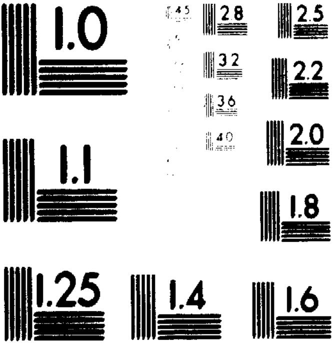

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INTEGRATED APPLICATIONS OF TECHNOLOGIES FOR COMPLETE UTILISATION OF AGRICULTURAL CROPS

A Report prepared for UNIDO
by Centre for Development Alternatives

1984

CONTENTS

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PREFACE

Total utilisation of agricultural crops as raw materials for industrial applications has been a concept which has attracted considerable attention in the recent past. The Centre for Development Alternatives has been examining alternatives which could be used for rural industrialisation using this concept where every part of a crop can be efficiently utilised. This report prepared for UNIDO is an outcome of such a detailed study. The report is prepared jointly by

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It has had the benefit of advice, through discussions of a number of professionals.

2. INTRODUCTION :

Past experience has clearly shown that rural industrialisation is not setting up large industries in rural areas. It is more the full exploitation of rural resources, particularly the agricultural resources. In food crops, the proportion of agricultural residues to the food obtained for human consumption is approximately 1.5 to 1 for roots and tubers; 2 to 1 for cereal grains; 2 to 1 for oil seeds and 10 to 1 for sugar crops. This biomass should be viewed as an asset and utilised effectively. This aspect has not received the attention that it deserves. A new concept of "leaf to root" utilisation has to be developed and demonstrated.

The Centre for Development Alternatives (CDA) has been advocating that every part of an agricultural plant must become a raw material for industries. For example, several industries may be set up around a paddy plantation. Straw may be used for making cardboard, wrapping paper, roof thatch, bed for mushrooms, apart from animal fodder; paddy husk may be used as fuel and the resultant ash for producing sodium silicate, solar grade silica, silica gel, ceramic materials and refractories and cement-like products. It can also be used for making particle board, activated carbon, furfural, fillers, and extenders, fire resistant compositions, paddy husk bricks, for mulching, soil reclamation and as a filler in fertilizer industries and animal feed. Rice bran extracted for oil, for edible and non-edible purposes like soaps, detergents, paints etc. The deoiled rice bran contains 20 to 25 per cen protein and used as animal fodder. Rice is used apart from food and several products, for use in beer, wine and several startch-based industries, like adhesives, chemicals, etc.

If systematic studies are conducted, it is easy to prove which agricultural crops a farmer may grow taking into account not only for selling agricultural produce but also converting other residues into industrial products. Setting up several industries centred around each plant, using every part of the plant from leaf to root, would lead to a large number of decentralised industries in rural areas where the bulk produce fetches better returns to the farmer; his earnings reinvested in the industries right in front of him; additional gainful employment to rural people; and bringing city comforts to the villagers.

To understand the validity of this concept and its suitability for action, a study has been undertaken in a district in Tamil Nadu state for Paddy crop. The study is devided into three aspects.

a) A survey of the possible industries which could be established around a Paddy crop and preparation of an inventory of such industries.

b) A study of the present utilisation pattern and available potential.

c) The possibilities for setting up additional industries and a plan of action.

3. CHOICE OF PROJECT AREA & METHODOLOGY :

Based on an initial survey of the state resources and possible utilisation patterns, it was decided to confine the present study to North Arcot district and to Rice cultivation. Fig. 1 and 2 illustrate the reasons behind such a choice. As a continuation of such a survey, we propose to study a dry crop like groundnut in the same district. Our initial attempt has been to look for possible implementation of the suggestions coming out of this report. To achieve this, we had involved officials of the Government of Tamil Nadu and prepresentatives of several banks who could later finance the working of a project.

The report has been prepared in three distinct parts. The first part represents an outcome of a survey conducted in the district by a team of officers based on individual interviews with the farmers. The second part projects a product technology profile and gives details about the possible industries which can be established around paddy plantation. The third part deals with why an individual farmer has not been able to establish such industries and proposes a collective action which will hopefully provide for a better utilisation of a paddy crop through a number of industries centered around the basic crop.

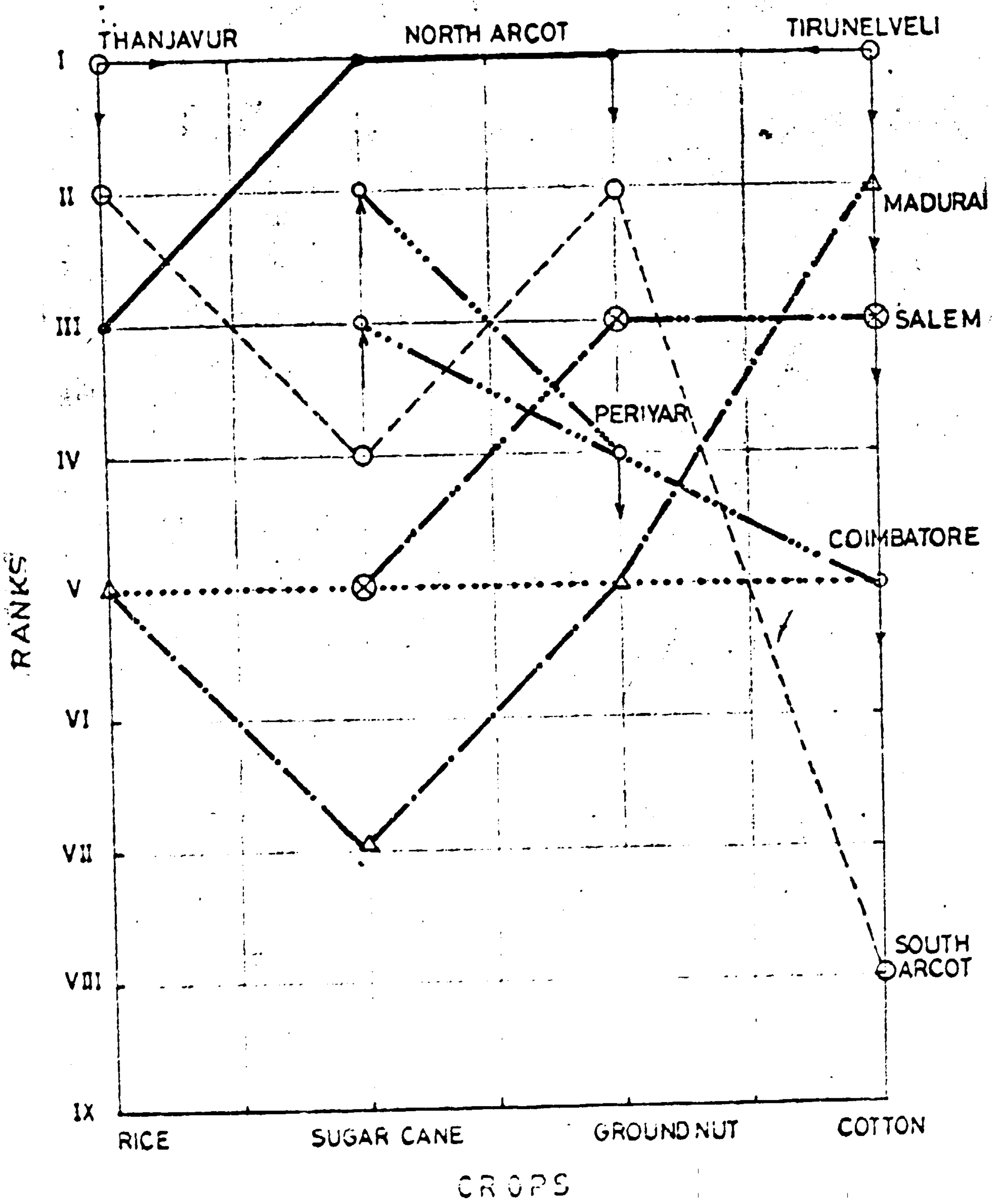
4. BACKGROUND DATA ON NORTH ARCOT DISTRICT :

From a preliminary study, an area where sufficient Paddy is being grown but where a feasible number of rice mills, furfural plants and bran oil processing units are not functional has been selected. North Arcot district which is not necessarily the best Paddy growing area but which represents an area where concerted agro-industrial plan can be implemented has been chosen for such a study. North Arcot District with an area of 12,268 sq.km. accounts for 9.43% of the state total area, and with 4.4 million human population account for 9.1% of the state total population. The district with 77% of the people living in rural areas is mainly depending on agriculture. The density of human population of 359 persons per sq.km. in the district is slightly less compared to the state average figure of 371 per sq. km.

The district is surrounded by Chingleput in the east, South Arcot in south, Dharmapuri in West and Andhra Pradesh in North. The district head-quarters, Vellore is about 135 kms. from Madras city.

Among the major food crops grown in Tamil Nadu, it has been decided to cover paddy (in the first instance) and groundnut - one purely irrigated and another rainfed-crops in this study. Districts are arranged in order (among these two crops) based on 1979-80 crop production statistics. North Arcot, with the production of 7.3 lakh tonnes of rice which accounts for 13 % of the state production occupies third position next to Thanjavur and South Arcot. In case

DISTRICT WISE PRODUCTION RANKING FOR FOUR SELECTED CROPS IN TAMIL NADU 1979-80



DISTRICT WISE PRODUCTION RANKING FOR FOUR SELECTED CROPS IN TAMIL NADU 1979-80

CROPS	NORTH ARCOT	SOUTH ARCOT	SALEM	MADURAI	PERIYAR	COIMBATORE	TANJAVUR	TIRUNEL-VELI
	DISTRICTS WITH RANKS							
1. RICE	III	II	XI	V	X	XIV	I	VII
2. SUGAR CANE	I	IV	V	VII	II	III	IX	XII
3. GROUNDNUT	I	II	III	V	IV	X	IX	Neg.
4. COTTON	XI	VIII	III	II	VI	V	X	I

[ ] DISTRICTS HOLDING UP TO V th RANK IN RESPECT OF SELECTED CROPS

DISTRICTS HAVING 3 CROPS	DISTRICTS HAVING 2 CROPS	DISTRICTS HAVING ONE CROP
1. NORTH ARCOT i) RICE III ii) SUGAR CANE I iii) GROUND NUT I 2. SOUTH ARCOT i) RICE II ii) SUGAR CANE IV iii) GROUND NUT II 3. SALEM i) SUGAR CANE V ii) GROUND NUT III iii) COTTON III 4. MADURAI i) RICE V ii) GROUND NUT V iii) COTTON II	1. PERIYAR i) SUGAR CANE II ii) GROUND NUT IV 2. COIMBATORE i) SUGAR CANE III ii) COTTON V	1. TANJAVUR RICE I 2. TIRUNELVELI COTTON I 3. CHENGALPATTU RICE IV

of groundnut production, out of 10.6 lakh tonnes of state total production, North Arcot alone produces 2.23 lakh tonnes (which account for 21%) and occupies first rank in the state. Thus the district has a prominent place in the state both in rice and ground-nut production, hence North Arcot has been chosen for this study. Further, the government officials who participated in the initial discussions felt that this area would be suitable for followup implementation as well. The information regarding various crops grown in various districts is shown in Table 1.

The district has a fairly good annual rain fall which ranges from 1014 mm to 1284 mm except in 1978-79 and 1980-81 which have recorded very low rain fall.

Annual Rain Fall (June - May) (in mm.) (actual)

1976 - 77	..	1166.6
1977 - 78	..	1283.8
1978 - 79	..	933.3
1979 - 80	..	1013.7
1980 - 81	..	608.4
1981 - 82	..	1064.7

The district has three medium and minor irrigation projects, with a total ayacut area of 4485 hectares. It has 748 canals with a total length of 1909 kms.

Area Under Irrigation

	(1979-80) Project	(Under Medium and Small Projects)	Ayacut Area)
1)	Sathanur		2782
2)	Thandrai		1017
3)	Polar		686
		Total	4485

The district has large number of wells (279,961) which account for 19% of the total number of wells in the state. These are the major source of irrigation in the district, followed by 3189 tanks. The table below shows the sources of irrigation in the district.

Net area Irrigated by Different Sources

1977-78 (in hectares)

Government Canals	:	19,648
Tanks	:	123,945
Tube wells	:	1,332
Wells sole irrigated	:	138,276
Wells supplements other sources of irrigation	:	34,772
Other sources i.e. Sprints, Channels	:	3,659
Total	:	321,632

Source: Annual statistical abstract for Tamil Nadu 1978-79 Department of Statistics, Madras.

Area & Production :

In North Arcot district almost all the farmers grow paddy depending on the availability of irrigational facilities. The small and marginal farmers cultivate paddy mainly to meet their domestic demand while big farmers grow for commercial purpose. In places where irrigational facilities are assured, farmers grow three crops in a year without much gap between one crop and the other. The three crops and total area cultivated under paddy during 1981-82 in the district are presented below:

		Hectares	% to total
I	Crop (July to Oct.)	104,000	60
II	Crop (Nov. to Feb.)	63,000	36
III	Crop (March to June)	7,000	4
	Total	174,000	100

The first crop (July to Oct.) is grown on largest area (60%) followed by 2nd crop (36%). The third crop is grown in a small area (4%). Thus the paddy is grown mainly in two seasons as indicated above.

The common varieties of paddy cultivated in the district are Kichide; IR 20, IR 8 and Masuri - the latter three are HYV. The duration of the crop ranges 120 to 160 days.

In the district paddy is cultivated in total area ranging from 1,35,564 hectares (in 1980-81) to 318,707 hec. (in 1978-79). The average area for the last 5 years is worked out at 264,000 hectares. Due to unprecedented draught situation (during the last 3 years) in the state as a whole the area under paddy crop has decreased (since 1980-81). In the district, Arakonam taluk has grown paddy (during 1980-81) in largest area with 53,973 acres followed by Cheyyar (47.036), Polur (40,114), Arni (39,127), Wandavasi (26,652), Tiruvannamalai (21,778) and Arcot (20,755).

The average yeild of rice per hectare varies from 1704 kg to 234 during the last 5 years and the average is worked out as 2140 kgs. whic is higher than the state average of 2050 kgs. In terms of paddy, it works-out to 44 bags (75 kg. each) per hectare. Due to unprecedented draught conditions during last three years, the total area under paddy cultivation, and production figure are on the lower side. In the normal monsoon year the production of rice in the district would be more than 6.5 lakh tonnes.

Marketable Surplus :

As per the marketing committee (Vellore) estimates, the marketeble surplus of rice in the district is about 65% of the total production in 1981-82. The marketable surplus for 1980-81 is 50% and 1979-80 is 40% indicating the average for the last three years is 52%. It is estimated (based on the average production of rice for the last five years of 5,65,000 tonnes per annum) the marketable surplus is about 2.94 lakh tonnes of rice in the district.

5. PRODUCTION AND UTILISATION OF BYPRODUCTS :

Based on the average annual production of rice and area under paddy crop for the last five years, the availability of byproducts such as hay, bran and husk are estimated.

Hay : The first byproduct from the paddy crop available to the farmer is hay. The information collected from farmers reveals that the production of hay per hectare is about 5 tonnes. At this rate it is estimated that the district produces about 13.2 lakh tonnes of hay per annum.

Hay is stored and utlised for feeding cattle straight without any treatment. It is reported, that in many cases, the hay is not sold to others but utlised for feeding their own cattle as each farmer has, few dry as well as milch animals. But few big farmers sell hay to others when there is surplus. Hay is of very poor value if not chemically treated. At present farmers are not aware of straw treatment. The use of urea spray on straw is essential to improve Nutritional value. Straw treatment holds considerable potential for increasing livestock productivity hence extensive field testing and demonstration of this technology is advocated.

Rice : In the district mainly boiled and par boiled rice are prepared. The places like Arni and Polur are well known throughout the state for production of good quality rice (cleaned rice, free from stones). Packed, in 25 kg. cloth bag with trade mark, is a speciality in some Arni mills.

The marketable surplus of rice from this district mainly goes to places like Salem, Coimbatore, Madras, Tirupur etc. and sometimes to Kerala also.

Rice Mills and Milling Techniques :

The district has about 2000 ordinary rice mills (1980-81 data) located throughout the district and 4 modern rice mills situated in Tiruvannamalai (2) Arni (1) and Cheyyar (1). (Details in Table). The major cocentrated centres for ricemills in the district are Arni, Vellore, Arcot, Tiruvannamalai, Gudiyatham, Thirupathur, Vaniyambadi, Arkonam, Kaveripakkam, Vanadavasi, Polur and Cheyyar. Among the four modern rice mills in the district, three are under private management and one is under the management of civil supplies department (Cheyyar).

This unit is hulling paddy procured through compulsory levy from the private millers, both within and outside the district. During normal monsoon years only paddy procured from within the distric is milled but due to shortage this ayear paddy is coming here from Thanjavur also. Annually, about 16,000 tonnes of paddy are milled. The unit is working in three shifts even in the lean period.

Procurement price of Paddy

Superfine	Rs. 129 per quintal
Fine	Rs. 126 per quintal
Coarse/common	Rs. 123 per quintal

Due to wide margin between the prevailing market price for paddy (which is about Rs.200/-) and the Government procurement price, the millers are trying to evade the levy. After hulling, rice is taken over by the Department and the bran is sold on tender basis. At present bran is disposed to rice bran oil extracting unit at Savur (near Arni) at the rate of Rs.1200/- per tonne. 30-40% of the total production of husk is used for par boiling paddy in the same mill and the rest is disposed to other private millers for fuel purpose at the rate of Rs.30/- per tonne. The ash (burnt out husk) is sold as manure at the rate of Rs.25/- per tonne.

Yield from Paddy at this Mill

Rice par boiled	=	68%
Raw Rice	=	66%
Bran	=	12%
Husk	=	19 to 20%

The ordinary rice mills on the other hand can be classified into three categories:

1) Private owned: The millers buy paddy from farmers, local mandies and in regulated markets. After par boiling and drying, paddy is milled and the rice is sold both within and out side the state. Similarly bran is also sold out. The majority of the mills in the district are in this group.

2) Private owned-serving units: Under this category millers only provide facilities for par-boiling and hulling paddy for which the levy a service charge. Sometimes, the bran is retained by the miller as a service charge for paddy hulling. Very few mills are providing these facilities to local farmers who mainly bring paddy for their domestic consumption purpose.

3) Cooperative : Thereis only one unit at Vellore functioning under the cooperative system which is mainly hulling paddy for civil supplies department and collecting service charges.

Bran Oil extractions Unit, Savur:

National Extraction Industries, Savur, Arni was established during 1976 at a total investment of Rs.30 lakh (under partnership management). The daily capacity of the unit is to process 25 tonnes of bran in 3 shifts (i.e. 7500 tonnes/annum). The unit is working at i full capacity by employing 20 workers per shift. The bran required for this unit is procured from different places like Nellore, Adoni, Vijayawada in Andhra Pradesh and Chintamani in Karnataka states and also from the modern rice mills at Cheyyar and Madras. Small quantity of bran is also purchased from local mills. The price of bran varies from Rs.650/- to Rs.1600/- per tonne based on the yield of oil and quality etc. The average price is about 1200/- per tonne.

