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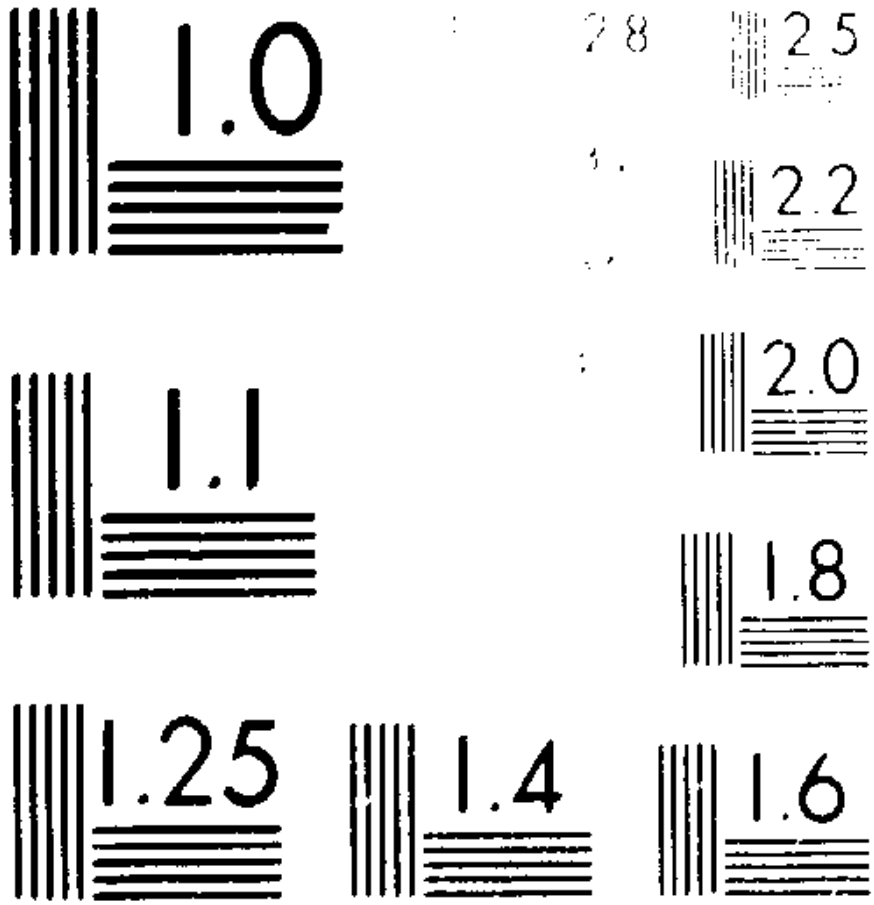
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DP/ID/SER.B/211
29 January 1980
ENGLISH

UPDATING OF AN APPRAISAL ON THE VIABILITY OF PRODUCING PARTICLE BOARD FROM BAGASSE

SI/SWA/79/801

KINGDOM OF SWAZILAND

TERMINAL REPORT:

PRODUCTION OF CEMENT BONDED PARTICLE BOARD IN SWAZILAND*/

Prepared for the Government of the Kingdom of Swaziland by the United Nations Industrial Development Organization executing agency for the United Nations Development Programme.

Based on the work of G.K. Elliot, expert in the production and marketing of wood based panels

United Nations Industrial Development Organization
Vienna

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Explanatory Notes

A comma (,) is used to distinguish thousands and millions.
A full stop (.) is used to indicate decimals.
References to tons are to metric tons, unless otherwise stated.
The monetary unit in Swaziland is the Emalangeni (E).
During the period covered by this report the value of the Emalangeni to the United States dollar was E1 = US $ 1.20.
The following abbreviations of organisations are used in this report.

A.F.C.O.L.	Associated Furniture Co. Ltd of South Africa
B.S.	British Standards Institute
NIDCS	National Industrial Development Corporation of Swaziland
R.S.A.	Republic of South Africa
SEDCO	Small Enterprises Development Company

The designations employed and the presentation of the material in this report do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontier or boundaries.

ABSTRACT

This project arose from a review of previous reports of the various International Agencies which the Government of Swaziland considered as potential ventures which might attract investment from developed nations. A UNIDO report on the "Prospects for the Production of Particle Board in the Kingdom of Swaziland" prepared under project SI/SWA/71/804 was among those selected.

