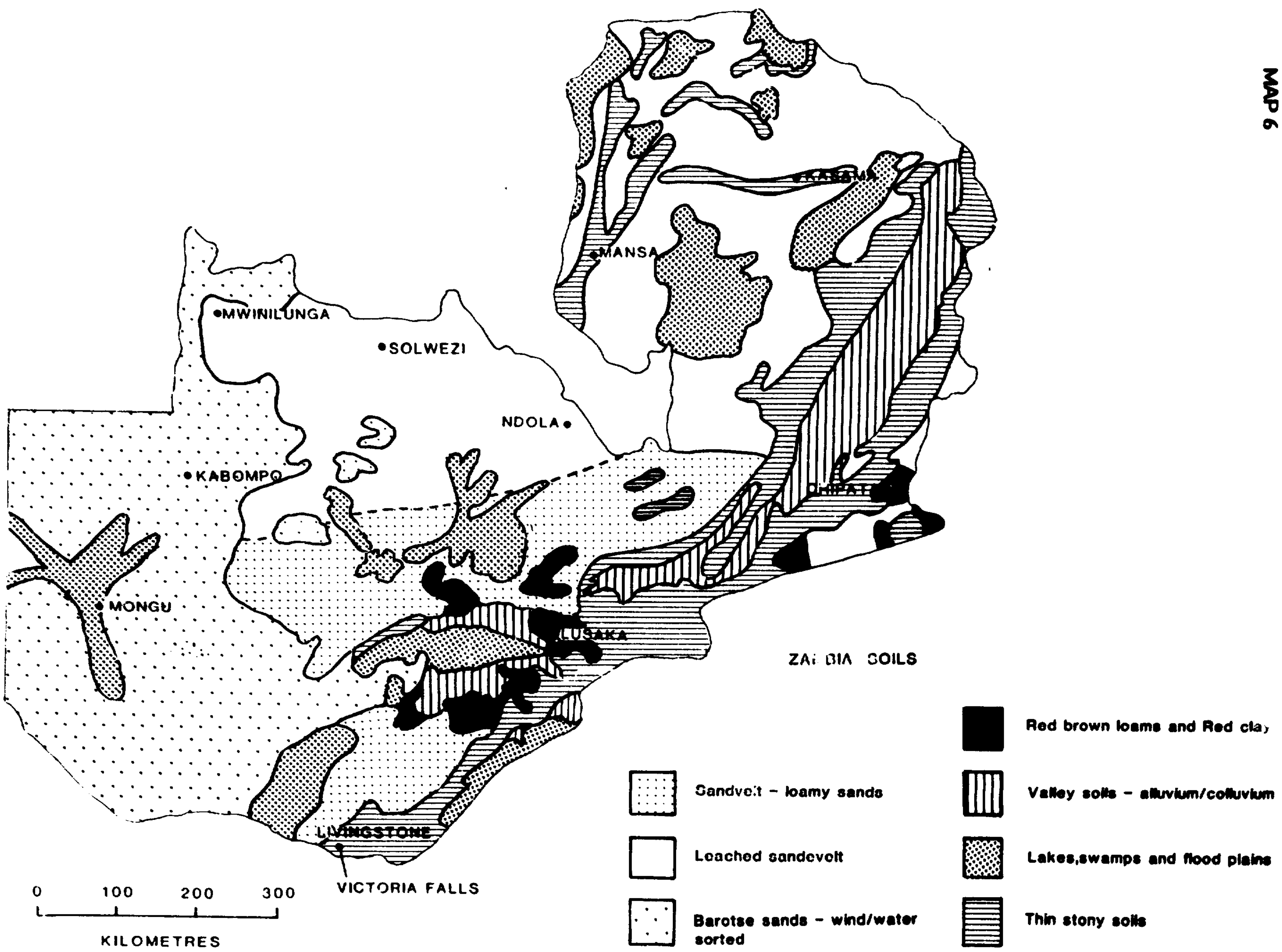
Soils of dambos and floodplains that do not receive new deposits of alluvium on flooding, become strongly weathered and very acid in the topsoil (even where they are alkaline in the subsoil). Soils of this type occur on the upper Zambesi floodplain near Mongu, on the Kafue Flats and in dambos in southern Zambia.

Termite mounds are a striking feature of Zambia's landscape, and the termites have an important bearing on Zambia's soils. Termites bring material from deep in the ground to the surface and this material is washed over the ground over a long period of years. Since the termites can only carry soil particles smaller than 2mm in diameter, their activities lead to a sorting of soil material and can reverse the action of leaching by bringing unweathered soil particles to the surface. Lime is often found in the core of old termite mounds, deposited through the evaporation of lime-containing ground water drawn up by capillary action. In general the activities of termites have ameliorating effects on the soil.

Vegetation has a major influence on Zambian soils. Under woodland and forest, deep rooting trees bring up nutrients from deep down in the soil profile and build these into branches and leaves. When these fall and decay, or are burnt by man, the nutrients are released and become available to support plant growth. On the deeply weathered and strongly acid soils of Northern Zambia the greater part of the soil's nutrient supply is contained in the organic litter on the soil surface derived from the natural vegetation, and the largest part of the nutrient reserves of an area are 'locked-up' in the living vegetation. The lopping of trees to produce firewood for ash production - the Chitemene system - is described in more detail later in Chapter 5 of the report. Lopping, however, is a better practice than total felling which interrupts the cycling of nutrients between soil and vegetation.

The main soil groups of Zambia are shown in Map 6. In terms of area the sandveld and Barotse sands are the most important soils of Zambia.

MAP 6



ZAMBIA SOILS
MWINILUNGA
SOLWEZI
NDOLA
KABOMPO
MONGU
MANSA
KASAMA
CHIPATA
LUSAKA
LIVINGSTONE
VICTORIA FALLS
N
0 100 200 300
KILOMETRES
Sandveit - loamy sands
Leached sandeveit
Barotse sands - wind/water sorted
Red brown loams and Red clay
Valley soils - alluvium/colluvium
Lakes,swamps and flood plains
Thin stony soils

Cassava soils in Zambia cannot be identified per se, as the crop has a wide adaptation in terms of soil type and texture. The crop will produce subsistence yields on all but waterlogged soils. Cassava's ability to grow on very infertile soils has been confused with lack of fertilizer response. In fact the crop will respond dramatically to balanced fertilizer applications, especially in impoverished soils. Its ability to produce in soils too acid and/or too infertile for other crops has resulted in its reputation as a soil depletive crop. All crops deplete the soil of nutrients to a greater or lesser extent. Cassava is more efficient than most at obtaining nutrients from already depleted soils. This is a major source of confusion.

In general casssava can be found growing in all soils with the exception of waterlogged soils in areas where the climate is suitable for its production. Thus the crop cannot be associated with any one soil series in particular. Its ability to produce a subsistence crop from leached acid soils with low nutrients favours its production in soils of this type. It is under these circumstances, especially where inputs are economically out of the reach of the growers, that cassava has an important part to play in Zambian agriculture.

Unfortunately the unique ability of cassava to produce in relatively infertile soils tends to prejudice the crop's access to more fertile soils where its true productivity would be realised. In more than one country cassava is reserved as a crop for infertile soils and 'banned' from more fertile soils. It is to be hoped that such an unenlightened attitude does not exist in Zambia.

6. CASSAVA IN ZAMBIA - AN ANALYSIS OF THE CURRENT SITUATION

6.1 Areas of Production

Some cassava is grown throughout Zambia as a famine reserve crop. However, in certain areas cassava forms an important part of the main staple food. These areas are in the Western, North-Western, Northern and Luapula Provinces, as was shown in Map 1.

The production of cassava by Province was estimated in the agricultural census of 1970-71 and is shown in Table 5.

Table 5: Cassava Production in Zambia by Province, 1969-70

Province	Ha ('000)	Production* ('000 tons)	Yield* (t/ha)	% of Total Sold
Luapula	41.2	255	6.2	19
Northern	40.3	268	6.7	14
North Western	34.0	201	5.9	23
Western	33.6	104	3.1	18
Copperbelt	8.5	27	3.2	46
Eastern	2.2	18	8.2	30
Central	1.6	7	4.5	3
Southern	0.25	1	4.0	10
Total	161.7	881	5.5	19

* Converted from published figures of flour equivalent at 5 tons fresh roots : 1 ton flour

Source: Census of Agriculture, 1970-71

These data indicate that cassava yields in Zambia are low by international standards, and FAO's estimates are even lower. However, it is difficult to measure accurately the acreage of this crop, which is grown on scattered plots; and production is also difficult to record since cassava is normally grown for more than 2 years.

Our reviews of the limited cassava trials carried out in Zambia and our field observations indicate that yields per hectare have been underestimated.

Due to the virtual absence of any marketing system for cassava in Zambia it is impossible to estimate the current status of cassava production in the country. The small quantity of cassava and cassava products which change hands, provides little, if any indication on the extent of production in any particular area. Only an exhaustive detailed survey extending into the subsistence agricultural areas could provide meaningful production statistics under the current status of the crop. It is understood that a survey is currently underway in parts of the North West Province.

Although the main cassava producing areas are largely decided by environmental factors (predominantly frost, drought and acid soils as described in Chapter 5), tribal traditions play an important part in the crops pattern of distribution. In the North Western Province the main tribes are the Lunda, Luvale and Kaonde. The first two are traditional cassava eaters who have practised an almost sedentary type of agriculture for many years. They account for much of the cassava grown in this Province.

The Kaonde are traditionally hunters and gatherers with sorghum and millet as a staple diet, and until recently did not eat cassava. In 1964/5 the Zambian Government began a programme of encouraging nomadic tribes to settle along lines of communication to facilitate the provision of such services as medicine and education. This has had a marked effect on the Kaonde, stimulating them to adopt a more sedentary form of agriculture. This led to a change in staple from sorghum to cassava which is a much lower risk than sorghum, a change adopted from the Lunda and Luvale.

In the Northern and Luapula Provinces there are six main tribes of which the Bemba predominate. Cassava is the basic staple of the Lavwa tribe, and together with millet the staple of the Bemba.

The main tribes of Western Province are the Lozi and related groups. These tribes grow cassava on the Barotse sands although maize is the main staple. The Nkoya tribe, found to the east of Kaoma, include cassava in a widely diversified cropping pattern with an average of 4 major crops per holding although maize is the main staple.

Beyond the outskirts of the larger towns in Zambia extensive gardens have been laid out by wage-workers as a supplementary source of food. These gardens are generally irregular in shape and cassava is often an important crop. This type of production accounts for the majority of the cassava grown on the Copperbelt.

The emphasis that agricultural extension workers are placing on maize production is believed to be causing a decline in cassava production in many parts of Northern Zambia. For example up to 90 per cent of the inhabitants of the Northern Province now include maize in their diet. This despite the consistently low maize yields obtained in many parts of the province. A similar decline in millet production is believed to be occurring in the traditional production areas.

6.2 Methods of Production

Zambian cassava production is almost entirely at the subsistence level. In some cases cassava surplus to the immediate needs of the family, is produced for sale, especially in the vicinity of densely populated areas eg the Copperbelt. No examples of truly commercial production, where the produce is destined entirely for sale, have been reported.

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As most of the cassava is produced at the subsistence level, traditional forms of cultivation are practised. As these vary in different parts of Zambia they have been reviewed to provide a more complete understanding of production systems. Three different types of agriculture predominate in cassava growing areas (Map 7):

- shifting 'axe and hoe' cultivation
- fishing and semi-permanent hoe cultivation
- semi-permanent hoe and plough cultivation

<u>Shifting Axe and Hoe Cultivation</u> This type of agriculture is commonly practised in North-Western and North-Eastern Zambia, where rainfall exceeds 1,000 mm per year and where the soils are heavily leached. The system employed is referred to as 'Chitemene cultivation' of which there are several types. In general the Chitemene system of cultivation involves the incomplete clearing of forest to provide branches and saplings which are then transported to the area to be cultivated and burned. The intention is to obtain a deeper layer of ashes after burning than would be possible by burning the vegetation in situ. In this way an intense burn is achieved, which provides more ash (in place of charcoal) which is rich in plant nutrients, especially potash and phosphate. In addition the higher temperatures generated increase the availability of nutrients in the soil, especially nitrogen and sulphur, and have a sterilisation effect on the soil, killing seeds, roots, and stumps (thereby reducing weed competition) and killing many harmful and competitive soil microorganisms. By leaving the trunks of trees intact regrowth of combustible material from the partially cleared area occurs much more rapidly than it would from an area where trees are felled. In this way the fallow period required between successive cuts is relatively short. The choice of areas to be used for burning and cultivating depends on the availability of combustible material and is characteristically confined to the heavily wooded, well drained watersheds.

Typically crops are planted in the ash-enriched soil for a 3-4 year period after which the nutrients become depleted and the capacity to produce crops reduced. The cultivated area is abandoned and the whole area allowed to regenerate.

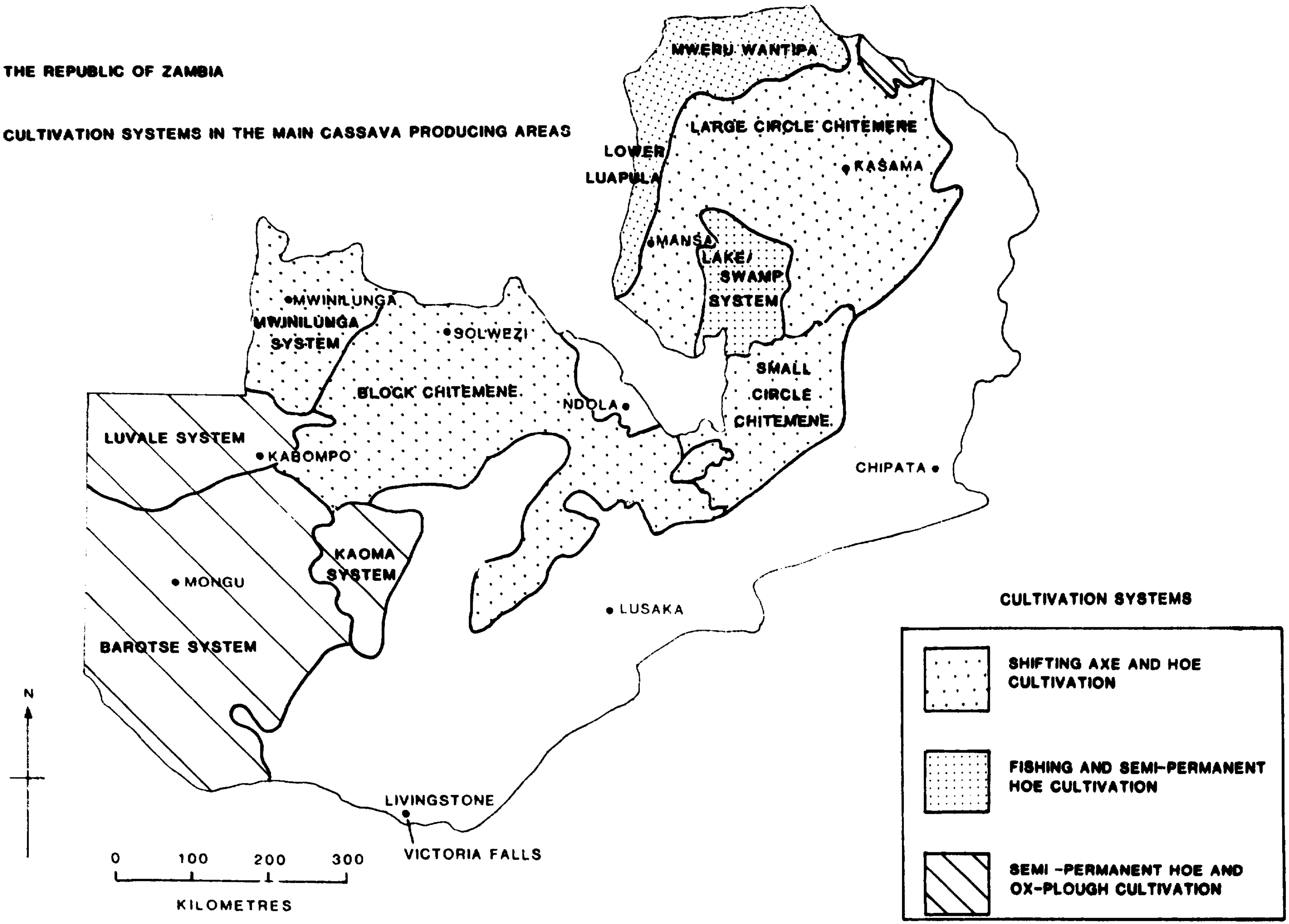
There are four main types of shifting axe and hoe cultivation practised in Zambia within the chitemene system:

- large circle chitemene
- small circle chitemene
- block chitemene
- Mwinilunga system.

The areas where each type predominates is shown in Map 7.

THE REPUBLIC OF ZAMBIA

CULTIVATION SYSTEMS IN THE MAIN CASSAVA PRODUCING AREAS



MAP 7

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Cassava is grown under all systems but occupies a major or lesser role in the cropping programme depending on the dietary preferences of the appropriate tribes. For example the large circle chitemene is the agricultural system of the Bemba of Northern Zambia who, as consumers of millet and cassava grow both crops in association. The small circle chitemene is the system of the Lala of the southern portion of Northern province, who are sorghum eaters. As such sorghum is given priority in the cropping programme.

Fishing and Semi Permanent Hoe Cultivation   This type of agriculture is commonly practised around the lakes and large swamps of North-East and central Zambia. In these communities fishing is the predominant activity, but crop production is required to supplement their food supply. Cassava is the predominant staple crop as it needs little attention and yields are comparatively high on the rich alluvial soils even after several crops have been taken.

Semi-Permanent Hoe and Ox-Plough Cultivation   In addition to using family labour this system employs oxen for ploughing. The system is employed in both North-East and North-West Zambia. In the North-East cassava is produced using ox plough cultivation in the Manbwe area. In North-West and Western Zambia three types of this system can be recognised; the Luvale, Barotse and Kaoma systems.

6.3 Land Preparation

Land preparation starts during the dry season and is carried out jointly by husband and wife. The husband concentrates on the more arduous tasks such as clearing the land. The trees and shrubs are cleared, stacked and burnt during early October. As soon as the rains begin and the soil is softened hoeing (or ox ploughing) begins. Hoeing may be carried out to a depth of up to 45 cm.

Cassava does not grow well under waterlogged conditions and therefore the freer draining soils in any locality are always selected. The crop is grown either on the flat. on ridges or mounds.

The method used is generally determined by the annual rainfall distribution, the drainage properties and depth of the soil. However traditions are such that individual farmers, even within the same field, may use different methods. In lower rainfall areas of North-Western and Western Provinces cassava is grown on the flat whereas in the higher rainfall areas of North-Western, Luapula and Northern Provinces it is grown on mounds or ridges. In all areas mounds or ridges are used along the edges of dambos or lakes.

Both ridges and mounds vary considerably in size and shape, and rarely follow any organised pattern. They are built-up by hand using a hoe and weeds are often incorporated during the procedure.

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6.4 Varieties

The local varieties of cassava in Zambia are named after the village from which each was collected or after the person who introduced it into the area. This has resulted in what appears to be a large number of varieties within Zambia and presents a considerable task to those responsible for the germ plasm pool of the country.

No co-ordinated varietal collection has been carried out for Zambia although such a task is underway currently. Some limited collections have been made on an ad hoc basis in the past, but many varieties have been discarded due to disease or lost due to frost. It is therefore impossible to present a complete list of cassava varieties grown in Zambia. As up to 40 different languages are spoken by the inhabitants of the cassava producing areas of Zambia, one variety may bear many different names, making the assembling of a national varietal collection without duplications a complicated and time consuming task.

Cassava varieties are subdivided by the growers into sweet and bitter varieties based on their taste, which in turn, reflects the content of HCN. Depending on taste, the cassava may be eaten raw or prepared in different ways. This is discussed elsewhere in the report. Table 6 presents the names of the most common varieties grown in the different Provinces.

Table 6: Common Varieties Grown in Zambia

	Provinces		
Type	**Western**	**North-Western**	**Northern & Luapula**
Bitter	Ngubu	Mandama	Matutu Mushi
	Usiku	Matali	Lyon Go
	Litale	Litale	Nyanta
	Njamba	Nsangashila	
	Kakota		
	Likalumusi		
Sweet	Kabumpa	Kabumpa	Mbeleshi
	Nalumino	Mutemba	Lubuta
	Mutambo	Mwakamoya	
	Mandelema		
	Salingai		

The distinction between bitter and sweet varieties is fairly constant throughout Zambia. The sweet varieties are often eaten raw at 12-18 months of age when the tubers are still very small. The bitter varieties are never eaten raw and are not usually harvested until they are 2-3 years old.

6.5 Planting Material

The quality of planting material used by the farmers is poor and often the material observed was broken or twisted off rather than cut cleanly. The length of planting material varied between 200mm and 1m. Most farmers realised that the longer planting material was required when dry planting, but there was considerable variation within regions and even within fields.

The use of poor quality planting material contributes substantially to low yields and late maturing crops. The low value and subsistence nature of cassava as a crop has led farmers to increase the area under the crop rather than looking to improved cultural practices to increase productivity. For example, many farmers were observed to be using planting material from both extremities of the plant. The soft vegetative growth from the top of the plant imposes severe water stress on the cutting through transpiration losses, often resulting in the death of the cutting, especially when dry planted. Cuttings from the base of the plant were seen to include part of the root system which cannot be propagated into another healthy plant. Branched and diseased cuttings were also observed.

Planting material of the local varieties is in abundant supply in most areas. It is obtained either from the mature crop as it is harvested or by pruning back a younger crop. However in areas where frost occurs, planting material can become scarce during the following planting season.

To combat this loss of planting material, the farmers of Western Province cut their cassava back (before there is any danger of frost) almost to ground level and bury the stems in a pit covered with grass to protect them from the frost. In other parts of Zambia farmers seldom store planting material for longer than a couple of months, and more often only for a few weks. Bundles of planting material are put in a shallow pit or trench, upright and in the shade where they survive reasonably well.

Any farmer who wants to start growing cassava is normally given cassava cuttings by a friend, although when the IRDP at Kabompo wanted to buy cuttings they were charged K1 per bundle. This works out at approximately K100/ha which is excessively high.

Poor quality planting material is responsible for extensive termite damage witnessed in North-Western Province. The healthy plants managed to survive but high proportions of the sticks planted did not germinate due to termite attacks. The farmer compensated by increasing his plant population. However this resulted in clusters of healthy plants that survive the termites being in great competition with each other. Late planting (January to March) substantially increases the likelihood of termite attack and very few plants survive.

6.6 Planting Methods

The planting methods used in Zambia vary tremendously from field to field. The plants are usually grouped in clusters of 2 to 3 or even more per station. The angle of planting varies from haphazard to 45^0 facing the same direction to 45^0 facing alternate directions.

The time of planting is October to December and most farmers realise (although one research station did not) that anything planted between January and September, ie within 3 months of the end of the rains or during the dry season is unlikely to be very productive.

The plant population per mound or ridge is usually excessively high resulting in stunted plants, poor root development and low yields. However the distance between mounds and ridges is such that the overall plant density per hectare may even be too low and excessive bush regrowth and weeds occur. This also causes reductions in yield due to competition for limited nutrients. Also, extra work is created for the farmer if and when he weeds his crop.

6.7 Crop Management

After planting, the cassava receives very little further attention but benefits from attention given to any inter-crop. In semi-permanent agriculture where maize is interplanted in cassava in its establishing year, the cassava benefits from the compound fertiliser applied to the maize at planting and a later application of nitrogenous fertiliser as a top dressing. Fertiliser is not normally applied specifically to cassava.

Cassava is rarely weeded more than once a year. The main reason for weeding appears to be to prevent fire damage rather than to prevent weed competition with the crop. It is not normal for cassava to be inter-cultivated except when preparations are being made to plant an intercrop.

In general the level of basic crop technology applied to the cassava crop in Zambia is low and reflects the status of the crop within the agricultural sector. The rate of uptake of any technology will depend on the creation of a market that is seen to function and acquires the confidence of the farmers.

Some farmers have tried using fertiliser on cassava but found that the keeping quality of the roots when left underground after maturity was reduced from 2-3 years to 1 year. Black spots appeared in the roots and decomposition started. The flavour and cooking qualities were also adversely affected when fertilised cassava was used to make flour. This is probably a function of storage and would not occur if the crop was harvested at optimum maturity. It is likely that the fertiliser used by these farmers was high in nitrogen as it was probably intended for maize. One of the tobacco mixtures which is low in nitrogen would have been much more suitable. However the damage has been done and farmers are likely to resist the application of fertilisers to cassava. With the establishment of a market and pricing structure there will be an incentive for farmers to harvest when the crop is mature. This will avoid the storage problems yet yields will be increased and the long term fertility of the soil improved. Farmers are at present reluctant to spend money on fertiliser to increase yield as marketing any surplus can be difficult without an organised market and price structure.

Sometimes the cassava leaves are removed by hand during the second wet season to let sunlight into the intercropped beans or groundnuts.

6.8 Harvesting

In many areas cassava is grown as a famine reserve crop and is therefore harvested over extended periods, often up to 4 years. By this time the roots are fibrous and in many cases starting to decompose. In many instances the crop is never harvested.

However in areas where cassava forms an important part of the staple diet, harvesting of the sweet varieties commences at 12-18 months. The roots are harvested when required as they are often eaten raw. The larger tubers are periodically removed and the plants earthed up again to allow the plants to continue growing.

The bitter varieties are not usually harvested during the first two years. As with the sweet varieties harvesting is without exception done by hand. During the wet season the roots are easily pulled from the soil without causing any damage. However much more care is required during the dry season when the ground is hard.

In North-Western Province the bitter varieties are harvested when required commencing immediately after the second wet season. The roots are left in the ground fur up to 3 years without any deterioration in quality.

By comparison, in Northern Province, the mature crop is harvested continuously throughout the dry season, sun dried, and stored as chips in traditional pepper pot grain stores.

6.9 Conclusions on Agronomy

It is clear that productivity and quality can be raised by improving agronomic practices, notably by better planting material, more uniform plant spacing and better weed control and more effective diagnosis, prevention and control of pests and diseases. Recommendations on agronomy are set out in Chapter 10 as part of the proposed integrated cassava project.

7. UTILISATION OF CASSAVA IN ZAMBIA

Cassava, being a subsistence crop in Zambia, is largely used as required by the rural households. The main use is in the preparation of Nshima, the traditional porridge which forms the staple of the country. In the urban and maize producing areas Nshima is made from maize. In the more rural areas and those where maize does not grow well Nshima is made from cassava or millet or a mixture of the two. Nshima is made from flour and the preparation of the flour varies slightly within the country: however the effect is to prepare a storable commodity from the very perishable fresh roots.

The "sweet" varieties are generally eaten raw, cooked like potatoes by boiling or roasted on an open fire.

7 1 Nshima Flour Production

The "bitter" varieties are predominantly used to make flour and are rarely eaten in any other form.

