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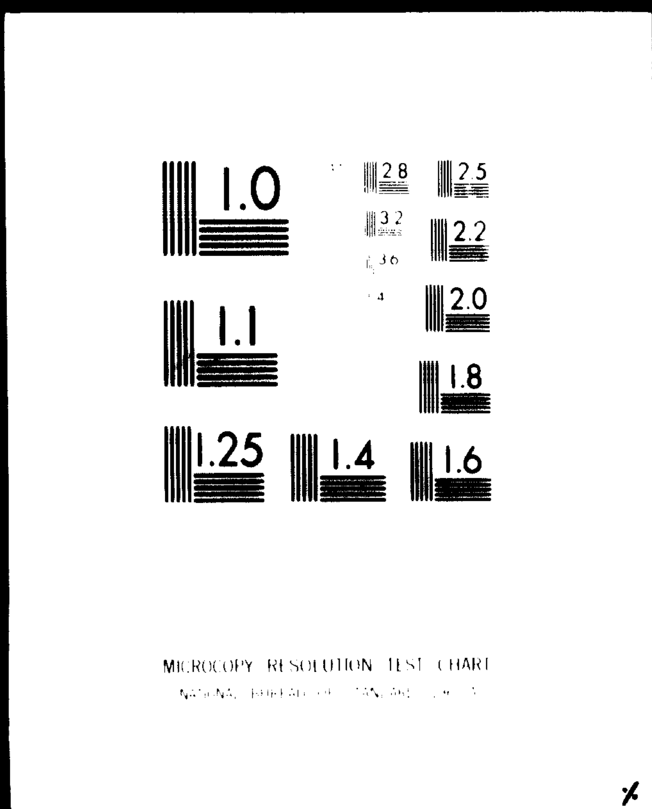
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ECONOMIC VIABILITY IN AFRICAN CONDITIONS OF THE SMALL SCALE OPEN PAN SUGAR TECHNOLOGY[1/]

by

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INTRODUCTION

This paper presents a financial appraisal of small scale open pan sugar technology in African conditions given a number of working assumptions relating to climatic setting, technology performance and economic factors. The method of analysis closely follows that used in a companion paper (1).

The paper is organised into four chapters. Chapter I describes the basic methodology; Chapters II and III provide information on the agricultural and factory parameters, respectively, used in the calculation of financial performance, which is discussed in Chapter IV.

I. METHODOLOGY

The economic viability of open pan sulphitation (OPS) sugar technology is examined here in two scenarios representing different African climatic conditions. These scenarios differ in terms of length of crushing season and in the cane growing cycle, and are described - for the purposes of this paper and for comparison with reference (1) - as long season rainfed (270 gross operating days) and short season rainfed (150 days). In addition, two scales of operation are considered, 100 tonnes of cane per day (tcd) and 150 tcd, although only one size of factory. The variation is introduced by means of a difference in the number of eight hour shifts worked per day, viz. two and three respectively. There are, therefore, four different models being analysed from the technical point of view.

Assessment of viability, as depicted by these models, is based on a comparison of revenues and costs, in similar manner to that presented in reference (1), over a 25 year sugar production period. In the companion paper, many of the basic parameters were based on data collected from a number of factories and feasibility studies for a number of African countries, (Egypt, Ethiopia, Ghana and Kenya). As yet, however, in the countries in which field work was undertaken only three OPS factories exist and none has been operating for more than a few months. Much of the basic data has therefore been drawn from that used in analysis of large scale situations or from small scale experience elsewhere (in particular India).

Since OPS technology is relatively less well known a brief description is given here of the factory specification and performance assumed in this paper. The basic factory specification is fairly similar to that outlined in a booklet published by the Planning Research and Action Institute, India (2). Specifications of complete units currently offered by Indian machinery manufacturers are closely modelled on this. The major differences relate to the increased crushing capacity of the plant considered in this paper compared with that detailed by P.R.A.I. (60 tcd). Annex I provides a list of the principal factory plant and equipment.

It is assumed that downtime will amount to 25% of available cane crushing time, reducing the net crushing days to 202 (long season) and 112 (short season). Unplanned stoppage would appear to be more frequent with OPS technology and this is reflected in a higher percentage downtime. Annual cane requirements associated with the four models are thus 20,200 tonnes (100 tcd long season); 30,300 tonnes (150 tcd long season); 11,200 tonnes (100 tcd short season) and 16,800 tonnes (150 tcd short season).