The report, written in 1973 has been reviewed and updated and it is concluded that the market opportunities in 1979 for the export of board produced in Swaziland have considerably diminished. Specifically the market for bagasse based board in Southern Africa has collapsed and the prospects for wood based resin bonded board are bleak because of the entrenchment of RSA producers and the considerable economies of scale presented by increased capacity in RSA at the very borders of Swaziland.

Cement based particle board is recommended for manufacture and exclusive sale in Swaziland. The product has considerable potential and specific application to low income and middle income housing a sector well identified as a particular and burgeoning need in the Kingdom. The product has specific application to the exterior situation, it is fire proof, weather proof and biohazard resistant. It is recommended as a small scale labour intensive process, with investment of E3.8 million for a production capacity of 6,750m^3/annum, creating 154 jobs.

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I INTRODUCTION

01. A United Nations Industrial Development Organisation report,[1/] dated September, 1973 and entitled "Prospects for the production of Particle Board in the Kingdom of Swaziland recommended that a manufacturing capacity be established in Swaziland to service the market in near-neighbouring countries. The raw material for this board was shown to be available from either begasse - the fibrous residue obtained when sugar cane (Saccharum officinarum) is crushed to extract the sugar juices - or from plantation grown forest tree species - principally Pinus patula or Eucalyptus saligna/grandis; thermo-setting resin was also available locally.

02. Although this report elicited favourable reaction from both the sugar industry and the forest based industry in Swaziland, no direct action was taken. In September 1978 the Government of Swaziland identified this report as one which might offer ultimate investment potential, especially to investors from developed countries and co-operating units within the Kingdom. In December, 1978 the Government requested the United Nations Development Programme (UNDP) to provide assistance in updating the report, with UNIDO designated as the executing agency. A short-term mission of two months by an expert in the production and marketing of wood based panels, Mr. G.K. Elliot, was initiated and work began on 5th September, 1979.

03. The expert was attached to the National Industrial Development Corporation of Swaziland (NIDCS).

He undertook the following duties

(a) To up-date the previous report prepared under project SI/SWA/77/804.

(b) To prepare a technico-economic feasibility study of board production, indicating the raw material availability, product specification and technology proposed.

1/ Prepared under project SI/SWA/71/804

(c) To provide an analysis of investment and production costs and profits and evaluate market opportunities in Swaziland and near neighbouring countries.

(d) To recommend measures to be taken by authorities and international organisations to assure speedy implementation of the project.

His job description is given in Appendix IV.

04. During the mission the expert prepared a preliminary report which was discussed with officials of UNDP and NIDCS, copies are on file at each of these agencies.

05. In the course of the project the expert made a number of visits to the forest and sugar industries in Swaziland and to the particle board industry in the nearest neighbour country R.S.A. Included in these were:

06. Swaziland Sugar Industry
Mhlume Sugar Company Limited
Ubombo Ranches, Big Bend
Third Sugar Mill, head office Mbabane.

07. Forest based Industry
Usuthu Pulp Company Limited; Peak Timbers Limited,;
Shiselweni Forestry Company Limited; Swaziland Plantations Limited;
Tyrone Timbers, Mbabene; Tonkwane Estate, Menkayane Saumills.

08. Particle Board Industry
Resin Products, Limited, Matsapa; Bison Board, Piet Retief.

2. FINDINGS

09. Among the wood based sheet materials, particle board shows the fastest growth rate, the greatest degree of product diversification and possibly the most aggressive pricing policy. Table 1 illustrates the historical and projected growth of the three major types of wood based panels, showing the major areas of consumption and growth together with the consumption pattern in Africa. It is anticipated that by 1990 particle board will be the leading wood based sheet material and a rapid rise in consumption is forecast for Africa.