Roots from plants which have been growing for 2 years or more are harvested as the demand arises. These are washed and then suspended into a pit of water. The water in the pit is normally stagnant and the same water used from previous makings. The roots are then allowed to ferment and soak for a period of three to five days. Residence time in the pit is dependent upon speed of fermentation. This in turn is affected by ambient temperature and the effect of previous makings providing a viable culture of organisms to start the fermentation as rapidly as possible. The traditional reason for soaking is to rid the root of the poisonous effect of hydrogen cyanide. The roots are considered "ready" when they have become soft and the peel comes off very easily. In some areas roots are peeled before they are soaked.

(At this point we wish to oberve that the traditional soaking and fermenting process will not be suitable for cassava intended for starch production, since poor starch will result from this raw material. We recommend in Chapter 10 that as part of the project a small washing plant should be set up in each village supplying the proposed factory).

After soaking, the softened root is removed from the water, peeled and split longitudinally along natural cleavage lines to reveal a central pithy core. This is removed and discarded, the remaining root is then broken further into small "chunks or chips" and placed on rush matting to dry. In order to keep the drying chips away from livestock, the rush matting is often placed on a rack above the ground. This has an additional beneficial effect since drying is then assisted by air movement as well as the sun. Drying may take several days, and is prolonged during damp weather or if the mats are not taken indoors at night with rising humidity.

Once dry "to the touch" the chips are pounded in a mortar and pestle to make flour. Usually more than a day's requirement of flour is made, the flour storing reasonably well in the "kitchen area" of the home. Where considerable quantities of chips are made these may be stored in beehive-shaped mud grain stores. During the dry season with low relative humidities, the chips will remain in good condition in these stores.

When eaten the flour is added to boiling water and mixed to obtain a thick porridge consistency. This is usually moulded and shaped by hand on a plate and served with a stew or relish. Feeding is communal from the plate. Different boiling times were noted for maize and cassava Nshima, maize requiring 20-30 minutes of boiling to get the correct consistency whereas cassava needed only 5 minutes and in some cases addition of cassava flour to boiled water taken off the heat was all that was required.

7.2 Cassava Leaves

Cassava leaves are generally thought of as the poor man's relish. However they are in fact widely eaten throughout the cassava producing areas especially during the wet season when they are readily available and fish is not so readily available. Fish is the most common relish for many of these areas, especially during the dry season.

In Luapula Province young cassava leaves are sometimes eaten without cooking but generally the leaves of rape, sweet potato, pumpkin and beans are preferred. The older cassava leaves are too tough to eat even after cooking.

To cook cassava leaves, the young leaves are first pounded and must be cooked immediately. Women are sometimes seen running with the pounded leaves to their cooking pots. The leaves are boiled in water for 2-3 hours, by which time there is little water left in the pot. More water is added and the leaves boiled for a further 30 minutes.

To make the leaves more tender there are several things that can be added, usually with the second lot of water. Salt is used in preference to soda if available. The soda is manufactured by rural families by collecting the ash after burning a variety of plants including cassava stalks and certain tree species. Of particular importance is the Mwanda or Musamba tree (Brachytegia longifolia). This tree is very common and is widely used as a source of firewood. Pounded groundnuts can also be used to soften the cassava leaves and are usually added after the leaves have been boiled for 2-3 hours. Salad or cooking oil is also used, especially by urban families. Roasted cassava is often eaten with roasted groundnuts.

7.3 Alcoholic Beverages

In North Western Province beer is made from the cassava peel after it has been dried and pounded. It is called Masangu or 7 day beer. This beer is also made in Luapula Province but not in Northern Province.

Cassava is used in North Western Province to make gin, called Lutuku. The distillation of this liquid is highly illegal, but widespread.

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7.4 Nutritional Considerations

In many parts of the cassava growing areas the staple diet consists of cassava and fish. This is a reasonably balanced diet and severe malnutrition is relatively uncommon in the traditional rural sector. However it is the custom in Zambia for the adult males to be fed first, the women and children making do with what is left. This often results in young children getting little or no relish and therefore less protein in their diet.

However malnutrition can be a problem in the urban areas especially when a mother goes out to work and leaves older children looking after and feeding the younger children. In the urban areas within the cassava producing areas there is a definite trend away from cassava as the staple, towards maize as it is generally more readily available. Meat, fish and other foodstuffs rich in protein are often expensive and difficult to obtain in the urban areas, resulting in large proportions of dietary protein coming from the staple.

The trend towards eating more maize, especially in the urban areas, constitutes a substantial increase in the crude protein intake, especially of children, as maize flour contains 7-8 percent crude protein compared to only 1-2 percent in cassava flour. The nutritional value of some of the traditional foodstuffs is shown in Table 7.

Great care must therefore be taken that any increase in the availability and consumption of cassava flour must be accompanied by a nationwide publicity campaign on how to best prepare a balanced diet, using cassava as a staple.

TABLE 7

NUTRITIONAL VALUE OF TRADITIONAL FOODSTUFF

Foodstuff	Dry Matter DM %	Crude Protein CP %	Crude Fibre CF %	Metabolisable Energy (ME)
Cassava flour	90.4	1.2	3.5	2,670
Fresh cassava leaves	28.0	15.3	6.9	-
Finger meal millet	90.0	10.3	8.1	2,557
Maize meal	89.8	8.6	2.0	2,934

Source: The University of Zambia, 1978.

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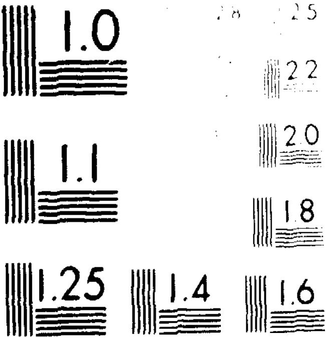
1.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

8. MARKET POTENTIAL FOR CASSAVA AND CASSAVA PRODUCTS IN ZAMBIA

8.1 Traditional Market

Traditionally there used to be a substantial internal trade of cassava flour within the subsistence economy. In 1953 the Department of Agriculture, Northern Rhodesia, reported that 1,000 tons of cassava flour were exported from the Kabompo and Zambezi Districts of North Western Province to the Western Province, mainly in exchange for fish. The marketed surplus has been substantially reduced and is now almost non-existent, largely due to cassava being regarded as a subsistence crop only and farmers being discouraged from growing it as a cash crop.

In Northern Province farmers sometimes sell the standing crop and it is common for households to sell up to 50 kg of cassava flour per year.

In North Western Province fresh roots, sun-dried chips and flour are available in limited quantities on the local markets. In addition sun-dried 'pellets' are made from bitter varieties by squeezing out the water by hand immediately after soaking, peeling and then forming balls or pellets up to 5 cm in diameter. These pellets are then sun-dried until they are hard, and marketed.

In all areas the marketing of fresh roots is extremely localised, is normally limited to the sweet varieties, and is limited to the production areas. Fresh leaves are also sold locally. In particular fresh leaves from the urban gardens on the Copperbelt and along the line of rail sell extremely well.

Unlike the other major staple crops in Zambia, an organised market structure for cassava does not exist at present. This has resulted in the farmers having considerable difficulty in marketing any surplus cassava. Farmers from Kabompo reported spending up to 10 days trying to market one sack of sun-dried chips. This involved travelling by bus almost 500 km to the Copperbelt.

There was an attempt to organise the market for cassava two or three seasons ago. Namboard and the Co-operative Unions were instructed to buy cassava chips, and equipped with funds to do so. No producer price was set, however.

We were unable to ascertain the precise facts, but there are indications that prices paid, certainly in Northern Province, were too high for the flour milled from bought chips to be acceptable to the market. The stock is still sitting unsold in the Northern Co-operative Union's warehouse at Kasama.

This experiment has not been repeated. The fact that official buying was withdrawn makes it the more important to the success of the proposed project that a producer price should be declared and that the seriousness of the Government in encouraging cassava should be demonstrated.

8.2 Demand and Market Study

8.2.1 The potential demand for marketed cassava in 1981. The potential demand for marketed cassava-derived products in Zambia can be divided into two broad segments:

- an accurately measurable demand for starch, glucose, dextrins and potable alcohol in industries which at present rely entirely on imports for their supplies of these products. We were greatly helped by The Development Bank of Zambia, who gave us access to their survey of this demand. We were able to verify the accuracy of this survey and to extend the sample of firms covered.*

- a much larger but less precisely measurable demand for cassava flour in the consumer market and in the baking, brewing and stock feed industries.

  We interviewed all the brewing and stock feed producers, and also the largest bakers of bread and biscuits.

The accuracy of measurement of the market for starch and derived products results from the certainty that, provided quality standards are met, industrial users will buy all their supplies within Zambia rather than go through the frustrating delays of obtaining foreign exchange for imports: and the prevailing import prices give a good indication of what the market is now paying.

The market for cassava flour is less certain because the minor share which the product can gain of the present maize market could vary considerably: and the acceptable market price for cassava flour could also vary considerably, as discussed below.

Table 8 shows estimates of the current potential market. The text following the table explains the basis of the estimates and includes comments on likely future trends.

***Footnote:**

Since our survey was made we have had access to the results of another study, carried out by a private entrepreneur, which confirm the figures of demand for starch and glucose by existing industrial users.

Official statistics of imports are much lower than the three surveys indicate, eg imports of starch are shown as: 1977, 147 tonnes; 1978, 214 tonnes; 1979, 164 tonnes.

We are satisfied from the consistency of the three user surveys' findings that our estimates of demand are correct, and that the official figures are incomplete.

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TABLE 8

Estimated potential for marketed cassava products in Zambia in 1981.

Product	Application	Present Potential (Tonnes/year)	Present Delivered Price + 10% (a) (K/tonne)	Reason for using cassava
Starch	Textiles	300	900	Import Replacement
	Food - biscuits, Blancmanges, Puddings,etc.	500 +	850	Import Replacement
Glucose	Food - biscuits, Puddings,etc.	1,400	1,050	Import Replacement
	Pharmaceuticals	30	1,200	Import Replacement
Dextrins	Glue for paper	150	1,800	Import Replacement
	Pharmaceuticals	5	1,800	Import Replacement
	TOTAL ABOVE	2,400 approx		
			Estimated Acceptable Price	
Cassava Flour	Nshima	40 - 45,000	Breakfast Meal + 7% (= roller + 35%	(i) Urban immigrant demand (ii) Quality improvement
	Blends with wheat flour	7-8,000(10%)	Roller meal price	(i) Replace imported wheat (ii) Release maize for other uses
	Chibuku & mosi beer	3,000 (10%)	Roller meal price	Release maize for other uses
	Stockfeed	12,500 (10%)	Roller meal price less 10%	Release maize but added protein required
	Potable alcohol (liquor blending)	litres 750,000	55n/litre	Import Replacement

(a) Users of starch and derived products, now imported, would be willing to pay at least a 10% premium for local supplies.

8.2.2 The market for starch and derived products in 1981

8.2.2.1 Starch is used as a thickener in prepared foods, such as pasta and blancmanges, and in the biscuit industry as a substitute for wheat flour. Firms making these products, such as Speciality Foods Limited, Ndola and Family Biscuits Limited, Lusaka, are all in the private sector. Consumption of starch in these products is about 500 tons a year, and rising at about 10% a year.

The second application for starch is in the sizeing of textile yarns. Kafue Textiles Limited, an Indeco company, uses 150 tons a year and Kabwe Textile Mills, being built by the Chinese Government, could use about 100 tons a year. There are two smaller, private mills.

Total usage of starch is estimated at 800 tons in 1981.

8.2.2.2 Glucose is used as a sweetener in the food industry, which consumed about 1400 tons in 1981. There is no consumption in the soft drinks industry, which imports and dilutes concentrates, sweetening them with cane sugar to the proprietors' specifications.

There is a small usage of glucose in anhydrous form as the basis for injections, and some is used in the manufacture of pills. The state-owned pharmaceutical industry is working far below capacity, partly because of a lack of foreign exchange to keep machinery in operation.

8.2.2.3 Dextrins are mainly used in glue for the paper processing industry, particularly in envelopes. Consumption was about 150 tons in 1981.

8.2.2.4 Potable and power alcohol. Duncan, Gilbey and Matheson (Z) Limited, in which Indeco has a substantial holding, imports potable alcohol from South Africa for blending into a range of spirits. The company is negotiating imports from Zimbabwe.

The company's management estimates that imports of alcohol for blending have risen from 500,000 litres five years ago to 750,000 litres in 1981.

Theoretically, this market could be supplied by alcohol derived from cassava, but there are good resons why this should not be so:

- other studies, to which we have had access, show that molasses is a much more efficient source of alcohol than cassava. There is a State-owned sugar plantation at Nakambala. If a current feasibility study proves favourable, the molasses from Nakambala will be used for power alcohol; but the minor amount needed for potable alcohol could be supplied from this source.

- the alue of the potable alcohol market is small. The expected import price from Zimbabwe is K0.55 (US $0.60) per litre, which puts a value of just over K400,000 on the market. It is highly unlikely that a potable alcohol unit, added to the proposed factory could produce alcohol from cassava to make a profit on an output of this size.

We have therefore excluded alcohol from our proposals regarding a cassava processing factory in Zambia, but we shall include it in the more generalised factory concept.

8.2.2.5 Total volume and value of market for starch and derived products. The total volume of imports of starch, glucose and dextrins was about 2,400 tons in 1981. The total value of the market in 1981 is calculated at K2½ million, taking import prices and adding a conservative 10% as the Kwacha premium which industrial users would be willing to pay for a local source of supply.

8.2.3 **The potential market for cassava flour.** There are four principal potential applications for cassava flour: Nshima; bread baking; beer making; and stock feed.

8.2.3.1 Nshima. As explained in Chapter 7 above, cassava is used to make Nshima in the four main cassava growing Provinces, but little is marketed.

One entrepreneur has a hammer mill outside Lusaka. He buys cassava chips in Western Province, mills cassava flour and sells it in 1 kg bags to NIEC Stores Limited, owning the largest supermarkets in Lusaka and the Copperbelt. This business has grown to 130 tons a year. The flour is sold retail at K0.67/kg in Lusaka and K0.69/kg in the Copperbelt, compared with K0.27/kg for maize breakfast meal and K0.21/kg for roller meal.

This enterprise, Kamms, is the only one of its kind in Zambia. Its high prices reflect its high costs (chips delivered to the hammer mill cost K0.33/kg); but they also illustrate the willingness of the immigrant population in Lusaka and the Copperbelt to pay a premium over maize meal prices for cassava flour. This is partly a matter of taste and also one of ease of preparation: a blending of cassava with maize makes Nshima much easier to stir.

There is good evidence of a latent demand for cassava flour in the urban concentrations. Alan Marter of the Rural Development Studies Bureau, University of Zambia, found that 30% of a sample of 100 respondents in Lusaka would make cassava their main staple at the same price as maize*, most of the 30% having come from cassava-growing provinces.

* Footnote: "Cassava or Maize", July 1978.

During our study we found that 80% of a sample of 50 respondents in Lusaka and the Copperbelt, who had come from Northern, Luapula and North-Western Provinces, would like to make cassava their main staple at a small premium over maize.

The extent of migration from these Provinces to the urbanised centres of population was indicated in Table 1. The population of Lusaka, Copperbelt and Central Provinces rose by 928,000 people between 1969 and 1980. The Preliminary Report on the 1980 Census of Population notes that most of the increase was at the expense of Northern and Luapula Provinces, the chief cassava growing areas.

It is impossible to be precise in estimating the extent of the latent demand for cassava flour in Nshima. We have estimated in Table 8 that cassava flour could replace 10% of the maize sold in Lusaka, Copperbelt and Central Provinces at a premium of 7% over maize breakfast meal, equal to 35% over roller meal. This would result in a consumption of 40,000 - 45,000 tons of marketed cassava flour a year, rising by at least 4% a year with the population increase and continuing urbanisation.

8.2.3.2 Bread Baking. National wheat production is rising, but at about 10,000 tons (see Appendix 3) is small compared to the annual average import of about 75,000 tons, costing K28 million.

Some private bakers dilute wheat flour with up to 10% of maize. The largest baking firm, part of Indeco, uses 100% wheat flour, and is unable to supply total demand.

Tests at the National Institute of Scientific Research have shown that 10% of cassava flour can be blended with wheat without impairing flavour or texture. Such a blend would easily meet national standards, which specify a protein content of not less than 6.5%. Wheat's protein content is about 12%.

The argument for using cassava rather than maize as the blending material is the national need to rely more on the more reliable crop.

We have estimated in Table 8 that 10% of wheat imports could be substituted by cassava flour, but that, since cassava has no qualitative advantage over maize in this application, it would command no premium over roller meal.

8.2.3.3 Beer Making. National Breweries Limited and Zambia Breweries Limited, both Indeco subsidiaries, make respectively Chibuku beer and lager. There are no private breweries.

Chibuku is an opaque beer, made from maize and delivered in bulk, still fermenting. It must be drunk within a few days before it goes bad. It retails at K0.18 a litre.

Lager beer (known as mosi) is brewed from imported malted barley (60%), maize (20%) and sugar (20%). It retails between K0.55 and K0.78 per bottle of 375 ml, equivalent to K1.49 - K2.08 a litre.

Production is very high, relative to the population:

Output (Million litres)

	Chibuku	**Lager**	**Total**
1977	202	99	301
1978	176	105	281
1979	181	105	286
1980	186	108	294

National Breweries use about 27,000 tons of maize a year and Zambia Breweries 2-3000 tons. During years of maize shortage they have had to restrict output. Neither brewery has experimented with cassava as a substitute material but both are willing to test it, particularly after hearing that Minster Agriculture Limited is advising a brewery in Zimbabwe on its use.

We have tentatively estimated that cassava could substitute 10% of the maize used in brewing. This could amount to about 3,000 tons a year, in flour form. The reason for the substitution would again be the greater reliability of cassava as a crop. It would have no technical advantage, and would command no premium over the maize roller meal price.

8.2.3.4 Stockfeed is produced by National Milling Company and Indeco Milling Company, both Indeco subsidiaries.

Total output averages 120,000 - 125,000 tons a year, of which over 75% is poultry feed, 18% is pig feed and 6% is cattle feed.

Maize and bran are the major constituents. The added protein content of meat and fish meal is almost all imported.

It would be possible for cassava to substitute some of the carbohydrate content of stockfeed; but the very low protein content of cassava would require the addition of imported protein to balance this deficiency.

Theoretically, cassava might be used to substitute 10% of the present ingredients of stockfeed; but at a price at least 10% lower than that of roller meal. We do not recommend that any effort should be spent in promoting cassava in this application, other than to sell the waste from the proposed factory.

8.2.3 Export Potential

We have researched the potential markets for the export of cassava and cassava products from Zambia, but we conclude that there is no scope during the next decade, and possibly little thereafter.

Cassava roots are too perishable to be exported, even to neighbouring countries.

Cassava chips are not so perishable. However, the world market outside Southern and Central Africa is intensely competitive, with Thailand exporting millions of tons of cassava pellets and the EEC trying to restrict imports of this product. There is no scope for a new, small-scale supplier. Within Southern and Central Africa, most of Zambia's neighbours are already much larger producers of cassava than Zambia herself. (Zaire, 12 mn t; Mozambique 2½ mn t; Tanzania 4¼ mn t; Angola 1¾ mn.t). Zimbabwe is not shown as a producer by FAO, but transport charges from the cassava-producing Provinces in Zambia to the Zimbabwe border would be at least K100/ton by rail and K250 by road.

As regards starch, glucose and dextrins, the industrialised nations manufacture the bulk of their requirements themselves, with maize, largely imported but partly home-grown, as the principal source of starch. The rest of their consumptionof starch, glucose and dextrins is made up by imports; but this trade is substantially controlled by a few large and often vertically integrated companies.

If Zambia was to set up a cassava processing capacity, greater than that required to supply the home market, and so relying on exporting to some extent, two options would be open: either to set up a sophisticated and costly marketing organisation, seeking to sell direct to overseas users of starch, glucose and dextrins; or else to sell to one or more of the large international companies, thus putting a dangerously high proportion of production into an ologopolistic market.

If, in the long term, the cassava processing industry in Zambia expands to the point where an additional factory, geared to exporting, would not seriously affect the viability of the industry if it failed, then it could be contemplated. This point is, however, more than a decade in the future.

We recommend that exporting should be left out of the planned activities of the proposed factory during its first five years, and that it should rely on import substitution as its benefit to Zambia. As explained in Chapter 11, on implementation scheduling, the factory should not be built until the supply of raw material is assured, which will take some years. Exporting should thus not be considered for at least a decade from now.

8.2.4 Estimated Future Market and Factory Sales

The market in Zambia for starch, glucose and dextrins has been rising by about 10% a year in volume for the last two years, and is expected to show a similar increase in 1982.

We expect this high growth rate to slacken somewhat in future, as shown in Table 9 below.

Table 9 - Estimated demand in Zambia for starch, glucose, and dextrins

Year	Volume change from previous Year (%)	Annual demand (values at 1981 prices (a)) Starch Tonnes	Starch K'000	Glucose Tonnes	Glucose K'000	Dextrins Tonnes	Dextrins K'000	Total K'000
1981	10	800	640	1430	1573	155	263	2475
1982	10	880	704	1575	1733	170	289	2725
1983	9	960	768	1700	1870	185	315	2950
1984	8	1035	828	1835	2020	200	340	3190
1985	7	1110	888	1960	2155	215	365	3215
1986	6	1175	940	2075	2283	230	390	3615
1987	5	1235	988	2180	2400	240	405	3795
1988	5	1300	1040	2290	2520	250	425	3985
1989	5	1365	1092	2400	2640	265	450	4180
1990	5	1435	1148	2520	2770	280	475	4395
1991	5	1510	1208	2650	2915	290	495	4620

(a) 1981 import prices + 10% premium less K100/tonne for delivery. (Net price for starch, K800/tonne; glucose, K1100/tonne; dextrins, K1700/tonnes).

Figures have been slightly rounded.

As discussed in Chapter 9 'The Proposed Project' and Chapter 11 'Implementation Scheduling' we do not envisage the factory coming into commercial production until 1987, and then only provided that an adequate supply of marketed chips and roots seems assured.

Assuming that the factory project goes ahead, we have estimated its sales on the basis that, after three years of operation, it will be able to meet the quality requirements of almost all industrial users; but that, during the first three years of operation it will take longer to convince users of starch than users of glucose and dextrins. These assumptions are reflected in the estimates in Table 10.

Table 10 - Estimated Factory Sales at 1981 prices

Year	Starch			Glucose			Dextrins			Total
	Tot demand tonnes	Sales tonnes	K'000	Tot demand tonnes	Sales tonnes	K'000	Tot demand tonnes	Sales tonnes	K'000	Sales K'000
1987	1235	645	516	2180	1600	1760	240	160	272	2548
1988	1300	825	660	2290	1750	1925	250	175	298	2883
1989	1365	1005	804	2400	1950	2145	265	195	332	3281
1990	1435	1185	948	2520	2150	2365	280	215	366	3679
1991	1510	1365	1092	2650	2350	2585	290	235	400	4077

9. THE PROPOSED PROJECT

The main conclusions reached in previous chapters are the following:

- Agronomically cassava is doubtful as a commercial crop in Zambia due to climatic conditions
- Agronomic practices can be improved to increase yields
- The crop is produced by smallholders on a subsistence basis, which means small quantities of fresh roots in very dispersed locations
- The cassava fresh root has a life of only 24 hours before deterioration begins
- The smallholders already have a tradition of cassava flour making
- There is currently no organised market for cassava or cassava products other than the small quantity marketed by Kamms
- There is a potential for the sale of considerable quantities of flour and a developing market for starch and starch products.

9.1 Overall Proposal

We propose an integrated project which will stimulate the production and use of cassava in Zambia by the following means:

- organising a market for the crop
- improving agronomic practices and yields
- when these two measures have caused supplies to increase, setting up a starch, glucose and dextrins factory which will provide a further stimulus to cassava growers.

In order to overcome as far as possible the problem of perishability of fresh cassava roots we propose that the major source of raw material for the factory should be dried chips. This is a new concept in cassava processing in Africa. It will not yield starch of as high a quality as fresh roots; but the starch produced should be adequate for most end-uses requiring starch as such, and it will certainly be adequate as a product for further processing into glucose and dextrins, which together account for most of the potential output from the factory.

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It is fundamental to the success of the project that the inevitable losses in root quality, which would occur through time delays in transport, should be prevented by local drying and chip production.

The factory would also buy in a minority supply of fresh roots for the production of high quality starch, but this would be from farmers close to the factory. This operation would be separate from the procurement system for chips.

An alternative source of supply would be to set up a plantation within transportable distance to the factory.

We do propose that there should be a plantation close to the factory, but not for the purpose of supplying it with cassava; rather, it should be a breeding ground for healthy plant stock of the best varieties, for distribution to farmers. A plantation set up to supply the factory would not, in our judgement, be economic partly because the ort, uni-modal rainy season would lead to serious under-utilisation of machinery and partly because of the cost of hired labour. Nor would it help the large number of farmers in Northern Province who should benefit from receiving cash income from their sales of cassava chips to Namboard or the Co-operative Union.

9.2 Organisation of the Market for Cassava

9.2.1 Cassava Chips

As a means of encouraging production in the traditional cassava growing areas, it is proposed that the purchase of chips from farmers only takes place in selected provinces - namely:

- Western
- North Western
- Luapula
- Northern
- Copperbelt.

The price paid for the cassava chips would be announced and controlled by Government in the same manner as that for maize. We suggest that a producer price of 20n/kg (£200/tonne) would be sufficient to stimulate production and to allow a reasonable profit to the factory (see chapter 12).

It is anticipated that the collection and marketing of the cassava chips be the same as that for maize. Thus chip purchasing would be seasonal (June - November) and through rural depots of co-operative unions and Namboard. The chips would be transported to district or regional centres where they would be further processed.

Cassava chips are at present cut into various shapes and sizes and vary in quality and moisture content. They are not, unfortunately, a standard commodity such as grain, which varies in moisture content but has a standard shape.

It is critical to the keeping quality of cassava chips that they should be thoroughly dried. If the centre of the chip is still moist it will rot, and the rot will spread to other chips in the store.

We recommend that farmers should be instructed to cut peeled cassava roots into slices of not more than 5mm in thickness and between 50mm and 80mm in length.

They should also be instructed to dry them on raised mats, as most already do.

Buyers will need to be trained in quality control and be able to undertake simple acceptance tests before accepting a consignment from a farmer. The buyers of maize presently undertake grading procedures. This is an elaborate process and one which sorts maize into five different quality standards, each with a laid down purchase price. With cassava chips it is proposed that the chips be:

- white in colour with no peel present
- dry to the touch (tending to rattle when shaken)
- able to pass through a 50 mm screen
- free from foreign matter.

The above standard would qualify for the statutory price. Any chips not satisfying these quality criteria would be either:

- rejected if considered too wet
- purchased at a reduced rate

Samples which are considered too wet can be re-dried in the sun by the farmer and offered for sale again at a later date. (Providing no secondary deterioration has occurred).