Sugar recovery is estimated on the basis of the following parameters: (i) Cane contains 15% fibre; (ii) raw juice % cane 65 (no imbibition); (iii) clear juice % cane 61.5; (iv) 1st rab (massecuite) % clear juice 20 with rab at 86° Brix; (v) 1st sugar % 1st rab 37.5; (vi) 2nd rab % 1st molasses 90 and 2nd sugar % 2nd rab 22.5; (vii) 3rd rab % 2nd molasses 90 and 3rd sugar % 3rd rab 17.5. For further information see (3), (4).

By products in relation to cane comprise bagasse 35%, filter cake 4% and final molasses (at 80° Brix) 4.25%. Sucrose losses may be shown from the above parameters to be bagasse 19.2%, filter cake 2.3%, molasses 14.5% and undetermined 14.0% giving an approximate recovery of 50%. These assumptions regarding losses are not particularly demanding, when translated into implications for factory efficiency, in Indian conditions, where <u>modern</u> OPS units are expected to achieve 60% recovery. However, technology transferred to a different environment cannot be automatically assumed to give equal results.

With an assumed cane sucrose content of 13% (as in paper (1)), the sugar % cane ratio works out at 6½%, broken down into 4.25% first sugar, 1.5% second sugar and 0.75% third sugar.

II. AGRICULTURAL PARAMETERS

The methodology underlying the calculations follows closely that described in the companion paper (1): in particular in the description of operations with associated unit per hectare costs. As in the large scale situation, in practice unit costs vary widely depending on circumstances, and the figures used here are designed to reflect average conditions. Furthermore cane yields, given similar situations, will reflect the amount and kind of inputs expended. Annex II provides information on assumed costs and yields, showing long and short season figures separately (where those differ) and also for purposes of comparison, in terms of the corresponding large scale figures. The land development costs relate to a situation where a certain amount of land clearance is necessary. The cane yields in relation to the annual inputs are on the high side compared with the large scale yields: in a normal year, once the cane cycle is established, operating cost per tonne of cane works out at 75% of the corresponding large scale cost for both long and short season situations.

The cane cycles have been assumed to be identical to those used in paper (1): for the long season (rainfed) situation, one plant crop (22 months) and two ratoons (18 months each) plus 2 months fallow; the short season cycle comprises one plant crop (13 months) and four ratoons (11 months each) plus 2 months fallow. On the basis of the cane yields shown in Annex II the required cane areas are as follows:-

long season: 100 tcd 443 hectares, 150 tcd 665 hectares

short season: 100 tcd 406 hectares, 150 tcd 609 hectares.

Other agricultural costs not shown in Annex II relate to harvesting and administration. It is assumed that capital expenditure on cane transport equipment would be low: 1 62 hp tractor and 9 3-tonne trailers to deliver 100 tonnes of cane per day, 1 62 hp tractor and 15 3-tonne trailers for 150 tonnes of cane. Several tractors purchased initially for land preparation would there after be surplus to requirements on the cultivation side and transferred to cane transportation. Cane trailer requirements were based on estimated trip lengths of 3.0 and 4.2 km for the 100 tcd and 150 tcd situations respectively. Cane transportation is assumed to take place for two shifts per day.

Harvesting costs are based on the same unit running costs and rates of pay as those given in Annex II of paper (1).

Agricultural administration costs are based on three items of expenditure: a fixed employment cost of $4000 per annum ($8000 at high prices) covering the cost of an agricultural/transport manager and clerical assistance; a land rent of $10 per hectare ($15 at high prices); and a material cost of $0.1 per tonne of cane ($0.15 at high prices).

It is assumed that equipment has a longer life than in the large scale situations, reflecting lower annual operating hours: replacement expenditure is calculated at 15% pa. commencing 6 years after initial purchase (5% year 4 and 10% year 5).

III. FACTORY PARAMETERS

A. Cost and revenue data

A breakdown of the factory capital cost is given in Annex III. The smaller than usual percentage mark up from low to high prices for factory plant and equipment reflects the much higher number of potential suppliers of small scale sugar machinery. It is assumed here that this equipment would be imported - on a turnkey basis as in the large scale case - though it is now feasible for developing African countries to manufacture some part of this themselves.

A large element in the overall capital cost is provision for a 200 KVA generator set (plus a small standby unit) to supply power for the crusher unit and other electric motors. This cost could be considerably reduced if direct access to electricity is available. On the other hand, water availability has been assumed (with consumption estimated at up to 20,000 litres per day). Estimation of the initial training cost has been based on the assumption that three key factory employees would attend a six month training course in India.