TABLE 1 APPARANT CONSUMPTION AND AVERAGE ANNUAL GROWTH RATE OF THE PRINCIPAL WOOD BASED SHEET MATERIALS

PRODUCT AND AREA	TOTAL CONSUMPTION (x 1000m³)			AVERAGE ANNUAL GROWTH RATE (percent)	
	1960	1970	1990	1960-70	1970-90
Particle Board					
World	2,789	19,904	85,000	21.7	7.5
of which					
Europe	1,876	12,473	45,000	20.9	6 6
Africa	43	121	1,000	10.9	1[illegible].1
Plywood					
World	15,596	33,134	72,000	7.8	4.0
of which					
North America	9,523	18,239	34,000	6.7	3.2
Africa	142	283	1,700	7.1	9.4
Fibre Building Board					
World	9,419	14,917	29,000	4.7	3.5
of which					
North America	5,609	7,479	12,000	2.9	2.4
Africa	180	119	500	(-ve)	7.4

Source F.L.C. Reed and Associated. In Proc World Consult. Wood based panels .New Delhi India 1975 Doc. FO/WCWB9/75

10. Particle board has a low volume/weight ratio and is generally a low value product especially when used in its uncoated form in construction and furniture manufacture. Consequently the product is vulnerable to rises in the cost of transport and is sensitive to general changes in the level of the economy. Since the mid 1970's particle board consumption has not shown the spectacular advances hitherto forecast. In world terms there is now a 20 percent over-capacity of potential production and an aggressive pricing policy within the major producing regions which has resulted in a retrenchment in world trade. African countries have not escaped these trends for although there has been a rise in production from 53,000 m^3 in 1966 to 316,000m^3 in 1977 in the region as a whole, exports have remained small - some 3,000 to 5,000m^3 and imports have declined from 34 percent to less than 12 percent of production over the period (F.A.O. 1979).

A. Review of markets for Particle Board in near neighbour Countries of Swaziland

11. In the near neighbouring areas, considered in the previous project as potential markets for board produced in Swaziland, considerable changes have taken place since 1973.

East African Countries

12. This area comprises Kenya, Tanzania and Uganda. In 1973 the installed capacity for particle board production in the three countries combined was 11,000 metric tons (16,500m^3) Since then the Budongo mill in Uganda has closed with a loss of capacity of 5,000 metric tons, and although a small captive plant at Nakuru in Kenya is in operation the product is exclusively marketed to a within - company furniture manufacturing plant.

13. Additonally both Kenya and Tanzania have increased their fibre building board capacity, the former by 6,000 metric tons per annum and the latter by 8,000 metric tons per annum (UNIDO 1976)

14. Market growth in wood based panels within the region has centred on the desire for self sufficiency, imports of board products have virtually ceased and consumption is now considered to be in balance with production.

15. Zambia

The Zambian market for selected forest products - sawnwood and poles - from Swaziland achieved minor significance in the early 1970's. Consequently some consideration was given in the 1973 report to market opportunities for board produced in Swaziland. Since then however a retrenched market for wood based sheet materials has developed as Zambian self sufficiency in wood goods has been forced by continuing transport, communication, and economic difficulties.

North African and near Eastern Countries

16. Brief consideration was given to the rapidly expanding Neer Eastern markets for wood goods in the 1973 report. Table 2 shows the development of the market for particle board in this region. The greatest expansion has been in Iran, Egypt and Israel. Of these countries only Iran was major importer in 1977, and almost all of her imports originated from Europe, principally from the countries of the European Economic Community.

TABLE 2 PARTICLE BOARD PRODUCTION, TRADE AND CONSUMPTION - SELECTED N. AFRICA COUNTRIES

(Units x 1000m^3)

COUNTRY	PRODUCTION		EXPORT		IMPORT		APPARANT CONSUMPTION	
	1970	1977	1970	1977	1970	1977	1970	1977
Egypt	17	29	6	-	-	-	11	29
Ethiopia	3	3	-	-	-	-	3	3
Somalia	1	2	-	-	-	-	1	2
Sudan	4	5	-	-	-	-	4	5
Iran	34	35	-	-	-	24	34	59
Israel	54	57	9	3	-	-	45	54

Source : F.A.O. (1979)

Republic of South Africa

17. The previous report argued the case for marketing particle board manufactured in Swaziland into her nearest neighbour country - the Republic of South Africa. Among the factors pertinent to this argument were the prospects for market growth anticipated by both producers and end users and, - of considerable importance to Swaziland - the expected increase in consumption in the Transvaal region. This area enjoyed 60 percent of the market demand but contained less than 30 percent of the production capacity in 1973. Swaziland, with abundant reserves of wood, and an indigenous - though totally export orientated - resin manufacturing capacity, was stategically placed to meet the expected escalation in the market for particle board in R.S.A.