From the depots or mobile buyers the chips would be transported to larger national flour mills to await further processing into flour. In some cases the chips would be purchased direct by the existing milling installations.

Chips delivered to existing milling installations would be hammer milled to flour and packaged into suitable containers for either retail sale or for bulk purchasing by industrial end users. It is anticipated that the flour will be sold for inclusion into Nshima or to the brewing industry for mosi and Chibuku manufacture or to the bakeries for inclusion into bread and biscuit making.

Where hammer milling capacity does not exist and where there would be a reasonable demand for flour for Nshima purposes, it is proposed that hammer milling installations be set up at the rural buying centres. Flour from these installations would be mainly sold locally but could be distributed along the national network as exists at present.

The hammer mill installations would be very simple factories based on machinery already manufactured in Zambia. These may be driven either by electricity if available or have their own prime movers.

Where demand exists these installations could also mill maize into flour for local consumption.

Cassava chips would therefore become a traded commodity and moved along the existing transport network currently operated by Namboard. The buying functions of Namboard are being increasingly decentralised and will be operated by the Co-operative Unions. It is hoped that this will result in faster payment to the farmer.

The marketing channels are outlined in chapter 8, the main potential market being for cassava flour. Many of the existing flour mills have roller mills and facilities for heat treatment of maize with steam prior to milling. This process would not be necessary for cassava chips where only a hammer mill is required. Many mills already have hammer mills installed for the animal feed market or for the preparation of breakfast meal from maize. The separate milling of cassava chips would therefore fit well into a production system. The purchasing would occur at the same time as maize and storage capacity at mills will need to be increased. It is recommended that the traditional systems of storage on concrete floors with tarpaulin covering be adopted. This is cheap and can be easily constructed from local materials and using local labour. The chips should be milled as soon after purchase as possible since they will not store as well as maize. The resultant flour would be packed into retail packs for sale in 2 kg and 10 kg polythene bags and in 90 kg hessian sacks for distribution to industrial users.

The industrial users are expected to be the bakers and brewers where cassava flour would be used as a substitute for maize or imported wheat and barley (malt). These industries currently purchase flour or maize grits from the parastatal milling operations. These organisations would therefore be responsible for distribution and sales of cassava flour.

For the retail markets the parastatal milling companies would pack for distribution into the Government owned supermarket and retail chain. Flour would also be available for sale to wholesalers in the normal manner.

9.2.2 Cassava Roots

As explained in Chapter 10, it is proposed to buy in about 5 tonnes/day of fresh cassava roots during the dry season to produce high quality starch for those end-users who may find chip-based starch inadequate for their quality.

The purchasing of these roots should be by direct negotiation between the factory, or an appointed agent, and the local farmers. It would be disastrous for the Government to declare a producer price for roots, and to have farmers delivering them to collection points from which they could not be moved to the factory before deteriorating.

The yield of industrially recoverable starch per kg. of roots is only 30% of that from dried chips, and it could be argued that, if the producer price for chips is 20n/kg, the price offered by the factory for roots should be 6n/kg. On the other hand, the farmer incurs more cost in preparing, planting, weeding and harvesting than in soaking, peeling and chipping, and he would probably be loath to accept 6n for roots rather than 20n for chips. We propose therefore, that the factory should negotiate contracts for the supply of fresh roots at 10n/kg.

It may be possible to charge a higher selling price for root-based starch than chip-based, in view of its higher quality. Since the quantity involved is minor, we have not allowed for such a premium in the financial evaluation.

9.3 Agronomic Improvements

There are several ways in which productivity can be increased by judicious advice:

- better planting material
- more uniform plant spacing
- better weed control.
- better control of pests and insects
- rotational cropping

All of these improvements can be achieved without cash inputs.

9.3.1 Better Planting Material. Cassava cuttings should not include branches, leafy sections of green stem or roots. The best material to be used is the central portion of the stem where the thickness of the woody tissue is equal to the thickness of the central pith.

There is no detriment to using long cuttings: in fact these tend to be more drought tolerant and lead to a rapid early growth rate.

Cuttings should be selected from plants free, or with low incidence of pests and diseases. Both scale insects and mealy bugs are transmitted from crop to crop on planting material and infested cuttings should be discarded. Plants showing symptoms of mosaic disease and bacterial blight should be avoided when selecting cuttings.

In areas where frost is a hazard, the stem can be seriously affected, leading to poor cuttings with low germination potential. Only unfrosted material should be used even if this means that stems are cut and stored in pits before frost can damage them.

9.3.2 Uniform Plant Spacing. Currently farmers are planting a number of cuttings in close proximity on mounds or ridges and leaving large distances between mounds. This leads to severe competition for light, water and nutrients within the mound but allows weed growth to establish between mounds. By better spatial arrangement the crop will require less weeding and provide more unform yields. It is probable that the use of multiple cuttings per mound is related to the use of poor quality planting material. The introduction of better quality cuttings will be needed as a pre-requisite to more organised plant spacing.

9.3.3 Better weed control. Currently weed control is practised during mounding/ridging and during the dry season to reduce the risk of uncontrolled fires destroying the cassava crop. By introducing better cuttings which are spaced out more evenly, better weed control will accrue from shedin[illegible] However, where the use of interplanted crops allows, weeds sh[illegible] hoed out as they compete with the cassava for water and nut[illegible] sh regrowth in particular should be controlled as the woody s[illegible] very vigorous and strongly compete with the cassava.

Varietal screening and the selection of recommended cassava varieties are still at an early stage in Zambia, and it is not anticipated that much advice on variety can yet be provided to growers.

However, a tuber research unit has been set up recently at Manza, and its work should contribute in the coming years to identifying these varieties most suitable to the Zambian climate. It will be important that, as the most suitable varieties are identified, multiplication units are set up from which good planting material can be distributed to farmers.

9.3.4 Better diagnosis, prevention and control of pests and diseases. Appendix 4 contains a discription of the pests and diseases attacking cassava in Zambia and of the most effective measures against them. The main points are summarised below.

Existing Pests	Damage Caused	Effective Measures
Scale insects	Suck nourishment	Avoid infested planting stock. Plant early in rainy season.
Mealy Bugs	Suck sap Inject harmful substance	Plant early in rainy season.
Termites	Attack cuttings, young plants, even hollow out tubers in drought	Plant early in rainy season Dip or dust with insecticide
Existing Diseases		
Cassava Mosaic (major endemic disease)	Spread by whitefly. Leaf distortion & reduced yields	Use resistant varieties Rogue infected plants.
Cassava Bacterial Blight	Wilt, defoliation, stem die-back	Use resistant varieties Plant healthy stock

(Note: frost damage produces similar symptoms; some reported bacterial blight may be the result of frost instead).

Potential Pests & Diseases

Green Sulphur Mite	Attacks leaves, reduces yields	

Chemical controls can be used to combat the above pests and diseases, but the small Zambian farmer cannot usually afford them.

Much more practical is the assistance which the extension services can provide in advising on resistant varieties, on the best planting times and on the diagnosis of infested or infected planting stock.

It is important that the extension services should be trained in these matters during the 1982-3 season (see Chapter 11, 'Implementation Scheduling'.

9.3.5 Rotational cropping. Rotational cropping is essential to avoid the build-up of crop specific pests and diseases. In the case of cassava it is more than ever necessary to prevent soil erosion.

Many factors affect the choice of rotation crops, including climate, soil and nutritional and industrial requirements. Where the main objective is to grow cassava, the use of leguminous or pasture crops is attractive, as they require little in terms of additional inputs other than the expanded land area needed to effect a rotation programme. Moreover, leaf meal could be produced from these crops for incorporation into the cassava products to increase their protein content, or the rotation crop could be grazed.

This is another matter on which the extension services should be trained to assist cassava growers.

It will be essential to improving agronomic practices in the short term, and to speeding the adoption of the best varieties in the longer term, that MAWD's extension services should be enthused, and trained to promote these practices and varieties. At present the extension services are, at best, not promoting cassava production. By promoting maize, even in the areas where it is not the most suitable crop, they may well be discouraging cassava.

9.4 Establishment of Factory

The measures proposed above should encourage farmers to increase their output of cassava, in response to a producer price for chips and to advice on agronomic practices.

When it is clear that farmers have increased production of cassava as a cash crop sufficiently, a factory should be set up to produce the high value-added products, starch, glucose and dextrins, as a substitute for imports.

The proposed factory is described in Chaper 10 below.

10. THE STARCH FACTORY

Provided that the proposed organisation of the market for cassava chips leads to an adequate increase in supply, a factory should be set up to produce starch, glucose and dextrins. We show in Chapter 11 that this should not be built before 1986, aiming for commercial production by mid-1987.

Initially the factory should work on two shifts, with some spare capacity to compensate for inexperience. After 3-4 years it should be necessary to introduce a third shift.

After that, it would not be desirable to extend the capacity of the factory, since the area required to supply chips would have been stretched to its economic limit; rather, it would be necessary to set up a factory of the same size in another suitable location.

In the following sub-sections we discuss the best location for the first proposed factory; the engineering of the project; the processes for manufacturing glucose and dextrins from starch; the inputs required; and the cost of transport from factory to market.

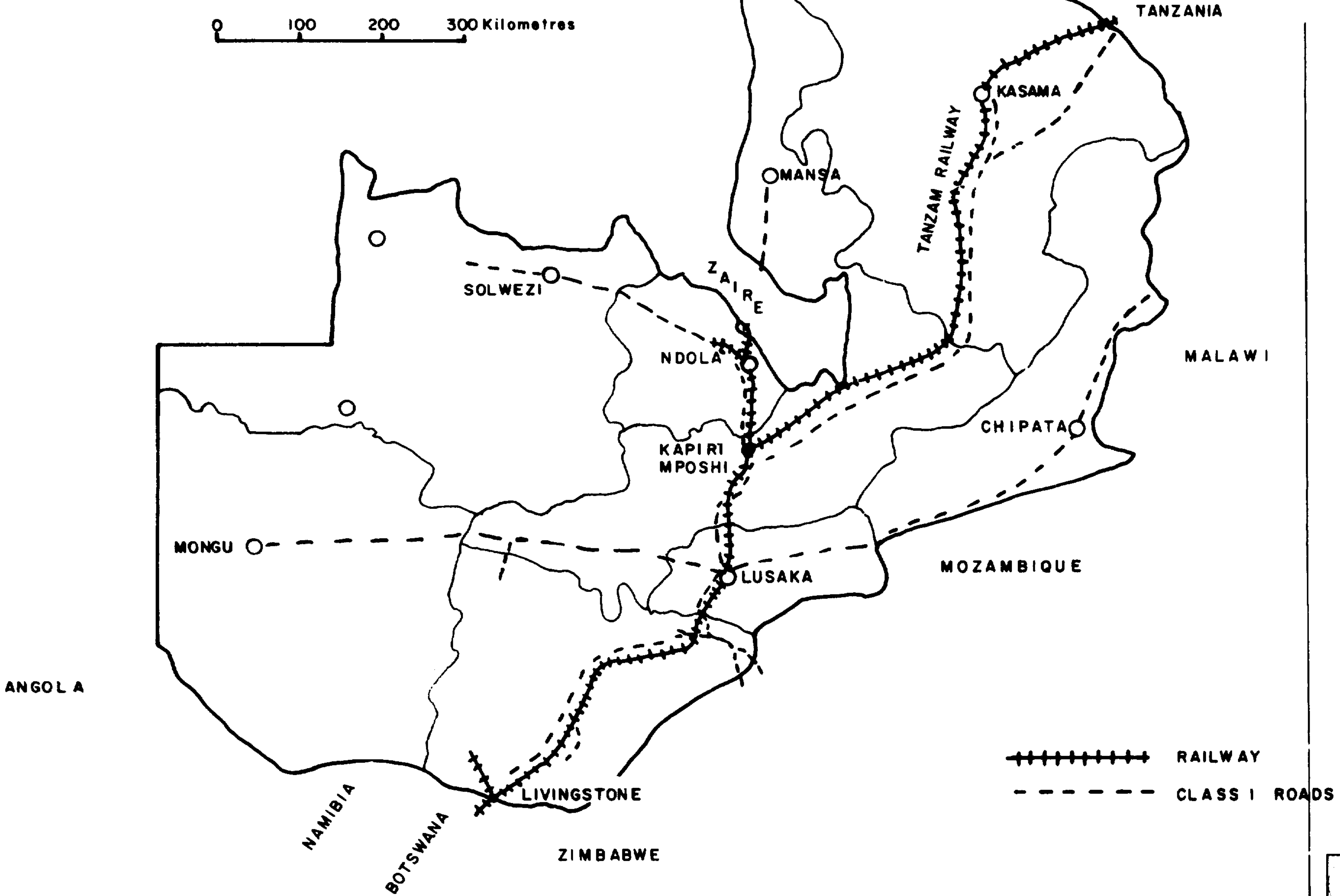
10.1 Location and Site

The factory would be sited in Kasama in Northern Province and would purchase cassava chips from the parastatal milling and distribution centres. The main criteria for choosing Kasama as a site for the factory are:

- well situated in the centre of the largest cassava growing area.
- Northern Province suitable for cassava production.
- Kasama is on the line of rail and has good road communications with centres of population and industry.(See Map 8).
- The town has readily available services such as power, water, and sewage disposal.
- Kasama is sufficiently large and developed with social amenities, such as schools and hospitals, to attract the calibre of staff required to run such a factory.
- Factory would provide employment in a rural area of the country.
- Transport distances for the cassava chips would be as short as possible since most raw material would be derived from Northern and Luapula Provinces.
- Some fresh roots for high grade starch production would be possible from the vicinity of Kasama.

REPUBLIC OF ZAMBIA
RAILWAYS AND CLASS I ROADS

MAP 8



MAP 8

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Kasama has areas designated for light industrial purposes and it is proposed that one of these would be used.

10.2 Factory Engineering

The starch factory would utilise the most up-to-date equipment currently on the market for starch extraction. The system proposed would be that normally used to extract starch from fresh roots and therefore in the case of chips these will be milled and made into a slurry before joining the flow line. After extraction the product would be dried and packaged for sale. Other products could also be made before the final drying process, these would be glucose and dextrins.

Diagrams of the flow line are shown on the next three pages, including a fresh root and chip reception area, root washing and rasping and chip hammer milling. Starch is extracted from the milk and slurry by a centrifugal process. This is followed by drying, packing and storage. Glucose and dextrins are obtained by the hydrolysis of starch using acid, or an enzyme or a combination of both. In this case simple acid hydrolysis will be used which is intended to free the glucose from the starch. Dextrins are then extracted by a further heating process. The whole design will use equipment as efficiently as possible and the reuse of the same drier for all the products will be planned.

Full flow diagrams of the starch lines, based respectively on roots and chips, are shown in Appendices 5 and 6.

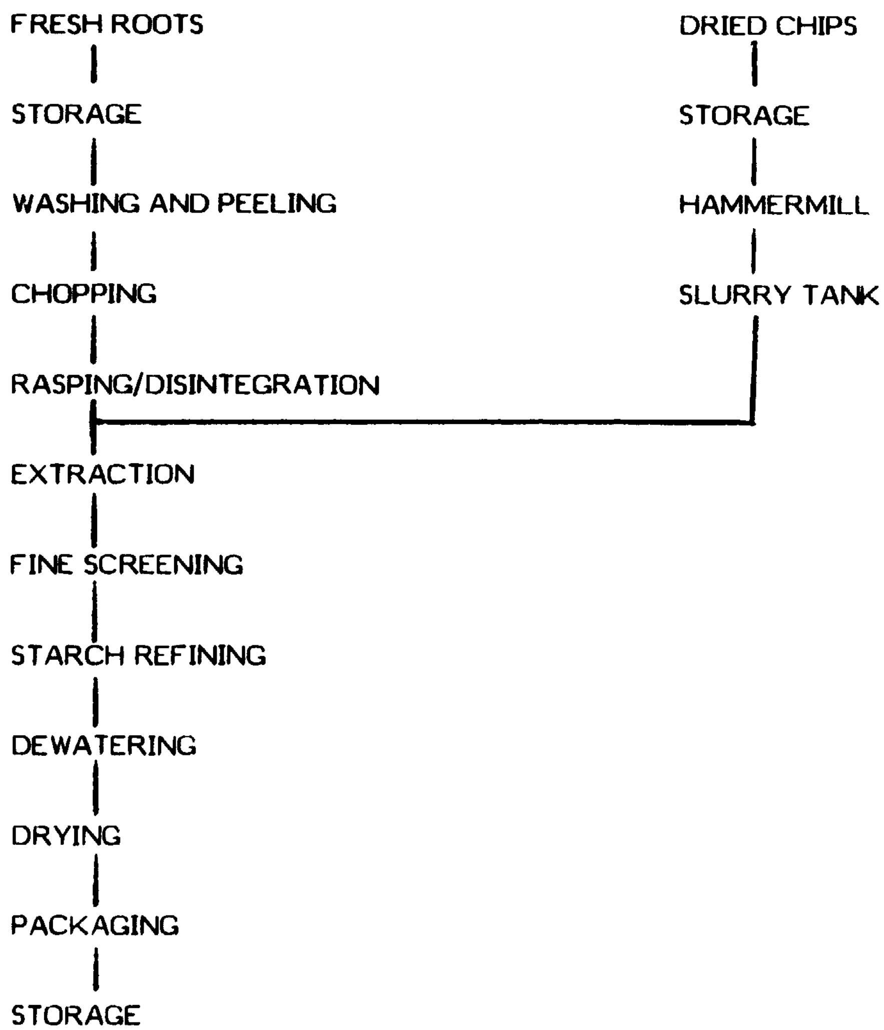
A list of machinery required for the proposed factory is given in Appendix 7. Appendix 8.1 gives details of machinery manufacturers able to undertake turnkey projects, and Appendix 8.2 shows those with experience of supplying some of the machinery required.

10.2.1 Material Storage.

Cassava chips will only be produced by the farmers during the dry season, the purchasing season being a maximum of six months as is currently organised for maize. Since the factory would need to operate for 12 months of the year it is proposed to store chips for processing in the wet season. The factory would contract with the parastatal buying system to obtain the requisite amount of raw material and deliver this in bags to the factory. The factory should receive chips rather than flour since the latter would be more difficult to store and handle over long periods.

The quantity of dried chips required by the factory would amount to 3,300 tonnes in its first year (equivalent to 16,500 tonnes fresh roots). Storage capacity of 2,000 tons would need to be erected at the factory site. The chips would be delivered to the factory in hessian sacks, each weighing 50 kilos, which would be emptied into a bulk storage area inside a large A frame building.

FLOW DIAGRAM FOR PROPOSED STARCH PLANT



TYPICAL MATERIAL BALANCE SHEET FOR CASSAVA STARCH PLANT

1 TONNE FRESH ROOTS
350 KG DRY MATTER (DM)
650 KG WATER

WASHING AND PEELING
310 KG DM
750 KG WATER

RASPING
310 KG DM
2950 KG WATER

EXTRACTION
310 KG DM
6450 KG WATER

REFINING
220 KG DM
370 KG WATER

DRYING
220 KG DM
30 KG WATER

TYPICAL MATERIAL BALANCE SHEET, CHIPS TO STARCH

DRIED CHIPS 1 TONNE
800 KG DM
200 KG WATER

FLOUR
800 KG DM
200 KG WATER

SLURRY TANK
800 KG DM
1000 KG WATER

FILTRATION
700 KG DM
1000 KG WATER

REFINING AND CONCENTRATION
700 KG DM
500 KG WATER

DRYING
870 KG DM
130 KG WATER

The floor area for the outside stack and frame building to allow 2000 tons storage would be approximately 750 square metres, this allows a stack height of 5 metres in bulk.

Contracts will be made with Namboard and co-operatives to supply the chips during the dry season to the factory. Grading standards will be the same as those stated for the buying centres.

Fresh roots will also be supplied to the starch factory during the dry season months. It is intended that 5 tonnes/day of fresh roots will be processed into 1 tonne/day of high-grade starch.

The average cassava yield of fresh roots in Zambia is approximately 5.5 tonnes per hectare. Thus the supply manager would be responsible for contracting with farmers to harvest one hectare equivalent per day. It is likely that the factory would need to collect these roots each day from the farmers in the vicinity of Kasama. The supply manager would therefore need to carefully organise which farmers are harvesting for the factory on any one day so that the transport need only go to one area to collect the roots. The average area grown by Zambian farmers is a quarter of a hectare, this is constrained by labour demands and the subsistence requirements of the households. This would mean four farmers harvesting per day. However the presence of the factory and the supply contracts would tend to encourage the farmer to plant larger areas since the crop would become a cash crop.

The raw materials for the starch factory would therefore be arriving daily during the dry season: chips from the parastatal depots in bags for storage and immediate processing, fresh roots from daily purchases from farmers. These would be processed on the day of arrival and would therefore only be stored temporarily on a concrete floor, preferably under shade.

10.2.2 Processing to Starch. Fresh roots would be washed soon after arrival at the factory to remove soil and then stored ready for peeling. Removing soil is essential to prevent wear on the rasping machine which is the critical process in starch extraction. A washer which removes the cork layer can be constructed so that the roots can go straight into the rasper.

Fresh roots would then be hand peeled. This is far more efficient than machines due to the irregular shape of cassava tubers. Peeling machines currently on the market tend to cause considerable wastage of the tubers. The peeling operation can be simply done by using a knife and cutting longitudinally through the peel. The knife can be inserted under the peel which can then be peeled off in large pieces. Ease of peeling is also a function of root maturity and variety which is another factor which should be considered by the factory purchasing officer. Experience has shown that peeling is best done by women who become particularly skilled at the operation.

The rasping machine is designed to break up the "flesh" of the roots and break the cells containing the starch. This stage is critical in starch extraction from cassava since the rasping operation determines to a large extent the amount of starch release. The measure of starch extraction during rasping is known as the "rasping effect" which may vary between 70 and 90% of the starch content released. The rasping machine would be power driven and consists of a rough drum revolving past the foot of the hopper. The roots are forced against the drum and disintegrated into very small particles. The resultant "milk" is run off for starch separation. These machines are simple in construction but need to be accurately set. They would best be constructed in Zambia to existing designs.

A secondary rasping may be necessary depending on the efficiency of the first machine. In separating the starch considerable amounts of water are added to the pulp. The resulting slurry should then be continuously stirred to keep the starch in suspension before screening.

The screening process is simply to remove the starch and the pulp and fibre. The pulp and fibre are then available for inclusion into animal feeds.

At this stage in the process the slurry from the chip reception would enter the line and thereafter the starch purification would be the same. The starch from the fresh roots would however be processed separately from the chips simply by undertaking the process at a different time of day. Approximately one hour of processing time would be required to extract the starch from the fresh root milk, which could be undertaken at the end of the day's processing. Storage tanks to accommodate one day's starch processing milk would therefore be necessary.

The chips would be taken from storage and fed through a hammer mill to make flour. Some supervision of the feed to the hammer mill should be done to ensure discoloured or mouldy chips were not able to contaminate the flour. The hammer mill would be of standard design and could also be manufactured in Zambia. The machine would have a capacity of 2 tonnes/hour, but two machines of one tonne/hour may be more applicable and less likely to cause delays to the factory should one machine break down.

The slurry process is simply the addition of water to the flour with continual stirring to remove the starch. This would be done in large stainless steel tanks with paddles.

The quality of the water would be important at this stage since from this point the process water is in contact with the starch. Therefore any impurities or chemicals in the water will finish in the product. The town supply at Kasama is reported to be of good potable quality but would need to be analysed before the factory was installed in case some water treatment is necessary. The fact that this good water supply is available is one of the reasons for choosing Kasama as the site for the factory.

Having obtained the starch in suspension the next stage is to remove it by a settling proc. This term is derived from the rural process of allowing the starch to settle out of suspension on inclined trays or tables. This process is still used in very small rural mills but has been modernised by using centrifugal force to separate the suspended starch from the water. For good quality starch it is essential to remove the starch from the water as rapidly as possible since some sugars remain in the water which subsequently ferment and can impart a sour taste to the flour. The starch will therefore be removed by centrifugal separators followed by further settlement and washing to give a concentrated slurry of starch. Some water can be removed from the slurry using further centrifugal techniques until the starch remaining has a moisture content of about 40%.

The final stages of starch processing will involve the removal of remaining moisture to approximately 12-15% and this is normally achieved by evaporation. Traditionally this drying process was done using inclined trays in the sun or wood fired drying floors but this system is slow and is applicable for installations of only 1-2 tonnes per day. An artificial means of drying would therefore be necessary, this would be by using indirect heat and passing the starch flour through a stream of air. A gentle heating is required to prevent gelatinisation.

The dried starch can now be finished and packed. The finishing process is one which breaks up any lumps and separates any non-starch particles before sieving. Sieving sizes are normally 100 - 200 mesh/inch (4 mesh/mm) to produce a fine grade powder. The starch can then be bagged and stored.

10.3 Glucose Manufacture

Glucose is formed when the starch molecule is broken down into its constituent parts by acid. The acid process is known as "Hydrolysis" which produces glucose or dextrose sugar, glucose being less sweet and less soluble in water than sucrose or beet and cane sugar. Glucose is the common name for the syrup and dextrose for the solid sugar. In small plants such as the one planned the seeding of glucose to form crystals and its subsequent drying is normally too capital intensive a process to be considered. It is therefore proposed that some of the starch from the factory be converted to glucose which will be sold in drums, charged out to customers at full cost.

Two methods are used for the hydrolysis of starch: acid; and partial acid hydrolysis followed by an enzyme conversion. The simplest conversion is to use the acid system exclusively. Hydrochloric acid is normally used. The acid is added to the starch slurry until a desired acidity or PH is reached whereupon the mixture is heated until the desired hydrolysis has taken place. This process can either be on a batch sytem or continuous. A batch system would suffice for such a size of plant and would be easier to operate than a continuous operation. Following hydrolysis the neutralisation takes place by the addition of sodium carbonate to bring the PH to near neutrality (6-7).

It is proposed that the glucose making process use the starch slurry from dried chips after the water has been added to form a slurry and the slurry screened to remove fibre. Quality control tests at this stage will show how much hydrolysis will need to take place. Since the chips will have been derived from fermented roots some hydrolysis will have already occured, but much of this will have been lost in the soaking water during preparation.

The final process is the refining and concentration of glucose. Refining consists of the removal of impurities, such as proteins and fats. These can be removed by centrifugal separation and finally filtration. Colours can be removed by filtration through activated carbon or fullers earth which absorbs all the impurities affecting colour without any effect on the glucose. Concentration, using vacuum batch converters, removes water from the liquid, leaving a concentrated glucose solution which can be packaged in bulk for distribution.

10.4 Dextrins Manufacture

Dextrins are made by the heat treatment of starch and are known as gelatinised starches. Dextrins are used mostly in the adhesive industry with cassava-derived dextrins being of particular value in remoistening gums for envelopes and stamps because of their adhesive properties and agreeable taste.