Labour requirements are shown in Annex IV. The managerial and skilled labour requirements are estimated to be the following:-

managerial: factory manager, 3 production superintendents (1 per shift), accountant/secretary.

skilled labour: head pan boiler (1 per shift), mechanic and electrician per shift plus day mechanic and day carpenter/mason.

The majority of those classified as semi-skilled are employed at the heating bels and centrifugal stations. Basic rates of pay for daily rated staff are taken as equal to those offered in the large scale factories, with overhead costs around half. Semi-skilled and unskilled production staff have been classified as seasonal.

The managerial input seems high compared with Indian practice and certainly is so compared with Indian specification, as contained for example in (2), but is in line with East African intentions for small scale units and would appear to be advisable if units are to have any chance of success.

Consumption and prices of material inputs are given in Annex V. Fuel consumption depends partly on the efficiency of the bagasse furnaces to satisfy all process heating needs. In addition to supplementary fuel to fire furnaces, diesel oil (or electricity) will be required to power the mills and cutters and electricity needed to run the crystallisers, centrifugals, sugar drier and the various pumps. The supplementary process heating fuel requirement is based on a material flow calculation utilising Indian data (4). Some of the required parameters have been given in chapter I above; in addition it is expected that 4 kg water is evaporated per 1 kg of dry bagasse fuel consumption. On the basis of these parameters it can be shown that on the basis of 100 tonnes of cane crushed per day approximately 48 tonnes of water will require to be evaporated at the clear juice heating bel stage in order to raise the rab to 86° Brix (from 19° to 20° Brix clear juice), implying a fuel requirement of 12 tonnes of dry bagasse. In addition, 5 tonnes of dry bagasse are required daily for the heating of the sulphitation and molasses bels. With the bagasse: cane ratio estimated to be 35% (at around 51% moisture) it would appear that around 17 tonnes of bagasse (on a dry basis) could be available per day under optimal conditions. However to allow for possible shortfall, a requirement of 1 tonne firewood per 100 tonnes cane has been allowed for, to be used in the molasses bels' furnaces.

Miscellaneous expenditure is based primarily on the (maintenance) cost of running 2 vehicles (saloon and pick-up truck) at £0.1 per km (at low prices). The total figure is taken as £6000 long season and £4800 short season at low prices, with the high price figures 50% more.

Estimation of capital replacement expenditure has been evaluated on the observation that certain prices of equipment, particularly pans and crystallisers, have a much shorter life than the 25 years taken for factory production. In the long season situation it is estimated that 45% of the value of plant and equipment requires replacement after every six years of operation, with a further 15% requiring replacement once (after thirteen years). In the short season situation it is estimated that 45% of plant and equipment requires replacement after every eight years of operation. In addition it is assumed that the factory vehicles require replacement after six years (long season) or eight years (short season).

As mentioned in chapter I, OPS factories produce up to three (sometimes four) grades of sugar, of differing qualities. These sugars have been priced on the basis that first sugar is of comparable quality to large scale factory mill-white sugar (certainly in India modern OPS units are capable of producing sugar of at least 'D29' standard, a common grade of Indian vacuum pan sugar); that second sugar is slightly 'inferior' in terms of colour and grain size; and that third sugar is distinctly darker in colour than the other two grades. The respective prices used (per tonne) are $300, $270 and $225 in the low price models with high prices being double the corresponding low price. Molasses is priced at $15 per tonne ($30 per tonne high price) as in the large scale factory models.

B. Production parameters in the early years of operation

The date of commencement of sugar production depends on the length of time required to obtain the first harvesting of cane. It is assumed, for convenience, that land clearance takes one year - as in the large scale situations - so that sugar production commences at the same time as in the corresponding large scale models. A new project cannot commence at or even near the full production rate if the plant crop/ratoon crop distribution is to remain within reasonable proportion, though planting over the first few years exceeds the normal (equilibrium) level to some extent in order to bring the factory into full production more quickly. It is assumed that the long season factory commences production in year 4 at a rate of 33% of normal, building up to 100% by year 7: in the short season model production commences one year earlier. The required agricultural operating cost expenditures in the early years (expressed as a percentage of normal) are shown in Annex VI, and the corresponding required distribution of expenditures on capital items in Annex VII.

Expenditure on factory materials, fuel and seasonal labour is pro rated to the proportion of cane crushed; expenditure on permanent labour including management is taken as 75% of normal in the first year of production and 100% from the second year onwards.

Finally, it is assumed that sugar recovery will be lower than normal in the first two years, as shown in Table 1.