18. During the period between 1973 and 1979 a number of developments have taken place in the region, not least of which concern discussions between potential investors on the manufacture of board in Swaziland. In the period 1972/74 the possibility of thin particle board manufactured by the Bison Mende process was evaluated by the Bison Board Company of South Africa and the Mhlume Sugar Company. The discussions founded on policy considerations and subsequently Bison Board established a Mende board production line at Malalane, in the Transvaal, in co-operation with the Transvaal Sugar Board. In 1975, as a direct result of the recommendation of the previous study, two associate companies of the Anglo-American Corporation: Bruply - a particle board manufacturer in Natal and in Cape Province, and Peak Timbers a forest owner and sawmill enterprise in Swaziland, undertook a feasibility study for particle board manufacture at Peak Timbers. This study confirmed the technical feasibility of the project but concluded that market uncertainties precluded investment at that time.

Installed Capacity

19. Not withstanding the loss of potential manufacturing in Swaziland, considerable expansion and a restructuring of of the industry in RSA have taken place since 1973. Table 3 shows the growth in manufacturing capacity between 1973 and 1979. Capacity has grown by some 75 percent from the level of 225,000m^3 recorded in 1973. RSA now holds almost 70 percent of installed capacity in the whole of Africa. Moreover this increased capacity is concentrated on the borders of Swaziland, at Piet Retief to the south, and at Malalane to the North.

TABLE 3

R.S.A. PARTICLE BOARD INSTALLED CAPACITY

COMPANY	PLANT LOCATION	PRODUCTION M^3/ANNUM 1973	1977
Bruply	Stellenbosch	45,000	45,000
	Pietermarizburg	50,000	60,000
Novoboard	Port Elizabeth	40,000	45,000
*Huletts	Amatakulu	40,000	40,000**
*Ultra board	Malalane	nil	40,000
Bison board	Piet Retief	50,000	170,000
		225,000	400,000

*Bagasse based board
**Presently not producing

Source Manufactures information, press releases, and various, published information.

20. Major elements of the increased capacity draw raw materials from Swaziland. Urea formaldehyde resin is manufactured at the Matsapa Industrial Estate by Resin Products, a wholly owned subsidiary of Bison Board, and this same company draws 75 percent of its wood raw material from the Eucalyptus plantations of the Shiselweni district of southern Swaziland.

21. Three types of particle board are manufactured in RSA.

(i) Flat pressed 3 layered board manufactured from wood represents 80 percent of the installed capacity. A wide range of grades and thicknesses can be produced, and although the major production is based on urea formaldehyde interior grade boards, significant advances have been made in the use of wattle bank extractive glues of exterior grade quality. Some 25-35,000m^3 of exterior grade board is now produced.

(ii) Flat pressed 3 layered board manufactured from bagasse represents 10 percent of the installed capacity. This board was manufactured at only one plant, at Amatakulu in Natal. Production ceased in 1974/75 due to market difficulties and the rather poor spectrum of properties offered by bagasse based board in competition with wood based board.

(iii) Continuously formed, thin particle board manufactured from bagasse is produced at one location - Malalane in the Transvaal. The technology of bagasse board production is now concentrated on this product which is marketed into specific sectors associated with furniture (drawer bottoms, drawer sides and hidden framing) door skins, and as core material for decorative plywood manufacture.

The Structure of the Industry

22. Whereas in 1973 the four major manufacturers shown in Table 3 operated independently, by 1978 a major restructuring of the industry had taken place and only Novoboard at Port Elisabeth remained independent. All other manufacturing facilities are now controlled by Bison Board.

23. Bison Board is wholly owned by Associated Furniture Companies Limited of South Africa. (A.F.C.O.L.) - the largest manufacturer of furniture in RSA. Bison Board aquired the Huletts plant by direct purchase, and control the manufacture of particle board at the Bruply sites through agreement between Anglo American and AFCOL. Thus an entrenched position in particle board manufacture in the RSA accrues giving both market advantage in the furniture industry and considerable benefits in the economies of scale to the Bison Board organisation.