Three groups of dextrins are recognised,

- British gums
- White dextrins
- Yellow dextrins

The demand identified in Zambia was for yellow and white dextrins. The difference in processes to form the three groups is mainly a function of temperature and PH. The resultant gums vary in solubility in water and in viscosity. In general therefore once the process line has been set up all three could be manufactured according to demand. A simple outline of the different processes is given below.

British gums are formed by heating the starch alone or in the presence of a catalyst to a temperature of between 180 - 220°C. The resultant product is light to dark brown and gives a solution in water with a lower viscosity than normal starch.

White dextrins are formed using a gentle heat treatment (C80 - 120°C), for a shorter time but in the presence of a stronger catalyst such as hydrochloric acid. The product is then less soluble in water and is almost white in colour.

Yellow dextrins are formed when lower catalyst or acid levels are used but higher temperatures (150 - 220°C). Some caramelisation takes place, causing a yellow to brown colouring. These dextrins are easily soluble in water forming solutions of low viscosity.

The dextrins will be in powder form on leaving the factory and packed in 25 kilo paper, polythene lined bags, or as customers direct.

10.5 Inputs Required

The major inputs required for the factory will be:

- manpower
- electricity
- water
- chemicals
- packaging materials
- transport
- oils and fuels.

10.5.1 Manpower. It is anticipated that the factory will work 16 hours per day over a five day week. At this working level the current market requirements for starch and starch products would be satisfied. Output could be increased by the introduction of a third shift.

Management levels are expected to be a total of 5 and factory workers a total of 71 on double shift, and 6 and 92 respectively on 3 shifts. The factory has not been designed to be fully automated but rather to create employment in Kasama. A list of the estimated labour is shown overleaf.

The administrative staff would need to cope with payments to farmers and clients for raw materials and accounting purposes, and therefore there will need to be quite a large number of staff.

Labour Force For Factory(double shift)

1	Manager
1	Assistant Manager
1	Technical/Mechanical Superintendant
1	Accountant
1	Sales and Raw Material Procurement Officer
5	

1	Laboratory Technician
3	Foremen
3	Mechanics/Maintenance Fitters
45	Operators/Labourers
5	Guards
3	Groundsmen
4	Clerks
3	Drivers
4	Office Staff (Secretarial Staff)
71	

Total Staff 76

The job title indicates the main duties of each member of staff. This is a suggested level which may need to be changed in the light of circumstances once the factory is established.

10.5.2 Electricity. Zambia is fortunate in having an abundant supply of electricity. Kasama is well served, there being a 110 KVA line to the town. Power requirements are estimated at 250 units per tonne of starch which will cost on average K10.00 per tonne produced.

10.5.3 Water. Water as stated, must be of good quality and in abundant supply. The starch extraction process is one where considerable quantities of water are used, an estimated 4300 litres per tonne of starch produced.

The quality of water must be high containing no iron salts which will react with the starch to give blue or discoloured products.

Water analysis will need to be done when final plans are drawn up in order to determine the need for water treatment plant. During the field study water analysis was not available but verbal assurance was given that the quality is satisfactory.

10.5.4 Chemicals. The main chemical supplies required will be for the manufacture of glucose and dextrins, and this will be hydrochloric acid. This should be obtainable in drums from local Zambian suppliers.

A further chemical may be needed in water treatment. Sulphur dioxide is usually added to the wash water to effectively bleach the starch.

10.5.5 Packaging Materials. The starch will be packed in 25 kg plastic bags and the glucose in 200 kg drums. Dextrins will also be packed in plastic bags. Delivery of the products will be by road and rail to Lusaka and the copperbelt.

10.5.6 Transport. The transport requirements of the factory will be

1 10 tonne lorry (or tractor and trailer)
1 Pick-up
1 Saloon car.

Dependent upon the vicinity of the contracted growers to the factory collection of roots may be easiest by tractor and trailer. This could substitute for the 10 tonne lorry since the latter will be used mainly for collection or delivery of products to the rail head and for chip and root collection. Chips will mostly be delivered and any long distance road transport will be done by contractor. It is anticipated that most of the fresh root supply will have to be collected for the factory.

Rail will be used as much as possible for inputs and in the delivery of products to the industrial users.

10.5.7 Oils and Fuels. Kasama again is well situated for the supply of oils and fuels. An attempt should be made to standardise on diesel whch will also be used for the drier so that bulk purchases can be made. Concessionary terms should be sought on the supply of fuels.

10.6 Delivery Costs

The markets for the starch, glucose and dextrins produced in the Kasama factory are mainly in the Copperbelt, Central and Lusaka Provinces, at a distance of between 625 and 800 kilometres (see map 8).

Transport costs were as follows in December 1981:

	Rail	Road
	Kwacha/tonne	
Kasama - Ndola (Copperbelt)	26.1	85
Kasama - Lusaka	27.4	100

Rail transport is much the cheaper method but locomotives and rolling stock are scarce, and even when they are available the haulage from Kasama to the Copperbelt or Lusaka is said to take 9-10 days (the gauges on the Tanzania - Zambia (TANZAM) and internal Zambian railways are different, and goods have to be transferred at the Kapiri Mposhi junction).

Rail should be used when facilities are available, but in evaluating the project we have allowed K100/tonne for delivery costs. The products are sufficiently high-priced to stand this level of transport cost.

11. IMPLEMENTATION SCHEDULING

Most projects have an assured supply, and depend mainly on as assessment of market demand for their viability. In the case of cassava processing on an industrial scale in Zambia, the reverse is true: there is a proven market demand for starch, glucose and dextrins, but it is uncertain whether the necessary supply of cassava can be stimulated to satisfy the demand.

We are sure that this supply of raw material, chiefly in chip form, must be stimulated before a processing factory is set up. It will take at least two seasons before the Zambian authorities can be confident that the measures, recommended in Chapter 9 above, have been successful in sufficiently increasing cassava production as a cash crop.

To recapitulate, it will be necessary to announce a producer price for chips and to provide a market for them, via Namboard and the co-operatives, in hammer mills. Namboard and CU staff must b trained in buying cassava chips, and extension staff trained in casssava agronomy.

The following timetable is appropriate to the proposed project:

Action	Timing
Zambian Government/NCDP adopts project	Sept/Oct 1982
Government/NCDP appoints Project Manager	Oct 1982
MAWD announces producer price for chips in 1983-4 season	late 1982 (simultaneous with maize price announcement).
Project Manager organises:	
- training of MAWD extension workers	1982-83
- training of Namboard/CU cassava chip buyers	1982-83
- storage trials of cassava chips	1982-83
- option on factory site in Kasama	early 1983
- census of existing hammer mills	late 1982
- construction of new hammer mills in Northern Province where necessary	1982-83

It is essential that the above actions are completed before the buying season begins in June 1983, so that farmers responding to the new incentives to grow cassava find that the market is indeed available.

After a period of two years, during which sales should increase and the system becomes established, the next action should be:

- brief re-appraisal of project feasibility	Aug/Sept 1985.

If the results are satisfactory, the timetable should proceed as follows:

Action	Timing
Project Manager	
- issues design brief/tender document for plant	Oct 1985
- issues tender documents for building work, with provisional specification for production building	Dec 1985
- appoints accountant, technical manager, 1 foreman, 1 mechanic, 2 office staff, 1 driver, 2 guards, 4 general workers	Jan/June 1986
- receives tenders for plant	Jan 1986
- updates specification for production building	Jan 1986
- receives tenders for building work	Feb 1986
- appoints contractor for plant	Mar 1986
- appoints contractor for building work	April 1986
- takes up option on factory site	early 1986
- appoints sales and raw materials purchasing officer, 2 clerks, 2 drivers, 1 guard, 4 general workers	July/Dec 1986
- appoints assistant manager and all staff up to one-shift level for trial run period	Jan/June 1987
Contractors	
- complete finished products store	Jan 1987
- complete production building sufficiently for plant to be installed	Jan 1987
- complete building work	April 1987
- start commissioning of plant and training staff	May 1987.

Trial runs at this stage will result in an estimated 50% of output being saleable. Quality testing and offers of samples to potential customers for testing will be made.

- Plant begins production on commercial scale	July 1987
- Staff is built up to two-shift level	July/Dec 1987

Inputs of finance are shown in Chapter 12, dealing with financial evaluation.

12. FINANCIAL EVALUATION

The main points of the financial evaluation of the starch, glucose and dextrins factory are set out below, including, in 12.1.6, a sensitivity analysis. The model can be used for a very rapid re-evaluation of the project at any time. If the project proceeds, actual results can be fed into the model to provide an instant picture of their implications on the factory's financial performance.

We also made a financial evaluation of a factory making starch only and supplying this to outside manufacturers of glucose and dextrins. The results of this evaluation, showing a much lower IRR than the multi-product factory, are shown in 12.2 below.

12.1 Financial Statements

The financial evaluation of the project has been done using a computer model the print out from which is attached as Appendix 9 Reports 1-13. The model logic for individual items is described in the notes attached as Reports 1A-12A, explaining the basis on which figures have been calculated.

In overall terms the model matrix is divided into two elements. Year C shown in the first two columns represents the construction period of 18 months. Year CP1 represents cost build ups in the first 12 months of project development and construction. This compression is possible since it is assumed all initial development will be done out of equity capital and has the advantage of enabling us to show more periods in the operations phase. Year CP2 represents the final six months of installation and trial runs. Thereafter ie years P1 onwards, operational years are shown in six monthly intervals (P1 = July-December, P2 = January-June). This format enables the model to demonstrate the effect of the seasonal raw material purchasing pattern on stocks and cash flow. For the same reason it is assumed that the project will have a financial year July 1st - June 30th so that year opening coincides with the major buying season.

The overall financial performance of the project is good as shown in the following summaries.

12.1.1 Profit and Loss (Report 8)

The project achieves a profit in its first year and as sales increase generates substantial cash flows to enable it to repay all borrowed capital by the end of operational year 6 period 1.

By year 6 period 2 the project is at optimal practical volume and the half year's results show the following:-

	K'000
Sales	2,088
Less raw materials	612
Gross added value	1,476
Less other variable costs	410
Contribution	1,065
Less fixed costs	597
Profit before tax	468
Tax at 45%	211
Nett Profit	258

Thus, allowing a reasonable retention of funds for future years, a dividend of between K150-200,000 could be declared for the half year, representing an annual dividend of 15-20% on the equity capital of K2,000,000. Such a distribution would only be possible from about year 5 onwards.

12.1.2 Balance Sheet and Capital Funding (Report 9)

The project will require initial capitalisation as follows (see Yr.C P2).

	K'000	K'000
Sources of funds		
Equity capital		2,000
Term loan capital (75% P & M)		1,800
Total funds		3,800
Application		
Fixed Assets		
Land	25	
Factory buildings	500	
Housing	250	
Plant and machinery	2,400	
Vehicles	70	3,245

	K'000	K'000
Pre-production Working Capital		
Stocks	36	
Debtors	31	
Cash in hand	194	261
Pre-production expenses		294
		3,800

NB Pre-production trial runs are expected to bring in sales equal to approximately 50% of the raw materials used.

The basis of the capitalisation is the assumption that term loan financing will be available to a maximum of 75% of the cost of plant and machinery. The remainder is to be funded from fixed capital with short term overdrafts used to fund the substantial initial working capital requirements until self generated funds are available to take over.

The project's funds flow is more than adequate to service this capital profile and the project becomes totally self financing by the end of year 6 period 1 at which time the position is as follows.

	K'000	K'000
Sources of funds		
Fixed capital		2,000
Revenue Reserves	2,104	
Less surplus cash	816	1,288
Nett capital employed		3,288
Applications of Funds		
Nett fixed assets		1,848
Current assets		
Stocks	1,003	
Debtors	482	
Cash in hand	96	
	1,581	
Less current liabilities	141	
		1,440
Total Nett Assets		3,288

NB
The cash surpluses represent additional funds flow not immediately needed in the business.

Working capital requirements are substantial and grow from an initial requirement Yr.1 P1 of K842,000 to a level K1,441,000 by Yr.5 P2 levelling off thereafter. Initially K400,000 has been financed by an overdraft facility. This represents less than 50% of the total requirement and can normally be expected to be available. The overdraft is paid off by the end of year three period 1.

Term lending of K1,800,000 is equal to 75% of the cost of plant and machinery. The moratorium is three years from disbursement in Year C period 2, and repayments, at six monthly rests, take place during the following three years. The term loan is divided between two headings to enable loans of different terms to be built into the model should this prove necessary in future.

The model takes a conservative view of capitalisation which could be reduced by using a short term overdraft on a revolving basis to fund raw material stock peaks.

12.1.3. Funds Flow Statements (Report 10)

The project sustains a surplus cash position throughout its life. Funds need to be retained to finance the relatively short term loan repayment cycle, where in certain years the annual cash flow goes into deficit.

Given this debt servicing level then distributions to risk capital will be minimal for the first five years of the project. Thereafter however good dividends can be paid. Cumulative surpluses are available sufficient for a small dividend of 5% per annum from year 2 onwards, building up from an annual cumulative surplus in Yr.2 P1 of K132,000 to one of K476,000 in Yr.4 P2.

12.1.4 Financial Ratios (Report 12)

The project's performance indicates the importance of achieving good throughput. Fixed expenses are high and in the early stages represent 53% of sales value dropping to 29% once higher throughput is achieved. This pattern is confirmed by the percentage of profit after tax to sales and it should be noted that given the high tax level of 45% the profit percentage is almost halved once tax becomes payable.

The profit on capital employed is good, achieving a level of 20.3% in terms of gross capital employed and a very creditable 30.9% on nett capital employed. This assumes substantial internal funding and early term loan repayments which mean that risk capital has to wait a considerable period before appreciable dividends can be paid.

The high capitalisation of the project is demonstrated by the fact that once established, capital is only turned over once a year and apart from the relatively high fixed capital investment, the current ratio of 11.2 to 1 indicates the high levels of stock and retained cash holdings needed to finance the crop purchases.

The overall capitalisation is conservative in development banking terms with term loans representing initially some 50% of capital employed. Debt service is reasonable dropping substantially during the major repayment period Yrs.3 P2 - Yr.6 P1. The term loan is repaid in a relatively short oeriod which could be extended if this became necessary.

12.1.5 Internal Rate of Return (Report 12)

The internal rate of return of the project is an overall 13.64%. This is marginally above the cost of term loan capital at 13.5% and it is this debt service burden, coupled with a high risk capital component which accounts for the difference between the fully operational return on capital employed and the overall internal rate of return.

Given the importance to peasant agriculture of opening new markets for their crops by local processing perhaps more reasonable interest rates could be considered, at levels more in line with lending to the agricultural sector rather than the industrial sector.

12.1.6 Sensitivity Analysis (Report 13)

We have calculated in the sensitivity analysis the effect on cumulative funds flow and on profit after tax of changes in volume of sales (sales factor) and selling prices (price factor). The range calculated is 0 to -15% in 5% stages.

In overall terms it will be seen that the project is much more sensitive to price fluctuations than to volume fluctuations. This is particularly marked in the schedules showing effect on cumulative cash flow. In the case of price variations a drop of five percent results in a periodic maximum cash shortfall of K126,630 whilst a drop of 10% in sales volume only shows a periodic cash shortfall of K36,070. Profits after tax are not as dramatically affected since the major cash shortfalls occur due to heavy debt servicing.

It would probably be possible to reschedule the debt service to enable the factory to continue should such adverse conditions arise as follows:

- in terms of price sensitivity a price drop of 5% could be easily accommodated by loan repayment scheduling. More than this would require a major rethink of the project.

- in terms of sales volume a drop of 10% could be easily accommodated and one of as high as 15% could possibly still yield a fundable project but investment return would be very low.

12.2 Factory for Cassava Starch Only

We have modelled the factory on the basis of the cassava factory producing and selling starch only. The basis of the model is that overall output and sales will be the same, and that capitalisation will be on a similar basis as follows:

	Multiple Product		Starch Only	
	K'000	%	K'000	%
Share Capital	2,000	52.6	1,700	58.6
Term Loan	1,800	47.4	1,200	41.4
	3,800	100.0	2,900	100.0

The marginal difference in structure is caused by rounding up figures, and gives the more conservative view of lower loan capital content. The overdraft has been retained on the same basis since this is tied to working capital which has not altered significantly. Fixed asset cost has been reduced by K900,000, the cost of the glucose and dextrin plant.

The term loan conditions and repayment has been retained on the same basis as the multiple product factory. The reports 1-12 for this option are shown in Appendix 10.

In overall terms the project's internal rate of return is reduced to 8.36%. It does not offer a very attractive proposition to risk investors and would require loan capital to be made available with longer grace periods.

12.2.1 Profit & Loss Account (Report 8)

The factory does not achieve profit break even until year 2 period 1. Subsequent profitability is at a very low level and dividends to equity capital are unlikely to be forthcoming until the 7th year of the project after all debt servicing has been completed.

12.2.2 Balance Sheets (Report 8)

The initial capitalisation of the factory at the end of the construction period is as follows:

	K'000
Sources of funds	
Equity	1,700
Term loans	1,200
	2,900

	K'000
Applications	
Fixed assets	2,345
Working capital	102
Cash	161
Pre-production expenses	292
	2,900

As set up the project has sufficient capital to start operations. Applying the same conditions, repayments are too burdensome as described in the fund flow statement comments below.

12.2.3 Funds Flow Statement (Report 10)

The factory initially has sufficient capital injections to meet its needs. However from year 2 onwards cumulative cash deficits build up to a maximum of K194,000 and are not paid off until the end of year 6.

This arises due to applying the same loan terms as the multi-product factory and the situation could be alleviated by providing longer grace periods. These will need to be of the order of six months' extra grace period on the overdraft and a full year's extra grace period on the term loan.

12.2.4 Key Financial Ratios (Report 11)

Contribution is reduced from 51% to 41%. Fixed costs as a percentage of sales are initially higher but level off at the same figure. This is due to fixed costs being reduced by the plant maintenance charges. Profit on sales is marginally lower in line with the lower contribution. Given the overall reduced profitability and cash flow all other key ratios also demonstrate a poorer performance from the starch only factory.

13. ECONOMIC EVALUATION

The most important elements in the economic evaluation of the project are shown below. All prices and costs are at constant 1981 levels.

13.1 Foreign Exchange Balance

Foreign exchange outgoings will be as follows:

- the estimated investment of K 3.245 million in fixed assets (Report 5) will include approximately K 2.8 million of imports (all the K 2.4 million of plant and equipment, over K 300,000 of factory and housing building components and all the K 70,000 of vehicles).

- interest on medium and long-term debts, payable by the project to Zambian leading institutions in Kwacha, is assumed to be payable by these institutions to overseas sources of finance in foreign exchange (Report 8)

- the import content of 'other variable costs' (Report 8), consisting of fuel, chemicals and packing materials, is estimated at 90% of their total

- the import content of maintenance costs (Report 8), consisting mainly of spare parts, is estimated at 67% of their total.

Conversely, the factory's sales will be entirely import substitution, apart from the 10% premium over 1981 import prices which users are assumed willing to pay for a Zambian source of supply. (See table 8, Chapter 8).

On the above assumptions the balance of outgoings and savings in foreign exchange will be as follows:

	Yr CP1	Yr CP2	Yr 1 P1+2	Yr 2 P1+2	Yr 3 P1+2 (K'000)	Yr 4 P1+2	Yr 5 P1+2	Yr 6 P1+2
Foreign Exchange Outgoings								
Fixed assets	850	1950	-	-	-	-	-	-
Med/Long term interest	-	61	244	244	244	182	102	20
Other variable costs	36	36	443	495	562	630	662	713
Maintenance	5	5	194	234	274	316	356	356
Total outgoings	891	2052	881	973	1080	1128	1120	1089
Sales x 90%(=F/E savings)	-	182	2293	2593	2954	3310	3670	3759
Period Balance	-891	-1870	+1412	+1620	+1874	+2182	+2550	+2670
Cumulative Balance	-891	-2761	-1349	+271	+2145	+4327	+6877	+9547

It is clear that foreign exchange outgoings will be recouped by the end of the second year of production.

13.2 Other Economic Factors

Among the other factors to be taken into account the following are significant:

- the factory will employ 77 people on double shift and almost 100 on three shifts. It may be necessary to employ expatriates initially for the technical manager and laboratory technician posts, involving some costs in foreign exchange. Other management staff and some of the mechanics and clerks will be transferred from other firms in Zambia, rather than trained up within the project organisation. Otherwise the factory can be staffed by people at present unemployed or underemployed.

- some thousands of farmers will be given the opportunity to earn cash from cassava rather than grow it solely as a subsistence crop.

- both these circumstances should have a multiplier effect on employment in Northern Province, helping to counteract the drift towards urbanisation.

14. CONCLUSION

The industrial market in Zambia for starch, glucose and dextrins, derivable from cassava, is growing. It relies entirely on imports, and would welcome a Zambian source of supply, provided that quality requirements are met.

The prices which users are willing to pay, the volume of the market and the prospective factory costs combine to make the proposed project financially attractive. It would be economically beneficial, especially in saving foreign exchange.

The critical question is whether Zambian farmers in Northern Province can be induced to increase cassava output sufficiently to supply the project. The actions outlined in Chapter 11 are urgent.

If they are effective in stimulating production, we are confident that the proposed project will be successful.

Submitted for P-E International Operations Limited
by

D R Atkinson
Project Leader

PE

TERMS OF REFERENCE FOR CONSULTING SERVICES

Elaboration of an Integrated Cassava Processing Factory concept for the production of a variety of marketable cassava products supported by relevant economic calculations.

Responsibilities and Duties of the Contractor.

A. With regard to the field study work to be carried out in Zambia the contractor is expected to carry out the following activities:

a) Assess the existing situation in the agricultural cassava production sector with regard to the variety, quantity and quality of cassava tubers presently produced;

b) Assess and evaluate the organisational aspects and managerial situation in the agricultural cassava production sector and the marketing proceedings presently applied;

c) Study the planting, growing, harvesting and post-harvesting techniques presently applied;

d) Assess the infrastructural situation and comment on its suitability and/or requirements;

e) Study the present utilisation of cassava tubers in view of direct consumption, village-scale processing small-scale processing and industrial-scale processing and comment on its suitability;

f) Assess the domestic market situation and specify the cassava products presently available, with regard to variety, quality, quantity and price structure;

g) Evaluate the domestic market potential for cassava products and specify types, quality and quantity of cassava products expected to be in demand and outline their most practical price structure and development trends;

h) Evaluate the opportunities that exist in the country for exports of cassava products. Specify these products with regard to quality and quantity and estimate the expected export benefit derived therefrom;

i) Based on the assessments, evaluations and otherwise studies as mentioned above, specify the types, quantity and quality of the marketable products to be produced by the cassava processing factory to be defined and estimate the quantity and quality of the cassava tuber raw materials required for this purpose;

j) Comment on the present situation in the agricultural cassava production sector and based on the assessments mentioned under the paragraph a) to e) above define the action to be taken in order to make available the required cassava tuber raw materials as estimated under para i) above. Estimate the average cassava raw material costs;

k) Estimate the costs involved in the up-dating of the agricultural cassava production sector and outline the expected man power, equipment and other requirements;

l) Assess wages and salaries commonly paid in the country under review and the water and power costs.

B. <u>With regard to the elaboration of the cassava processing factory concept, the contractor is expected to carry out the following activities.</u>

a) Define the most suitable processing technology for the production of each of the cassava products to be produced and prepare relevant quantified process and product flow diagrams;

b) Integrate the different product and process flow diagrams in one overall process and product flow that characterises the processing technology of the cassava processing factory to be defined. By doing so, due consideration has to be given to the utilisation of the by-products and residues of one process by the other in order to guarantee the optimum utilisation of the cassava tuber raw material;

c) Based on the quantified flow diagrams specify the required equipment by using relevant equipment items from known processes that are available in the market;

d) Outline the engineering design in principle for such equipment that may not be available in the market and has to be newly developed in connection with the cassava processing factory concept to be defined;

e) Prepare principal factory lay-out plans and specify the pipings, fittings, motors and other electrical and mechanical installations that are required for the appropriate function of the cassava processing factory to be defined;

f) Outline the type and size of the required factory buildings that meets with the conditions that exist in the country under review and specify the type of building material most suitably to be used;

g) Specify the service requirements - if any - of the cassava processing factory such as for example repair and maintenance workshops, laboratory, storage facilities, spare-part stocks, steam boiler, main water pumps, etc. as well as the administrative facilities;

h) Specify the techno-economic data of the cassava processing factory such as manpower requirements, energy, steam, and water consumption figures and define the throughput capacity (raw material) and the production capacity (products);

i) Based on the results of the studies mentioned under A) above, outline those measures in details that need to be taken inorder to secure the required raw material supply to the factory, the production concept of which has been defined;

j) Elaborate a suitable practical management plan for the integrated cassava processing facte y concept starting with cassava production controls and raw material provisioning and ending with marketing operations thereby covering the entire production process of the cassava processing factory.

C) <u>With regard to the economic and financial calculations to be prepared in support of the proposed cassava processing factory concept, the contractor is expected to carry out the following activities.</u>

a) Estimate the investment costs for the entire cassava processing factory as outlined and defined (para B above);

b) Based on the raw material cost assessment (para A,j) above and the specifications prepared (para B,h) above estimate the expected operating costs;

c) On this basis (para C,b) above define the cassava raw material price limits and comment on the incentives derived therefrom fro the cassava production sector/farmers;

d) Prepare a plant investment and schedule of construction layout over one or more stages consisting of fixed assets (equipment, land, buildings, others), preliminary expenses (planning services, start-up expenses, others) working capital, interest and total investment cost over a reasonable period;

e) Estimate the required working capital, depreciation, replacement and residual values as wrll as annual income and capital structure if considered appropriate and prepare relevant cash flow calculations;

f) On this basis and by obtaining all other relevant data prepare a comprehensive economic feasibility analysis as a basis for investment considerations.

ORGANISATIONS AND COMPANIES INTERVIEWED

1. Interviewed on General, Marketing and Technical Subjects

National Commission for Development Planning

Ministry of Commerce and Industry

Ministry of Agriculture and Water Development
(Planning Unit; Mt Makulu Research Station;)

National Council for Scientific Research

National Nutrition Commission

Development Bank of Zambia Ltd

Indeco Ltd

Indeco Milling Ltd, Ndola

National Milling Co. Ltd, Lusaka

Zambia Breweries Ltd, Lusaka and Ndola

National Breweries Ltd, Kitwe

Supa Baking Co. Ltd, Lusaka

Kabwe Industrial Fabrics Ltd, Kabwe

National Drug Co. Ltd, Lusaka and Kabwe

General Pharmaceuticals Ltd, Kabwe

Duncan Gilbey & Matheson Ltd, Lusaka

Kafue Textiles Ltd.