Percentage of oil yeidl from Bran (Modern Mills)

Raw Rice bran (cone polished)	:	16-20%
Par boiled	:	15-25%
Sheller-cum-Huller	:	10-25%
Local hullers (ordinary mill)	:	6%

The oil extracted from this mill is sold at Rs.7500/- per tonne. to TATA's and Hindustran Lever Ltd., for soap manufacturing.

The cake is sold to EID Parry Ltd. and Tamil Nadu Milk Cooperative producers' Union for Manufacturing Cattle Feed. The selling rate of deoiled cake varies from Rs.500/- to 875/- tonne depending on protein and sand content. The Deoiled Cake is sold at Rs. 875/- per tonne and has 16% protein 5 to 8% sand or at Rs.500-525/- if it has 14% protein 8-12% sand.

The unit is running with profits even though the raw material (bran) is procured from far off places which not only involeve heavy transport cost, and causes quality deteriotation of bran due to time involved. The same group is establishing another unit near vellore. If all the rice mills in the District are established with huller-cum-sheller then there will not be any dearth for raw material and few more oil extracting units can be started in the district.

Due to traditional hulling techniques adopted in the district the bran is not completely separated with husk. Only a small percentage (7%) of husk is separated which is used for par boiling paddy in in the same mill. It is considered as the cheapest fuel available locally. Husk is supplemented by groundnut shell. This mixture of bran and husk though not suitable for extracting oil (it contains 4 to 6% oil) is at present used for feeding cattle both within the district and sold to outside places like Erode, Salem, Coimbatore and Tirupur. However, the state government now insists that the millers must modernise their units by estabiishing hullers-cum-shellers so that theyield of rice will increase by about 2% (i.e. which works out to loss of 16866 tonnes of rice per annum) in the present system and bran from modern rice mill is suitable for extracting oil which contains 10 to 12% of oil instead of 4-6% oil content in the bran available now.

After extracting oil the deoiled cake can be used for feeding cattle without effecting any nutrients in it.

It is estimated that the district produces annually about 2.19 lakh tonnes of rice bran and husk mixture valued at 1095 lakh Rs.500/tonne) which is at present mostly fed to cattle directly. If all the mills were to establish huller-cum-sheller the pure bran availability within the district would be of the order of 1.6 lakh tonnes annually valued at Rs.1920 lakhs that is an additional value of Rs.825/-lakhs is available from bran alone which can be utilised for extracting oil. Even if the 60% of the total bran available in the district (i.e. 0.96 lakh tonnes) is utilised for extracting (oil yield 12% average) oil the district can produce 11,500 tonnes of oil worth Rs.862.5 lakhs annually at Rs. 7500 per tonne.

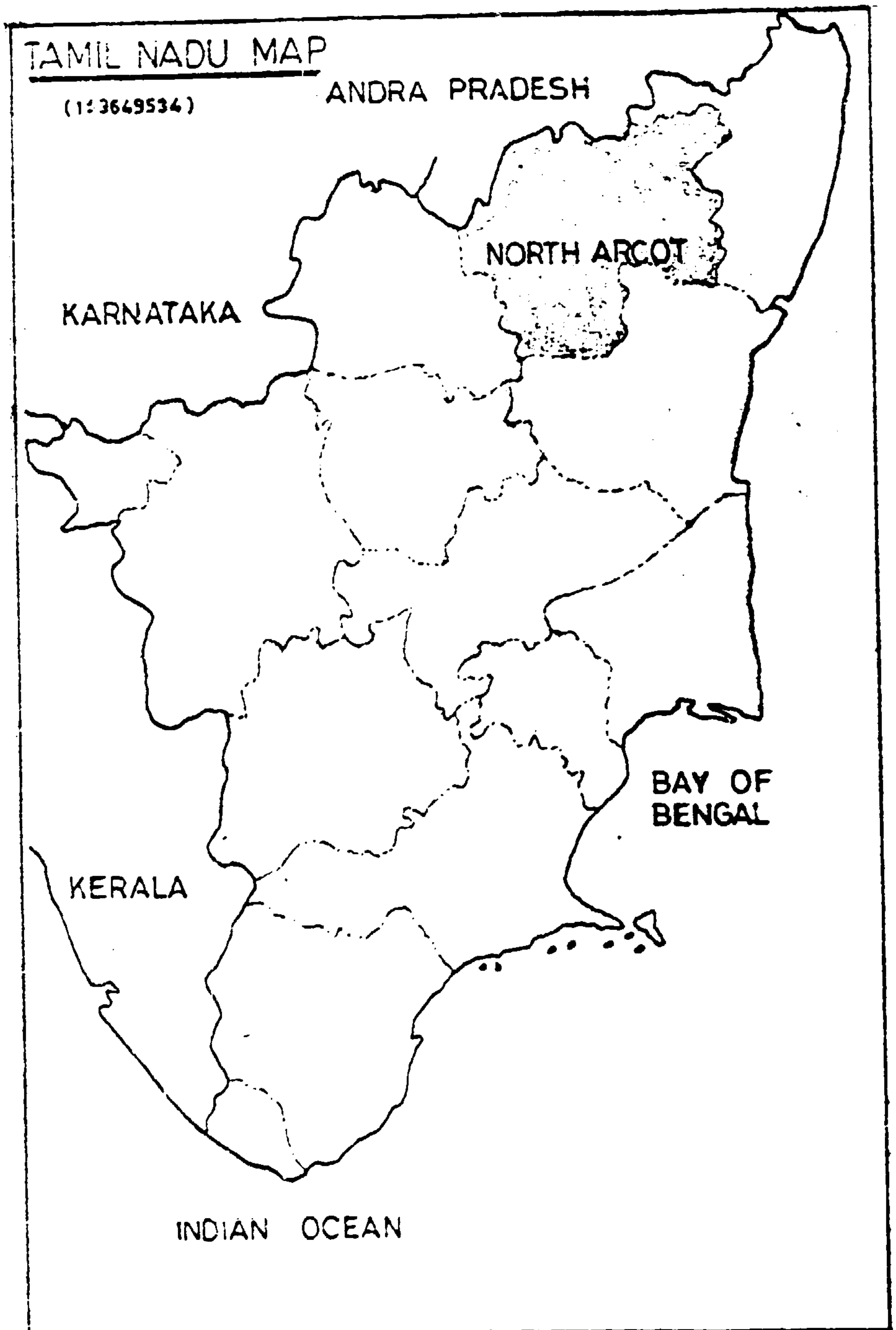
COMPARITIVE YIELD OF BYPRODUCTS FROM PADDY (843,284 tonnes)

	Modern Mills (huller)		Present system(sheller)	
	% Yield (%)	Total yield (tonnes)	% Yield (%)	Total Yield (tonnes)
Rice	69	581,866	67	565,000
Bran	19	160,224	26	219,254
Husk	12	101,194	7	59,030

Hay 13,20,000

8,43,204 tonnes of unhusked rice →
- → 5,65,000 Rice
- → 2,19,000 Bran
- → 59,030 Husk

Each Bran oil mill would use 7500 tonnes of Bran per year and there is a scope to establish atleast 20 Bran oil units in the district while only three are operational at the present time. Even amon these three only one is successfully running. Improper management, lack of timely raw material arising from improper location of the rice mills vis-a-vis the Bran oil units contribute to this situation. The suggested location and a plan of action is indicated in the map in the following page.



TAMIL NADU MAP
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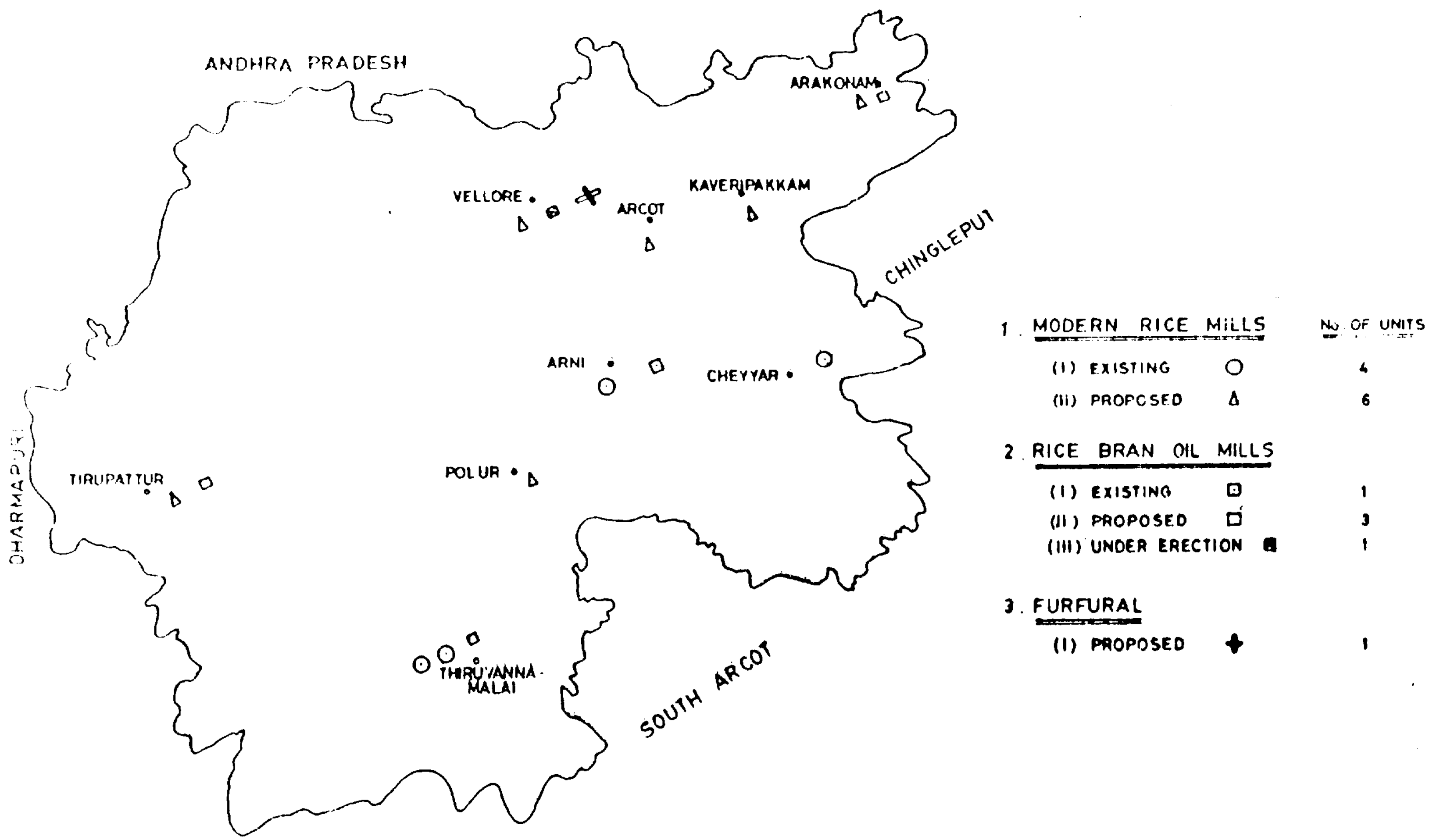
ANDRA PRADESH
NORTH ARCOT
KARNATAKA
BAY OF BENGAL
KERALA
INDIAN OCEAN

NORTH ARCOT DISTRICT MAP



Area : Hectares
Yield : Kg./hectare
Production : Tonnes

NORTH ARCOT DISTRICT

ESTIMATED AREA AND PRODUCTION OF PADDY CROP 1975-76 to 1981-82

YEAR	PADDY		
	Area	Yield	Production (Rice)
1975-76	2,80,000	2,100	5,88,000
1976-77	2,75,767	2,073	5,71,680
1977-78	2,75,767	2,073	5,71,680
1978-79	3,18,707	2,335	7,37,390
1979-80	2,94,840	2,179	6,42,660
1980-81	1,35,564	1,793	2,31,000
1981-82**	1,74,000	2,345	4,08,000
Average for preceding five years	2,64,000	2,140	5,65,000

**Forecast

Source: Office of the Assistant Director of Statistics, North Arcot District, Vellore.

NORTH ARCOT DISTRICT

ESTIMATED AREA AND PRODUCTION BY SEASON

Area: Hectares
Production: Tonnes

	Paddy			
	Area		Production	
	1980-81	1981-82	1980-81	1981-82
I Crop (...July - October)	75,000	1,04,000	1,37,000	2,27,000
II Crop (...Nov. - March)	45,000	63,000	85,000	1,65,000
III Crop (...Feb. - June)	5,000	7,000	9,000	16,000
Total	1,25,000	1,74,000	2,31,000	4,08,000

G. Nut 1st Crop : Winter (Rainfed)
2nd Crop : Summer (Irrigated)

Source: Office of Asstt. Director of Statistics, Vellore.

NORTH ARCOT DISTRICT

AREA UNDER PADDY CROP (Taluk wise) 1980-81

(in acres)

Name of the Taluk		Paddy
1.	Vellore	17,561
2.	Arcot	20,755
3.	Walajah	12,036
4.	Tirupattur	11,037
5.	Vaniyambadi	9,096
6.	Gudyatham	18,545
7.	Cheyyar	47,036
8.	Arni	39,127
9.	Wandavash	26,652
10.	Tiruvannamalai	21,778
11.	Chengam	17,923
12.	Arakonam	53,973
13.	Polur	40,112
	Total	3,35,631

Source : Office of Asst. Director of Statistics, Vellore.

NORTH ARCOT DISTRICT

AREA UNDER TOTAL PRODUCTION MARKETABLE SURPLUS, PADDY IN NORTH ARCOT DISTRICT

Year	Name of the produce	Acrage Hectare	Yield/ Hectare Kg.	Total Production MT	Marketable surplus (in MT..)	% of Marketable surplus (%)
1981-82	Paddy (Hectare)	1,35,380	2,500	3,38,450	2,19,790	65
1980-81	Paddy (Acre)	5,01,500	2,000	4,01,200	2,01,200	50
1979-80	Paddy (Acres)	7,59,089	2,500	7,59,489	3,00,000	40

Source : Marketing Committeee, Vellore.

NORTH ARCOT DISTRICT

NUMBER OF RICE MILLS DURING 1980-81.

Area	Rice Mills	
	Ordinary	Modern
Arakonam	116	—
Vellore	182	—
Panapakkam	8	—
Kelpennathur	6	—
Tiruvannamalai	139	2
Vandavasi	97	—
Chetpet	70	—
Polur	96	—
Vetavalam	4	—
Kaveripakkam	107	—
Arcot	144	—
Kalavai	41	—
Thellar	3	—
Pernamallur	5	—
Manglamanandur	2	—
Pudupalam	37	—
Ammur	12	—
Kelvaithnakuppam	7	—
Arni	221	1
Vaniyambadi	136	—
Therkolam	52	—
Dusi	52	—
Gudiyatham	139	—
Chengam	45	—
Thandrampet	40	—
Thirupathur	135	—
Cheyyar	93	1
Desur	5	—
Katpadi	3	—
Total	1997	4

Source: Marketing Committee, Vellore.

6. TECHNOLOGICAL POSSIBILITIES :

Paddy being an agricultural raw material, both the technology and product spectrum will be of wide range and variety. These are shown Figs. 3-11 and Table 1 respectively. The technology spectrum varies from simple mechanical processing thro combustion, hydrolysis, gassifica tion, pyrolysis and fusion. The product spectrum varies fromlarge deman, high volume low cost consumbales such as Food and processed foods, paper, cement thro fine chemicals to low volume high cost items such as silicon. The published information is very large, in view of the national and international awareness and high priority accorded to application of science and technology to development of rural areas in developping countries. Three major sources and some private collections are used in writing this note.

Both in preparing Figs. 3-11 and Table 1, the technology and products are arranged in a systematic way from the simple to the complex With such an arrangment one can apply SYSTEMS METHODOLOGY for providing answers raised in developmental planning studies.

The first technology shown inFig. 3 is the agriculture with the two products - Paddy and Hay. The possibility of Algae growth exists and this could be an import product, if scientific studies are conduc ted. Hay, the stalk portion is an important raw material for paper and paper based products. The technology is well established. Its present u as a fodder and composting the waste as organic manure could be improvis and if planned well, this raw material could be a valuable cellubsic