24. Expansion of installed capacity has been concentrated in the Transvaal region thus rationalising the centres of production with the main market areas. Thus the Transvaal which in 1973 hold only 29 percent of production capacity and 60 percent of the market now contains 52 percent of the production capacity.

Consumption of Particle Board

25. Table 4 illustrates the rising trend of particle board consumption between 1967 and 1978, and forecasts consumption to 1990. Emphasis is placed on the static state of the market between 1973/75 and 1976/78. This was a period of uncertainty in the forest based industries as a whole which saw both the construction and furniture sectors in sharp decline and only show recovery (Standard Bank Review Jan 1979). Forecasts for overall recovery in these two vital sectors vary only narrowly and manufacturers of particle board now predict between 5 and 7 percent annual growth rate; a significant decrease from that forecast in the early 1970's (see Table 1)

TABLE 4

R.S.A. PARTICLE BOARD CONSUMPTION TRENDS

(units x 1000m³ rounded)

	1967 1969	1970 1972	1973 1975	1976 1978	1979 1981	1982 1984	1985 1985	1986 1990
Actual	76	128	235	240				
Forecast								
-5%/annum growth rate-					278	322	372	431
-7%/annum growth rate-					294	360	441	

Source Manufacturing Statistics 1970-1978

26. Comparison between Tables 3 and 4 shows that there is significant over production in the RSA market, with little more than 60 percent of installed capacity presently utilised. Full utilisation of capacity, even at the most optimistic forecast of market growth cannot be anticipated before the late 1980's.

27. There have been no significant changes in the pattern of consumption in the short period between 1973 and 1979. Uncoated boards, 650 to 700 kg/m³ manufactured to thicknesses between 12mm and 19mm occupy some 60 percent of the market. Laminated board accounts for between 25 and 30 percent of the consumption, equally divided between shelving and direct sales to furniture manufacturers. The furniture industry has lost some ground to construction with the advent of exterior grade board which is considered to be a growth sector in the market. Table 5 summarises the end use pattern.

TABLE 5

R.S.A. END USE ANALYSIS OF PARTICLE BOARD CONSUMPTION

End Use Sector	% Total		% Within End Use
Furniture	69	Domestic (excl. Kitchen) 9-19mm standard grade raw board.	60
		Kitchen 16-19mm standard graded faced board	25
		Office 16-19mm standard grade raw board	15
Construction	25	General construction - including exterior grade board. 9-16mm	60
		Built-in Fitments (Joinery) 16-18mm faced boards	20
		Partitions 32-44mm. low density boards	15
		Others	5
Others	6	Includes D.I.Y all grades and finishes	50
		Shop and bar fittings, Boards faced and various thichknesses	30
		Others - including coffins	20

B. The Market for Building Boards in Swaziland

28. A market review in 1973, based on invoice analysis of sales from the principal builders merchants in 1971/72 concluded that the size of the market for all building board products in the Kingdom was less than 1000m^3 per year. The major board types used were asbestos ceiling board (29 percent) fibre building boards (25 percent) and blockboard (18 percent). Particle board occupied less than 10 percent of the market.

29. Although building activity within the Kingdom has shown some increase since 1973 the market for board products within the Kingdom continues to be nugatory.

C. The Construction Industry in Swaziland

30. A recent World Bank/UNIDO Co-operative Programme document (UNIDO. 1979) critically reviews the construction industry within the Kingdom.

31. Prospects for the domestic construction industry are promising with increasing public awareness of the need to encourage this sector. Overall growth of the industry is estimated at 15 percent annually during the Third Five year Plan (1978-83). The number of persons directly engaged in construction is expected to double during the period, rising to some 8,600 persons.

32. The annual volume for all construction activity including roads, buildings and site facilities is estimated to be some E15 million, about 5 percent of the gross national product. Of this foreign based companies account for 60 percent direct labour forces of the public sector 24 percent and locally established firms (both Swazi and expatriate), 16 percent.

33. The Ministry of Public Works and Communication (MPWC) through its Building Branch holds the major share of building construction in Swaziland. In 1977/78 the planned budget was E7.1 million of which E4 million was actually expended, 54 percent by direct labour and 46 percent by private contractors. During the next five years the proposed annual outlay is still higher, averaging some E10 million per year.