Buhler Maig Zambia

Kabwe Textile Mills

Family Biscuits Ltd, Lusaka

Imco Ltd, Lusaka

Zambia Bottlers Ltd, Lusaka

Kamms, Makeni, Lusaka

Local Government and Lands

Brian Colquhoun, Hugh O'Donnell & Partners (Zambia)

PE

2. Individuals Interviewed by Agronomist Team

Provincial Agricultural Officer, Solwezi	K J Sinyangwe
Crop Husbandry Officer, Solwezi	W K Ngalande
District Secretary, Chizela,	Major Chisha
Marketing and Co-operatives Officer, Solwezi	E C Kamalamba
Planning Officer, Solwezi	J Hansen
Nutritional District Council, Kabompo	Miss R Iversen
IRDP, Kabompo	Dr J Pemle
Farm Management and Extension Officer, IRDP, Kabompo	M Galama
G.T.Z. Frankfurt, W.Germany	H D Drechsler
IRDP Control Unit, Lusaka	D N Siame
IRDP Co-ordinator, Kabompo	Dr U Weyl
Chairman District Council, Acting District Governor Kabompo	A Njambela
District Secretary, Kabompo, NWP	M Mukwamataba
Supervisor of Crop Trial Plots - IRDP, Kabompo, NWP	C Samukonga
IRDP Co-ordinator, Mpika, NP	D Pudsey
Horticultural Officer, Acting Provincial Agricultural Officer, Kasama	Mr Chibela
Provincial Land Use Planning Officer, Kasama	Mr Faeste
Officer in Charge, Misamfu Research Station, Kasama	O K Sinyangwe
Project Co-ordinator Agronomist, Misamfu Research Station, Kasama	H C Svads
IRDP Extension Training Officer, Kasama	H Moebjerg
Home Economics Officer, Kasama	Miss M Malama
Cartographer, MAWD, Kasama	G Chileshe
Mill Manager, Northern Co-operative Union, Kasama	Y I Umar
Assist Director, Mt Makulu Research Station, Lusaka	D M Naik
Assist Director, Mr Makulu Research Station, Lusaka	R Vernon
Livestock & Pest Research Centre, National Council for Scientific Research, Lusaka	Dr J B Jayasinghe
Cereals Co-ordinator, Mt Makulu Research Station, Lusaka	A Prior
Commercial Farmer, Ndola	C Gent
Commercial Farmer,Mkushi	A D Anderson
Economist, Planning Unit MAWD, Lusaka	B Baldwin
Agronomist, IRDP, Mpika	R Mellok

APPENDIX 3

PE

CROP INTAKE BY OFFICIAL MARKETING ORGANISATIONS IN ZAMBIA

Commodity	Unit of Quantity	Marketing Year Ending 30 April				
		1976-77	1977-78	1978-79	1979-80	1980-81
Bought by Namboard and PCUs						
White maize	90kg bag	8,333,022	7,738,347	6,462,847	3,732,879	4,247,404
Sunflower	50kg bag	319,291	266,413	151,027	238,371	[illegible]
S/G nuts	80kg bag	118,340	93,275	27,921	34,215	25,351
Paddy rice	80kg bag	26,162	23,256	36,565	23,156	22,665
Soya beans	90kg bag	6,714	14,151	13,186	14,387	39,233
Wheat	90kg bag	43,867	59,158	58,342	72,530	106,495
Barley	90kg bag	1,717	3,181	736	-	-
Mixed beans	90kg bag	1,872	2,119	294	2,981	29,995
Sugar beans	90kg bag	117	71	380	374	789
Velvet beans	90kg bag	208	71	102	227	256
Sorghum	90kg bag	1,175	8,881	9,094	1,661	1,038
Cow peas	90kg bag	189	175	114	54	130
Sunhemp	90kg bag	71	126	82	39	100
Finger millet	90kg bag	28	6	-	2	2,642
Bought by other State Bodies						
Seed cotton	kg	3,884,450	8,928,831	8,429,639	14,916,241	22,912,830
•Tea leaves	kg	10,168	81,446	144,120	249,279	313,858
•Roasted coffee	kg	32,692	43,947	77,225	23,911	28,096
+Sugar-cane	mt	779,611	691,369	774,811	887,515	919,717
Tobacco-Virginia	kg	6,262,492	5,588,072	3,703,608	4,590,567	4,126,679
Tobacco-Burley	kg	211,590	311,742	264,049	380,783	554,416

• refers to Calendar year 1976-77 means 1976 calendar year and so on

+ refers to Fiscal year ending 31 March

PESTS AND DISEASES OF CASSAVA IN ZAMBIA

PE

INTRODUCTION

Although a countrywide survey of the pest and disease situation has not been carried out, sufficient circumstantial evidence is available through reports and observation to suggest that a number of serious pests and diseases are present in Zambia. These must be seen to be responsible for significant yield losses and pose a serious threat to increased production. A better understanding of pests and diseases by the extension services could lead to an improvement of the current situation.

PESTS

The protracted dry season renders cassava prone to insect pests which thrive under dry conditions. A number of these colonise the cassava to draw their food requirements from the plant.

Scale Insects

Severe infestations by this pest were observed during the consultants' visit to Zambia, particularly at Misamfu Research Station, Kasama, in Northern Province. The insects resembled **Aonidomytilus albus** but proper identification should be carried out by a competent entomologist.

Heavy scale populations cover the stem and lateral buds. Sucking activities weaken the plant, cause defoliation and death to the stem apex, and may even kill young plants. Although wind dispersal is known to occur the pest is usually transmitted from crop to crop on infested cuttings. The scale population increases during dry periods: therefore crops of cassava planted late in the rainy season, thereby entering the dry season in an immature stage of development, are particularly prone to severe damage.

Some natural parasitism of the scale occurs, particularly by the coccinellid **Chilocorus distigma.** Avoidance of infested plants for use as planting material is the best method available to subsistence farmers. Applications of systemic insecticides to plants which will be used for planting material is recommended for those situations where cash is available. As a last resort, infested cuttings can be dipped in insecticide but even after killing the scales, the performance of the cutting may be poor.

Mealybugs. This important pest has been reported in Northern Zambia and again is favoured by the dry season. High mealybug infestations are reported to cause severe problems to the cassava plant. Initially attacking the terminal area of the shoots, the insects invade older parts of the shoot, petioles and leaves when population pressure becomes severe. The damage to the plant is done in two ways; by sucking sap and by introducing an unidentified substance into the plant during sap-sucking which causes stunting of the shoot. Heavy populations result in gross distortion of the shoot apex, die-back and in severe cases death of the plant. The causative organism **Phenacoccus Manioti** is believed to have been introduced to Africa from S. America.

The insect pest is dispersed on infested planting material or by wind. Control by chemical methods through the dipping of cuttings is the only sure method of combatting the pest. No natural predators are known which are effective at low-level mealybug populations. Farmers can reduce potential damage by the pest by planting early in the rainy season to ensure that the crop is well established and thus better equipped to withstand an attack during the dry season.

Termites. These insect pests attack cuttings, young plants and even root-tubers in extreme cases. The severity of the attack is related to the length of the drought, and plants established late in the rainy season are particularly prone to attack. Wilted shoots and dead plants are the symptoms of termite attack. The tubers of apparently healthy plants may be found to have been hollowed out by termites on harvesting. Very high losses are reported when cuttings are planted into termite infested soils during dry periods. Insecticide treatment to cuttings by dipping or dusting has been shown to be an effective method of protection.

Whiteflies. Although not considered to be an economic pest of cassava per se, the whitefly **Bemisia tabaci** (and other **Bemisia spp**) have been observed on cassava in Zambia. The importance of this pest is related to its suggested role as vector of African Mosaic Disease.

DISEASES

Cassava Mosaic Disease. This is the major disease of cassava in Africa and is endemic throughout the continent, Zambia included. Believed to be caused by a virus (or a complex of viruses) transmitted by the whitefly (**Bemisia** spp), the disease causes considerable losses. Depending on the severity of infection the symptoms vary from mild yellowish mottling of leaves to severe leaf distortion and yellow areas. Leaves are reduced in size by severe infections and root yields may be reduced by as much as 80 percent depending on the cultivar grown. Differing degrees of resistance to the disease are known, and the use of those showing high degrees of resistance is a recommended method of combatting the disease. Recent research indicates that roguing infected plants may hold promise as a means of preventing the serious build-up of the disease in clean plantations.

Cassava Bacterial Blight. This disease is reported in the Northern Province and is caused by **Xanthomonas Manihotis.** The organism causes water-soaked angular spots on leaves which may develop into more serious symptons including blight, wilt, defoliation and stem die-back. Exudation of gum from leaf veins, petioles and immature stem may also occur. As the disease is caused by a vascular pathogen, it can move throughout the plant even to the roots. Similarly the disease is passed from year to year by the use of infected planting material cut from plants with the disease. Infection from diseased plants to healthy plants within a crop is by rain splash or on contaminated hand tools, clothing etc. Varieties showing high levels of resistance to the disease are known and are recommended in countries where available. Cuttings from healthy plants should be used as planting material where possible.

Methods are available for the production of disease-free cuttings from diseased plants, and can be used where otherwise healthy material is not available.*

FROST DAMAGE

Although frosts are predictable during most years in many parts of Zambia, especially the Central and Southern Plateau areas, occasional frosts may occur all over the country. Mild frost affects cassava by causing bronzing of the leaves. As the severity of the frost increases its effects on the plant increase from leaf scorch, defoliation, stem-tip, die-back, to total death of above-ground parts of the plant. Providing the soil does not freeze the cassava plant will survive air frosts of -10^{0}C. Even though all the above-ground parts of the plant will be killed, growth is resumed from buds on the stem base or planting piece below soil level.

Frosted cassava which has been defoliated and the green-portions of the stem killed resemble those severely attacked by cassava bacterial blight or **Phoma** spp. Some reports of these diseases in Zambia may have been caused by frost.

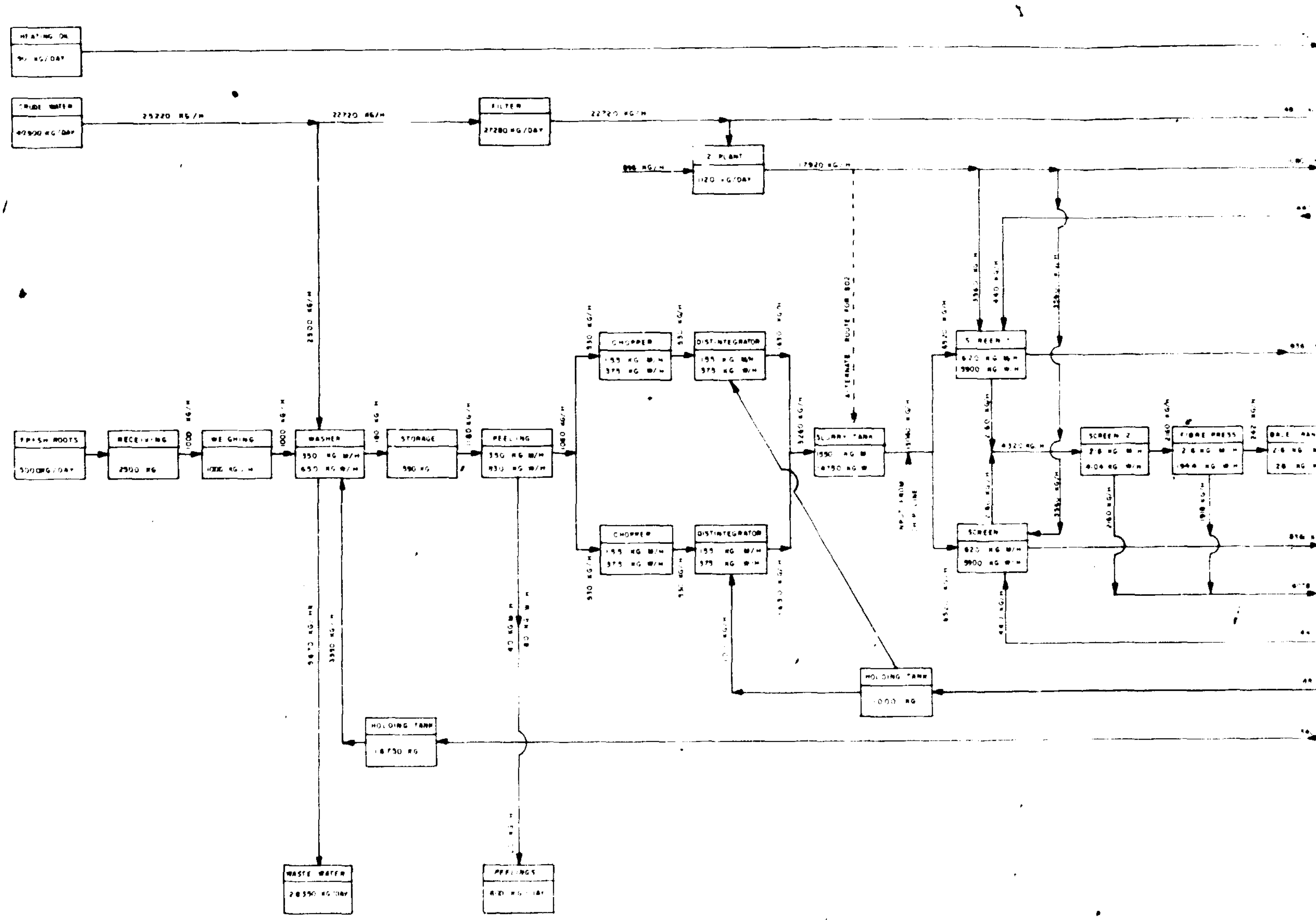
OTHER PESTS AND DISEASES

Pests and diseases other than those described above may occur in Zambia, but no reports are available.

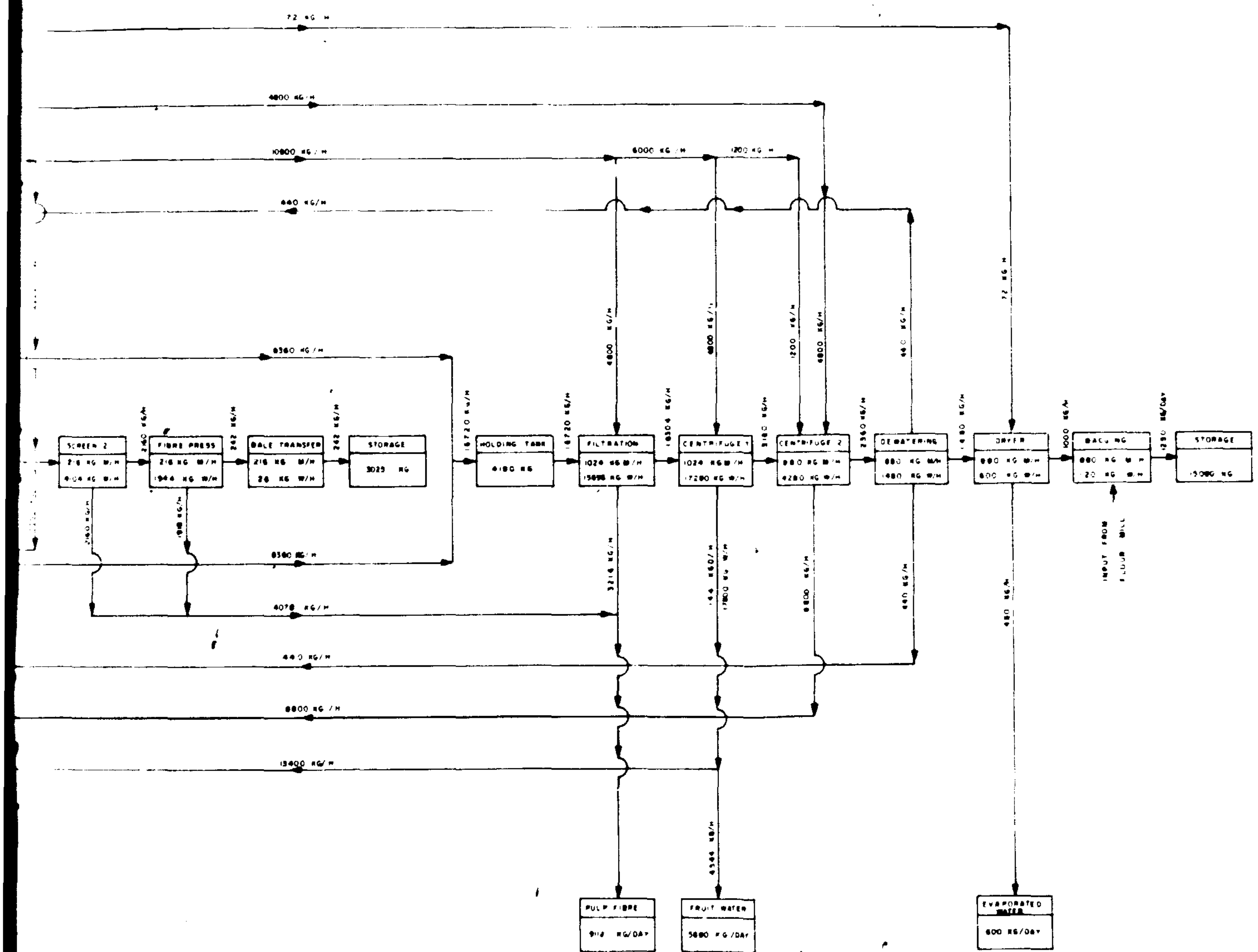
They may occur in neighbouring countries and can be expected to spread into Zambia. One such example is the pest 'green spider mite'. This pest was introduced by accident from the Americas to Uganda and is spreading to many parts of Central West and East Africa. The mite is particularly severe in areas with long dry seasons and its activities in the growing point and developing leaves at the stem apex, cause a severe reduction in leaf size. This results in poorer yields. The Zambian authorities should be on the lookout for the appearance of this pest.

***Footnote:**

Ref: 'The International Exchange and Testing of Cassava Germ Plasma in Africa edited Eugene Terry & Reginald Macintyre; pub'd 1975 by International Development Research Centre.


HEATING OIL
CRUDE WATER
FILTER
FRESH ROOTS
RECEIVING
2500 KG
WEIGHING
WASHER
STORAGE
PEELING
CHOPPER
DISTINTEGRATOR
SLURRY TANK
SCREEN
SCREEN 2
FIBRE PRESS
HOLDING TANK
WASTE WATER
PEELINGS
ALTERNATE ROUTE FOR SO2

SECTION 1



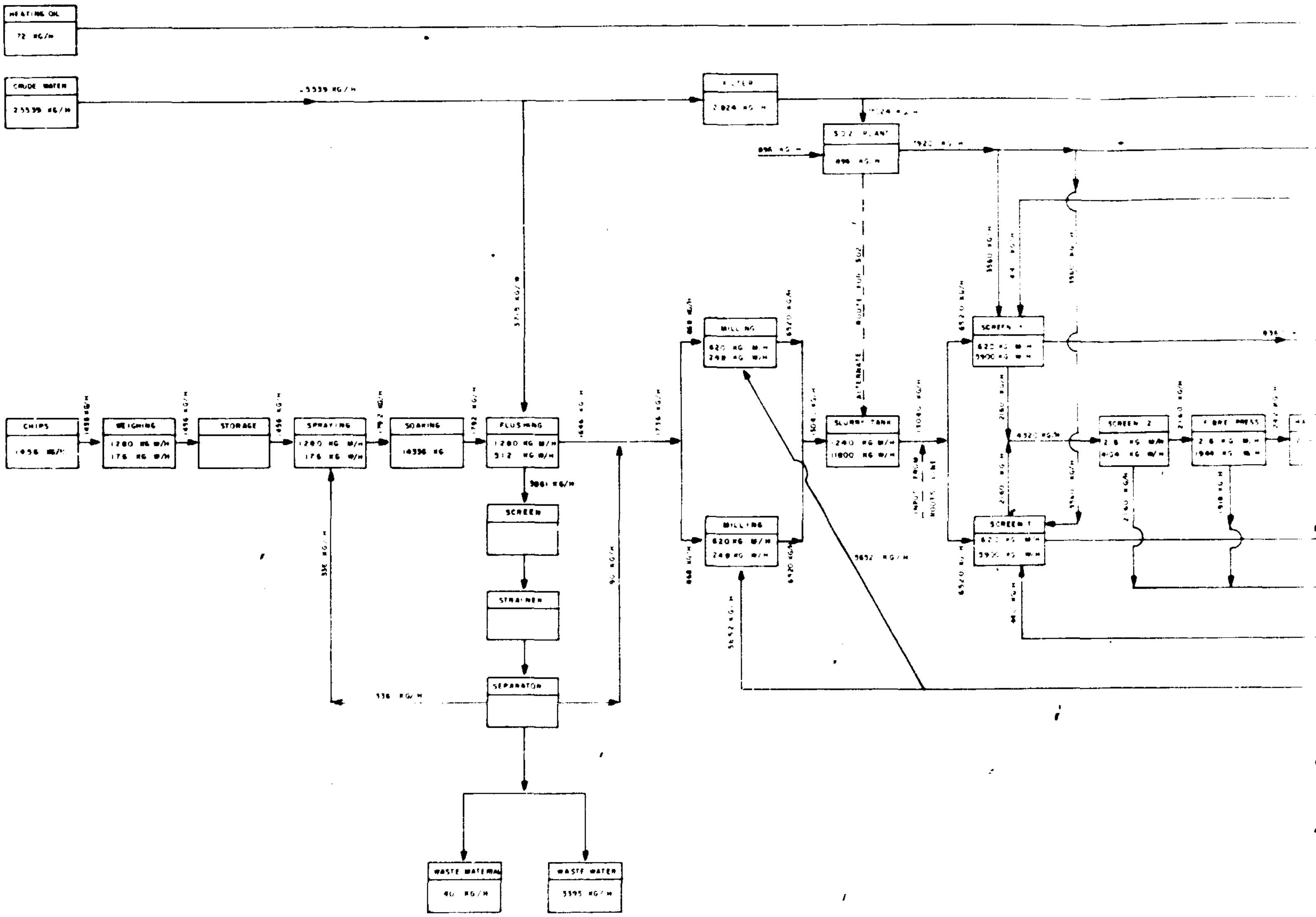
W - DRY MATTER
W - WATER

THROUGHPUT BASED ON ROOT INPUT OVER 5HRS AND CONVERSION AFTER SLURRY TANK IN 1 1/4 HRS TO GIVE STARCH OUTPUT OF 1 TONNE/HR

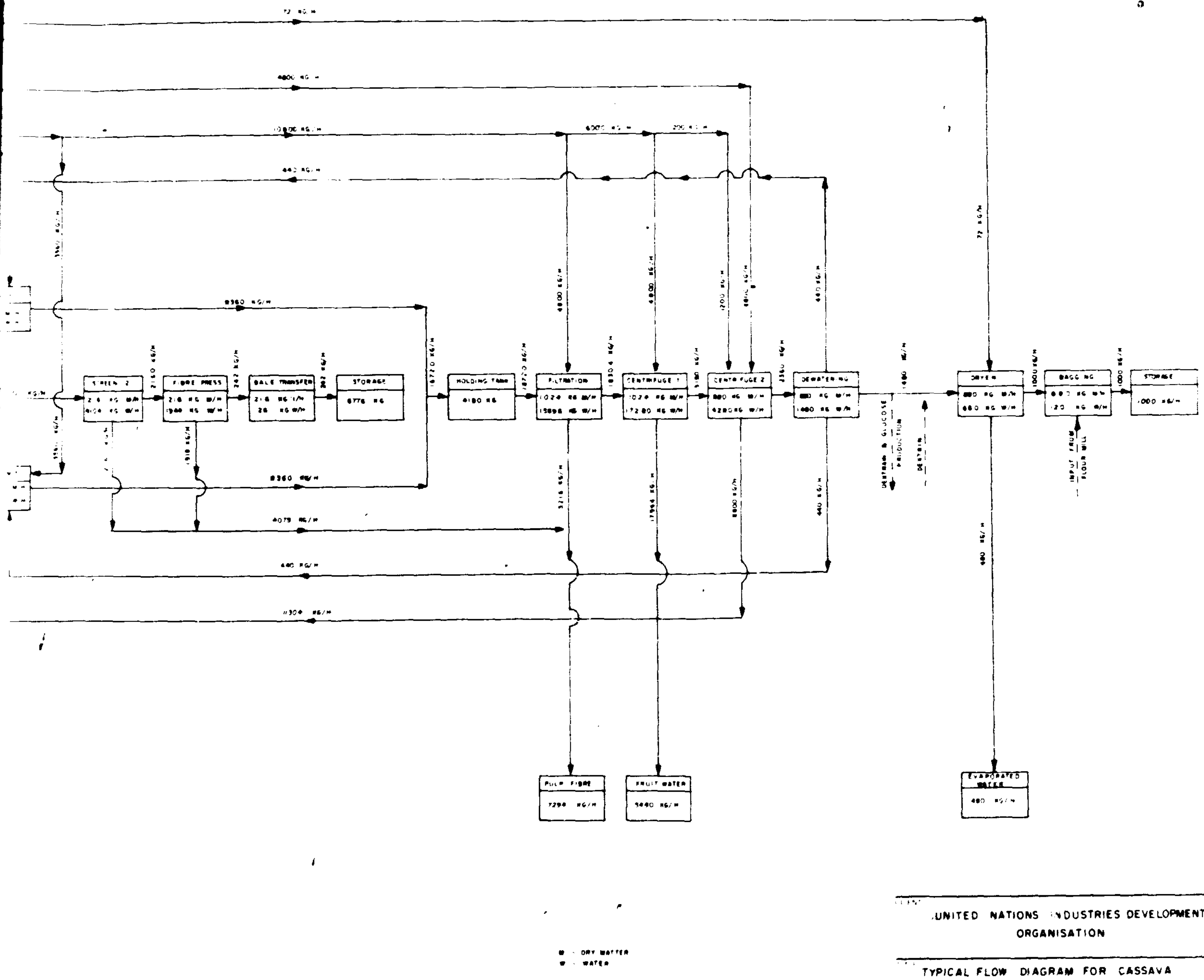
CLIENT	UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION
TITLE	TYPICAL FLOW DIAGRAM FOR CASSAVA STARCH PLANT EXTRACTED FROM ROOTS
SCALE / DRAWN / DATE	RWW — MARCH 82
JOB / DRAWING / REVISION	0290851 — 1

The P E Consulting Group

SECTION 2


HEATING OIL
72 KG/H
CRUDE WATER
25539 KG/H
FILTER
SO2 PLANT
896 KG/H
CHIPS
1456 KG/H
WEIGHING
1280 KG W/H
176 KG W/H
STORAGE
SPRAYING
1280 KG W/H
176 KG W/H
SOAKING
14336 KG
FLUSHING
1280 KG W/H
512 KG W/H
SCREEN
STRAINER
SEPARATOR
336 KG/H
WASTE MATERIAL
40 KG/H
WASTE WATER
3395 KG/H
MILLING
620 KG W/H
248 KG W/H
ALTERNATE ROUTE FOR SO2
SLURRY TANK
1240 KG W/H
11800 KG W/H
INPUT FROM ROUTE LINE
SCREEN 1
SCREEN 2
FIBRE PRESS

SECTION 1



UNITED NATIONS INDUSTRIES DEVELOPMENT ORGANISATION

TYPICAL FLOW DIAGRAM FOR CASSAVA STARCH PLANT EXTRACTED FROM CHIPS

—	R W W	MARCH 82
0290851	2	

The P E Consulting Group

SECTION 2

PE

LIST OF MACHINERY REQUIRED FOR PROPOSED FACTORY

A. STARCH EXTRACTION - Fresh Roots and Chips

2 x Conveyor/Elevator
1 x Washer
2 x Chopper
2 x Rasping Machine
2 x Elevator
2 x Hopper
2 x Dosage Screw
1 x Disintegrator
1 x Pump
2 x Slurry Tank with paddle
1 x Starch Separator
1 x Pump
1 x Starch Separator
1 x Cyclone for sand extraction
1 x Separator
1 x Pump
1 x Separator
1 x Pump
1 x Vacuum Filter with feed tank
1 x Screw conveyor
1 x Flash drier
1 x Screen/Sieve
1 x Starch Bulk Silo
1 x Bagging Machine
1 x Sewing Machine
1 x Conveyor

PE

B. GLUCOSE PRODUCTION

1 x Pump
1 x Balance Tank/Starch Suspension Tank
1 x Acid Tank
1 x Vacuum Filter with feed tank
1 x Pump
1 x Water Tank
1 x Flow Meter
1 x Pump
1 x Water Heater
1 x Plate Heat Exchanger
1 x Centrifugal Heat Exchanger
1 x Monopump and Filter
1 x Temperature Recorder
1 x Plate Heat Exchanger (cooler)
1 x Expansion Chamber
1 x pH Meter
1 x Caustic Tank
1 x Pump
1 x Filter/Clarifier
1 x Holding Tank
1 x Filling Machine
1 x Drum Filling & Weighing Machine

C. DEXTRIN PRODUCTION

1 x Conveyor Elevator
1 x Reactor Vessel
1 x Pump
1 x Acid Tank
1 x Pump
1 x Water
1 x Conveyor
1 x Sifter
1 x Conveyor
1 x Bulk Store/Bin
1 x Bagging Machine
1 x Sack Sewing

D. UTILITIES REQUIRED

1 x Boiler
1 x Sulphur Dioxide Plant
1 x Hydrochloric Acid Plant
1 x Caustic Soda Mixing Plant
1 x Effluent Treatment Plant (Civil engineering)
Process Piping
Process Control Systems
Utility Piping
Electrical Works and Cable
Building Materials
Spare parts, workshop and store.