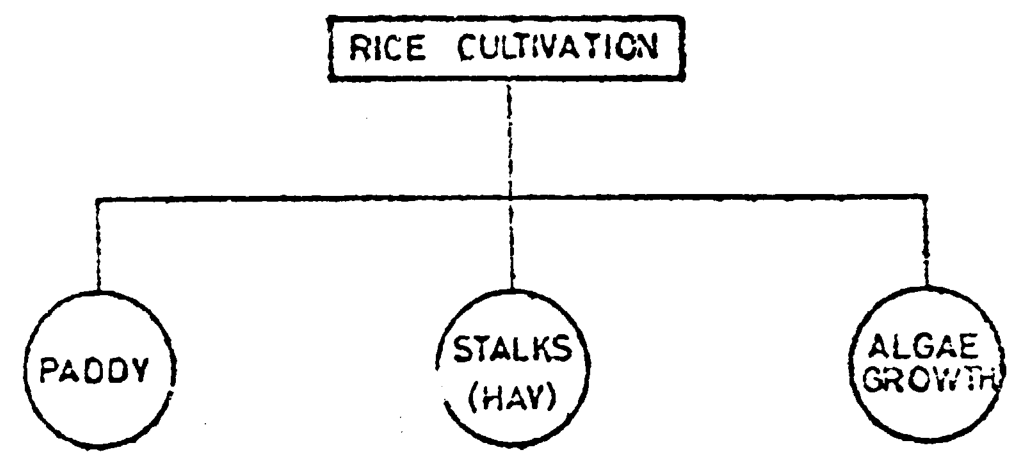


FIG.3

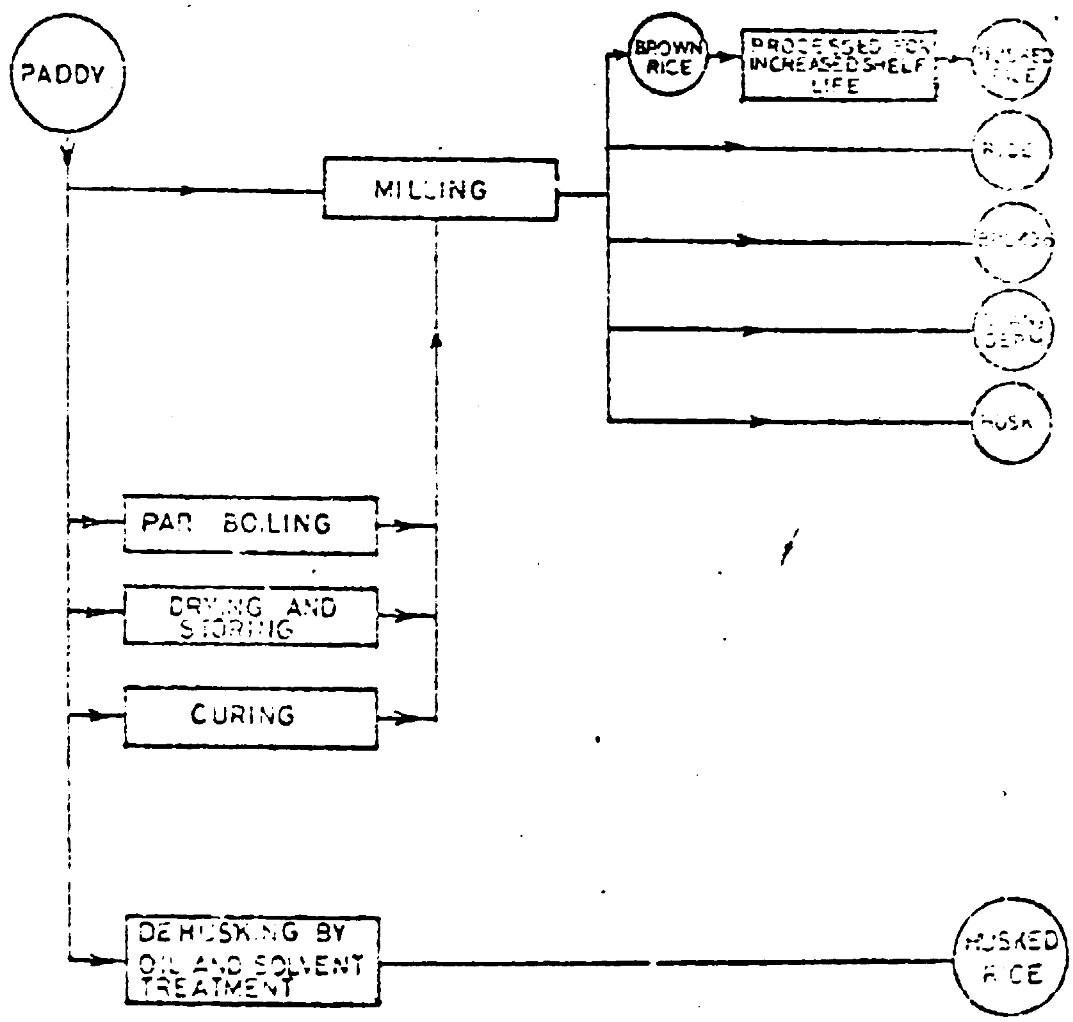
TABLE - 1 : PRODUCT SPECTRUM

S.No.	PRODUCT	TECHNOLOGY ROUTE IDENTIFICATION
1.	PADDY	I - 1
2.	HAY	I - 2
3.	BROWN RICE	I - 1 : II - 1
4.	HUSKED RICE	I - 1 : II - 2
5.	RICE	I - 1 : II - 3
6.	BROKENS	I - 1 : II - 4
7.	BRAN, GERM	I - 1 : II - 5
8.	HUSK	I - 1 : II - 6
9.	READY TO EAT, LITTLE OR NO COOKING	I - 1 : II - 3 : III - 1
10.	MIXTURES WITH BLACK GRAM TO BE FERMENTED	I - 1 : II - 3 : III - 2
11.	MIXTURES WITH BLACK GRAM TO BE DEEP FRIED	I - 1 : II - 3 : III - 3
12.	CURED RICE	I - 1 : II - 3 : III - 4
13.	FORTIFIED RICE	I - 1 : II - 3 : III - 5
14.	BROKENS FOR HOUSEHOLD USE	I - 1 : II - 4 : IV - 1
15.	STARCH	I - 1 : II - 4 : IV - 2
16.	EDIBLE RICE BRAN OIL	I - 1 : II - 5 : V - 1
17.	RICE BRAN OIL : SOAP MAKING	I - 1 : II - 5 : V - 2
18.	CATTLE AND POULTRY FEED	I - 1 : II - 5 : V - 3
19.	RICE GERM OIL	I - 1 : II - 5 : V - 4
20.	DIETARY FORMULATIONS	I - 1 : II - 5 : V - 5
21.	MINIMAL TREATMENT PRODUCTS OF RICE HUSK	I - 1 : II - 6 . VIA - 1
22.	PARTICLE BOARDS FROM HUSK	I - 1 : II - 6 : VI A - 2
23.	COMBUSTION OF HUSK-ENERGY	I - 1 : II - 6 : VI B - 1
24.	RICE HUSK ASH	I - 1 : II - 6 : VI B - 2
25.	PRODUCER GAS - HUSK - ENERGY	I - 1 : II - 6 : VI C - 1
26.	TAR	I - 1 : II - 6 : VI C - 2
27.	ACTIVE CARBON - HUSK	I - 1 : II - 6 : VI D - 1
28.	LOW CALORIFIC VALUE GAS - ENERGY	I - 1 : II - 6 : VI E - 1
29.	METHANOL	I - 1 : II - 6 : VI E - 2

30.	ACETIC ACID	I - 1 : II - 6 : VI E - 3
31.	ACETONE	I - 1 : II - 6 : VI E - 4
32.	TAR	I - 1 : II - 6 : VI E - 5
33.	CHARCOAL	I - 1 : II - 6 : VI E - 6
34.	LOW CALORIFIC VALUE GAS (PYROLYSIS)	I - 1 : II - 6 : VI F - 1
35.	LIQUID (PYROLYSIS)	I - 1 : II - 6 : VI F - 2
36.	SILICON	I - 1 : II - 6 : VI F - 3
37.	SILICON TETRA CHLORIDE	I - 1 : II - 6 : VI F - 4
38.	TITANIUM TETRA CHLORIDE	I - 1 : II - 6 : VI F - 5
39.	EDIBLE CELLULOSE	I - 1 : II - 6 : VI G - 1
40.	PAPER	I - 1 : II - 6 : VI G - 1
41.	FURFURAL	I - 1 : II - 6 : VI H - 1
42.	OXALIC ACID	I - 1 : II - 6 : VI H - 2
43.	SUGARS (XYLOSE, SUCROSE)	I - 1 : II - 6 : VI H - 3
44.	MINIMAL TREATMENT PRODUCTS OF RICE HUSK ASH	I - 1 : II - 6 : VI B - 2 : VIIA -1
45.	REFRACTORY BRICKS	I - 1 : II - 6 : VI B - 2 : VIIB -1
46.	CERAMICS	I - 1 : II - 6 : VI B - 2 : VIIB -2
47.	RICE HUSK ASH BRICKS	I - 1 : II - 6 : VI B - 2 : VIIB -3
48.	SILICON	I - 1 : II - 6 : VI B - 2 : VIIC -1
49.	SODIUM SILICATE	I - 1 : II - 6 : VI B - 2 : VIIC -2
50.	SINTERED GLASS	I - 1 : II - 6 : VI B - 2 : VIIC -3
51.	DETERGENTS	I - 1 : II - 6 : VI B - 2 : VIIC -4
52.	BUILDING BRICKS FOR PRE FABRICATED HOUSES	I - 1 : II - 6 : VI B - 2 : VIID -1
53.	HYDROTHERMAL CALCIUM SILICATE	I - 1 : II - 6 : VI B - 2 : VIID -2
54.	CEMENT	I - 1 : II - 6 : VII D - 3 (OR) I - 1 : II - 6 : VI B - 2 : VIID -3.

source, with possibilities for developments involving bio-chemical or pyrolytic degradation. Paddy which constitutes the main raw material is discussed in the rest of the note. Agricultural technology changing from rain fed irrigation and from natural to artificial fertilizers, determines the relative yield of hay and paddy. An average value of 1 to 1.5 on weight basis is assumed.

The second technology shown in Fig. 4 involves milling of Paddy. Paddy consists of Hull and Kernel. The Kernel consists of Peri carp (outer bran), seed (inner bran endosperm and germ). Removal of hull leaving the kernel involves hullers and the kernel is called brown rice. Separation of the endosperm from the rest involves polishing and gives headrice, brokens, bran and germ. The brokens are screened to get various fractions - second head, screenings and Brewers rice. Parboiling is an alternative route involving semicooking of paddy and then milling. The milling technology is simple involving mechanical operations. However, most of the mills in India do not produce all the intermediates and are mainly aimed at producing polished rice with minimum amount of machinery. There is a lot of scope of development in having a modern milling industry to produce the intermediates to serve as feed stocks for a modern agro based industrial society. Development paper no. 27 of Food and Agricultural Organisation of United Nations, Rome, 1953 gives a comprehensive modern set up for milling of paddy. Govt. of India had constituted a committee in 1964 to study and evaluate overall performance of seven modern rice mills set up around that time, in relation to the traditional mills. For the present note, it suffices to state that a modern milling practice is essential for the development of agrobased industries discussed here in and that such possibility is straight forward and highly feasible, economically.



PADDY
MILLING
BROWN RICE
PAR BOILING
DRYING AND STORING
CURING
CURING
HUSK
HUSKED RICE

F.G.

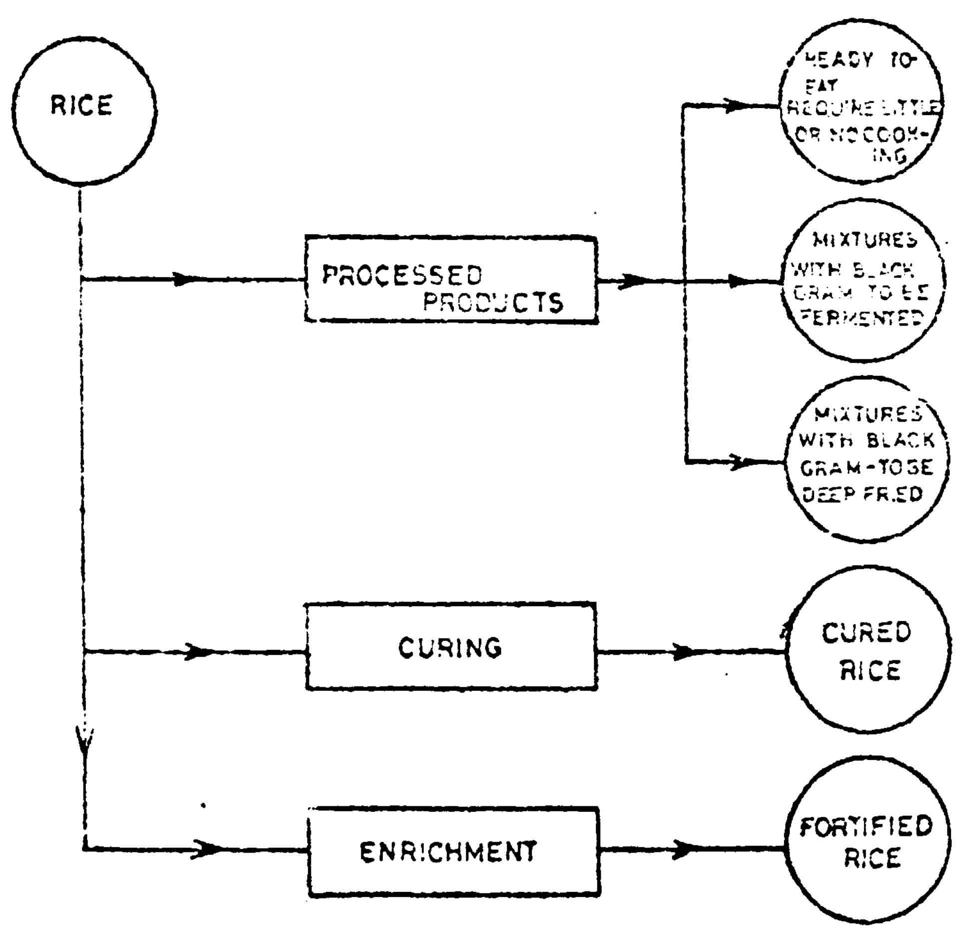

RICE
PROCESSED PRODUCTS
MIXTURES WITH BLACK GRAM TO BE FERMENTED
MIXTURES WITH BLACK GRAM TO BE DEEP FRIED
CURING
CURED RICE
ENRICHMENT
FORTIFIED RICE

FIG. 5

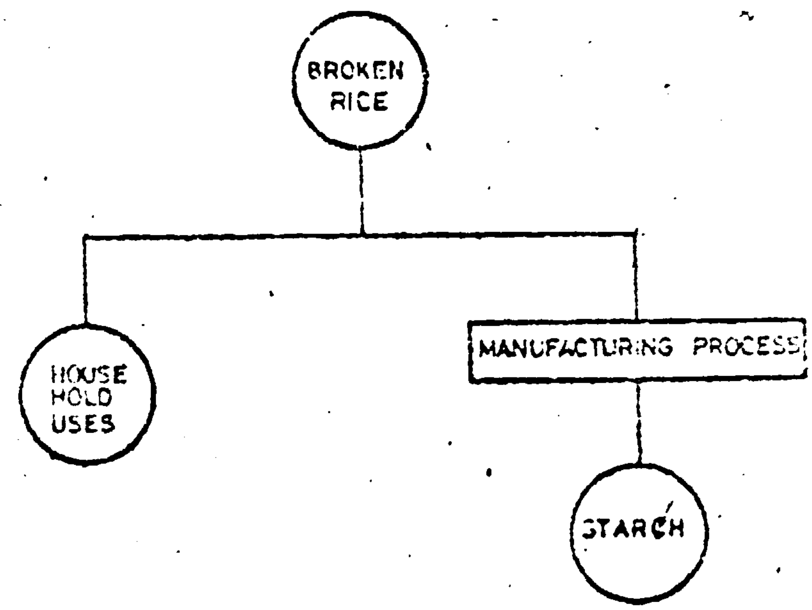


FIG. 6.

The third technology shown in Fig. 5 is with regard to processing brokens. As food shortages become past history this technology will generate the modern industrial activity to produce starch and brewary products. Such production systems are of capital intensive nature and require indigenization, adaption/transfer of technology activities.

The fifth technology shown in Fig. 7 is with regard to utilization of Rice Bran and Germ. The preliminary steps-serving d prenmatic density separation are simple mechanical processing steps. The fatter steps of solvent extraction and auto claving involve higher capital inputs. The dietary formulations is a labour intensive step. Some scientific problems such as degradation of oil quality, if solvent extraction is not done immediately after the bran is produced, exist, and these have to be circumvented by developing miniextractors to be used in rural areas or a centralised facility with adequate collection capabilities located in semi-urban areas. A base exists and the technology can be used straight away for commercial exploitation.

The sixth technology is with regard to utilisation of husk. Eight alternative technologies exist as shown in Fig. 8 with increasing degrees of complexity and about 19 products can be made. The simplest technology involves, minimal treatment and minimal additives. The next five involves - bombustion, gassification, carbonisation, destructive distillation and pyrolysis. The next two involve chemical degradation processes. Figs. 9 and 10 give details.

The seventh technology is with regard to utilisation of rice husk ash, as shown in Fig. 11. Four technological options producing about seven products are indicated.

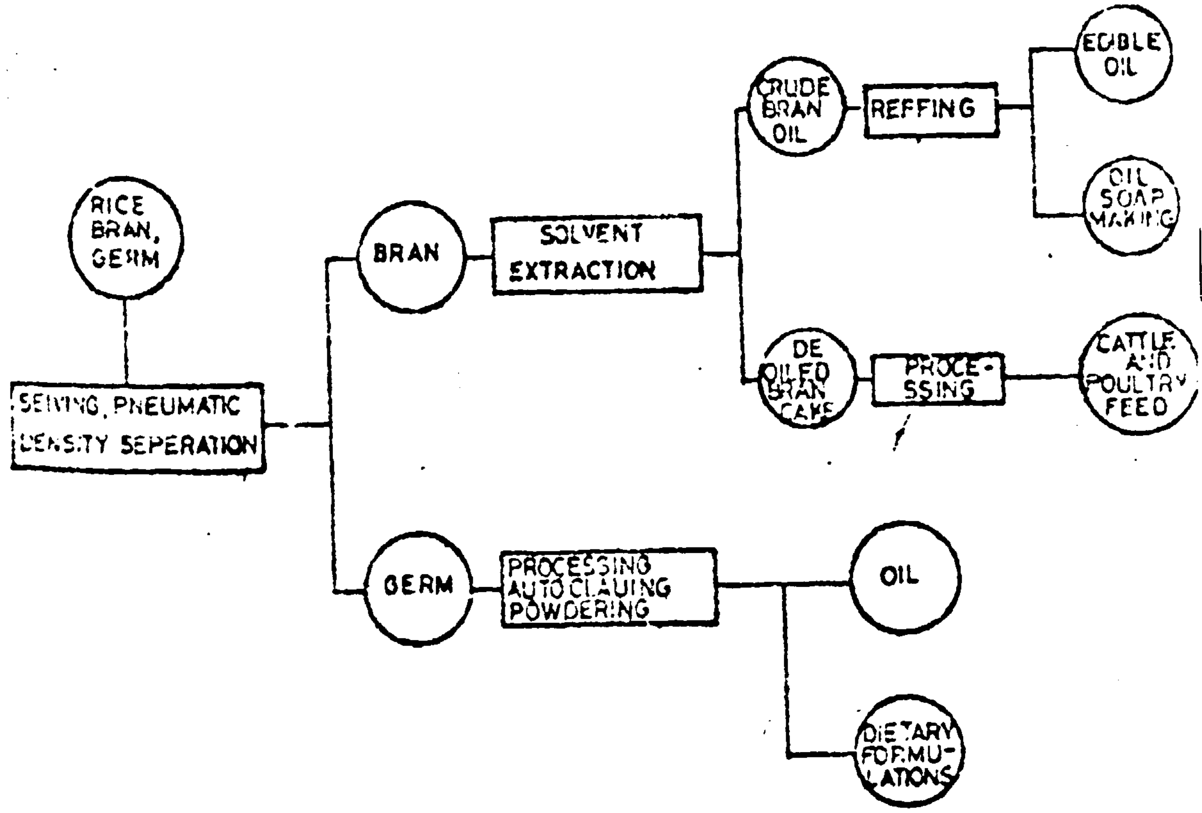

RICE BRAN, GERM
SEIVING, PNEUMATIC DENSITY SEPERATION
BRAN
SOLVENT EXTRACTION
CRUDE BRAN OIL
REFFING
EDIBLE OIL
OIL SOAP MAKING
DE OILED BRAN CAKE
PROCE-SSING
CATTLE AND POULTRY FEED
GERM
PROCESSING AUTOCLAUING POWDERING
OIL
DIETARY FORMU-LATIONS