Table 1 Outputs in early years as percentage of cane

Year of operations	First sugar	Second sugar	Third sugar	Molasses
First	2.0	1.0	1.5	5.0
Second	3.0	1.25	1.25	4.5
Third	4.25	1.5	0.75	4.25

IV. PRESENTATION OF RESULTS

Annex tables VIII and IX show the initial cash flow calculations, plus the internal rate of return and net present value (discounted at 10% per annum), for each of the 4 models (at low prices) plus the corresponding IRR and NPV calculations at high prices.

In all short season models, sugar production would show a loss: indeed even in the high price regime only the 150 tcd model achieves an operating profit in normal years - given the assumed technical and economic parameter values - before interest charges but including provision for the replacement of equipment.

In the long season situation all models earn a positive rate of return: in addition the advantage of three shift over two shift working would appear to be substantial, and on the figures given probably crucial in order to pay interest charges etc.

The broader implications of these results and a comparison with those obtained for the large scale models is presented in another paper (5). It is worth recording here, however, that the agricultural costs used price cane on a per tonne basis rather lower than in the large scale models and no allowance is m de in this paper for housing costs for managerial staff or skilled workers. On the other hand wage rates used, in particular for daily rated staff, have been the same as those used for similarly classified types of worker as would be paid by large factories. An investigation of the impact of changes in these assumptions will be presented elsewhere (6).

ANNEX I

Specification of plant and equipment required by OPS factory

1. Cart weighbridge 5 tonne capacity.
2. 2 x 3 roller hydraulic crusher (355mm x 530mm) with cane carrier and two sets of knives.
3. 100 hp electric motor for the crusher, 15 hp and 10 hp electric motors for knives.
4. 2 raw juice tanks.
5. 0.6 cubic meter capacity air compressor, sulphur oven and scrubber for gas filtration.
6. 4 sulphitation tanks.
7. 2 sulphited juice heating bels (each of 4 pans) fired by wet bagasse furnaces.
8. 24 settling tanks.
9. 3 filter presses (760mm x 760mm).
10. 6 clear juice heating bels (each of 5 pans) individually fired by a wet bagasse furnace.
11. 36 U-shaped crystallisers.
12. 3 centrifugals (305mm x 610mm).
13. 5 molasses heating bels (each of 3 pans) individually fired by a firewood fuelled furnace.
14. Sugar drier with hopper and elevator.
15. Pumps, small electric motors, pipes and fittings, sugar bagging and weighing equipment and other miscellaneous small items.

ANNEX II

Agricultural unit costs and yields

A. Initial capital expenditure		low price	$/ hectare	high price	% large scale
1. land clearance/preparation/ drainage		125		212	0.5
road construction		83		130	0.33
2. agricultural equipment		200		300	0.5
B. Annual operating cost excluding depreciation	**Area applicable**				
1. land preparation/ planting	ARA	200		320	0.83
2. plant crop cultivation:	area under plant crop				
long season		150		240	0.5
short season		240		385	0.5
3. ratoon crop cultivation:	area under ratoon crop				
long season		62.5		100	0.25
short season		93.8		150	0.25
4. civil engineering	total	5		8	0.33
C. Cane yields per hectare per month					
long season: small scale 4 tonnes					0.8
short season: small scale 2.5 tonnes					0.63

ANNEX III

OPS factory capital cost

		low price	$ 000	high price
1.	Plant and equipment (FOB India)	100.0		120.0
	Freight and insurance	10.0		12.0
	Port charges and internal transportation	5.0		6.0
	Installation including supervision	25.0		36.0
	Civil works	40.0		60.0
	sub total	180.0		240.0
2.	Generator sets	50.0		75.0
3.	Vehicles	20.0		30.0
4.	Office/laboratory equipment	5.0		7.5
5.	Initial training	6.0		10.5
	total	261.0		363.0

ANNEX IV

OPS factory employment

	Number of people		Average monthly employment cost $	
	100 tcd	150 tcd	low	high
1. Administration				
Management	2	2	600	1200
Clerical/storekeepers	4	4	82.5	175
Drivers	2	2	58.5	117
Unskilled	5	5	27.3	54.6
2. Production				
Management	3	3	345	690
Skilled workers	2	3	114.4	228.8
Semi-skilled workers	29	43	41.9	83.8
Unskilled workers	137	205	27.3	54.6
3. Maintenance				
Skilled workers	6	8	114.4	228.8
total	190	275		

ANNEX V

OPS factory operating costs
(excluding salaries and wages)