1. DETAILS OF MACHINERY MANUFACTURERS ABLE TO PROVIDE TURNKEY FACTORIES

PE

	NAME & ADDRESS OF COMPANY	COMMENTS
1.	ALFA LAVAL AB POSTFACK S14700 TUMBA, SWEDEN	Complete starch plants from cassava using centrifugal process. Fresh roots to starch only.
2.	HOVEX ENGINEERING LIMITED AE - KADE 35a P O BOX 105 VEENDAM, HOLLAND	Complete engineering design and installation of starch factories.
3.	KOMATSUGAWA CHEMICAL ENGINEERING COMPANY LIMITED 5F TMM BUILDING NO. 10-5, 1-CHOME IWAMOTO-CHO CHIYODA-KU TOKYO,101, JAPAN	Consulting engineering and project preparation.
4.	NIVOBA POSTBUS 40 9640 VEENDAM, HOLLAND	Compact containerised starch plants. Considerable experience of cassava processing especially from dried chips. Also glucose and dextrin plants.
5.	NEWELL DUNFORD ENGINEERING LTD NEWELL DUNFORD HOUSE PORTSMOUTH ROAD SURBITON SURREY UK	Complete gari manufacturing plants on turnkey basis. Little experience of starch production.
6.	PROJECTS DEVELOPMENT INSTITUTE (PRODA) 3 INDEPENDENCE LAYOUT P O BOX 609 ENUGU, NIGERIA	Design and fabrication of equipment for processing raw cassava into gari.
7.	SALZGITTER INDUSTRIEBAU GmbH POSTFACH 411169 3320 SALZGITTER 41 F R GERMANY	Complete starch glucose and dextrin plants from fresh cassava.
8.	STARCOSA GmbH POSTFACH 5105 AM ALLEN BALMHOF 5 D 3300 BRAUNSCHWEIG F R GERMANY	Cassava flour plants and complete starch plants.
9.	UBERSEE-TECHNIK RODINGSMARKT 29 2000 HAMBURG 11 F R GERMANY	Planning and erection of industrial plant, specialising in equipment for the production of starch, and starch derivatives.

2. LIST OF MANUFACTURERS WITH EXPERIENCE OF THE SUPPLY OF SOME MACHINERY

PE

	NAME & ADDRESS OF COMPANY	COMMENTS
1.	ANHYDRO A/S OSTMARKEN 8 DK-2860 SOBORG-COPENHAGEN DENMARK	Flash driers for starch drying only.
2.	A P V MITCHELL 30 THORNTON ROAD THORNTON HEATH SURREY UK	Driers for starch and complete design engineering for glucose factories
3.	BERNAUER SECADORES INDUSTRIAIS LTDA CIAXA POSTAL 37[illegible]8 SAO PAULO BRAZIL, S AMERICA	Manufacture and installation of driers. Flash fluid bed, rotary conveyor and bin dryers.
4.	BRITISH ARKADY CO LTD ARKADY SOYA MILLS OLD TRAFFORD MANCHESTER M16 ONJ UK	Mixers for dough making using cassava flour.
5.	BUELL LTD GEORGE STREET PARADE BIRMINGHAM B3 1QQ UK	Thermal drying of freshly harvested raw roots for pellet production.
6.	BUHLER-MAIG 19 STATION ROAD NEW BARNET HERTFORDSHIRE UK *(Also HQ in Germany)*	Pelletising of chips for feed and milling of dried chips
7.	NOVO INDUSTRI A/S NOVO ALLE DK 2880 BAGSVAERD DENMARK	Enzymes for hydrolysis of starch to modified products. Have process know-how especially ethanol and alcohol production.
8.	ROSIN ENGINEERING COMPANY 35/37 WILLIAM ROAD LONDON NW1 3ER UK	Drier manufacturers with experience of starch production from cassava.
9.	RONCAGLIA SpA MILLING ENGINEERING WORKS P O BOX 519 41100 MODENA ITALY	Flour milling and sifting machinery. Some experience of tapioca industry.
10.	WESTFALIA SEPARATOR AG D 4740 OELDE/WEST F WERNER-BABIG STR W GERMANY	Separators and decanters for starch separation.

BUDGET COSTINGS ERECTED IN ZAMBIA IN STERLING

A.	STARCH EXTRACTION (see list)	579,000
B	GLUCOSE PRODUCTION	512,000
C.	DEXTRIN PRODUCTION	200,000
D.	UTILITIES (Part included in buildings)	268,000
E.	BUILDINGS & CIVILS & HOUSING	412,000
		1,971,000

PE

FINANCIAL REPORTS MULTI-PRODUCT FACTORY

REPORT : 1 : SCENARIO 1

CASSAVA FACTORY:THROUGHPUT

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
1 QUANTITY:TONNES																
2 xxxxxxxxxxxxxxxxxx																
3D ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
4D YIELD RSL TO RST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
5 ROOT SLURRY	T	0.0	156.2	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7
6D YIELD R TO RSL	%	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260
7 ROOTS INPUT	T	0.0	60.1	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6
8																
9D CHIP STARCH SOLD	T	35	35	207	252	297	342	387	432	477	522	567	612	612	612	612
10D YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
11 CHIP SLURRY	T	364.6	364.6	2156	2625	3094	3562	4031	4500	4969	5437	5906	6375	6375	6375	6375
12D YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
13 CHIPS INPUT CST	T	52.1	52.1	308.0	375.0	442.0	508.9	575.9	642.9	709.8	776.8	843.7	910.7	910.7	910.7	910.7
8																
14D GLUCOSE SOLD	T	133	133	800	800	850	900	950	1000	1050	1100	1150	1200	1200	1200	1200
15D YIELD CST TO G	%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
16 CHIP STARCH G	T	133.0	133.0	800.0	800.0	850.0	900.0	950.0	1000	1050	1100	1150	1200	1200	1200	1200
10D YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
17 CHIP SLURRY G	T	1385	1385	8333	8333	8854	9375	9896	10417	10937	11458	11979	12500	12500	12500	12500
12D YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
18 CHIPS INPUT G	T	197.9	197.9	1190	1190	1265	1339	1414	1488	1562	1637	1711	1786	1786	1786	1786
8																
19D DEXTRIN SOLD	T	13	13	80	80	85	90	95	100	105	110	115	120	120	120	120
20D YIELD CST TO D	%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
21 CHIP STARCH D	T	13.0	13.0	80.0	80.0	85.0	90.0	95.0	100.0	105.0	110.0	115.0	120.0	120.0	120.0	120.0
10D YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
22 CHIP SLURRY D	T	135.4	135.4	833.3	833.3	885.4	937.5	989.6	1042	1094	1146	1198	1250	1250	1250	1250
12D YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
23 CHIPS INPUT D	T	19.3	19.3	119.0	119.0	126.5	133.9	141.4	148.8	156.2	163.7	171.1	178.6	178.6	178.6	178.6
8																
24 TOTAL CHIPS INPUT	T	269.3	269.3	1618	1685	1833	1982	2131	2280	2429	2577	2726	2875	2875	2875	2875
8																
25 TOTAL STARCH PROD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
8																
26 TOTAL STARCH SOLD	T	35.0	50.0	300.0	345.0	390.0	435.0	480.0	525.0	570.0	615.0	660.0	705.0	705.0	705.0	705.0
8																
28 TOTAL CHIP SLURRY	T	1885	1885	11323	11792	12833	13375	14917	15958	17000	18042	19083	20125	20125	20125	20125
8																
29 TOTAL CHIP STARCH	T	181.0	181.0	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
27 ==================		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

Report 1A

The model is primarily "driven" by the sales forecast. The quantity sales for each product may be seen in rows 3,9, 14, and 19.

Given the sales forecast this section of the model takes the sales forecast and calculates the tonnage of cassava roots and chips required to produce that quantity, using the conversion factors shown in each subsection. These conversion factors are based on the technical data described in technical section of the report.

It will be noted that over and above basic raw materials the model also calculates throughput of the two main stages of the factory ie slurry production and starch production. This is used in report three to assess the factory loading.

It will be noted that sales are apparently made during the construction period. This is done to generate costs for trial runs and chip purchases in season. By the simple device of valuing such sales at zero price, one months costs are automatically written off to developmental expenses in Period Yr.C 1. A further months chip stocks are raised as stock in the working capital routine. In period Yr.C 2 a further one month's sales are also raised to boost the cost loads on trial runs. The sales are however allowed to stand as revenue earning on the basis that having generated approximately three months' production resources they will produce one month's (ie 33⅓%) saleable product. Note that root starch production is only generated in period Yr C P2. since roots must be procured fresh. (ie purchased and processed at the same time). Sales are valued at 50% to give a realistic saleable product outturn. This is expected to be higher than the chip starch outturn since root starch will be produced in the final trial month period.

REPORT [illegible]
SCENARIO 1

CASSAVA FACTORY:VALUE OF INPUTS/OUTPUTS

		YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
VALUE:INPUTS																
ROOT PRICE	$/T	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
ROOTS CONSUMED		0	[illegible]	37	37	37	37	37	37	37	37	37	37	37	37	37
CHIP PRICE	$/T	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
CHIPS CONSUMED		54	54	324	337	367	396	426	456	486	515	545	575	575	575	575
TOTAL DIR MATERIALS		54	60	361	374	404	434	463	493	523	553	582	612	612	612	612
VALUE:OUTPUTS																
RST PRICE	$/T	0	400	800	800	800	800	800	800	800	800	800	800	800	800	800
ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
ROOT STARCH		0	6	74	74	74	74	74	74	74	74	74	74	74	74	74
CST PRICE	$/T	0	800	800	800	800	800	800	800	800	800	800	800	800	800	800
CHIP STARCH SOLD	T	30	35	207	252	297	342	387	432	477	522	567	612	612	612	612
CHIP STARCH		0	28	166	202	238	274	310	346	382	418	454	490	490	490	490
GLUCOSE PRICE	$/T	[illegible]	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
GLUCOSE SOLD	T	133	133	800	800	850	900	950	1000	1050	1100	1150	1200	1200	1200	1200
CHIP GLUCOSE		0	146	880	880	935	990	1045	1100	1155	1210	1265	1320	1320	1320	1320
DEXTRIN PRICE	$/T	0	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
DEXTRIN SOLD	T	[illegible]	13	80	80	85	90	95	100	105	110	115	120	120	120	120
CHIP DEXTRIN		0	22	136	136	145	153	162	170	179	187	196	204	204	204	204
TOTAL SALES		0	202	1256	1292	1392	1491	1591	1690	1790	1889	1989	2088	2088	2088	2088

Report 2A

This report takes the physical quantities in report 1 and converts them to purchases and sales values using agreed prices. Note that the root starch price changes as explained in Appendix 1A and that glucose sales prices have been uplifted by the drum costs. Drum costs are to be recharged to customers and the model approach, showing a higher sale price on the one side, and a materials cost in the variable expenses, ensures that adequate stocks are generated in the working capital routines.

REPORT 5.1
SCENARIO 1

CASSAVA FACTORY : OPERATING TIMES

	YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
PROCESSING TO RSL															
ROOT SLURRY T	0.0	156.2	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7
PROCESS RATE/HOUR	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
52 HOURS REQUIRED	0	12	75	75	75	75	75	75	75	75	75	75	75	75	75
53D HOURS PER SHIFT	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK	10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
55 WEEKS REQUIRED	0.0	0.2	1.1	1.1	1.1	1.1	1.1	1.1	0.7	0.7	0.7	0.7	0.7	0.7	0.7
56D WEEKS PER PERIOD	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
57 PROCESSING:RSL TO RST															
ROOT STARCH SOLD T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
58D PROCESS RATE/HOUR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
59 HOURS REQUIRED	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
53D HOURS PER SHIFT	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK	10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
60 WEEKS REQUIRED	0.0	0.2	1.3	1.3	1.3	1.3	1.3	1.3	0.8	0.8	0.8	0.8	0.8	0.8	0.8
56D WEEKS PER PERIOD	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
61 PROCESSING TO CSL															
TOTAL CHIP SLURRY T	1885	1885	11323	11792	12833	13875	14917	15958	17000	18042	19083	20125	20125	20125	20125
52D PROCESS RATE/HOUR	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
63 HOURS REQUIRED	145	145	871	[illegible]	987	1067	1147	1228	1308	1388	1468	1548	1548	1548	1548
53D HOURS PER SHIFT	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK	10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
64 WEEKS REQUIRED	2.1	2.1	12.4	13.0	14.1	15.2	16.4	17.5	11.6	12.3	13.0	13.8	13.8	13.8	13.8
56D WEEKS PER PERIOD	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
65 PROCESSING:CSL TO CST															
TOTAL CHIP STARCH T	181.0	181.0	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
58D PROCESS RATE/HOUR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
67 HOURS REQUIRED	181	181	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
53D HOURS PER SHIFT	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK	10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
68 WEEKS REQUIRED	2.6	2.6	15.5	16.2	17.6	19.0	20.5	21.9	[illegible]	15.4	16.3	17.2	17.2	17.2	17.2
56D WEEKS PER PERIOD	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
69 PROCESSING:CST TO G															
GLUCOSE SOLD T	133	133	800	800	850	900	950	1000	1000	1100	1150	1200	1200	1200	1200
PROCESS RATE/HOUR	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
71 HOURS REQUIRED	133	133	800	800	850	900	950	1000	1050	1100	1150	1200	1200	1200	1200
53D HOURS PER SHIFT	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK	10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
72 WEEKS REQUIRED	1.9	1.9	11.4	11.4	12.1	12.9	13.6	14.3	9.3	9.8	10.2	10.7	10.7	10.7	10.7
56D WEEKS PER PERIOD	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
73 PROCESSING:CST TO D															
DEXTRIN SOLD T	13	13	80	80	85	90	95	100	105	110	115	120	120	120	120
74D PROCESS RATE/HOUR	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
75 HOURS REQUIRED	81	81	500	500	531	563	594	625	656	688	719	750	750	750	750
53D HOURS PER SHIFT	7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
54D SHIFTS PER WEEK	10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
76 WEEKS REQUIRED	1.2	1.2	7.1	7.1	7.6	8.0	8.5	8.9	5.8	6.1	6.4	6.7	6.7	6.7	6.7
56D WEEKS PER PERIOD	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24

Report 3A

This routine is included to enable us to judge the factory load factors. The dextrin and glucose lines are separate to the main stream and have adequate capacity to process their offtake from the main line.

The critical process is slurry to starch by a small margin and to this must be added the element of the utilisation by the root starch production. Thus, maximum load is the sum of rows 60 and 68. This is reached in year 3 P2 after which the third shift is brought in.

Maximum capacity is conservatively set by assuming that the 1.25 tonne line has a practical operating optimum of 1 tonne per hour.

Shift hours are assumed to be as follows:

> 2 shift working = gross 16 hours
>
> less changeover, start up and closedown = nett 14 hours.
>
> 3 shift working = gross 24 hours
>
> less changeover etc = nett 22½ hours
>
> (NB - the print out rounds up to 8 hours per shift but the model calculates on the actual of 7½ hours).

REPORT 4.1 SCENARIO 1

CASSAVA FACTORY:OTHER VARIABLE COSTS

		YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
80	ELECTRICITY															
2	******************															
25	TOTAL STARCH PROD T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
510	UNITS PER TONNE	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
520	RATE PER UNIT	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
53	ELECTRICITY-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
34	WATER															
2	******************															
25	TOTAL STARCH PROD T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
350	LT.000 PER TONNE	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
360	RATE PER 000LITRE	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30
37	WATER-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
38	FUEL															
2	******************															
25	TOTAL STARCH PROD T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
890	LITRES PER TONNE	132	132	132	132	132	132	132	132	132	132	132	132	132	132	132
900	RATE PER LITRE	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
91	FUEL	12	13	81	84	91	98	105	112	118	125	132	139	139	139	139
92	CHEMICALS															
2	******************															
140	GLUCOSE SOLD T	133	133	800	800	850	900	950	1000	1050	1100	1150	1200	1200	1200	1200
930	EST.KGS PER TONNE	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
940	COST PER KG.	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
95	CHEMICALS	2	2	12	12	13	14	14	15	16	17	17	18	18	18	18
100	PACKING MATERIALS															
2	******************															
35	TOTAL STARCH SOLD T	35.0	50.0	300.0	345.0	390.0	435.0	480.0	525.0	570.0	615.0	660.0	705.0	705.0	705.0	705.0
1010	BAG UNIT WEIGHT KG	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
1020	BAG UNIT COST	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
103	TOTAL BAG COST S	1	2	12	14	16	17	19	21	23	25	26	28	28	28	28
140	GLUCOSE SOLD T	133	133	800	800	850	900	950	1000	1050	1100	1150	1200	1200	1200	1200
1040	DRUM UNIT WEIGHT KG	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
1050	DRUM UNIT COST	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
106	TOTAL DRUMS COST	20	20	120	120	128	135	143	150	158	165	173	180	180	180	180
190	DEXTRIN SOLD T	13	13	80	80	85	90	95	100	105	110	115	120	120	120	120
1070	BAG UNIT WEIGHT KG	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
1080	BAG UNIT COST	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
107	TOTAL BAGS COST	1	1	3	3	3	4	4	4	4	4	5	5	5	5	5
110	PACKING MATERIALS	22	22	135	137	147	156	166	175	185	194	204	213	213	213	213

Report 4A

In expressing the variable costs and given that quantity figures, especially of electricity and water are so high the units per tonne and prices are equal to 000's units where appropriate.

Note that drum costs are generated by the programme. This is a contra in the profit and loss account with the infiated sales price. This ensures stock of drums are created for the working capital requirements.

REPORT 5 : CASSAVA FACTORY:FIXED ASSET MAINT/DEPR

SCENARIO 1

			YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
115	FIXED ASSET COST																
	XXXXXXXXXXXXXXXXXX																
116D	LAND		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
117D	FACTORY BUILDINGS		375	500	500	500	500	500	500	500	500	500	500	500	500	500	500
118D	PLANT & EQUIPMENT		600	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400
119D	VEHICLES		70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
120D	HOUSING		185	250	250	250	250	250	250	250	250	250	250	250	250	250	250
122	TOTAL COST		1255	3245	3245	3245	3245	3245	3245	3245	3245	3245	3245	3245	3245	3245	3245
123D	LAND	MNT/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
124D	FACTORY BUILD	MNT/RT	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5
125D	PLANT	MNT/RT	0.0	0.0	10.0	10.0	12.5	12.5	15.0	15.0	17.5	17.5	20.0	20.0	20.0	20.0	20.0
126D	VEHICLES	MNT/RT	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
127D	HOUSING	MNT/RT	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5
128	MAINTENANCE		7	7	146	146	176	176	206	206	236	236	266	266	266	266	266
129D	LAND	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130D	FACTORY BUILD	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131D	PLANT	DEP/RT	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10
132D	VEHICLES	DEP/RT	0	0	20	20	20	20	20	20	20	20	20	20	20	20	20
133D	HOUSING	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
134	DEPRECIATION		0	0	127	127	127	127	127	127	127	127	127	127	127	127	127
135	TOTAL CUM DEP		0	0	127	254	381	508	635	762	889	1016	1143	1270	1397	1524	1651
141	NET FIXED ASSETS		1258	3245	3118	2991	2564	2737	2610	2483	2356	2229	2102	1975	1848	1721	1594

Report 5A

This routine assembles the maintenance and depreciation costs on fixed assets. Note that no depreciation costs are raised in the construction period and that only maintenance of vehicles is charged in this period.

After due thought it has been assumed that given a reasonable maintenance expenditure buildings should not be depreciated. In the case of plant and machinery it is assumed that the initial cost will include a supply of spares and that maintenance cost will rise progressively over the first five years levelling off at 20% per annum from year five onwards.

REPORT 6 1 CASSAVA FACTORY:WORKING CAPITAL

SCENARIO 1

			YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
145D	ROOT WEIGHT	T	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
31D	ROOT PRICE	$/T	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
146	ROOT VALUE		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5																	
147D	CHIP WEIGHT	T	269	45	1618	281	1833	330	2131	380	2427	430	2726	479	2875	479	2875
33D	CHIP PRICE	$/T	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
148	CHIP VALUE		54	9	324	56	367	66	426	76	486	86	545	96	575	96	575
8																	
110	PACKING MATERIALS		22	22	135	137	147	156	166	175	185	194	204	213	213	213	213
143D	STOCK PERIOD %		50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
144	PACKING MATS VALUE		11	11	68	69	73	78	83	88	92	97	102	107	107	107	107
8																	
45	TOTAL SALES		0	202	1256	1292	1392	1491	1591	1690	1790	1889	1989	2088	2088	2088	2088
152D	STOCK WEEKS HLF YR		0	2	4	4	4	4	4	4	4	4	4	4	4	4	4
153	FINISHED GOODS VALUE		0	16	193	199	214	229	245	260	275	291	306	321	321	321	321
9																	
154	TOTAL STOCKS		65	36	585	324	654	374	754	424	854	474	953	524	1003	524	1003
27	====================		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
155D	DEBTORS WEEKS HLF YR		0	4	6	6	6	6	6	6	6	6	6	6	6	6	6
156	DEBTORS/PREPAYMENTS		0	31	290	298	321	344	367	390	413	436	459	482	482	482	482
27	====================		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
157D	CASH PERIOD HLF YR		0	0	2	2	2	2	2	2	2	2	2	2	2	2	2
158	CASH		54	54	9	324	56	367	66	426	76	486	86	545	96	575	96
27	====================		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======
35	TOTAL DIR MATERIALS		54	66	361	374	404	434	463	493	523	553	582	612	612	612	612
160D	CREDITORS WEEKS HF Y		0	0	6	6	6	6	6	6	6	6	6	6	6	6	6
161	CREDITORS/ACCRUALS		0	0	83	86	93	100	107	114	121	128	134	141	141	141	141
27	====================		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

Report 6A

The working capital requirements of agro-industrial units are frequently complicated by the need for seasonal buying of raw materials. The model is constructed to cope with the particular problems of the cassava market.

Period 1 July to December the majority of cassava has to be acquired. For period 2 January - June supplies will only be available in June when the buying season begins. The effect on working capital is one of high stocks and low cash holdings at end period 1 and the reverse at end period 2. As can be seen the model has been constructed to incorporate this important cash flow feature.

Other working capital requirements have been estimated on the following basis:

- packing materials at three months usage
- finished goods stocks at four weeks sales
- debtors at six weeks sales
- creditors at six weeks materials purchases

Debtors and finished goods stocks are the most significant items. These are relatively conservatively estimated since stocks are valued at full market value rather than at cost and debtors could be reduced by insisting on earlier payment. It is in fact not unknown, in developing countries, for producers of important industrial inputs to insist on payment in advance.

Since purchases are to be through NAMBOARD we assume that some credit will be available.

REPORT 7 : SCENARIO 1

CASSAVA FACTORY:TAX/INT/DEBT/CAP

	YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
1140 CORPORATE TAX RATE %	0	0	0	0	0	0	0	0	0	0	0	0	45	45	45
1110 S-T DEBT INT RATE %	0	0	12	12	12	12	12	12	12	12	12	12	12	12	12
1120 M-T DEBT INT RATE %	0.00	6.75	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50
1130 L-T DEBT INT RATE %	0.00	6.75	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50
1620 SHORT-TERM DEBT	0	0	400	300	200	100	0	0	0	0	0	0	0	0	0
1630 CAPITAL	1650	350	0	0	0	0	0	0	0	0	0	0	0	0	0
1640 MEDIUM-TERM DEBT	0	900	0	0	0	0	0	0	0	0	0	0	0	0	0
1650 MEDIUM-TERM DEBT	0	0	0	0	0	0	0	150	150	150	150	150	150	0	0
1660 MEDIUM-TERM DEBT	0	900	900	900	900	900	900	750	600	450	300	150	0	0	0
1670 LONG-TERM DEBT	0	900	0	0	0	0	0	0	0	0	0	0	0	0	0
1680 LONG-TERM DEBT	0	0	0	0	0	0	0	150	150	150	150	150	150	0	0
1690 LONG-TERM DEBT	0	900	900	900	900	900	900	750	600	450	300	150	0	0	0

Report 7A

This section of the model is the one through which the capitalisation, debt service and tax charges are entered and/or calculated into the main financial statements.

Interest charges have been assessed on the basis of rates currently been asked in Zambia. The term loan is set at 75% of plant and machinery which is the amount that the Development Bank of Zambia has indicated it would be prepared to lend. The loan is split into two to enable the model to accommodate two sorts of term loan financing should this be necessary in the future.