FIG. 7

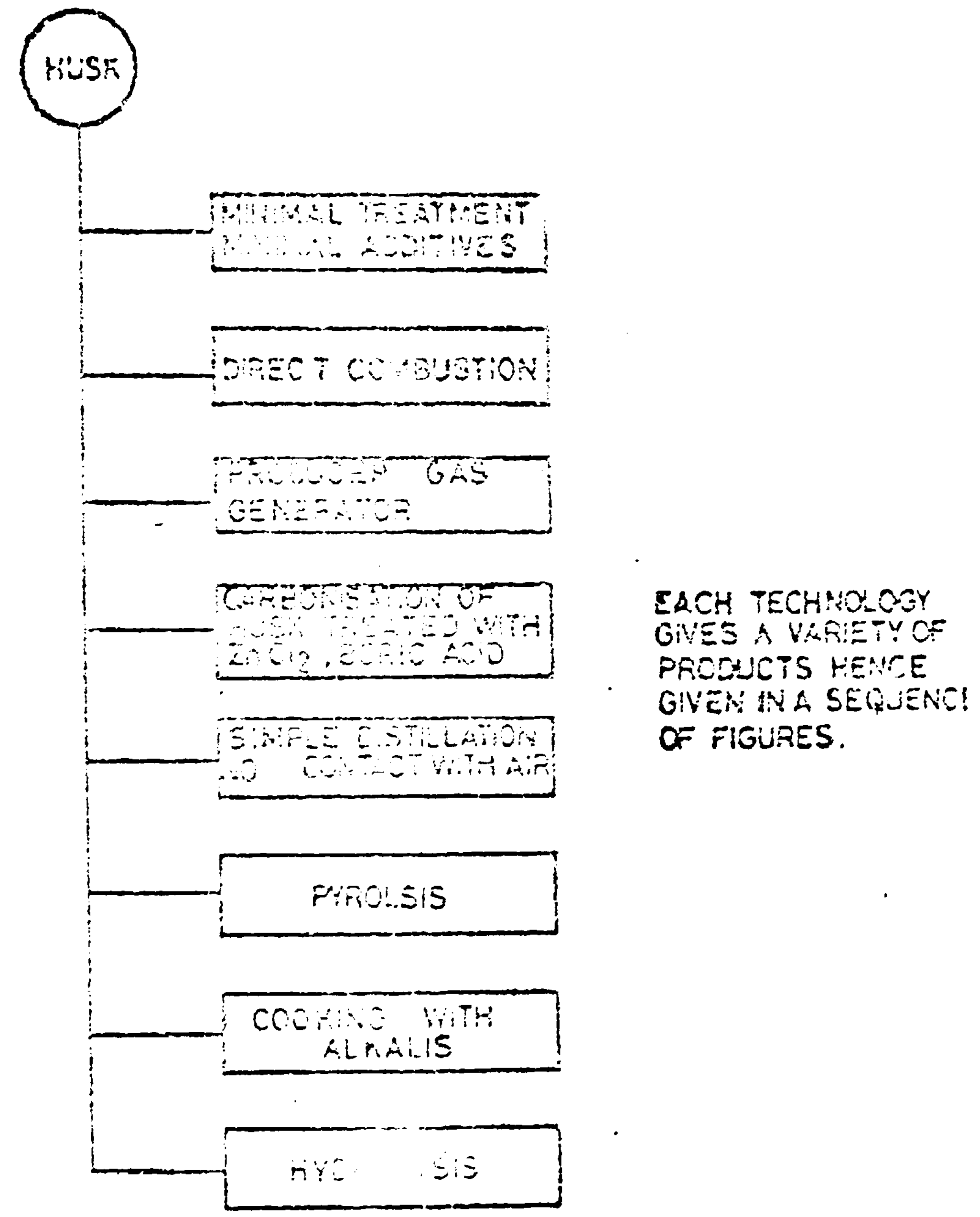
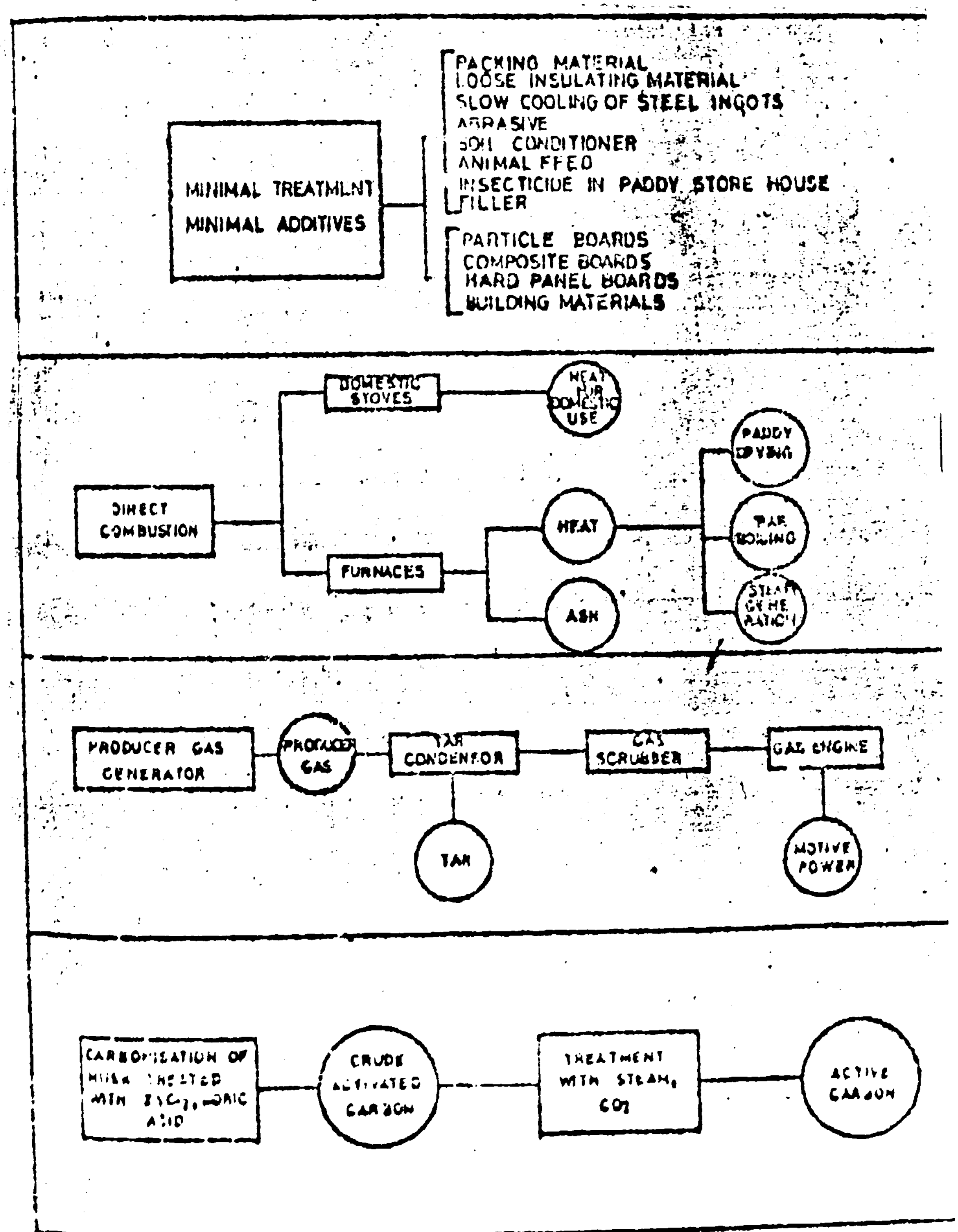
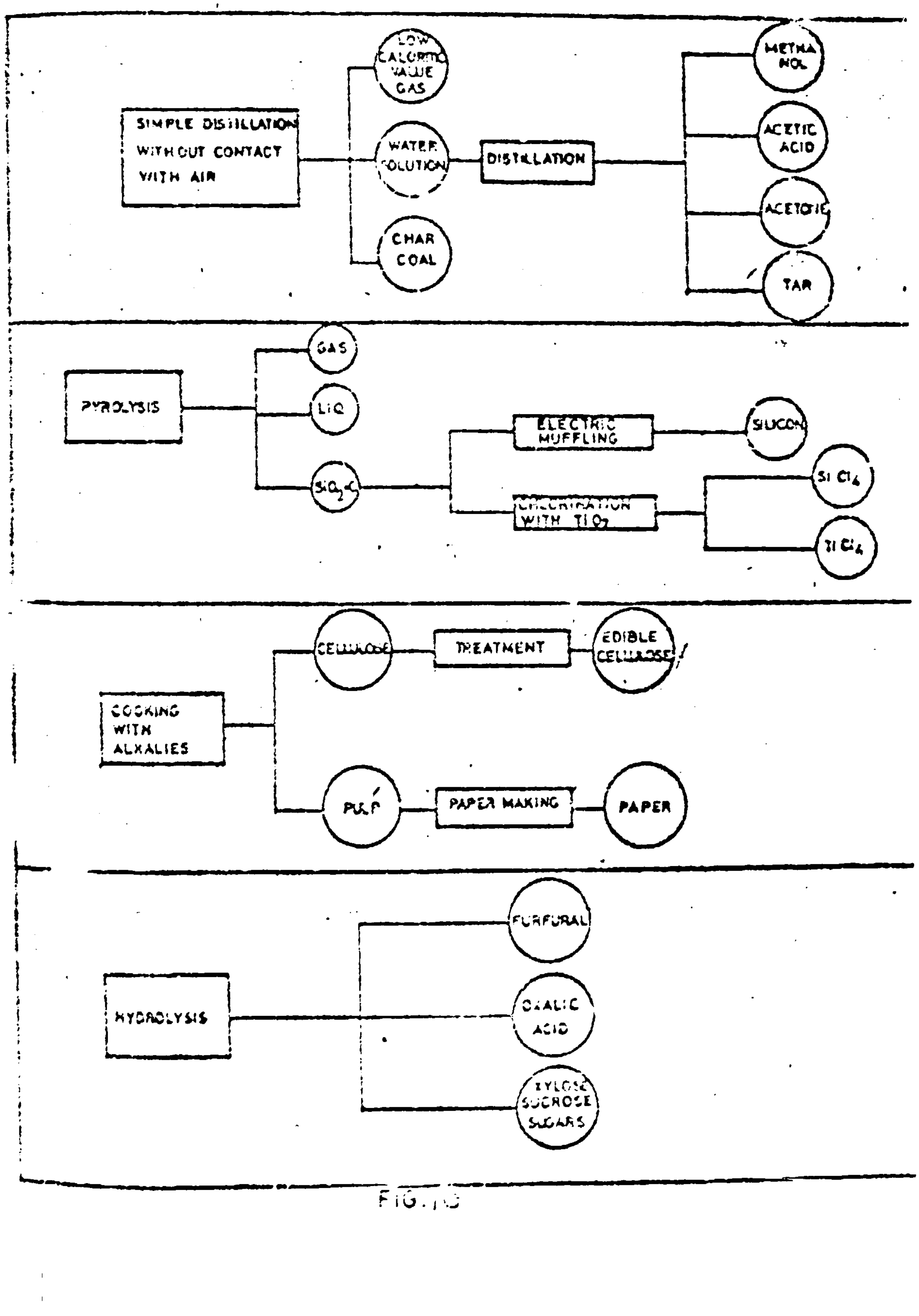

HUSK
MINIMAL TREATMENT
DIRECT COMBUSTION
PRODUCER GAS
GENERATOR
CARBONISATION OF
HUSK TREATED WITH
$ZnCl_2$, BORIC ACID
SIMPLE DISTILLATION
NO CONTACT WITH AIR
PYROLSIS
COOKING WITH
ALKALIS
EACH TECHNOLOGY
GIVES A VARIETY OF
PRODUCTS HENCE
GIVEN IN A SEQUENCE
OF FIGURES.

FIG.



PACKING MATERIAL
LOOSE INSULATING MATERIAL
SLOW COOLING OF STEEL INGOTS
ABRASIVE
SOIL CONDITIONER
ANIMAL FEED
INSECTICIDE IN PADDY STORE HOUSE
FILLER
MINIMAL TREATMENT
MINIMAL ADDITIVES
PARTICLE BOARDS
COMPOSITE BOARDS
HARD PANEL BOARDS
BUILDING MATERIALS
DOMESTIC STOVES
HEAT FOR DOMESTIC USE
PADDY DRYING
DIRECT COMBUSTION
HEAT
FURNACES
ASH
PRODUCER GAS GENERATOR
PRODUCER GAS
TAR CONDENSOR
GAS SCRUBBER
GAS ENGINE
TAR
MOTIVE POWER
CRUDE ACTIVATED CARBON
TREATMENT WITH STEAM, CO_2
ACTIVE CARBON

FIG. 5



SIMPLE DISTILLATION WITHOUT CONTACT WITH AIR
LOW CALORIFIC VALUE GAS
WATER SOLUTION
CHAR COAL
DISTILLATION
METHANOL
ACETIC ACID
ACETONE
TAR
PYROLYSIS
GAS
LIQ
SiO_2-C
ELECTRIC MUFFLING
SILICON
CHLORINATION WITH TiO_2
$SiCl_4$
$TiCl_4$
COOKING WITH ALKALIES
CELLULOSE
TREATMENT
EDIBLE CELLULOSE
PULP
PAPER MAKING
PAPER
HYDROLYSIS
FURFURAL
OXALIC ACID
XYLOSE SUCROSE SUGARS

FIG. 13

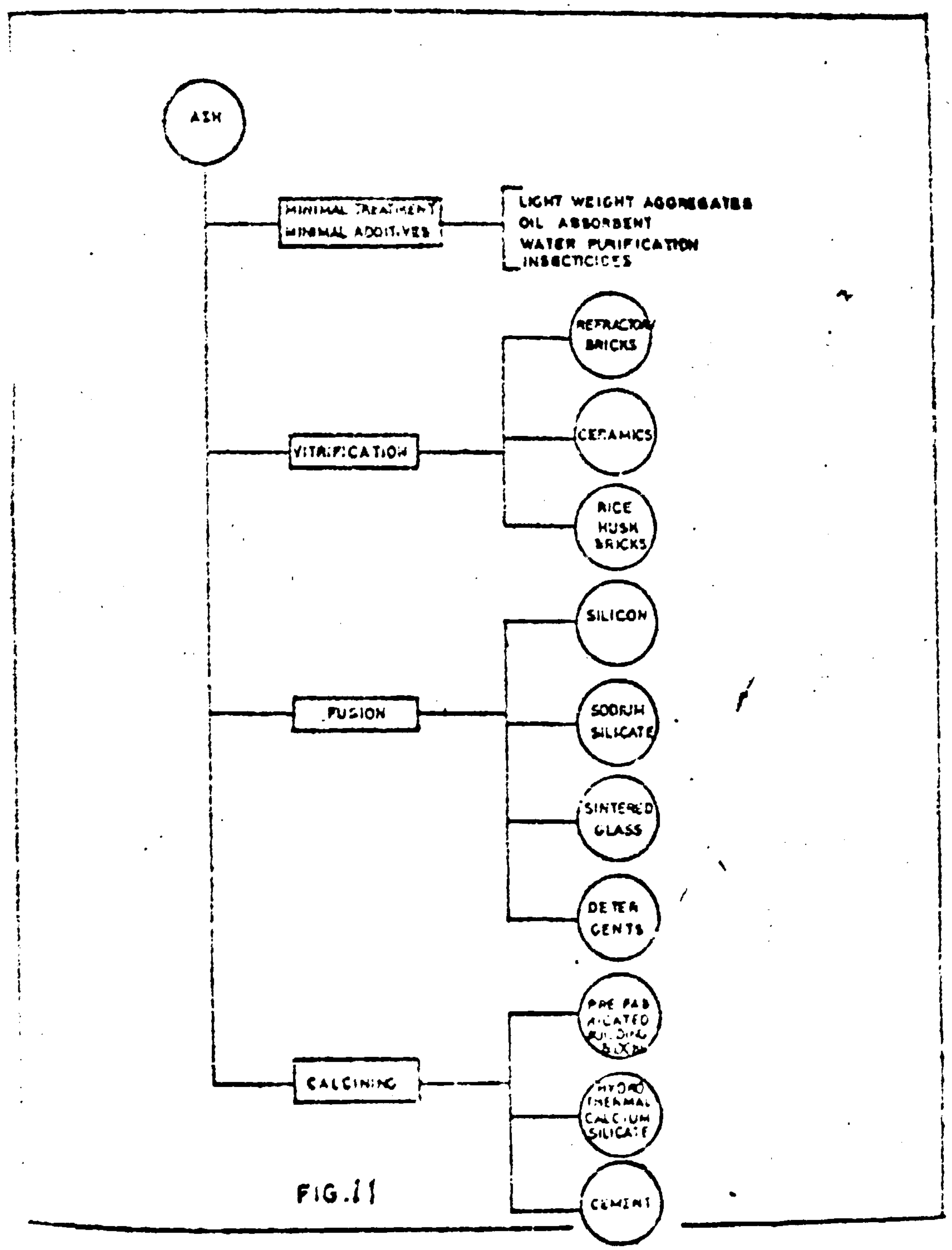

ASH
MINIMAL TREATMENT
MINIMAL ADDITIVES
LIGHT WEIGHT AGGREGATES
OIL ABSORBENT
WATER PURIFICATION
INSECTICIDES
VITRIFICATION
REFRACTORY BRICKS
CERAMICS
RICE HUSK BRICKS
FUSION
SILICON
SODIUM SILICATE
SINTERED GLASS
DETERGENTS
CALCINING
HYDRO THERMAL CALCIUM SILICATE
CEMENT

FIG. 11

8. ECONOMIC FEASIBILITY :

Traditional project planning studies involve, market survey, assessment of technology available, capital - labour inputs needed, economy of scale of production, break-even analysis, pay out time and dividends, with regard to any given raw-material product combination. The raw material product price differential is used as a basis for defining break up of manufacturing cost into labour cost, recurring cost, working capital and capital cost. The concept of net value added is also used to choose amongst product variation or raw material variation. Many a time since the total perspective of an agro-based industry is not taken into account an existing technology of an agro-based industry gets the lowest rank compared to a mineral based or petro based raw material and hence put off for a latter day use. However, even by the traditional method some products such as -Rice bran oil, furfural, cement from husk have received passing grades. A list of feasible technologies developed by CSIR are given in a report dated 1976. The references are given at the end.

In the present report, the first question attempted to be answere is, with the existing knowledge of science and technology what would be the expected returns for the output from an acre of land under paddy cultivation. Secondly, the status of the technology is examined. Proces which can straight away be adopted for commercialisation and those which require R & D inputs are identified. The capital-labour inputs needed are also examined. In this section, the first issue will be analysed.

First for each technology step, the input-output ratios, input-output cost differencials are used to calculate the cumulative values. In cases where are alternatives in a technology, average is calculated for the options. These are given in Tables 2 to 8. Assumptions, wherever made are stated table-wise. A summary is given in Table 9 which indicates the difference between INPUT-OUTPUT value differences for each technology. This can be taken as a net development potential index (NDPI). This data is basic to the economic feasibility analysis, and also answers the first question raised.

As indicated in the summary, Table 9, the average per acre value of the agriculture technology is Rs.1800/- which at present accrues to the farmer and Rs.1319/- per acre value of the milling accrues to the miller. With the existing knowledge of science and technology, the maximum average returns could be as high as Rs. 5000/- per acre. This figure could be bettered by choosing an optional plan of the system graph at best by another Rs.1000/- per acre.