Item	Consumption per 100 tonnes cane	Unit	Price $ low	Price $ high
1. Fuel:				
heavy diesel oil	500 litres	litre	0.16	0.24
firewood	1 tonne	tonne	12	18
lubricants	(10% of diesel oil expenditure)			
2. Process materials:				
lime	200 Kg	tonne	60	90
sulphur	50 Kg	tonne	300	450
castor seed	0.2 Kg	Kg	7	10.5
sugar bags (100 Kg)	(1% wastage)	each	0.9	1.35
filter cloths	2 cloths	each	8	12
3. Repairs & maintenance materials:				
150 tcd long season		5% installed factory cost		
100 tcd long season/150 tch short season		4% installed factory cost		
100 tcd short season		3% installed factory cost		
4. Miscellaneous expenditure	See text			

ANNEX VI

Expenditure on agricultural activities in early years

Year:	2	3	4	5	6	7	8
A. **Long season:**							
preparation/planting	67	167	133	100	100	100	100
plant cultivation	25	100	140	125	100	100	100
ratoon cultivation			35	75	115	130	110
civil engineering		25	50	75	100	100	100
harvesting			33	75	95	100	100
B. **Short season:**							
preparation/planting	150	175	125	100	100	100	100
plant cultivation	150	175	125	100	100	100	100
ratoon cultivation		40	90	125	140	120	105
civil engineering		25	50	100	100	100	100
harvesting		30	65	90	100	100	100

ANNEX VII

Time distribution of expenditure on fixed capital

Item	Year 1	2	3	4
A. Long season:				
agricultural equipment	100			
land clearance/preparation	40	40	20	
cane transport equipment			27	75
factory equipment and buildings			50	50
B. Short season:				
agricultural equipment	100			
land clearance/preparation	50	50		
cane transport equipment		25	75	
factory equipment and buildings		50	50	

ANNEX VIII

Summary of cash flow calculations $000 (low price)

	Year	Working capital	Agriculture Capital	Agriculture Operating	Factory Capital	Factory Operating	Revenue	Net Surplus
Long season 100 tcd	1		125.4	4.4				-129.8
	2	1.8	36.8	24.3				- 62.9
	3	3.3	27.7	60.7	130.5			-222.2
	4	16.4	28.0	103.6	130.5	62.1	85.5	-255.1
	5	25.1		139.7		113.4	240.8	- 37.4
	6	18.5		161.5		132.5	366.6	54.1
	7	3.2		169.7		138.0	385.7	74.8
	Normal			168.5		138.0	385.7	79.2
Long season 150 tcd	1		188.3	6.6				-194.9
	2	2.7	55.3	35.4				- 93.4
	3	5.0	41.8	89.8	130.5			-267.1
	4	24.6	42.1	156.4	130.5	79.1	128.3	-304.4
	5	37.6		214.1		149.3	361.2	- 39.8
	6	27.8		248.8		177.5	549.9	95.8
	7	4.8		261.7		184.5	578.6	127.6
	Normal			259.9		184.5	578.6	134.2

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ANNEX VIII (cont/d.)

	Year	Working capital	Agriculture Capital	Agriculture Operating	Factory Capital	Factory Operating	Revenue	Net Surplus
Short season 100 tcd	1		123.4	4.1				-127.5
	2	5.0	51.5	61.0	130.5			-248.0
	3	9.8	28.0	101.8	130.5	47.6	42.9	-274.8
	4	11.2		123.1		78.6	115.4	- 97.5
	5	11.9		141.7		93.5	192.7	- 54.4
	6	3.6		153.8		99.5	214.2	- 42.7
	normal			146.7		99.5	214.2	- 32.0
Short season 150 tcd	1		185.2	6.1				-191.3
	2	7.5	77.4	90.7	130.5			-306.1
	3	14.7	42.1	152.4	130.5	58.4	64.4	-333.7
	4	16.8		185.8		99.3	173.1	-128.8
	5	17.9		214.7		120.6	289.1	- 64.1
	6	5.4		233.5		129.2	321.3	- 46.8
	normal			222.9		129.2	321.3	- 30.8

ANNEX IX

Net present values and internal rates of return

	low prices		high prices	
	NPV[1/] $000	IRR %	NPV[1/] $000	IRR %
1. 100 tcd				
long season	- 185.1	6.5	518.8	15.4
short season	- 929.1	loss making	-1073.8	loss making
2. 150 tcd				
long season	- 22.3	9.5	1199.3	18.9
short season	-1117.0	loss making	-1145.4	loss making

1/ Discounted at 10% per annum.

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