Debt service has been set at three years moratorium and three years repayment in six monthly rests. The Development Bank of Zambia has indicated to us the length of moratorium period they were willing to grant, whilst repayment has been set to enable the earliest practical repayment period.

It is assumed that the project will enjoy a tax holiday for the first five years' operations.

REPORT 9 :
SCENARIO 1

CASSAVA FACTORY:PROFIT STATEMENTS

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
170	KWACHA THOUSAND															
2	******************															
171	SALES REVENUE:															
38	ROOT STARCH	0	6	74	74	74	74	74	74	74	74	74	74	74	74	74
40	CHIP STARCH	0	28	166	202	238	274	310	346	382	418	454	490	490	490	490
42	CHIP GLUCOSE	0	146	880	880	935	990	1045	1100	1155	1210	1265	1320	1320	1320	1320
44	CHIP DEXTRIN	0	22	136	136	145	153	162	170	179	187	196	204	204	204	204
121																
45	TOTAL SALES	0	202	1256	1292	1392	1491	1591	1690	1790	1889	1989	2088	2088	2088	2088
172	RAW MATERIALS:															
52	ROOTS CONSUMED	0	6	37	37	37	37	37	37	37	37	37	37	37	37	37
54	CHIPS CONSUMED	54	54	324	337	367	396	426	456	486	515	545	575	575	575	575
121																
55	TOTAL DIR MATERIALS	54	60	361	374	404	434	463	493	523	553	582	612	612	612	612
121																
173	GROSS ADDED VALUE	(54)	143	895	918	988	1057	1127	1197	1267	1336	1406	1476	1476	1476	1476
83	ELECTRICITY-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
87	WATER-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
91	FUEL	12	13	81	84	91	98	105	112	118	125	132	139	139	139	139
95	CHEMICALS	2	2	12	12	13	14	14	15	16	17	17	18	18	18	18
110	PACKING MATERIALS	22	22	135	137	147	156	166	175	185	194	204	213	213	213	213
121																
174	OTHER VARIABLE COSTS	40	42	252	257	277	296	315	334	353	372	391	410	410	410	410
121																
175	CONTRIBUTION	(94)	101	644	660	711	762	812	863	914	964	1015	1065	1065	1065	1065
176D	LABOUR & STAFF	73	72	117	117	117	117	117	117	152	152	152	152	152	152	152
177D	ELECTRICITY-FIXED	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
178D	WATER-FIXED	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
128	MAINTENANCE	7	7	146	146	176	176	206	206	236	236	266	266	266	266	266
179D	MISCELLANEOUS	50	25	50	50	50	50	50	50	50	50	50	50	50	50	50
134	DEPRECIATION	0	0	127	127	127	127	127	127	127	127	127	127	127	127	127
121																
180	TOTAL FIXED COSTS	133	107	442	442	472	472	502	502	567	567	597	597	597	597	597
121																
181	PROFIT BEFORE															
182	INTEREST & TAX	(227)	(6)	201	218	239	289	310	361	346	397	418	468	468	468	468
183	INTEREST:															
184	SHORT-TERM DEBT	0	0	24	24	18	12	6	0	0	0	0	0	0	0	0
185	MEDIUM-TERM DEBT	0	30	61	61	61	61	61	61	51	41	30	20	10	0	0
186	LONG-TERM DEBT	0	30	61	61	61	61	61	61	51	41	30	20	10	0	0
121																
187	TOTAL INTEREST	0	61	146	146	140	134	128	122	101	81	61	41	20	0	0
121																
188	PROFIT BEFORE TAX	(227)	(67)	56	73	99	156	183	239	245	316	357	428	448	468	468
189	TAXATION	0	0	0	0	0	0	0	0	0	0	0	0	202	211	211
121																
190	PROFIT AFTER TAX	(227)	(67)	56	73	99	156	183	239	245	316	357	428	246	258	258
27	================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

Report 8A

The variable elements of the profit statement have been entered from the previously described reports where they are calculated. In terms of the fixed expenses the following have been estimated at fixed annual levels:

- electricity
- water
- miscellaneous.

Depreciation and annual maintenance are calculated as described in report 5.

The major item is staff and labour which has been estimated in accordance with the following table for operating periods:

	Basic Single Shift			Increment 2 Shifts		Increment 3 Shifts		
	No	Rate K	Total K	No	Total K	No	Total K	
Management	5	9,000	45,000	-		1	9,000	
Lab.Technician	1	3,960	3,960	-				
Foremen	2	5,280	10,560	1	5,280	1	5,280	
Mechanics	2	4,300	8,600	1	4,300	1	4,300	
Admin/Clerks	7	3,300	23,100	1	3,300	1	3,300	
Drivers	3	3,000	9,000	-		1	3,000	
Guards	4	2,410	9,640	1	2,410	1	2,410	
Operatives	12	2,665	31,980	12	31,980	12	31,980	
Labourers/ Groundsmen	20	1,645	32,900	4	6,580	4	6,580	
	56		174,740	20	53,850	22	65,850	
Add 7½% shift allowance					4,038		4,263	*
Total			174,740		57,888		70,113	

* NB Management does not receive shift allowance.

per period

2 shifts $= \dfrac{175{,}000 + 58{,}000}{2} = 116{,}500$

3 shifts $= \dfrac{175{,}000 + 58{,}000 + 70{,}000}{2} = 151{,}500$

In building up the construction period the cost levels for the majority of items are either generated within the model or set at levels commensurate with operating period costs. The major item not described by the schedules is again labour and staff which has been estimated as follows using the above annual salary rates:

- In the first six months staff will build up to the following levels.

	No		Rate K	Total K
Management	3	x	9000/2	13,500
Foreman	1	x	5280/2	2,640
Mechanics	1	x	4300/2	2,150
Clerical	2	x	3300/2	3,300
Drivers	1	x	3000/2	1,500
Guards	2	x	2410/2	2,410
Operatives	-		-	-
Labourers	4	x	1645/2	3,290
		Total		28,790

- In the second six months staff will build up to the following levels.

	No		Rate K	Total K
Management	4	x	9000/2	18,000
Foreman	1	x	5280/2	2,640
Mechanics	1	x	4300/2	2,150
Clerical	4	x	3300/2	6,600
Drivers	3	x	3000/2	4,500
Guards	3	x	2410/2	3,615
Operatives	-		-	-
Labourers	8	x	1645/2	6,580
		Total		44,085

Total labour and staff period Yr C P1 72,875
say 73,000.

In the final six months of construction the full staffing will be engaged. However given the low output load this is expected only to be at a one shift level and in the case of operatives and factory labour, they will only be engaged during the last three months when trial runs take place. The staffing level is calculated as follows.

	No		Rate K	Total K
Management	5	x	9000/2	22,500
Foremen	2	x	5280/2	5,280
Lab.Technician	1	x	3960/2	1,980
Mechanics	2	x	4300/2	4,300
Clerical	7	x	3300/2	11,550
Guards	4	x	2410/2	4,820
Operatives	12	x	2665/4	7,995
Labourers/ Groundsmen	12	x	1645/2	9,870
Labourers/ Groundsmen	8	x	1645/4	3,290
				71,585
Say				72,000

REPORT 9 :
SCENARIO 1

CASSAVA FACTORY:BALANCE SHEETS

		YR0P1	[illegible]	[illegible]	[illegible]	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
170	KWACHA THOUSAND															
2	******************															
	[illegible]	[illegible]	3245	3118	2991	2864	2737	2410	2483	2356	2229	2102	1975	1848	1721	1594
171	CURRENT ASSETS:															
154	TOTAL STOCKS	65	36	585	324	654	374	754	424	854	474	953	524	1003	524	1003
156	DEBTORS/PREPAYMENTS	0	31	290	298	321	344	367	390	413	436	459	482	482	482	482
158	CASH	54	54	9	324	56	367	66	426	76	486	86	545	96	575	96
121																
192	TOTAL CURRENT ASSETS	119	121	884	946	1032	1085	1187	1240	1343	1396	1498	1551	1581	1581	1581
8																
193	CURRENT LIABILITIES:															
161	CREDITORS/ACCRUALS	0	0	83	86	93	100	107	114	121	128	134	141	141	141	141
1625	SHORT-TERM DEBT	0	0	400	300	200	100	0	0	0	0	0	0	0	0	0
121																
194	TOTAL CURRENT															
195	LIABILITIES	0	0	483	386	293	200	107	114	121	128	134	141	141	141	141
121																
196	NET CURRENT ASSETS	119	121	400	559	739	885	1080	1126	1222	1268	1364	1410	1440	1440	1440
8																
197	SURPLUS CASH	47	140	44	85	132	259	382	403	379	476	564	773	816	1201	1586
8																
121																
198	TOTAL NET ASSETS	1423	3506	3562	3635	3734	3890	4073	4012	3957	3973	4030	4158	4104	4362	4619
27																
8																
199	FINANCED BY:															
200	CAPITAL	1650	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
201	RESERVES	(227)	(294)	(238)	(165)	(66)	90	273	512	757	1073	1430	1858	2104	2362	2619
121																
202	TOTAL EQUITY	1423	1706	1762	1935	1934	2090	2273	2512	2757	3073	3430	3858	4104	4362	4619
8																
1660	MEDIUM-TERM DEBT	0	900	900	900	900	900	900	750	600	450	300	150	0	0	0
1690	LONG-TERM DEBT	0	900	900	900	900	900	900	750	600	450	300	150	0	0	0
121																
205	CAPITAL EMPLOYED	1423	3506	3562	3635	3734	3890	4073	4012	3957	3973	4030	4158	4104	4362	4619
27																
8																

Report 9A

The model constructs the balance sheets largely from data already calculated in previous reports. One item however requires particular mention, namely cash surplus. This item is made necessary as a balancing item since the cash in hand figure is already fixed on the basis of the working capital requirement.

This form of presentation has the major advantage of demonstrating clearly the surplus cash flow build up and available for possible equity distributions. It must agree with the cumulative surplus cash flow shown in report 10, funds flow statement, and thus gives a clear audit check that the model logic is working. Finally in any one year this figure represents accumulated reserves not immediately required in the business and therefore enables us to refine capital employment, and thus the relevant ratios, to a figure representing the capital actually used in the business in the year in question.

REPORT 10 : CASSAVA FACTORY:FUNDS FLOW STATEMENTS
SCENARIO 1

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
170	KWACHA THOUSAND															
2	******************															
206	SOURCES OF FUNDS:															
190	PROFIT AFTER TAX	(227)	(67)	56	73	99	156	183	239	245	316	357	428	246	258	258
134	DEPRECIATION	0	0	127	127	127	127	127	127	127	127	127	127	127	127	127
207	M-T & L-T DEBT INT	0	61	122	122	122	122	122	122	101	81	61	41	20	0	0
121																
208	CASH GENERATED FROM															
209	OPERATIONS	(227)	(6)	304	321	348	404	431	488	473	524	545	595	394	385	385
9																
1630	CAPITAL	1650	350	0	0	0	0	0	0	0	0	0	0	0	0	0
1640	MEDIUM-TERM DEBT	0	900	0	0	0	0	0	0	0	0	0	0	0	0	0
1670	LONG-TERM DEBT	0	900	^	0	0	0	0	0	0	0	0	0	0	0	0
121																
213	TOTAL SOURCES OF															
214	FUNDS	1423	2144	304	321	348	404	431	488	473	524	545	595	394	385	385
27																
3																
215	APPLICATIONS OF															
216	FUNDS:															
217	FIXED INVESTMENT	1258	1988	0	0	0	0	0	0	0	0	0	0	0	0	0
218	WORKING CAPITAL	119	2	279	159	179	146	196	46	96	46	96	46	30	0	0
8																
219	DEBT REPAYMENT:															
1650	MEDIUM-TERM DEBT	0	0	0	0	0	0	0	150	150	150	150	150	150	0	0
1680	LONG-TERM DEBT	0	0	0	0	0	0	0	150	150	150	150	150	150	0	0
121																
222	TOTAL DEBT REPAYMENT	0	0	0	0	0	0	0	300	300	300	300	300	300	0	0
8																
183	INTEREST:															
185	MEDIUM-TERM DEBT	0	30	61	61	61	61	61	61	51	41	30	20	10	0	0
186	LONG-TERM DEBT	0	30	61	61	61	61	61	61	51	41	30	20	10	0	0
121																
207	M-T & L-T DEBT INT	0	61	122	122	122	122	122	122	101	81	61	41	20	0	0
121																
223	TOTAL DEBT SERVICE	0	61	122	122	122	122	122	422	401	381	361	341	320	0	0
121																
224	TOTAL APPLICATIONS															
225	OF FUNDS	1377	2050	401	280	301	268	317	468	497	427	456	387	350	0	0
27																
226	SURPLUS CASH															
227	BALANCES:															
228	PERIOD	47	93	(96)	41	47	137	114	20	(24)	97	88	209	44	385	385
229	CUMULATIVE	47	140	44	85	132	269	382	403	379	476	564	773	816	1201	1586
27																

Report 10A

This statement is computed by the model from the data in previous reports. It should be noted that term loan interest is included in both inflows and outflows to give a total debt service on which the debt service ratio can be computed.

REPORT 11 : CASSAVA FACTORY:KEY FINANCIAL RATIOS

SCENARIO 1

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
230 8	CONTRIBUTION MARGIN%	0	50	51	51	51	51	51	51	51	51	51	51	51	51	51
231 8	FIXED COST/SALES%	0	53	35	34	34	32	32	30	32	30	30	29	29	29	29
232 8	PROFIT AFT TAX/SALE%	0	(33)	4	6	7	10	11	14	14	17	18	20	12	12	12
233 8	PR AFT B-T INT/SALE%	0	(3)	14	15	16	19	19	21	19	21	21	22	22	22	22
234 8	PROFIT/CAP EMPLOYED%	(31.9)	(6.6)	4.8	10.2	11.1	12.8	14.3	16.6	17.9	18.7	20.2	21.3	22.8	21.5	20.3
235 8	SALES/CAP EMPLOYED	0.0	0.1	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
236 8	CURRENT RATIO	0.0	0.0	1.8	2.4	3.5	5.4	11.1	10.9	11.1	10.9	11.1	11.0	11.2	11.2	11.2
237 8	DEBT/CAP EMPLOYED%	0	51	51	50	48	46	44	37	30	23	15	7	0	0	0
238 8	DEBT SERVICE COVER	0.0	(0.1)	2.5	2.6	2.9	3.3	3.5	1.2	1.2	1.4	1.5	1.7	1.2	0.0	0.0
239 8	PROFIT/NET CAP EMPLD	(32.9)	(6.9)	4.9	10.5	11.5	13.8	15.8	18.4	19.8	21.3	23.5	26.2	28.5	29.6	30.9
27	===================	======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

Report 11A

We have extracted certain key financial ratios to give an overview measurement of the project. The majority of the ratios are self explanatory and need no further comment as to their derivation. In the two profit/capital employed ratios we wish to clarify the basis of calculation as follows:

> These ratios have in the first instance been calculated as annual rates of return rather than six monthly rates. This has been done on the basis of adding the previous periods profit (loss) to that of the period being assessed, except in the first period where it has been necessary to multiply the current period profit or loss by two since no previous period exists.
>
> The difference between the profit/capital employed ratio (234) and the profit/net capital employed ratio (239) is that, in the latter case, the surplus cash figure in the balance sheet has been deducted from the capital employed to give the net figure.

REPORT 12 : SCENARIO 1

RATE OF RETURN ANALYSIS

		YR1	YR2	YR3	YR4	YR5	YR6	YR7	YR8	YR9	YR10
242	NET CASH FLOW	(3800)	187.6	426.9	677.1	855.6	998.2	748.4	769.1	769.1	2736
243	DISCOUNT PERCENTAGE	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64	13.64
245	D. C. F.	(3800)	165.1	330.6	461.4	513.0	526.7	347.5	314.2	276.5	865.5
246	N. P. V.	0.5									

Report 12

The model calculates the NPV against a given rate of return. It will be noted that the cash flow expressed in six monthly periods in the main model has been consolidated to annual figures for this calculation and that whilst the print out shows only the first 15 periods, after which the annual results are the same, the model does hold a full 20 periods enabling ten years project life to be discounted.

In compiling the report we have established the IRR that yields an NPV as near as possible to zero by using a separate Finesse routine available as part of the package.

The final years cash flow has been adjusted to include the recovery of working capital together with the disposal of fixed assets as follows:

Land	100%
Buildings	50%
Plant	5%
Vehicles	10%
Working Capital	100%.

Report 13: **Scenario 1**

-15.00 PERCENT CHANGE IN PRICE FACTOR

0.85	0.85	0.85	0.85
0.85	0.85	0.85	0.85

RESULTS IN PROFIT AFTER TAX

(226.71)	(97.36)	(132.54)	(121.[illegible])
85.29	85.29	85.29	85.29

-10.00 PERCENT CHANGE IN PRICE FACTOR

0.90	0.90	0.90	[illegible]
0.90	0.90	0.90	0.90

RESULTS IN PROFIT AFTER TAX

(226.71)	(37.24)	(67.74)	(55.51)
142.71	142.71	142.71	142.71

-5.00 PERCENT CHANGE IN PRICE FACTOR

0.95	0.95	0.95	0.95
0.95	0.95	0.95	0.95

RESULTS IN PROFIT AFTER TAX

(226.71)	(37.[illegible])	(6.94)	5.0[illegible]
200.13	200.13	200.13	200.13

0.00 PERCENT CHANGE IN PRICE FACTOR

1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00

RESULTS IN PROFIT AFTER TAX

(226.71)	(67.00)	55.56	72.5[illegible]
257.55	257.55	257.55	257.55

-15.00 PERCENT CHANGE IN PRICE FACTOR

0.85	0.85	0.85	0.85
0.85	0.85	0.85	0.85

RESULTS IN CUMULATIVE

46.62	[illegible]	(102.55)	([illegible])
(1523.28)	(1310.9[illegible])	(1098.71)	(886.42)

-10.00 PERCENT CHANGE IN PRICE FACTOR

0.90	0.90	0.90	0.90
0.90	0.90	0.90	0.90

RESULTS IN CUMULATIVE

46.62	124.44	(53.78)	(14[illegible].74)
(615.19)	(345.4[illegible])	(75.76)	193.95

-5.00 PERCENT CHANGE IN PRICE FACTOR

0.95	0.95	0.95	0.95
0.95	0.95	0.95	0.95

RESULTS IN CUMULATIVE

46.62	[illegible]	5.0[illegible]	(26.0[illegible])
[illegible]	[illegible]	[illegible]	1274.[illegible]

0.00 PERCENT CHANGE IN PRICE FACTOR

1.00	1.00	1.00	1.00
1.00	1.00	1.00	1.00

RESULTS IN CUMULATIVE

46.62	140.01	43.[illegible]	94.51
[illegible]	[illegible]	[illegible]	2354.58

RESULTS OF SENSITIVITY RUNS

0.85 0.85	0.85 0.85	0.85 0.85	0.85	0.85	0.85	0.85	0.85	0.85
(109.40) 80.29	(67.69) 35.29	(55.98) 35.29	(14.27)	(23.31)	32.65	58.61	114.57	74.15
0.90 0.90	0.90 0.90	0.90 0.90	0.90	0.90	0.90	0.90	0.90	0.90
(37.83) 142.71	0.66 142.71	33.34 142.71	70.23	86.15	127.10	158.03	215.97	131.57
0.95 0.95	0.95 0.95	0.95 0.95	0.95	0.95	0.95	0.95	0.95	0.95
39.75 200.15	81.41 200.15	120.02 200.15	[illegible]	155.64	221.55	[illegible]	[illegible]	188.99
1.00 1.00	1.00 1.00	1.00 1.00	1.00	1.00	1.00	1.00	1.00	1.00
99.32 257.55	152.96 257.55	182.59 257.55	239.25	245.11	316.00	356.38	427.77	246.41

0.85 0.85	0.85 0.85	0.85 0.85	0.85	0.85	0.85	0.85	0.85	0.85
(407.33) (674.13)	(470.41) (451.85)	(609.30) (249.56)	(836.93)	(1123.18)	(1303.35)	(1506.19)	(1606.96)	(1738.57)
0.90 0.90	0.90 0.90	0.90 0.90	0.90	0.90	0.90	0.90	0.90	0.90
(139.03) 462.65	(237.44) 735.36	(276.74) 1003.07	(423.76)	(522.45)	(710.60)	(817.41)	(913.69)	(584.88)
0.95 0.95	0.95 0.95	0.95 0.95	0.95	0.95	0.95	0.95	0.95	0.95
(46.71) 1601.44	16.33 1920.57	31.84 2250.69	(10.07)	(121.72)	(117.33)	126.53	(20.42)	(34.20)
1.00 1.00	1.00 1.00	1.00 1.00	1.00	1.00	1.00	1.00	1.00	1.00
131.62 2739.22	268.51 3123.77	382.42 3508.32	402.58	379.01	475.94	564.15	[illegible]	516.49

Report 13: Scenario 1

```
 -15.00 PERCENT CHANGE IN SALES FACTOR
   0.85      0.85      0.85      0.85       0.85
   0.85      0.85      0.85      0.85       0.85
         RESULTS IN PROFIT AFTER TAX
(212.64)   (82.10)   (40.67)   (26.37)     (7.33)
 169.65    169.65    169.65    169.65     169.65

 -10.00 PERCENT CHANGE IN SALES FACTOR
   0.90      0.90      0.90      0.90       0.90
   0.90      0.90      0.93      0.90       0.90
         RESULTS IN PROFIT AFTER TAX
(217.33)   (77.07)    (8.49)     6.65      28.22
 198.95    198.95    198.95    198.95     178.95

  -5.00 PERCENT CHANGE IN SALES FACTOR
   0.95      0.95      0.95      0.95       0.95
   0.95      0.95      0.95      0.95       0.95
         RESULTS IN PROFIT AFTER TAX
(222.02)   (72.03)    23.68     39.67      63.77
 228.25    228.25    228.25    228.25     228.25

   0.00 PERCENT CHANGE IN SALES FACTOR
   1.00      1.00      1.00      1.00       1.00
   1.00      1.00      1.00      1.[illegible]       1.00
         RESULTS IN PRC[illegible] AFTER TAX
(226.71)   (67.[illegible]    55.86     72.69      99.32
 257.55    257.55    257.55    257.55     257.55


 -15.00 PERCENT CHANGE IN SALES FACTOR
   0.85      0.85      0.85      0.85       0.85
   0.85      0.85      0.85      0.85       0.85
         RESULTS IN  CUMULATIVE
  79.48    157.08     66.16     16.79     (30.96)
 (21.42)   275.22    571.87    868.51    1165.16

 -10.00 PERCENT CHANGE IN SALES FACTOR
   0.90      0.90      0.90      0.90       0.90
   0.90      0.90      0.90      0.90       0.90
         RESULTS IN  CUMULATIVE
  67.86    151.39     58.69     39.39      23.23
 386.06    712.01   1037.96   1363.90    1689.85

  -5.00 PERCENT CHANGE IN SALES FACTOR
   0.95      0.95      0.95      0.95       0.95
   0.95      0.95      0.95      0.95       0.95
         RESULTS IN  CUMULATIVE
  57.24    145.70     51.22     62.00      77.43
 793.55   1148.80   1504.04   1859.29    2214.54

   0.00 PERCENT CHANGE IN SALES FACTOR
   1.00      1.00      1.00      1.00       1.00
   1.00      1.00      1.00      1.00       1.00
         RESULTS IN  CUMULATIVE
  46.62    140.01     43.75     84.61     131.62
1201.04   1585.58   1970.13   2354.68    2739.22
```

RESULTS OF SENSITIVITY RUNS

0.85 0.85	0.85 0.85	0.85	0.85	0.85	0.85	0.85	0.85
41.71 169.65	60.75 169.65	109.79	108.08	171.37	204.66	267.95	[illegible]
0.90 0.90	0.90 0.90	0.90	0.90	0.90	0.90	0.90	0.90
79.79 198.95	101.36 198.95	152.93	153.76	219.58	255.40	321.22	187.81
0.95 0.95	0.95 0.95	0.95	0.95	0.95	0.95	0.95	0.95
117.87 228.25	141.98 228.25	196.08	199.43	267.79	306.14	374.49	217.11
1.00 1.00	1.00 1.00	1.00	1.00	1.00	1.00	1.00	1.00
155.96 257.55	182.59 257.55	239.23	245.11	316.00	356.88	427.77	246.41

0.85 0.85	0.85 0.85	0.85	0.85	0.85	0.85	0.85	0.85
(1.41) 1461.80	5.01 1758.45	(97.36)	(243.61)	(284.40)	(334.07)	(278.28)	(318.07)
0.90 0.90	0.90 0.90	0.90	0.90	0.90	0.90	0.90	0.90
88.56 2015.79	130.82 2341.74	69.29	(36.07)	(30.95)	(34.66)	72.09	60.12
0.95 0.95	0.95 0.95	0.95	0.95	0.95	0.95	0.95	0.95
178.53 2569.78	256.62 2925.03	235.93	171.47	222.47	264.74	422.47	438.30
1.00 1.00	1.00 1.00	1.00	1.00	1.00	1.00	1.00	1.00
268.31 3123.77	382.42 3508.32	402.58	379.01	475.94	564.15	772.84	816.49