Table 10 gives the assessment of technologies, an essential step in traditional project feasiblity studies and incidentally is also the second question raised. To answer the third set of questions, certain problems such as an optional scheme, location, restrictions imposed such as capital intensive - labour intensive options are to be specified. Even though some cursory analysis can be made in a rudimentary fashion, it is felt, that after some more discussions, this could be attempted. It is also desirable for employing professional help in making a feasibility analysis, On the other hand, technological improve

TABLE-2

TECHNOLOGY-I

(AGRICULTURE : BASIS - 1 ACRE)

PRODUCT	QUANTITY PER ACRE (TONS)	UNIT COST PER TON IN RS.	NET VALUE IN RS.
	INPUT	: Rs. 500	
1. PADDY	1.5	1000	1500
2. HAY	1	300	300
	OUT PUT	: Rs.1800	
3. PAPER	0.3	5000	1500

TABLE-3

TECHNOLOGY-II

(MILLING : INPUT 1.5 TONS PADDY)

PRODUCT	QUANTITY IN TONS	UNIT COST PER TON IN RS.	NET VALUE IN RS.
	INPUT	: Rs.1500	
1. BR[illegible] RICE	0.244	3000	732
2. HUSKED RICE	0.244	3000	732
3. RICE	0.487	2000	974
4. HUSK	0.345	100	35
5. BROKENS	0.045	200	9
6. BRAN & GERM	0.135	200	27
	OUTPUT	: 2509	

SEVERAL SIMPLE ASSUMPTIONS ARE MADE IN WORKING COST DATA IN TABLES 2 TO 9.

TABLE-4

TECHNOLOGY-III

(PROCESSED FOODS : 0.05 TON RICE)

INPUT :	Rs. 100

OUTPUT :	Rs. 250

TABLE-5

TECHNOLOGY-IV

(PROCESSING OF BROKENS : INPUT 0.045 TON)

INPUT :	Rs. 9

OUTPUT :	Rs. 90

TABLE-6

TECHNOLOGY-V

(PROCESSING OF BRAN AND GERM : INPUT-0.135 TON)

PRODUCT	QUANTITY IN TONS	UNIT COST PER TON IN RS.	NET VALUE IN RS.
INPUT :		Rs. 27	
1. EDIBLE BRAN OIL	0.0135	6000	81
2. BRAN OIL FOR SOAPS ETC	0.0135	4500	61
3. CATTLE & POULTRY FEED	0.1	500	50
4. RICE GERM OIL	0.0043	10000	43
5. DIETARY FORMULATIONS	0.0004	25000	10
OUTPUT :		245	

TABLE-7

TECHNOLOGY-VI

(HUSK UTILISATION : INPUT-0.345 TON HUSK)

PRODUCT	QUANTITY IN TONS	UNIT COST PER TON IN RS.	NET VALUE IN RS.	CUMULANTS FOR EACH TECHNOLOGY
INPUT : Rs.35				
1. MINIMAL TREATMENT MINIMAL ADDITIVES (VI-A)	1	800	800	800
2. COMBUSTION (VI-B)	-	-	100	200
(a) ENERGY				
(b) RICE HUSK ASH	0.1	-	100	
3. PRODUCER GAS (VI-C)	-	-	100	150
(a) ENERGY				
(b) TAR	-	-	50	
4. ACTIVE CARBON (VI-D)	0.1	6000	600	600
5. SIMPLE DISTILLATION (VI-E)				
(a) Low C.V. GAS (ENERGY)	-	-	50	
(b) METHANOL	0.0045	5000	85	
(c) ACETIC	0.009	6000		
(d) ACETONE	0.003	10000		
(e) TAR				
(f) CHARCOAL	0.27	2000	540	675
6. PYROLYSIS (VI-F)				
(a) LOW C.V. GAS	-	-	50	
(b) LIQUID-PYROLYSIS	.	-	100	
(c) SILICON PRODUCTS	.	-	2000	2150
7. COOKING WITH ALKALIES (VI-G)				
(a) EDIBLE CELLULOSE		-	-	
(b) PAPER	-	-	-	2000

TECHNOLOGY VI (Contd.)

8. HYDROLYSIS (VI-H)				
(a) FURFURAL	-	-	-	
(b) OXALIC ACID	-	-	-	2000
(c) SUGARS	-	-	-	

OUTPUT : Rs. 1070

TABLE-8

TECHNOLOGY-VII

(RICE HUSK ASH PROCESSING : INPUT - 0.1 TON BLACK ASH)

PRODUCT	QUANTITY IN TONS	UNIT COST PER TON IN RS.	VALUE IN RS.	CUMULANT FOR EACH TECHNOLOGY
INPUT : Rs.100				
1. MINIMAL TREATMENT PRODUCTS (VII-A)	-	-	200	200
2. VITRIFICATION (VII-B)				
a. Refractory Bricks				
b. Ceramics				1000
c. Rice Husk Bricks				
3. FUSION (VII-C)				
a. Silicon				
b. Sodium Silicate				
c. Sintered Glass				1500
d. Detergents				
4. CALCINING (VII-D)				
a. Pre-Fabricated Building Blocks				
b. Hydrothermal Calcium Silicate				
c. Cement	0.[illegible]8	500	140	600
		OUTPUT : 520		3300

TABLE - 9

SUMMARY

TECHNOLOGY	DESCRIPTION	INPUT Rs.	OUTPUT Rs.	NET DEVELOPMENT POTENTIAL INDEX
I	AGRICULTURE	500*	1800	1300
II	MILLING	1500	2509	1009
III	PROCESSED FOODS	100	250	150
IV	BROKENS PROCESSING	9	90	81
V	PROCESSING OF BRA & GERM	27	245	218
VI	PROCESSING OF HUSK	35	1070	1035
VII	PROCESSING OF ASH	100	825	725
				4518
	*PAPER	300	1500	1200

TABLE - 10

1.	TECHNOLOGY-I (AGRICULTURE)	THE EFFORTS FOR IRRIGATION WATER MANAGEMENT, SOIL BUFFETING, SEEDS IMPROVEMENT ARE BEING TRIED AND NOT INDICATED.
2.	TECHNOLOGY-II (MILLING)	A
3.	TECHNOLOGY-III (PROCESSED FOODS)	A
4.	TECHNOLOGY-IV (PROCESSING OF BROKENS)	B
5.	TECHNOLOGY-V (PROCESSING OF BRAN AND GERM)	A SCOPE FOR R & D WORK FOR MINI-UNITS IF DISPERSAL IS PREFERRE
6.	TECHNOLOGY-VI (HUSK)	
	A. MINIMAL TREATMENT	A
	B. COMBUSTION	A
	C. GASSIFICATION	A
	D. CARBONISATION	A SCOPE FOR R & D IN CATERING TO HIGH QUALITY SPECIAL GRADES
	E. DESTRUCTIVE DISTILLATION	A
	F. PYROLYSIS	B MATERIALS PROBLEMS; REQUIRE R & D
	G. COOKING WITH ALKALIES	C REQUIRES R & D
	H. HYDROLYSIS	A
7.	TECHNOLOGY-VII (ASH)	
	A. MINIMAL TREATMENT	A
	B. VITRIFICATION	A
	C. FUSION	
	i) SILICON	B MATERIALS PROBLEMS; REQUIRES SPECIAL STUDIES FOR PURIFICATION TO HIGHER GRADES
	ii) SODIUM SILICATE	A

TABLE-10 (Contd.)

	iii) SINTERED GLASS	B	SPECIAL TECHNIQUES TO BE PERFECTED
	iv) DETERGENTS	A	
D.	CALCINING	A	

NOTATION

A	-	NO PROBLEMS ENVISAGED
B	-	ADAPTATION/TRANSFER OF TECHNOLOGY ADDITIONAL PROBLEMS STATED IN REMARKS
C	-	NOT SATISFACTORY; REQUIRES FURTHER R & D EFFORTS.

ments to answer the need of fitting the range of development potential with any additional restrictions imposed can also be posed by R & D efforts.

The following three specific questions are of importance in this context.

i) What are the expected returns per acre of irrigated land holding if the total development potential is realized at the existing level of science & technology?

ii) What is the status of existing technology vis-avis its potential for commercialization?

iii) For realising the total development potential, what are the additional capital - labour inputs needed?

In the following sections, these questions will be analysed.

THE TECHNOLOGY SPECTRUM has the followng seven components.

1) Agriculture
2) Milling
3) Processed Foods
4) Processing of Brokens
5) Processing of Bran and Germ
6) Processing of Husk
7) Processing of Husk Ash

A total of 54 products (some closely bunched) of commercial value constitute the product spectrum. Each technology has sub-systems and alternatives.

For each technology based on the input-output materials and unit costs the value accumulated is calculated. Without going into the question of optimal allocations, averages are calculated for sub-systems and alternatives. Such grossly simplified calculations indicate that per acre the value differential is Rs. 5000/- compared to Rs.1300/- and Rs.2300/-, stopping short of agriculture and milling respectively. The estimate is on the conservative side.

The technology assessment indicates that out of the 19 existing technologies examined, 14 can be commercialised with minimal risk, 4 have special materials and other problems and 1 requiring R & D efforts. To start with, the methodology used in generating "Intergated development plan" will be outlined and this will be followed by presentation of estimates to answer the third question. The last part presents the analysis of the above mentioned points (i) to (iv).

The input, output values of the raw materials and products for each technology are presented to arrive at the value differential available for development activities. To calculate the financial and labour inputs needed for realisation, and in particular to calculate the net value added two points needed to be conceptualized:

i) What is the minimum, break-even starting size? (Of for instance, the starting average, the produce from which is utilised for maximum returns, envisaged in the development plan?)

ii) What is an acceptable norm of working the cost structure for each of the technology components?

Consider for example, a product like Furfural, to be made from rice husk by hydrolysis (Technology VI-H). What should be the minimum economic size of the production system to be profitable? Similar question can and need be asked for the net-work, called "Integrated

Development of Paddy Crop" consisting of the six major technologies and the sub-systems. This is in essense the first point/ (i) given above The second point/ (ii) above concerns certain "traditional value judgements" about cost structure in adjudging profitability of a given technology.

These two questions are inter-related. In fact any answer to the second question predetermines the answer to the first. In a way some value judgement (of expectation) of the former is implied in answering the latter. Let this loop be examplified. Let the following nomenclature be used for brevity:

RMC - Raw Material cost per unit product

PC - Unit product cost

MC - Manufacturing cost per unit product

The difference between PC and RMC is defined earlier as Development Potential (DP) without reference to the technology involved, by assuming stochiometric conversions. The 'DP' can be realised by a manufacturing process (or a production system) using a technology, which involves the manufacturing cost 'MC'. The first question asks, when is a technology considered feasible? In fact the question is asked in a more precise form - what is the SCALE OF PRODUCTION when a given technology is considered feasible financially? The second question asks what are the NORMS used in arriving at a given 'MC' for a given TECHNOLOGY. The following is the break up of 'MC' the manufacturing cost:

FCC : Fixed capital costs per unit of product consisting of:

PSC - Production system cost

FAC - Cost of fixed assets such as land, buildings and other such solvent assets.

WCC : Working capital costs per unit of product consisting of:

RMC - Raw Material Costs

UC - Cost of Utilities

LC - Labour Costs

OHC - Over Head Costs (Recurring)

Let the fixed costs (FCC) include depreciation (Property tax, insurance, rent etc.) and working costs (WCC) include interest charges such that the normal returns on capital are accounted for, then one can expres following relationships.

$$MC = FCC + WCC$$
$$= (PSC + FAC) + (RMC + UC + LC + OHC) \quad - \quad (1)$$

The word PROFITABILITY is used only when there is a margin between PC and MC. Let this be indicated by "PR".

$$PR = SP - MC \; ; \; SP - \text{SALES PRICE} \quad --- \quad (2)$$

PROFITABILITY as defined above is the minimum bound to be assured like the development potential "DP". It is called minimum bound since if it is just zero, only the capital costs, interests on WCC and gainful employment of labour are guaranteed and nothing else accrues. So far any viable venture then:

$$PR \geqslant 0 \quad --- \quad (3)$$

Tradition (tradition of industrailised society) demands, a few other benefits such as :

DIVIDEND BONUS NET VALUE ADDED

The first is a demand from capital, the second from labour and the third from economists (in the name of societal good). If one takes such as overview then one should write equations (3) as :

$$PR = D + B + NVA \qquad \text{---- (4)}$$

where $D = (FCC + WCC)\, d$

$B = (FCC - WCC)\, b$

NVA = Net value added for unit product

$d, b,$ = rates of dividend and bonus per unit product. The "NET VALUE ADDED" as defined above, is defined as something besides what has been accounted for. The reason for such a choice is that the word literally as it stands is incomplete in the absense of stating net value added to whom and how.

The entire cost structure presented above, now brings into focus, the role of SCALE OF PRODUCTION. For a given TECHNOLOGY one would argue whether there is a scale of production, above which it is PROFITABLE OR feasible (commercially and or economically). Hence tradition plays a large role in deciding what should be the MINIMUM SCALE OF PRODUCTION beyond which a TECHNOLOGY is profitable. This tradition is reflected in placing a value judgement on each item appearing in the cost structure. For instance, one may leave the return on capital in computing manufacturing costs and let it show up in dividend. One may argue that NET VALUE ADDED is reflected in the gainful employment of capital of capital and labour and no specific item as such need be left. One may bloat up "overheads" and make good in a overall inter dependent and interlinked business units.

To make the "NET VALUE ADDED", a rational concept, one could ask for, the net value added for unit capital or unit of labour employment created, over a base and link it up in arriving at a meaningful SCALE OF PRODUCTION. However, for the purpose of the present study report it would be left as defined in equation (4). The NET VALUE ADDED then will be implied in the returns on CAPITAL and the GAINFUL EMPLOYMENT GENERATED for the LABOUR.

None of the "FEASIBILITY", judgements passed on, in this country. to the knowledge of the author, can be subjected to atleast a verbal analysis. The scientists and technologists are simply told, a particular TECHNOLOGY IS NOT FEASIBLE and there ends the matter.

NOTIONALLY then, let it be assumed, that there exists a SCALE OF PRODUCTION for any given TECHNOLOGY and let the analysis be made to understand the role of economies of scale. Basically all costs involved in manufacture can be put into two categories - i) those that increase with SCALE OF PRODUCTION and (ii) those that decrease with SCALE OF PRODUCTION. Let the SCALE OF PRODUCTION denoted as S units per year. A very general relationship of costs of either type will have arrymptotic ends insensitive to S.

One can consider three zones on Fig. 12. In zone I, s cost (ii) dominate and charges in S are ineffective. In zone II, the rate of var of both the type of costs effect choice of S. In zone III, cost (i) dominates and changes in S are ineffective. Assume for an instance that the cost curves present such a neat compatible zonal present such a neat compatible zonal existance. The total cost function Vs S will look like as shown in Fig. 13.

The total cost will show a minimum as depicted. Under such ideal circumstances, one can define a UNIQUE VALUE FOR CHOICE OF "S". Yet

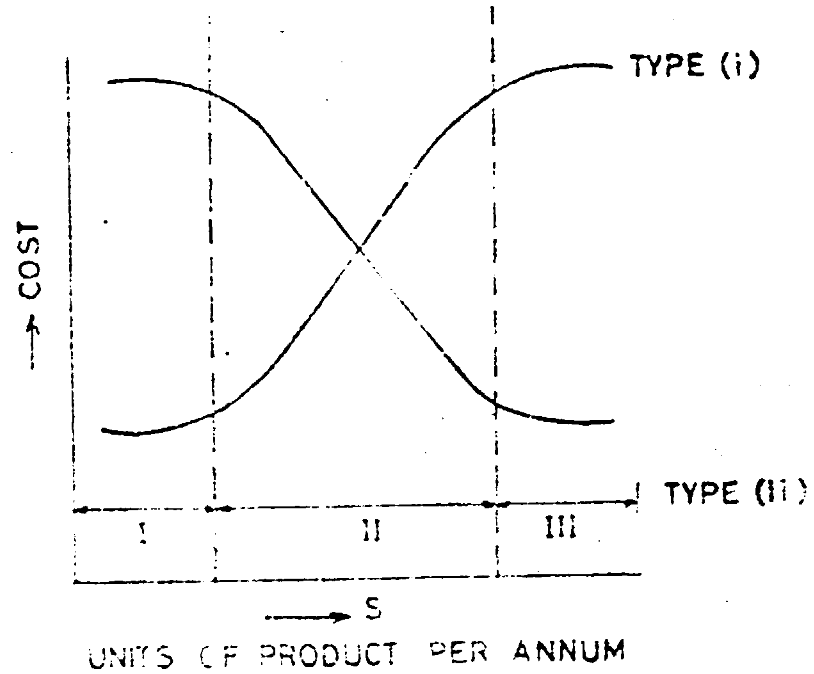
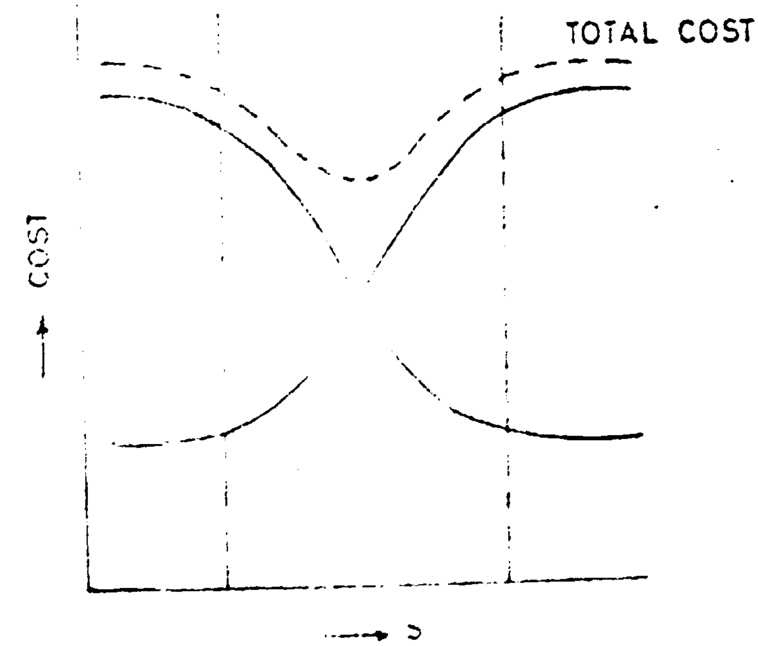

TYPE (i)
COST
TYPE (ii)
I
II
III
S
UNITS OF PRODUCT PER ANNUM

FIG.12


TOTAL COST
COST
S

it is not the minimum S, we are seeking, beyond which the technology is profitable. Let eg. (2), which is an indication of PROFITABILITY be also plotted as a function of S. This is shown in Fig. 14.

It is possible to visualize, how profitability is related to scale of production "S". Three possibilities show up which are shown in Fig. 15 along with the concommitant profitability - scale of production relationships.

Under the ideal situation of watching cost curves then, one can quantitatively fix the parameter "S" for maximisation of profit for a given technology or on the otherhand pass unambiguous value judgements, whether a given technology is profitable or not. (The word feasible is not used, because a societal decision can call for solutions which are not motivated by profit alone).

The analysis presented, then makes two points - (i) some tradition is always involved in cost analysis. (ii) Even within the ambit of any specifiable tradition, feasibility or otherwise can be quantitative, only when a rigorous scanning is possible. The main import of this analysis is that tradition of first kind is unavoidable and that of the second kind is not only avoidable, but has to be avoided for progress or for giving lines to define technological goals clearly.

Let some attention be paid to non-ideal (extra modellistic) real situations. The TECHNOLOGY, feasibility/profitability of which is being analysed may be trusted within a given span of S. This limits the range of S. A second thing that can happen is that the cost curves may not fall in the same range of C or S. For example, see a non-ideal situation depicted in Fig. 16.

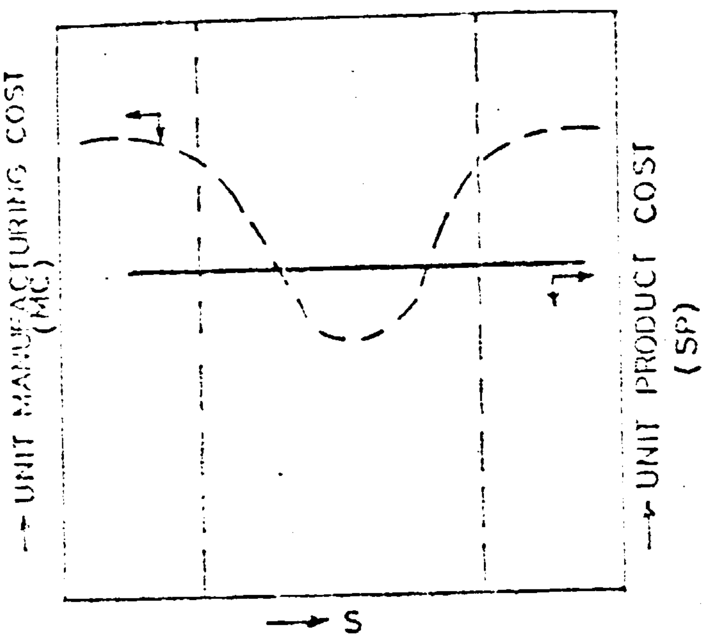


FIG.14

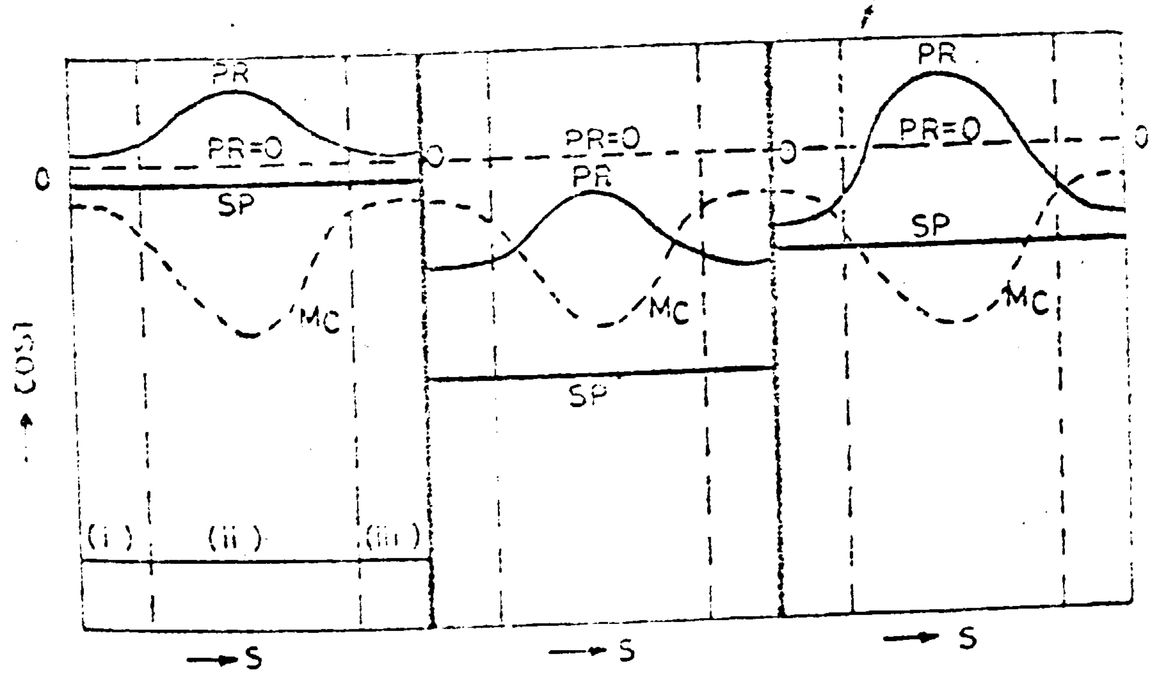


FIG.15(a) FIG.15(b) FIG.15(c)

One could still logically proceed in constructing meaningful profitability vs S relationships. However, this point requires more careful attention. Consider for instance SO-CALLED LABOUR INTENSIVE TECHNOLOGIES. (OR EVEN LABOUR INTENSIVE AND LESS CAPITAL INTENSIVE), which are often mistaken as small "S" (SCALE) and hence appropriate for some specified purpose. It is necessary to indicate an example of type (i) curve PSC which may be recalled as production system cost. An example of type (ii) cost is labour cost. These two typify labour-capital, intensive-extensive dichotomy. Referring to Figs. 14 and 15 within bounds, a reduction in S can always achieve this result without a technological change, without even pushing product cost and within the margins of traditional profitability. Without any technological change, suppose we push this argument further, a decrease in S unprofitable, as is evidenced in many small scale industries. The analysis presented in this article can be carefully used to define the technological goals quantitatively, for generating new technologies either for small S range or for high S range.

As a passing reference, it may be pointed out that assymptotes of the cost curves (i) and (ii) type at low S range occur in less industrilized or urban technologies and high S range in highly sophisticated (saturated, Lacking any more potential for exploitation) technologies.

In summary then, the methodology adopted in the present study report in working out the cost structure, the traditional unavoidable part is explicitly specifed, and every effort made (and explained at appropriate places), to avoid the avoidable part of tradition in passin

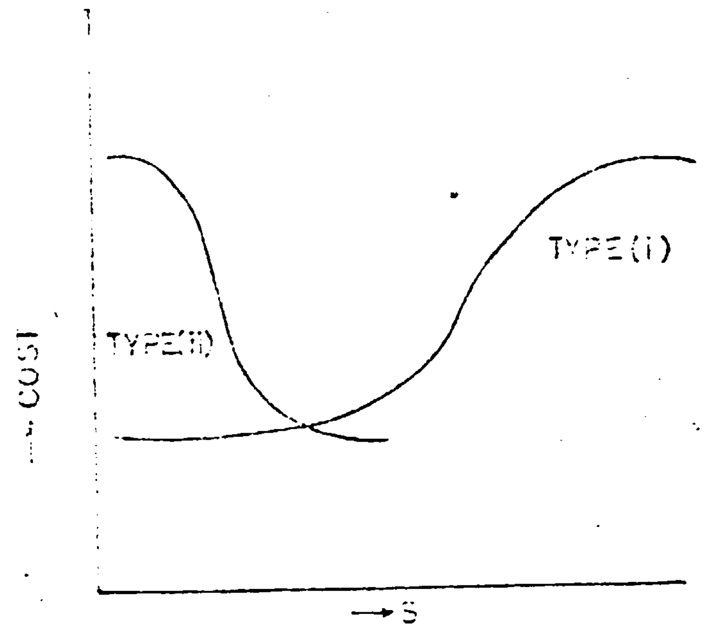


FIG.15(a)

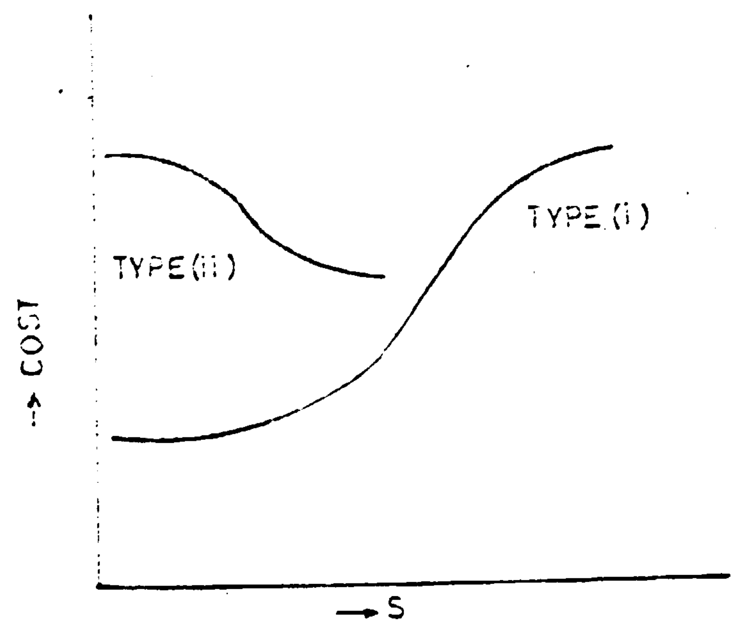


FIG.15(b)

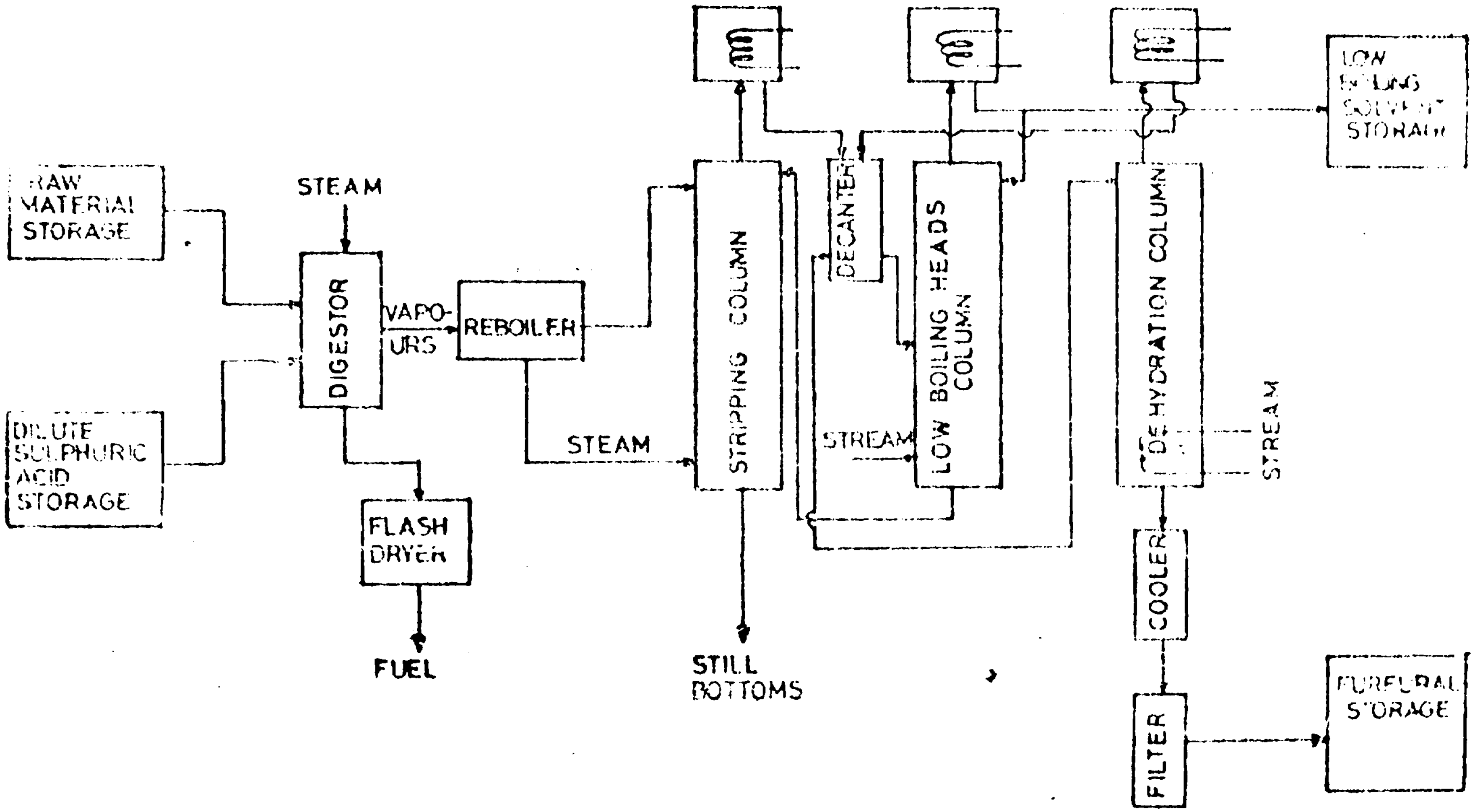


FIG.17 FLOW SHEET

MANUFACTURE OF FURFURAL : QUARKER-OATS PROCESS [REF.(1)]

value judgements. The example chosen is "furfural from husk". The question for which an answer that is being sought are - (i) what are bounds of S and (ii) what are the profitability relationship to S.

Furfural From Husk :

This technology was designated VI-H category in the earlier part of the report. A typical feasibility report, for a fixed annual production capacity is given for purposes of comparison in Appendix I. Fixing up of this capacity is supposed to have been by market survey of supply and demand, and levels of profitability acceptable to prospective financial agencies (The latter is hopefully reflected in the conclusion statements of the report given in Appendix - I).

The reason for choosing furfural will be evident from Table 11, where in the actual contents of exploitable raw materials per Kg of paddy are given. Pentosans are sources for furfural manufacture. Pentosans being the lowest in magnitude (after correcting for % furfura yeild), study of furfural manufacture is taken up first for study.

a) Process description and flow sheet :

Any pentosan on hydrolysis yields pentose which on dehydration yields furfural. A variety of naturally occuring materials along with theoretical yield (% of raw material) is given in Table 12. The chemical reactions involved are given below:

1. Transformation of pentosans to pentosos (hydrolysis)

$$C_5H_8O_4 + n.H_2O \xrightarrow[H_2O]{\text{TEMPERATURE, PRESSURE}} n\ C_5H_{10}O_5$$

2. Transformation of pentosos to furfural (dehydration)

$$n\ C_5H_{10}O_5 \xrightarrow[TH]{\text{TEMPERATURE, PRESSURE}} n\ C_5H_4O_2 + n.H_2O$$

(FURFURAL)

The actual reaction mechanism (according to Schoneman) is

Pentosans → Pentoses → Int.Product → Furfural → Furfural

(Polymeric) (Monomeric) Condensation ↓ Product

Furfural is a very useful raw material and its industrial uses are listed in Table 13.

In industrial manufacture, theoretical yields cannot be attained. 72.7% of the theoretical yields, if referred to pentasan content or 1/3 of the pentosans contained in case of agricultural raw materials are considered safe estimates. The following are the typical variations in the technology.

1)	Temperature range for digestion	100–290°C
2)	Liquid/solid ratio	10–0.25
3)	Catalyst	Non-oxidising mineral acid or strong organic acid or salts.
4)	Reaction	2 or 1
5)	Removal of furfural from digester	Continuous blowing of steam or extraction wi[illegible] water
6)	Operation	Continuous or batch.

TABLE 11

EXPLOITABLE RAW MATERIALS FROM 1Kg. of PADDY

RICE	0.65	
HUSK	0.23	
BRAN	0.08	(3)
BROKENS	0.03	
GERM	0.01	

	per kg. of husk	per kg. of paddy
MOISTURE	0.10	0.023
ASH	0.15	0.034
PROTEIN	0.04	0.01
WAXES	0.04	0.01
LIGNIN	0.18	0.041
PENTOSANS	0.24	0.055 (1)
CELLULOSE	0.25	0.058

	per kg. of ash	per kg. of paddy
SILICA	0.95	0.032

(2)

TABLE 12

RAW MATERIAL	MOISTURE (PERCENT)	THEORETICAL YIELD-FURFURAL (PERCENT)
CLEANED OAT HULLS	6	20
CORN COBS	20	19
COTTON SEED HULL BRAN	9.5	17.5
RICE HULLS	10	12
FLAX SHIVES	10	12
PEANUT HULLS	7.5	11
BUCK WHEAT HULLS	11	15
CORN STALKS	15	16.5
TAN BARK OAK	3	13
YELLOW PINE	6	5
BAGASSE	10	15

TABLE 13

INDUSTRIAL USES OF FURFURAL

SOLVENT FOR RESINS AND WAXES

EXTRACTIVE FOR MINERAL OILS

REFINING OF ANIMAL AND VEGETABLE OILS

CONCENTRATION OF VITAMINS A & D FROM FISH LIVER OILS

PRODUCTION OF PLASTICS

EXTRACTION OF 1-3 BUTADIENE FROM CRACK GASES

PLASTIC FIBRE PRODUCTION

PURIFICATION OF LOW GRADE WOOD RESINES

QUALITY IMPROVEMENT OF DIESEL OIL

ADDITIUE FOR MOTOR FUELS

AROMA AGENT FOR BRANDY AND PERFUME INDUSTRY

DISINFECTANT

HERBICIDE

ANTIFREEZE

BASIC SUBSTANCE FOR FURAN CHEMISTRY

Hitchcock and Duffey reported in 1948 that for extraction of furfural from cat hulls by Quicker process, \$2 per \$1 of annual sales are required as investment costs and 15,000,000 lbs. furfural per year as minimum economical size plant.

Krishna and Sethuraman reported a comparitive study of the various international technologies available in 1966, and their findings are summerised in Table 14. Thampi and Kuloor reported that for rice hulls, dilute sulphuric acid and liquid/solid ratio 4:1, 50-100 psi and digestion periods of two hours are recommended. They have also provided some cost estimates.

Jaeggle describes a continuous process for processing agricultural residues by a Swiss process - Escher. Wyss and also presented the relative reactor volumes and typical cost structure as of 1976. The reactor volumes data and cost structure are given in Table 15 and 16 respectively. A minimum size of 2000 tons of furfural per annum for baggage or corn cob based plants is recommended.

Panickar gave a comprehensive review of furfural manufacture - Chemistry, Technology and some pilot plant data.