FINANCIAL REPORTS FOR CASSAVA STARCH FACTORY ONLY

REPORT 1 : CASSAVA FACTORY:THROUGHPUT

FACTORY FOR CASSAVA STARCH ONLY

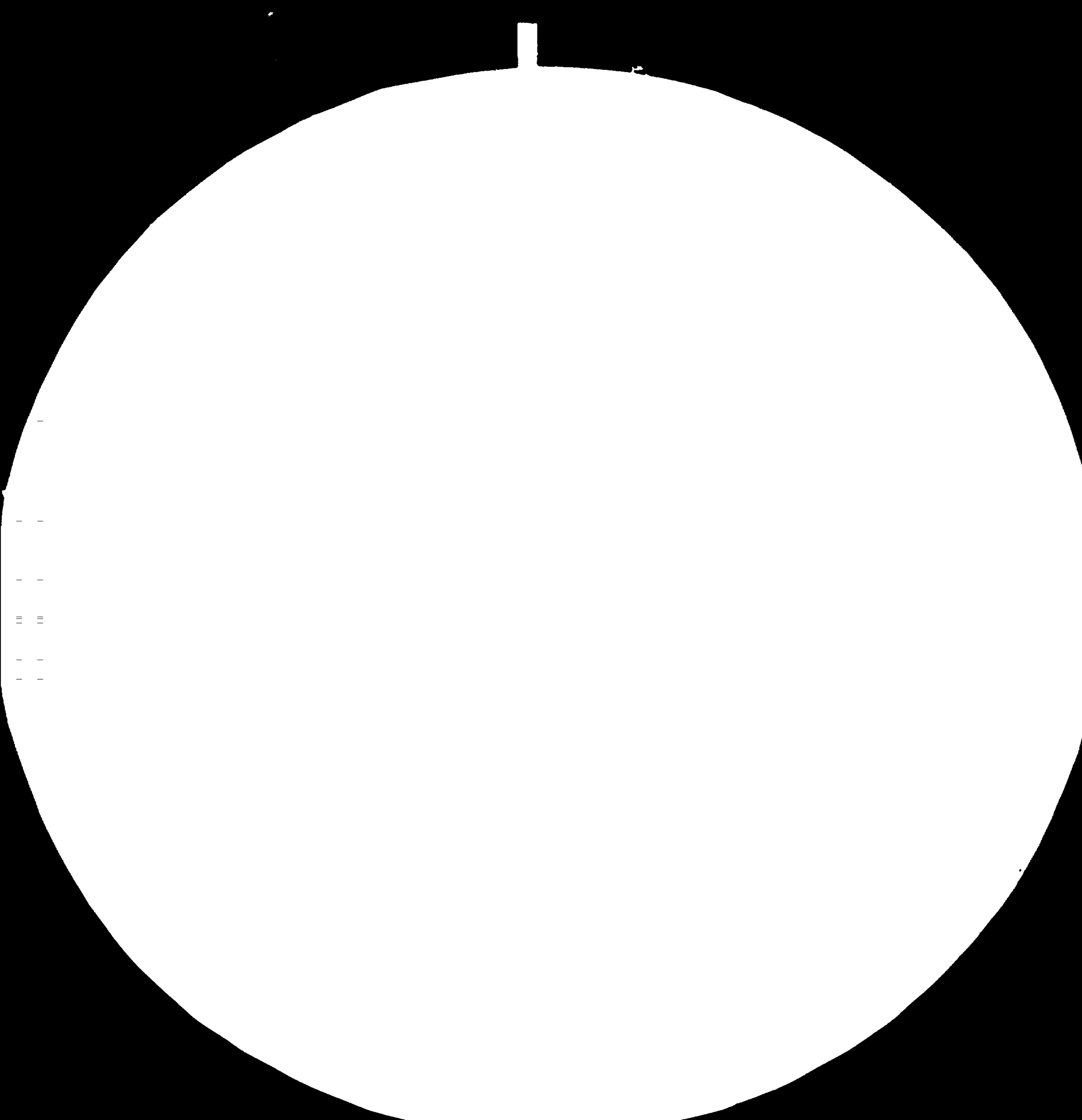
			YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
1	QUANTITY:TONNES																
2	******************																
3D	ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
4D	YIELD RSL TO RST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
5	ROOT SLURRY	T	0.0	156.2	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7
6D	YIELD R TO RSL	%	260	260	260	260	260	260	260	260	260	260	260	260	260	260	260
7	ROOTS INPUT	T	0.0	60.1	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6	372.6
8																	
9D	CHIP STARCH SOLD	T	181	181	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
10D	YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
11	CHIP SLURRY	T	1885	1885	11323	11792	12833	13875	14917	15958	17000	18042	19083	20125	20125	20125	20125
12D	YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
13	CHIPS INPUT CST	T	269.3	269.3	1618	1685	1833	1982	2131	2280	2429	2577	2726	2875	2875	2875	2875
8																	
14D	GLUCOSE SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15D	YIELD CST TO G	%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
16	CHIP STARCH G	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10D	YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
17	CHIP SLURRY G	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12D	YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
18	CHIPS INPUT G	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8																	
19D	DEXTRIN SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20D	YIELD CST TO D	%	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
21	CHIP STARCH D	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10D	YIELD CSL TO CST	%	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
22	CHIP SLURRY D	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12D	YIELD C TO CSL	%	700	700	700	700	700	700	700	700	700	700	700	700	700	700	700
23	CHIPS INPUT D	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8																	
24	TOTAL CHIPS INPUT	T	269.3	269.3	1618	1685	1833	1982	2131	2280	2429	2577	2726	2875	2875	2875	2875
8																	
25	TOTAL STARCH PROD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
8																	
26	TOTAL STARCH SOLD	T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
8																	
29	TOTAL CHIP SLURRY	T	1885	1885	11323	11792	12833	13875	14917	15958	17000	18042	19083	20125	20125	20125	20125
8																	
29	TOTAL CHIP STARCH	T	181.0	181.0	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
27	==================		======	======	======	======	======	======	======	======	======	======	======	======	======	======	======

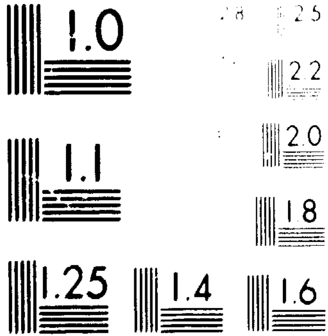
REPORT 2 : CASSAVA FACTORY:VALUE OF INPUTS/OUTPUTS

FACTORY FOR CASSAVA STARCH ONLY

			YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
30	VALUE:INPUTS																
2																	
31D	ROOT PRICE	K/T	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
32	ROOTS CONSUMED		0	6	37	37	37	37	37	37	37	37	37	37	37	37	37
6																	
33D	CHIP PRICE	K/T	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
34	CHIPS CONSUMED		54	54	324	337	367	396	426	456	486	515	545	575	575	575	575
8																	
35	TOTAL DIR MATERIALS		54	60	361	374	404	434	463	493	523	553	582	612	612	612	612
27																	
36	VALUE:OUTPUTS																
2																	
37D	RST PRICE	K/T	0	400	800	800	800	800	800	800	800	800	800	800	800	800	800
3D	ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
38	ROOT STARCH		0	6	74	74	74	74	74	74	74	74	74	74	74	74	74
8																	
39D	CST PRICE	K/T	0	800	800	800	800	800	800	800	300	300	800	300	800	800	800
9D	CHIP STARCH SOLD	T	181	181	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
40	CHIP STARCH		0	145	870	906	986	1066	1146	1226	1306	1386	1466	1546	1546	1546	1546
8																	
41D	GLUCOSE PRICE	K/T	0	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
14D	GLUCOSE SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	CHIP GLUCOSE		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8																	
43D	DEXTRIN PRICE	K/T	0	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
19D	DEXTRIN SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	CHIP DEXTRIN		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8																	
45	TOTAL SALES		0	151	944	980	1060	1140	1220	1300	1380	1460	1540	1620	1620	1620	1620
27																	

82-11-15




1.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

REPORT 3 :
FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY : OPERATING TIMES

		YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
50 PROCESS:R TO RSL																
5 ROOT SLURRY	T	0.0	156.2	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7	968.7
510 PROCESS RATE/HOUR		13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
52 HOURS REQUIRED		0	12	75	75	75	75	75	75	75	75	75	75	75	75	75
530 HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
540 SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
55 WEEKS REQUIRED		0.0	0.2	1.1	1.1	1.1	1.1	1.1	1.1	0.7	0.7	0.7	0.7	0.7	0.7	0.7
560 WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
57 PROCESS:RSL TO RST																
30 ROOT STARCH SOLD	T	0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
580 PROCESS RATE/HOUR		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
59 HOURS REQUIRED		0	15	93	93	93	93	93	93	93	93	93	93	93	93	93
530 HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
540 SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
60 WEEKS REQUIRED		0.0	0.2	1.3	1.3	1.3	1.3	1.3	1.3	0.8	0.8	0.8	0.8	0.8	0.8	0.8
560 WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
61 PROCESS:C TO CS																
28 TOTAL CHIP SLURRY	T	1885	1885	11323	11792	12833	13875	14917	15958	17000	18042	19083	20125	20125	20125	20125
620 PROCESS RATE/HOUR		13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
63 HOURS REQUIRED		145	145	871	907	987	1067	1147	1228	1308	1388	1468	1548	1548	1548	1548
530 HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
540 SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
64 WEEKS REQUIRED		2.1	2.1	12.4	13.0	14.1	15.2	16.4	17.5	11.6	12.3	13.0	13.8	13.8	13.8	13.8
560 WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
65 PROCESS:RSL TO CST																
27 TOTAL CHIP STARCH	T	181.0	181.0	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
660 PROCESS RATE/HOUR		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
67 HOURS REQUIRED		181	181	1087	1132	1232	1332	1432	1532	1632	1732	1832	1932	1932	1932	1932
530 HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
540 SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
68 WEEKS REQUIRED		2.6	2.6	15.5	16.2	17.6	19.0	20.5	21.9	14.5	15.4	16.3	17.2	17.2	17.2	17.2
560 WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
69 PROCESS:CST TO G																
140 GLUCOSE SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
700 PROCESS RATE/HOUR		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
71 HOURS REQUIRED		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
530 HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
540 SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
72 WEEKS REQUIRED		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
560 WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
73 PROCESS:CST TO D																
190 DEXTRIN SOLD	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
740 PROCESS RATE/HOUR		0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
75 HOURS REQUIRED		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
530 HOURS PER SHIFT		7	7	7	7	7	7	7	7	8	8	8	8	8	8	8
540 SHIFTS PER WEEK		10	10	10	10	10	10	10	10	15	15	15	15	15	15	15
76 WEEKS REQUIRED		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
560 WEEKS PER PERIOD		24	24	24	24	24	24	24	24	24	24	24	24	24	24	24

REPORT 4 : CASSAVA FACTORY:OTHER VARIABLE COSTS

FACTORY FOR CASSAVA STARCH ONLY

		YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
80	ELECTRICITY															
25	TOTAL STARCH PROD T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
81D	UNITS PER TONNE	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
82D	RATE PER UNIT	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
83	ELECTRICITY-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
84	WATER															
25	TOTAL STARCH PROD T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
85D	LT.000 PER TONNE	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
86D	RATE PER 000LITRE	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30	2.30
87	WATER-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
88	FUEL															
25	TOTAL STARCH PROD T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
89L	LITRES PER TONNE	132	132	132	132	132	132	132	132	132	132	132	132	132	132	132
90L	RATE PER LITRE	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
91	FUEL	12	13	81	84	91	98	105	112	118	125	132	[illegible]	139	139	139
92	CHEMICALS															
14L	GLUCOSE SOLD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
93L	EST.KGS PER TONNE	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
94D	COST PER KG.	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
95	CHEMICALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	PACKING MATERIALS															
26	TOTAL STARCH SOLD T	181.0	196.0	1180	1225	1325	1425	1525	1625	1725	1825	1925	2025	2025	2025	2025
101D	BAG UNIT WEIGHT KG	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
102D	BAG UNIT COST	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
103	TOTAL BAG COST A	7	8	47	49	53	57	61	65	69	73	77	81	81	81	81
14D	GLUCOSE SOLD T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
104D	DRUM UNIT WEIGHT KG	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
105D	DRUM UNIT COST	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
106	TOTAL DRUMS COST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19L	DEXTRIN SOLD T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107D	BAG UNIT WEIGHT KG	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
108D	BAG UNIT COST	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
109	TOTAL BAGS COST	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	PACKING MATERIALS	7	8	47	49	53	57	61	65	69	73	77	81	81	81	81

REPORT 5 : FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY:FIXED ASSET MAINT/DEPR

			YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
115	FIXED ASSET COST																
2	XXXXXXXXXXXXXXXXXX																
116D	LAND		25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
117D	FACTORY BUILDINGS		375	500	500	500	500	500	500	500	500	500	500	500	500	500	500
118D	PLANT & EQUIPMENT		600	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
119D	VEHICLES		70	70	70	70	70	70	70	70	70	70	70	70	70	70	70
120D	HOUSING		188	250	250	250	250	250	250	250	250	250	250	250	250	250	250
121																	
122	TOTAL COST		1258	2345	2345	2345	2345	2345	2345	2345	2345	2345	2345	2345	2345	2345	2345
8																	
8																	
123D	LAND	MNT/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
124D	FACTORY BUILD	MNT/RT	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5
125D	PLANT	MNT/RT	0.0	0.0	10.0	10.0	12.5	12.5	15.0	15.0	17.5	17.5	20.0	20.0	20.0	20.0	20.0
126D	VEHICLES	MNT/RT	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
127D	HOUSING	MNT/RT	0	0	5	5	5	5	5	5	5	5	5	5	5	5	5
8																	
128	MAINTENANCE		7	7	101	101	120	120	138	138	157	157	176	176	176	176	176
27																	
8																	
9																	
129D	LAND	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130D	FACTORY BUILD	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131D	PLANT	DEP/RT	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10
132D	VEHICLES	DEP/RT	0	0	20	20	20	20	20	20	20	20	20	20	20	20	20
133D	HOUSING	DEP/RT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8																	
134	DEPRECIATION		0	0	82	82	82	82	82	82	82	82	82	82	82	82	82
27																	
8																	
135	TOTAL CUM DEP		0	0	82	164	246	328	410	492	574	656	738	820	902	984	1066
121																	
8																	
141	NET FIXED ASSETS		1258	2345	2263	2181	2099	2017	1935	1853	1771	1689	1607	1525	1443	1361	1279
27																	

REPORT 5 : CASSAVA FACTORY: WORKING CAPITAL

FACTORY FOR CASSAVA STARCH ONLY

			YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
1450	ROOT WEIGHT	T	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
310	ROOT PRICE	N/T	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
146 5	ROOT VALUE		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1470	CHIP WEIGHT	T	269	45	1618	281	1833	330	2131	380	2429	430	2726	479	2875	479	2875
330	CHIP PRICE	N/T	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
148 8	CHIP VALUE		54	9	324	56	367	66	426	76	486	86	545	96	575	96	575
110	PACKING MATERIALS		7	8	47	49	53	57	61	65	69	73	77	81	81	81	81
1430	STOCK PERIOD %		50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
144 3	PACKING MATS VALUE		4	4	24	25	27	29	31	33	35	37	39	41	41	41	41
45	TOTAL SALES		0	151	944	980	1060	1140	1220	1300	1380	1460	1540	1620	1620	1620	1620
1520	STOCK WEEKS HLF YR		0	2	4	4	4	4	4	4	4	4	4	4	4	4	4
153 3	FINISHED GOODS VALUE		0	12	145	151	163	175	198	200	212	225	237	249	249	249	249
154 27	TOTAL STOCKS		58	25	493	232	557	270	645	309	733	348	821	386	865	386	865
1550	DEBTOR WEEKS HLF YR		0	4	6	6	6	6	6	6	6	6	6	6	6	6	6
156 27	DEBTORS/PREPAYMENTS		0	23	218	226	245	263	282	300	318	337	355	374	374	374	374
1570	CASH PERIOD HLF YR		0	0	2	2	2	2	2	2	2	2	2	2	2	2	2
158 27	CASH		54	54	9	324	56	367	66	426	76	486	86	545	96	575	96
50	TOTAL DIR MATERIALS		54	60	361	374	404	434	463	493	523	553	582	612	612	612	612
1600	CREDITORS WEEKS HF Y		0	0	6	6	6	6	6	6	6	6	6	6	6	6	6
161 27	CREDITORS/ACCRUALS		0	0	83	86	93	100	107	114	121	128	134	141	141	141	141

REPORT 7 : CASSAVA FACTORY:TAX/INT/DEBT/CAP

FACTORY FOR CASSAVA STARCH ONLY

		YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
1140	CORPORATE TAX RAT	[illegible]	0	0	0	0	0	0	0	0	0	0	0	45	45	45
1110	S-T DEBT INT RAT	[illegible]	0	12	12	12	12	12	12	12	12	12	12	12	12	12
1120	M-T DEBT INT RAT	[illegible]	6.75	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50
1130	L-T DEBT INT RAT	[illegible]	6.75	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50	13.50
1620	SHORT-TERM DEBT	[illegible]	0	400	300	200	100	0	0	0	0	0	0	0	0	0
1630	CAPITAL	[illegible]	100	0	0	0	0	0	0	0	0	0	0	0	0	0
1640	MEDIUM-TERM DEBT	[illegible]	500	0	0	0	0	0	0	0	0	0	0	0	0	0
1650	MEDIUM-TERM DEBT	[illegible]	0	0	0	0	0	0	100	100	100	100	100	100	0	0
1660	MEDIUM-TERM DEBT	[illegible]	500	500	500	500	500	500	500	400	300	200	100	0	0	0
1670	LONG-TERM DEBT	[illegible]	600	0	0	0	0	0	0	0	0	0	0	0	0	0
1680	LONG-TERM DEBT	[illegible]	0	0	0	0	0	0	100	100	100	100	100	100	0	0
1690	LONG-TERM DEBT	[illegible]	600	600	600	600	600	600	500	400	300	200	100	0	0	0

REPORT 8 : FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY:PROFIT STATEMENTS

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
170	KWACHA THOUSAND															
2	XXXXXXXXXXXXXXXXX															
171	SALES REVENUE:															
38	ROOT STARCH	0	6	74	74	74	74	74	74	74	74	74	74	74	74	74
40	CHIP STARCH	0	145	870	906	986	1066	1146	1226	1306	1386	1466	1546	1546	1546	1546
42	CHIP GLUCOSE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	CHIP DEXTRIN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121	------------------															
45	TOTAL SALES	0	151	944	980	1060	1140	1220	1300	1380	1460	1540	1620	1620	1620	1620
172	RAW MATERIALS:															
32	ROOTS CONSUMED	0	6	37	37	37	37	37	37	37	37	37	37	37	37	37
34	CHIPS CONSUMED	54	54	324	337	367	396	426	456	486	515	545	575	575	575	575
121	------------------															
35	TOTAL DIR MATERIALS	54	60	361	374	404	434	463	493	523	553	582	612	612	612	612
121	------------------															
173	GROSS ADDED VALUE	(54)	91	583	606	656	706	757	807	857	907	958	1008	1008	1008	1008
83	ELECTRICITY-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
87	WATER-VARIABLE	2	2	12	12	13	14	15	16	17	18	19	20	20	20	20
91	FUEL	12	13	81	84	91	98	105	112	118	125	132	139	139	139	139
95	CHEMICALS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	PACKING MATERIALS	7	8	47	49	53	57	61	65	69	73	77	81	81	81	31
121	------------------															
174	OTHER VARIABLE COSTS	23	25	152	157	170	183	196	209	222	235	247	260	260	260	260
121	------------------															
175	CONTRIBUTION	(77)	66	432	448	486	523	561	598	635	673	710	747	747	747	747
176D	LABOUR & STAFF	73	72	117	117	117	117	117	117	152	152	152	152	152	152	152
177D	ELECTRICITY-FIXED	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
178D	WATER-FIXED	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
128	MAINTENANCE	7	7	101	101	120	120	138	138	157	157	176	176	176	176	176
179D	MISCELLANEOUS	50	25	50	50	50	50	50	50	50	50	50	50	50	50	50
134	DEPRECIATION	0	0	82	82	82	82	82	82	82	82	82	82	82	82	82
121	------------------															
180	TOTAL FIXED COSTS	133	107	352	352	371	371	390	390	443	443	462	462	462	462	462
121	------------------															
181	PROFIT BEFORE															
182	INTEREST & TAX	(210)	(41)	79	96	115	152	171	208	192	229	248	285	285	285	285
183	INTEREST:															
184	SHORT-TERM DEBT	0	0	24	24	18	12	6	0	0	0	0	0	0	0	0
185	MEDIUM-TERM DEBT	0	20	41	41	41	41	41	41	34	27	20	14	7	0	0
186	LONG-TERM DEBT	0	20	41	41	41	41	41	41	34	27	20	14	7	0	0
121	------------------															
187	TOTAL INTEREST	0	41	105	105	99	93	67	81	68	54	41	27	14	0	0
121	------------------															
188	PROFIT BEFORE TAX	(210)	(82)	(26)	(9)	16	59	84	127	124	175	207	258	272	195	285
189	TAXATION	0	0	0	0	0	0	0	0	0	0	0	0	122	128	128
121	------------------															
190	PROFIT AFTER TAX	(210)	(82)	(26)	(9)	16	59	84	127	124	175	207	258	149	157	157
27	==================	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====

REPORT 9 : FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY:BALANCE SHEETS

		YRCP1	YRCP2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
170	KWACHA THOUSAND															
141	NET FIXED ASSETS	1258	2345	2263	2181	2099	2017	1935	1853	1771	1689	1607	1525	1443	1361	1279
191	CURRENT ASSETS:															
154	TOTAL STOCKS	58	25	493	232	557	270	645	309	733	348	821	386	845	386	845
156	DEBTORS/PREPAYMENTS	0	23	218	226	245	263	282	300	318	337	355	374	374	374	374
158	CASH	54	54	9	324	56	367	64	426	76	486	86	545	96	575	96
192	TOTAL CURRENT ASSETS	112	102	720	782	858	900	992	1035	1127	1170	1262	1305	1315	1335	1315
193	CURRENT LIABILITIES:															
161	CREDITORS/ACCRUALS	0	0	83	86	93	100	107	114	121	128	134	141	141	141	141
1620	SHORT-TERM DEBT	0	0	400	300	200	100	0	0	0	0	0	0	0	0	0
194 195	TOTAL CURRENT LIABILITIES	0	0	483	386	293	200	107	114	121	128	134	141	141	141	141
196	NET CURRENT ASSETS	112	102	236	395	564	700	886	921	1007	1043	1128	1164	1194	1194	1194
197	SURPLUS CASH	21	161	83	(2)	(74)	(68)	(88)	(115)	(194)	(172)	(168)	(64)	(62)	177	416
198	TOTAL NET ASSETS	1390	2608	2583	2574	2590	2649	2733	2660	2584	2559	2567	2625	2575	2731	2889
199	FINANCED BY:															
200	CAPITAL	1600	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700	1700
201	RESERVES	(210)	(292)	(317)	(326)	(310)	(251)	(167)	(40)	84	259	467	725	875	1031	1189
202	TOTAL EQUITY	1390	1408	1383	1374	1390	1449	1533	1660	1784	1959	2167	2425	2575	2731	2889
1660	MEDIUM-TERM DEBT	0	600	600	600	600	600	600	500	400	300	200	100	0	0	0
1690	LONG-TERM DEBT	0	600	600	600	600	600	600	500	400	300	200	100	0	0	0
205	CAPITAL EMPLOYED	1390	2608	2583	2574	2590	2649	2733	2660	2584	2559	2567	2625	2575	2731	2889

REPORT 10 : CASSAVA FACTORY:FUNDS FLOW STATEMENTS

FACTORY FOR CASSAVA STARCH ONLY

	YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
KWACHA THOUSAND															
XXXXXXXXXXXXXXXXXX															
SOURCES OF FUNDS:															
PROFIT AFTER TAX	(210)	(82)	(26)	(9)	16	59	84	127	124	175	207	258	149	157	157
DEPRECIATION	0	0	82	82	82	82	82	82	82	82	82	82	82	82	82
M-T & L-T DEBT INT	0	41	81	81	81	81	81	81	68	54	41	27	14	0	0
CASH GENERATED FROM OPERATIONS	(210)	(41)	137	154	179	222	247	290	274	311	330	367	245	239	239
CAPITAL	1600	100	0	0	0	0	0	0	0	0	0	0	0	0	0
MEDIUM TERM DEBT	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0
LONG-TERM DEBT	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL SOURCES OF FUNDS	1390	1259	137	154	179	222	247	290	274	311	330	367	245	239	239
APPLICATIONS OF FUNDS:															
FIXED INVESTMENT	1258	1088	0	0	0	0	0	0	0	0	0	0	0	0	0
WORKING CAPITAL	112	(10)	134	139	167	136	135	36	85	36	85	36	30	(0)	0
DEBT REPAYMENT:															
MEDIUM-TERM DEBT	0	0	0	0	0	0	0	100	100	100	100	100	100	0	0
LONG-TERM DEBT	0	0	0	0	0	0	0	100	100	100	100	100	100	0	0
TOTAL DEBT REPAYMENT	0	0	0	0	0	0	0	200	200	200	200	200	200	0	0
INTEREST:															
MEDIUM-TERM DEBT	0	20	41	41	41	41	41	41	34	27	20	14	7	0	0
LONG-TERM DEBT	0	20	41	41	41	41	41	41	34	27	20	14	7	0	0
M-T & L-T DEBT INT	0	41	81	81	81	81	81	81	68	54	41	27	14	0	0
TOTAL DEBT SERVICE	0	41	81	81	81	81	81	281	268	254	241	227	214	0	0
TOTAL APPLICATIONS OF FUNDS	1369	1118	215	240	250	217	266	317	353	290	326	263	243	(0)	0
SURPLUS CASH BALANCES:															
PERIOD	21	141	(78)	(86)	(71)	5	(20)	(27)	(79)	21	4	104	2	239	239
CUMULATIVE	21	161	83	(2)	(74)	(68)	(88)	(115)	(194)	(172)	(168)	(64)	(62)	177	416

REPORT 11 : FACTORY FOR CASSAVA STARCH ONLY

CASSAVA FACTORY/NET FINANCIAL RATIOS

		YR0P1	YR0P2	YR1P1	YR1P2	YR2P1	YR2P2	YR3P1	YR3P2	YR4P1	YR4P2	YR5P1	YR5P2	YR6P1	YR6P2	YR7P1
230	CONTRIBUTION MARGIN%	0	44	46	46	46	46	46	46	46	46	46	46	46	46	46
231	FIXED COST/SALES%	0	71	37	36	35	33	32	30	32	30	30	29	29	29	29
232	PROFIT AFT TAX/SALES	0	(54)	(3)	(1)	1	5	7	10	9	12	13	16	9	10	10
233	PR AFT S-T INT/SALES	0	(27)	6	7	9	12	14	16	14	16	16	18	18	18	18
234	PROFIT/CAP EMPLOYED%	(30.2)	(9.6)	0.5	5.0	6.5	8.9	11.2	14.0	15.5	16.5	18.6	20.3	22.2	20.9	19.8
235	SALES/CAP EMPLOYED	0.0	0.1	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
236	CURRENT RATIO	0.0	0.0	1.5	2.0	2.9	4.5	9.3	9.1	9.3	9.2	9.4	9.2	9.4	9.4	9.4
237	DEBT/CAP EMPLOYED%	0	46	46	47	46	45	44	38	31	23	16	8	0	0	0
238	DEBT SERVICE COVER	0.0	(1.0)	1.7	1.9	2.2	2.7	3.0	1.0	1.0	1.2	1.4	1.6	1.1	0.0	0.0
239	PROFIT/NET CAP EMPLD	(30.7)	(10.3)	0.6	5.0	6.3	8.7	10.8	13.4	14.4	15.4	17.4	19.8	21.6	22.3	23.1

REPORT 12 : RATE OF RETURN ANALYSIS
FACTORY FOR CASSAVA STARCH ONLY

		YR1	YR2	YR3	YR4	YR5	YR6	YR7	YR8	YR9	YR10
242	NET CASH FLOW	(2900)	(1.6)	96.2	315.8	463.9	575.9	454.1	477.8	477.8	2153
243D	DISCOUNT PERCENTAGE	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36	8.36
245	D. C. F.	(2900)	(1.5)	81.9	248.2	336.4	385.5	280.5	272.4	251.4	1045
246	N. P. V.	0.2