(b) Basis of Cost Estimation :

Cost estimates can be done to a very great detail depending upon information available. However, simple preconstruction cost estimates are used in feasibility studies. We are mainly concerned with cost-capacity relationships for a given technology. For the costing subheads mentioned in Equation (1), the following assumptions are made to workout manufacturing costs:

TABLE 14 : COMPARISON OF VARIOUS INTERNATIONAL TECHNOLOGIES FOR FURFURAL FROM AGRICULTURAL WASTES

NO.	CHARACTERSTICS	DNIPROPETROVSKI (RUSSIAN)	SKUG-SEVO (SWEDISH)	AGRI FURANS (FRENCH)	RONI (ITALY)	SEBA'A (ITALY)	QUAKER OATS (USA)
	RAW MATERIAL	MAIZE BAGASSE, SUN FLOWER PLANT BAGASSE	BIRCH WOOD	MAIZE BAGASSE	MAIZE BAGASSE	BIRCH WOOD	OAT HULLS, MAIZE BAGASSE
2.	TYPE OF PROCESS	CONTINUOUS	CONTINUOUS	BATCH	CONTINUOUS	BATCH	BATCH
3.	ACID USED FOR HYDROLYSIS	DIL HCl	NONE	NONE	DIL SULPHURIC	CONC SULPHURIC	DIL SULPHURIC
4.	TYPE OF HYDROLYSER OR DIGESTOR	HORIZONTAL, TUBE INSIDE TUBE WITH SCREW CONVEYOR	VERTICAL, ELECTRO-MAGNETIC VIBRATION AUTOCLAVE ACID RESISTANT "AVESTA-852 MV" AUTOCLAVE	VERTICAL M.S AUTOCLAVE	VERTICAL [illegible] AUTOCLAVE WITH MIXERS	VERTICAL CLAD STEEL AUTOCLAVE	HORIZONTAL (CYLINDRICAL) CARBON BRICK LINED
	YIELD OF FURFURAL, THEORITICAL % POSSIBLE	77	47	65	60	50	49
	COST OF EQUIPMENT ($/ANNUAL TON OF PRODUCTION)	—	236	315	361	966	—
7.	UTILITIES PER TON OF FURFURAL						
	a) STEAM, TONS	—	13.6	11.00	12.00	14.00	21.00
	b) WATER, M3	—	272	15	640	128	320
	c) H_2SO_4, KG	—	—	—	100	578	350
	d) SUPER PHOSPHATE, KG	—	—	600	—	—	—
	e) HCl	6.8% ON RAW MATERIAL	—	—	—	—	—
	f) ELECTRIC POWER (KWH)	—	249	250	200	400	385
	PRODUCTION COST PER TON OF FURFURAL	450	—	758	—	—	703
	UTILISATION OF RESIDUE	PRODUCTION OF PHENOLS, [illegible] [illegible]ATED CARBON [illegible]	FUEL	FERTILISER	FUEL	FUEL	FUEL

I	FCC	PSC	Increasing cost curve	USE x = 0.6
		FAC	"	Use cost-ratio factor = 0.8
II	WCC	RMC	"	Linear with capacity
		UC	"	"
		LC	Decreasing cost curve	Equation given below
		OHC	Increasing cost curve	Use cost-ratio factor = 0.2

In assuming linear cost-capacity relationships for RMC and UC, it is implied that advantages that accrue due to increasing capacity are not explited in the range under consideration; in other words the flow sheet and equipment choices of the technology remain fixed.

Jelen suggest the normal cost-capacity relation for production system costs (PSC) as:

$$\left[\frac{C_L}{C_S} = \left(\frac{Q_L}{Q_S}\right)^x\right]_{PSC} \qquad -(5)$$

where is the cost of equipment of capacity Q_L, the cost of equipment of capacity Q_s and x is the cost-capacity exponent with a range of $0.3 < x < 1$ for most equipment. An average of 0.6 is usually recommended in the absenceof any information.

Wessel recommends the following cost-capacity relationship for labour costs (LC).

$$\frac{\text{Operating man hours}}{\text{Tons of product}} = t$$

$$\frac{\text{Number of process steps}}{(\text{Capacity in Tons/day})} = 0.76 \qquad -(6)$$

The value of 't' depends upon process details such as batch, average or well instrumented continuous etc. For the present purposes, then, one can rearrange the above as

$$C_S = t \frac{N}{Q_S^{0.8}}$$

$$C_L = t \frac{N}{Q_L^{0.8}}$$

$$\therefore \left[\frac{C_L}{C_S} = \left(\frac{Q_S}{Q_L}\right)^{0.8} = \left(\frac{Q_L}{Q_S}\right)^{-0.8}\right]_{LC} \quad \text{--- (7)}$$

The proposed linear relationships for RMC and UC can be written as,

$$\left[\frac{C_L}{C_S} = \frac{Q_L}{Q_S}\right] \text{ RMC or UC} \quad \text{--- (8)}$$

It is implied in the above two equations that in the range $Q_S < Q < Q_L$ no changes in technology are incorporated.

Usually the fixed capital costs (FCC) and overhead costs (OHC) are related to production system costs (PSC). Hence one can write the cost-capacity relationships for these items as,

--- (9)

$$(C_S)_{FCC} = \alpha \quad (C_S)_{PSC}$$

$$(C_L)_{FCC} = \alpha \quad (C_L)_{PSC}$$

$$\frac{(C_L)_{FCC}}{(C_S)_{FCC}} = \frac{(C_L)_{PSC}}{(C_S)_{PSC}} = \left(\frac{Q_L}{Q_S}\right)^{0.6}$$

Similarly for overhead costs,

$$\frac{(C_L)_{OHC}}{(C_S)_{OHC}} = \left[\frac{Q_L}{Q_S}\right]^{0.6}$$

Hence, one can write the equations for the manufacturing costs as,

$$(MC)_S = \left\{\left[(C_S)_{PSC} + (C_S)_{FAC}\right] + \left[(C_S)_{RMC} + (C_S)_{UC} + (C_S)_{LC} + (C_S)_{OHC}\right]\right\} \frac{1}{R\ldots}$$

$$(MC)_L = \left\{\left[(C_L)_{FSC} + (C_L)_{FAC}\right] + \left[(C_L)_{RMC} + (C_L)_{UC} + (C_L)_{LC} + (C_L)_{OHC}\right]\right\} \times \ldots$$

$$= \left[(C_S)_{PSC}\left(\frac{Q_L}{Q_S}\right)^{0.6} + (C_S)_{FAC}\left(\frac{Q_L}{Q_S}\right)^{0.6} + (C_S)_{RMC}\left(\frac{Q_L}{Q_S}\right)^{1.0}\right.$$

$$\left. + (C_S)_{UC}\left(\frac{Q_L}{Q_S}\right)^{1.0} + (C_S)_{LC}\left(\frac{Q_L}{Q_S}\right)^{-0.8} + (C_S)_{OHC}\left(\frac{Q_L}{Q_S}\right)^{0.6}\right] \times \frac{1}{Q_L}$$

$$= \left\{\left[(C_S)_{PSC} + (C_S)_{FAC} + (C_S)_{OHC}\right]\left(\frac{Q_L}{Q_S}\right)^{0.6}\right.$$

$$+ \left[(C_S)_{RMC} + (C_S)_{UC}\right]\left(\frac{Q_L}{Q_S}\right)^{1.0}$$

$$\left. + \left[(C_S)_{LC}\right]\left(\frac{Q_L}{Q_S}\right)^{-0.8}\right\} \times \frac{1}{Q_L}$$

--- (12)

Let the following cost ratios be defined,

$$\frac{(C_S)_{PHC}}{(C_S)_{PSC}} = \alpha \quad \frac{(C_S)_{RMC}}{(C_S)_{PSC}} = \gamma \quad \frac{(C_S)_{LC}}{(C_S)_{PSC}} = A$$

$$\frac{(C_S)_{OHC}}{(C_S)_{PSC}} = \beta \quad \frac{(C_S)_{UC}}{(C_S)_{PSC}} = \delta \qquad \text{--- (13)}$$

One can write equations (11) and (12) as,

$$(MC)_S = \left[(1+\alpha+\beta)+(\gamma+\delta)+A\right](C_S)_{PSC} \times \frac{1}{Q_S} \qquad \text{---(14)}$$

$$(MC)_L = \left\{(1+\alpha+\beta)\left(\frac{Q_L}{Q_S}\right)^{0.6}+(\gamma+\delta)\left(\frac{Q_L}{Q_S}\right)+A\left(\frac{Q_L}{Q_S}\right)^{-0.8}\right\}(C_S)_{PSC} \times \frac{1}{Q_L} \qquad \text{---(15)}$$

Hence the overall cost-capacity relationship becomes,

$$\frac{(MC)_L}{(MC)_S} \times \frac{Q_L}{Q_S} \; \frac{(1+\alpha+\beta)\left(\frac{Q_L}{Q_S}\right)^{0.6}+(\gamma+\delta)\left(\frac{Q_L}{Q_S}\right)+A\left(\frac{Q_L}{Q_S}\right)^{-0.8}}{(1+\alpha+\beta)+(\gamma+\delta)+A} \qquad \text{---(16)}$$

It may be recalled at this juncture that and are of the order of 0.8 and 0.2 as per tradition of industrial culture; indicates the value of material that is being used for development to the capital inputs needed for the production system; indicates the ENERGY intensiveness of technology; A indicates the labour (or capital intensiveness of technology.

C. Assessment of Technology reported in literature :

The cost data for Escher-Wyss Technology (Swiss firm) is given in Table 16. The factors and A are computed as follows:

$\alpha = 0.8$; $\beta = 0.2$; 2PSC = 918 DM ; PSC = 459 DM ;

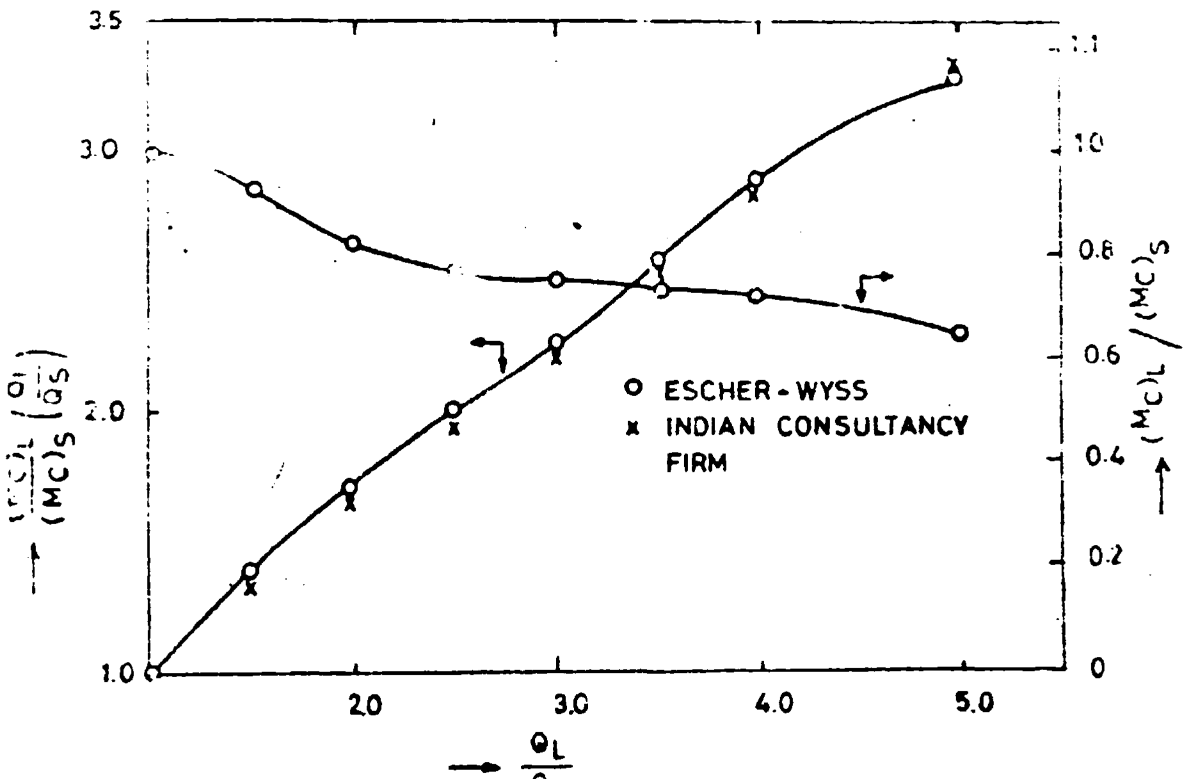
$\gamma = \frac{700}{459} = 1.5$; $\delta = \frac{165}{459} = 0.36$; $A = \frac{160}{459} = 0.35$;

Using the above, then equation (16) becomes

$$\frac{Q_L}{Q_S} \cdot \frac{(MC)_L}{(MC)_S} = \frac{2\left(\frac{Q_L}{Q_S}\right)^{0.6} + 1.86\left(\frac{Q_L}{Q_S}\right) + 0.35\left(\frac{Q_L}{Q_S}\right)^{-0.8}}{4.21} \qquad \text{---(17)}$$

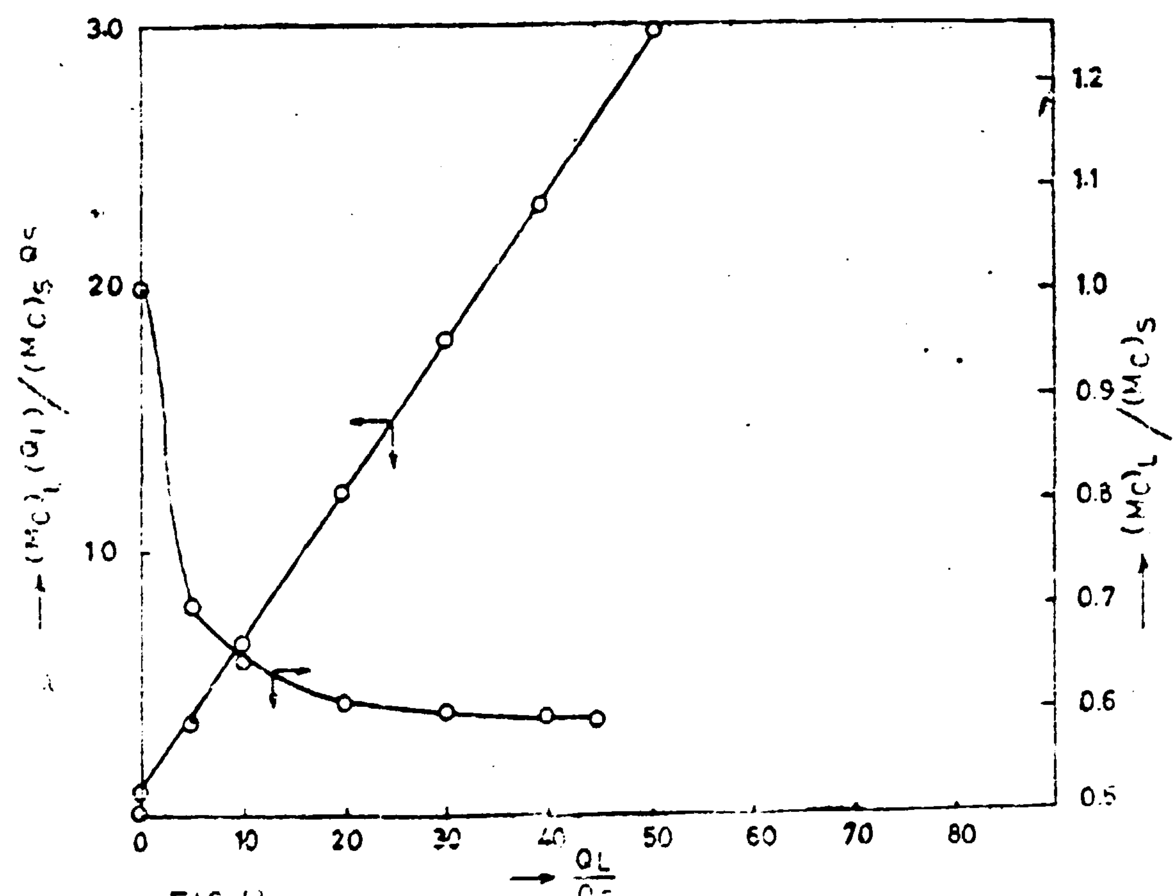
A plot of equation 17 is shown in Fig. 18. The figure indicates that the total manufacturing cost increases with capacity, while the unit manufacturing costs decrease. This is a natural characteristic one expects. Fig. 18 further indicates that reduction in unit manufacturing costs is prominent in the range of scale up of 2.5 and beyond 5. However, to state specifically the economic size for the Escher-Wyss technology, it is to be noted that the cost data provided by the manufacture is for 5000 TPA plant.

Let Q_L = 5000 TPA ; $(MC)_L$ = 2063 DM and Sale price of furfural = 3200 DM. The proper question to be asked is, what will be the Q_S when $(MC)_S$ = 3200 DM? Since at that capacity, there are no profits. Fig. 7 indicates $\frac{(MC)L}{(MC)S}$ VS $\frac{QL}{QS}$ relationship. One can read from it, that when $\frac{(MC)L}{(MC)S} = \frac{2063}{3200} = 0.65$, $\frac{QL}{QS} = 5$, thereby meaning THAT when Q_S = 1000 TPA, there no profits. Hence both the gross indicator



ESCHER - WYSS
INDIAN CONSULTANCY FIRM
3.5
3.0
2.0
1.0
1.1
1.0
0.8
0.6
0.4
0.2
0
2.0
3.0
4.0
5.0

FIG.18



3.0
20
10
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0
10
20
30
50
60
70
80

FIG.19

2.5 mentioned earlier and the lowest bound of 1000 TPA taken together indicates THAT the economical limit of 2000 TPA recommended by manufacturers are compatible with the analysis presented here.

It is not possible to assess the various foreign technologies reviewed by Krishna and Sethuraman in 1966, given in Table 4, for lack of sufficient information.

The feasibility report prepared by an Indian Consultancy Firm during the current year or early last year given in Appendix I, is supposed to be based on imported machinery paying a sizable sum of consultancy charges for an installed capacity of 6000 TPA, with baggage as raw material. Using the unit costs and the values of

and A (given in the appendix) the cost-capacity relation is also shown in Fig. 18. The curves being same, the same remarks apply. Some fragmentary information on costs and sizes of furfural plants reported in literature is given in Table 17.

D) Minimum Economical Size :

Comparing the cost analysis given in the preceeding section, to the methodology given at the beginning of this article, it is found that (i) the unit product price is high and (ii) cost-capacity relationship constants are such that, the analysis is in the zone where increas scale ensures higher profits. To realise the full range presented in the section on 'Methodology', is not yet possible with the existing cost data. Hence, the cost data was estimated for 1TPD plant, lower than existing national and international standards (see table 17). These details are given in Appendix II. The saleint conclusion drawn (the rest are given in Appendix - II) is that, at existing market prices of furfural, even 1TPD plant is also economically feasible. The cost estimation provided in appendix II is cursory. Efforts will be made to provide a detailed estimate in subsequent study reports.

CONCLUSION :

The National and International standards of a minimum of 6 to 7 TPD furfural plants are characteristic of capital and energy intensiveness of the technology. The existing high market prices of furfural makes even 1 TPD plants economically feasible. The parameters such plants do not indicate permissiable scaleups for cost reduction beyond 5, Even for such small plants the capital investment is in the range of 80 lakhs amounting to 1.6 lakhs per person employed both indicating the inappropriateness to rural development.

In view of the above, there seems to be three possible solutions - (i) small scale equipment costs should be pushed down by encouraging small scale equipment manufacture or (ii) Digesting and producing 10% furfural solution can be done on small scale level and purification to industrial grade to be done centrally or (iii) New technology to be developed to reduce steam requirement. First solution will only minimize the production system costs and not utility

TABLE - 15

SPECIFIC REACTOR VOLUMES FOR SOME PENTOSAN CONTAINING RAW MATERIALS (ESCHER-WYSS TECHNOLOGY).

Raw Materials	Approx. Raw material demand t(bd) per tonne of furfural	Approx. specific reactor volume M^3 per tonne of furfural
CORN COBS	10	50
BAGASSE	12.5	170
BIRCH WOOD	14	105
OLIVE PRESS CAKE	20	80
QUEBRACHO WOOD AFTER TANNIN EXTRACT	18	100
BEACH BARK	20	160

TABLE - 16

ECONOMICS OF A FURFURAL PLANT WITH AND WITHOUT INTEGRATED ACETIC ACID PRODUCTION - (a) CORN COBS AS RAW MATERIAL (b) BAGASSE (PLANT INTEGRATED INTO A SUGAR MILL) - CAPACITY 5000 TONS FURFURAL PER ANNUM.

(ESCHER-WYSS TECHNOLOGY - COST ESTIMATES, 1976)

	CORN COBS AS RAW MATERIAL				BAGASSE AS RAW MA			
	1	2	3	4	5	6	7	
Raw material	700	34	700	32	875	49.5	875	
Steam	165	8	145	6.6	95	5.4	75	
Wages & Salaries	160	7.8	160	7.3	45	2.5	45	
Maintenance & Repairs	120	5.8	125	5.7	95	5.4	100	
Operating costs	1145	55.6	1130	51.6	1110	62.8	1095	
Amortisation & Interest	918	44.4	1060	48.4	658	37.2	791	
TOTAL COST	2063	100	2190	100.0	1768	100.0	1886	1
Assumed receipts from sales furfural/T	3200	--	3200	--	3200	--	3200	
acetic acid/0.6T	--	660	--	660	--	660	--	6
GROSS PROFIT	1137	--	1670	--	1432	--	1974	

contd. from table 16.

1. Costs per ton of furfural in DM
2. Percentage
3. Costs per ton of furfural +0.6 Ton Acetic Acid in DM
4. Percentage
5. Costs per ton of furfural in DM
6. Percentage
7. Costs per ton of furfural +0.6T Acetic Acid in DM
8. Percentage

*1 kwH = 0.1 DM

Steam produced from combustion of residue cooling water: Assuming the adoption of cooling towers when producing acetic acid.

TABLE 17

PRICES, PLANT SIZE, CAPITAL INVESTMENTS FOR FURFURAL

1. INTERNATIONAL PRICE, Rs. 1kg.

USA - 9.30
Italy-13.50
UK - 11.20
West Germany - 11.60

2. PLANT SIZE AND COST, NATIONAL

6 TPD Rs.26 Million
12 TPD Rs.38 Million
20 TPD Rs.42 Million
(Southern Agrifurane)

Estimated production costs Rs.7800/- per ton of furfural.

3. PLANT SIZE AND COST, INTERNATIONAL

Hungary	22TPD	$8 million (1978)	Rosenlaw Sulzer Escher-Wyes
Bulgaria	15TPD	SF 7.3 million	---
Kenya	15TPD	£ 12 million	Sulzer Escher-Wyss

costs. The second solution would involve collection and transportation costs. The third requires technological innovation.

For purposes of the work scheduled for CDA, the minimum size of 1 TPD furfural plant will be assumed and further data collected from national furfural industry coming up in rural settings will be subjected to analysis.

8. RICE BRAN PROCESSING INDUSTRY - A CASE STUDY :

Rice Bran is a by-product of rice milling industry and is a good source of edible oil which is not utilised properly in a profitable manner so far in the country. When paddy is milled besides 60 to 70% rice, 20 to 25% husk and 4 to 8% of bran is also obtained. The oil content in the bran varies from 4 to 8% for huller mills to 15% to 28% for bran from d modern mills depending upon whether the paddy is milled raw or par boiled. Oil content in different brans is listed in Table 18. Economy of extraction of oil from bran depends upon the type of bran and also the time lag between when bran is removed from the paddy till it is processed in a solvent extraction plant. Because of low oil content in huller bran and high per cent of silica, huller bran is considered unsuitable for extraction of oil on economic and quality considerations. It is clear from Table 19 that most of the paddy is milled in huller type of mills in the country as well as in Tamil Nadu and hence th bran available for oil extraction is only 42.6% of the total bran available. Out of the 84,21,600 tons processing capacity rice bran accounts for only 20,19,600 tons which is only 24%. In tamilnadu the total processing capacity is 2,51,400 tons out of which the capacity registered for rice bran is only 71,400 tons. The reasons for this under utilisation of bran for edible grade may be summerised as follows:

1) Paddy is mostly milled in huller types of mills which produce poor quality bran and switch over from the older huller type mills to sheller type or modern type mills is yet to take place in spite of Government's efforts.

TABLE - 18

OIL CONTENT IN DIFFERENT BRANS

Sl.No.	Method of Milling	Bran Obtained from	Oil Conte (%)
1.	Huller	Raw Paddy	4 - 8
		Parboiled Paddy	4 - 8
2.	Sheller	Raw Paddy	12 - 15
		Parboiled Paddy	12 - 20
3.	Modern	Raw Paddy	15 - 20
		Parboiled Paddy	25 - 28

TABLE 19 : STATEWISE DISTRIBUTION OF RICE MILLS AND CAPACITIES AS ON 1/1/1980

Sl. No.	State	Hullers including battery of hullers		Shellers including sheller-cum-Polishers		Huller-cum-Sheller		Modern Rice Mills		Total	
		No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity
1.	Andhra Pradesh	5587	16.75	1094	13.13	3805	45.66	1881	94.05	12351	169.5
2.	[illegible]	465	1.40	N.A.	-	2163	25.95	103	5.15	2733	32.51
3.	Bihar	4749	14.25	63	0.75	9	0.11	51	2.55	4872	17.67
4.	Gujarat	7022	8.47	440	5.28	138	1.66	203	10.40	3603	25.81
5.	Haryana	1060	3.18	278	3.34	-	-	278	13.90	1516	20.15
6.	[illegible]	1791	2.13	783	9.40	487	5.84	391	19.55	8752	35.92
7.	Himachal Pradesh	1122	5.37	2	0.02	-	-	-	-	1124	3.39
8.	Jammu & Kashmir	-	-	-	-	-	-	-	-	-	-
9.	Kerala	13039	39.12	7	0.08	6	0.07	20	1.00	13072	40.27
10.	Madhya Pradesh	3114	9.34	239	2.87	227	2.72	94	4.70	3672	30.19
11.	Maharashtra	6355	19.07	440	5.28	487	5.84	-	-	7282	1.42
12.	Manipur	71	0.21	-	-	97	1.16	1	0.05	169	-
13.	Nagaland	-	-	-	-	-	-	-	-	-	-
14.	Orissa	3050	9.95	34	0.41	220	2.56	674	33.70	3978	45.9
15.	Meghalaya	34	0.10	7	0.08	-	-	-	-	41	0.18
16.	Punjab	2777	8.33	54	0.65	1	0.01	639	31.95	3471	40.94
17.	Rajasthan	293	0.88	15	0.18	8	0.10	5	0.25	321	1.41
18.	Sikkim	17	0.05	-	-	-	-	-	-	17	0.05
19.	Tamil Nadu	15145	45.44	317	3.80	222	2.66	-	-	15585	51.90
20.	Tripura	-	-	-	-	-	-	-	-	-	-
21.	Uttara Pradesh	5284	15.85	502	5.02	181	2.17	294	14.70	6261	38.74
22.	West Bengal	205	0.62	3	0.04	2	0.02	430	21.50	640	22.18
23.	A & N Admn	162	0.49	-	-	-	-	-	-	162	0.49
24.	Arunachal	-	-	-	-	-	-	-	-	-	-
25.	U.T. Chandigarh	19	0.06	2	0.02	-	-	-	-	21	0.08
26.	Dadra & N.H.	16	0.05	3	0.04	-	-	2	0.10	21	0.19
27.	Lakshadweep	-	-	-	-	-	-	-	-	-	-
28.	Pondicherry	199	0.60	-	-	12	0.14	-	-	211	0.74
29.	Delhi Admn.	41	0.12	-	-	-	-	-	-	41	0.12
30.	Goa, Daman & Diu	587	1.75	-	-	-	-	-	-	587	1.75
31.	Mizoram	-	-	-	-	-	-	-	-	-	-
	[illegible] TOTAL	73365	219.92	4283	51.40	8065	95.78	5071	203.55	90725	562.24

2) Solvent extraction plants are concentrated in less paddy growing areas. Since the Free Fatty Acid content of rice bran increases with the time. Any delay in processing the bran will result in only n edible oils. Table 20 shows the approximate rate at which Free Fatty acid is developed in rice bran. Thus, longer the distance of the solvent extraction plant from the rice mills, more time lapse will be there by the time the bran is collected, transported and finally processed in the plant and as a result, the FFA content in the oil will be very high, making it unsuitable for edible purposes.

3) Rice mills are scattered over a large area and are of small capacity and thus for every solvent extraction plant, having a capacity of 60 TPD will require a support of atleast 60 to 100 rice mills of 1 to 2 tons per hour capacity and it is necessary to locate the plant in s a way that the bran could be brought into the plant and processed within 24 hours in the absence of stabilisation facility for the bran in the rice mill itself.

4) A study of some of the existing methods adopted by solvent extractors has revealed that the solvent extractors are not making any efforts to collect bran in an organised manner. While some of them by most of their requirements through brokers and fix an average percentage c oil in bran at 16%. The others ask the rice millers to door deliver the bran and pay a price according to oil content in bran. In the second case, the base price for bran is fixed for 16% oil content anc for additional percentage increase in oil content proportionate amour is paid for low FFA bran, additional incentive prices are also given. However, this practice does not guarantee the supply of quality bran since bran available per day in a rice mill will be of the order of 800 to 1200 kgs. and the miller has to wait till he accumulates a truck load of bran by which time the FFA content in bran increases resulting in financial loss for the miller for no fault of his as well as loss of an essential commodity like/edible oil itself.

To correct the above situation, the following plan of action is proposed:

TABLE - 20

RATE OF FFA DEVELOPMENT IN RICE BRAN

Rice bran type	Time after milling	FFA (as oleic acid)
Raw Rice Bran	4 hrs.	1.4%
	28 hrs.	4.2%
	40 hrs.	14.0%
	60 hrs.	21.0%
Parboiled Rice Bran	4 hrs.	2.5%
	28 hrs.	2.5%
	40 hrs.	3.7%
	60 hrs.	6.2%

FIRST ALTERNATIVE :

a) Smaller solvent extraction plants should be encouraged in areas where rice mills are concentrated which will ensure timely processing of bran as well as utilisation of full capacity of the plant.

b) A minimum base price should be fixed for rice bran depending upon the oil content and additional increments should be given for increase in oil content, decrease in silica content and decrease in Free Fatta Acid content. While fixing the minimum base price, a minimum oil percentage may be fixed at 16% level. This minimum as well as the incrementals may be in a similar fashion followed in case of sugarcane (based on average factory yields) or alternatively like in the case of milk, the price can be fixed based on individual bran sample analysis.

c) Since it is not possible for the millers to door deliver the bran solvent extraction plants should collect the bran on twice a day from each mill in their collection role and payments for the bran collected in the morning may be made in the evening when thefactory collects the bran for the second time on that day (This practice is followed in case of collection of milk in Amul Dairy).

The additional cost involved in organising collection of bran and payment of price according to quality will be compensated by the additonal price which the solvent extractors would be able to get for edible oil when compared with a non-edible oil about Rs.3500/- plus the savings from less hexame loss (two to three lit./tons of bran) in the plant because of lower husk content in the bran. This may also eliminate the necessary of installing a husk separator in th solvent extraction plant.

d) In addition, in order to improve the processable bran potential, it is also necessary to replace the existing huller mills into sheller mills or sheller-cum-huller mills. The existing Government Legislation enforcing the huller millers to convert their mills into

Sheller-cu-Huller or modern mill has already tested in court and it has stood the test of law. However, since the convertion involves capital investment on the part of mill owners, Government can consider giving them subsidy and liberal finance so as to speed up the modernisation of the mills.

e) Government can attach rice mills in each area to a solvent extraction plant and make it compulsory for them to sell the bran to the solvent extractors.

f) Deoiled bran/cattle feed may be made available at the mills by by the solvent extractors to encourage farmers to leave behind the bran in the mill in case of custom milling.

SECOND ALTERNATIVE :

a) The Government has already come out with the scheme to make installation of rice bran stabilisers compulsory on the part of rice millers in order to ensure availability of good quality bran. However, since this scheme has come as a surprise and the Engineering Industry is not at well geared for the supply of suitable rice bran stabiliser and the few fabricators who are in the field are trying to exploit the situation by quoting 2 to 3 times more than the price at which a batch type electrical stabiliser could be sold. Government can ask the State owned Karnataka implements co., Bangalore to obtain the necessary designs from CFTRI, Mysore and fabricate these stabilisers.

b) In the event if all the rice millers are asked to instal bran stabilisers solvent extraction plant need not organise collection of bran but can ask the millers to door deliver the bran which is the present practice. However, this system cannot avoid middlemen buying rice bran from the millers and exploit the situation.

Since at present, financial institutions are averse to the idea of promoting small continuous solvent extraction plants and batch type plants, Government should take up this issue with the financial institutions. However, a detailed economic analysis may be made to find out the viability of such smaller plants before taking any decision. It is also necessary to educate both the rice millers as well solvent extraction units on the above issues. Series of educative courses in batches may be organised for their benefit, in order to convince and educate them the need for organising collection of bran or stabilisation of bran.

THIRD ALTERNATIVE :

a) Government can establish solvent extraction plants exclusively for rice bran and organise collection of bran upgrading, stabilisation and processing in the pattern of milk project in Gujarat.

(In Tamil Nadu a solvent extraction plant of 300 TPD capacity with an investment of 1 crore has been established by the Government of Tamil Nadu exclusively for the utilisation of bran from the 3000 and add huller mills in Tamil Nadu).

FOURTH ALTERNATIVE :

Stabilisation of rice bran as a separate industry may be encouraged. These rice bran stabilisation industries may be located in the areas where rice mills are concentrated. However, this is equivalent to encouraging middlemen between the solvent extractor and rice miller and exploitation of small man, in this case, the mill owners cannot be avoided.

APPENDIX I

PROJECT REPORTED BY AN INDIAN CONSULTANCY ORGANISATION DURING 1979-80.

FINANCIAL DETAILS GIVEN

Capacity : 6000 TPA Furfural

Raw Material: Cane Sugar Bagasse

	Rs. in lakhs
Land & Buildings	40
Plant & Machinery	220*
Know-how & Engg. Fees	40*
Utilities	35
Miscellaneous fixed assets	15
Preliminary pre-operative expenses	45
	395
Margin for working	20
CAPITAL	415

*Estimates depend upon source of foreign know-how and foreign exchange rates.

Utilities : Power 400 KWH/Ton of Furfural
Water 22,000 gals/ton of furfural
Steam 30T/ton of furfurals

Employment : About 150 persons

Profitability : Turn-over expected to be Rs.500 lakhs Gross profit expected to be around 40% of the shar capital of about Rs.140/lakhs.

Cost of imported Furfural : Rs. 15000/-

Raw material needed : 20 tons/ton of furfural

ANALYSIS

1) PSC (260 lakhs) $\frac{260 \times 10^5}{6 \times 10^3} \times 1/100 = 433$

2) FCC (120 lakhs) $\frac{120 \times 10^5}{6 \times 10^3} \times 1/10 = 200$

3) UC (35 lakhs) $\frac{10 \times 10^5}{6 \times 10^3} = 583$

4) LC ... ... = 200

5) RMC ... ... = 200

$$\alpha + \beta = 200/433 \cong 0.5$$
$$\gamma = 200/433 \cong 0.5$$
$$\delta = 583/433 = 1.3$$
$$A = 200/433 \cong 0.5$$

The above constants were used in calculating the data plotted in Fig. 7.

APPENDIX II

ROUGH COST ESTIMATES OF 1TPD (or 300 TPA) FURFURAL PLANT

A. Production System Costs : (Based on 1978 costs used as guideli

Reactor - Volume 50 M^3	Rs. 5.00 lakhs
Distillation columns 3	Rs. 6.00 lakhs
Condensors - 3 / Reboiler - 1 / Cooler - 1	Rs. 4.00 lakhs
Storage tanks 3	Rs. 3.00 lakhs
Drier and Filter	Rs. 4.00 lakhs
Boiler	Rs. 8.00 lakhs
Total	Rs. 30.00 lakhs

B. **Raw Material Costs**

Requirement - 10 tons/ton of furfural

Husk is valued at Rs.100/- per ton in line with cost estimates for integrated development.

C. Utilities costs

i)	power	400 kwh/ton of furfural	- Rs. 120/-
ii)	water	22,000 gal.s/ton of furfural	- Rs. 70/-
iii)	steam	30 tons/ton of furfural	- Rs.2100/-
			Rs.2290/-

D. LABOUR COSTS

Usual requirements are of the order of 50. This works out to be an annual wage bill of Rs.3 lakhs.

E. Unit costs, Cost-ratios

$$PSC = \frac{30 \times 10^5}{300} \times 0.1 = 1000$$

$$FAC = \alpha \; PSC = 800 \quad ; \alpha = 0.8$$

$$OHC = \beta \times PSC = 200 \quad ; \beta = 0.2$$

$$RMC = 1000 \quad ; \gamma = 1.0$$

$$UC = 2300 \quad ; \delta = 2.3$$

$$LC = \frac{3 \times 10^5}{300} = 1000 \quad ; A = 1.0$$

Therefore MC = 6300

FCC = FAC + PAC = 1800

WCC = RMC + UC + LC + OHC = 4500

F. CONCLUSIONS :

1) With furfural costs being quoted at Rs.15000/- per ton. This leaves a very good profit margin for the plant to be feasible.

2) Of the various costs the largest cost is steam cost. Higher bound of this cost now-a-days is around Rs.150/- per ton, whereas a conservative estimate of Rs.70/- per ton (on coal costs) is used. This can push utility costs by another Rs. 2400/- Even then there is sufficient margin.

3) Total capital investment costs of the order of \$ 2.00 per \$ 1.0 of product sold is a normal practice of western technology, However, furfural at current prices being a high cost low volume item, it looks like, one is getting Rs. 0.50 investment per Rs. 1.00 of product sold.

4) Total capital investments and labour (employment generated) are given in the following page.

PRODUCTION SYSTEM	35.00	lakhs
FIXED ASSETS COST	28.00	lakhs
OVER HEAD COSTS	7.00	lakhs
RAW MATERIAL COSTS	3.00	lakhs
UTILITIES COSTS	6.90	lakhs
LABOUR COSTS	3.50	lakhs
TOTAL	83.40	lakhs

CAPITAL OUTLAY PER PERSON EMPLOYED IS Rs. 1.7 lakhs.

5) The cost-capacity calculations are made for 1TPD plant and shown in Fig. 8. The size equilibriation denotes the mismatch beyond a scale of 5.