34. A total of 120 building contractors are registered with the Building Branch, classified as follows:

Foreign based companies, registered in Swaziland	17
Joint Ventures	3
Local companies, expatriate owned	75
Swazi contractors	25

35. In the private sector foreign firms dominate the market for building construction. Among these, firms based on RSA predominate. The foreign firms registered in Swaziland are concerned principally with specific one off projects of high value and they enjoy considerable cost advantage in the direct purchase and bulk shipment of materials direct from RSA. The local companies expatriate owned are genuinely based in Swaziland and handle many medium sized building and construction projects at the level of E2-3 million. The Swazi contractors are new to the scene and are supported by the Small Enterprises Development Company (SEDCO) in purchasing, technology and site management. Their contribution is at present small.

Housing

36. The 1976 census shows that Swaziland with a population close to 500,000 has 18,339 permanent dwellings, 33,779 houses built of temporary materials and 32,409 dwellings which are constructed partly of permanent materials and partly of non-durable materials. Over 85 percent of the people live in the rural areas and provide their own housing.

37. Urban drift is however an increasingly important factor in housing. In the main centres, Mbabane and Manzini unplanned and substandard housing has been built and continues to be built. In the decade between 1966 and 1976 the urban population rose by 63 percent from 22,800 to 37,400. In the urbanised areas there are also problems associated with the provision of housing for civil servants, technical assistance personnel, and others in the middle and higher income groups. Civil service personnel pay subsidised rentals and subsidized mortgage rates are also available. Government has a pool of 1700 houses for its employees and leases some 120 houses from the private sector.

38. Government wishes to encourage home ownership but several considerations inhibit progress in this area. There is a shortage of suitably serviced areas in the urban areas, whereas on Swazi Nation Land the absence of individual title deeds is an obstacle to securing mortgage loans from lending institutions.

39. Mortgage finance is available from the Swaziland Development and Savings Bank (SDSB) and the Swaziland Building Society (SBS). Mortgage loans have not, as yet achieved significance in the portfolio of either institution, partly because of bureaucratic difficulties associated with the fragmentation of functions involved in property transfers among several Government offices.

40. During the Second Five Year Plan, three Government institutions were established to promote housing.

(i) A housing unit was established in the Ministry of Local Administration in 1975, to design and build 100 units by self help methods, using SDSB loans. This project has been successfully completed.

(ii) The National Housing Corporation (NHC) has not been so successful. Envisaged as a commercial enterprise to provide low and middle income housing at market prices, some 530 units were planned. Not all have been completed and 230 units remain unoccupied.

(iii) The Industrial Housing Company (Pty) Limited was set up as a subsidiary of the National Industrial Development Corporation of Swaziland. (NIDCS) and has completed 318 housing units with 192 more under construction.

In addition to the above the Building Unit of MPWC has built some 500 Government pool and institutional housing units in the past 5 years.

41. The capacity of the building industry is not yet sufficient. There is a shortage of suitably trained manpower particularly at artisan and supervisory level. Most building materials are imported but cement, most of the required timber, and concrete aggregates are produced locally.

Future prospects for housing

42. Co-ordination of policy and effort for housing development is still lacking and numerous organisations are involved. The overall objectives for housing development in the Third Five Year Plan are however specific. First priority is given to the concentration of financial resources and expertise in the provision of housing for low income earners, particularly through self help schemes. Second, the Government will seek to encourage home ownership. Third, co-ordination of all agencies concerned with housing and lands will be encouraged.

43. Specific reference is made in the Third Plan to housing construction. The Government will attempt to provide the following during the five year period.

(i) 1,350 serviced sites for self-help low income housing
(ii) 1,500 low and medium income housing for sale or rent.
(iii) Water sanitation and roads for 1,200 sites in slum areas.

44. Other sources within Government also emphasise housing needs. The Ministry of Works, Power and Communications estimated that 30,000 low income housing units are needed in the long term. The Ministry of Education in planning for the future developent of education facilities estimate a need for 2500 units comprising classrooms, teachers housing and administrative buildings by 1986. The Ministry of Health has an extensive programme for the construction of rural clinics and maternity centres. The Ministry of Agriculture points to the need for better housing in the rurual areas and will concentrate its activities on the Rural Development Areas.

D. Choice of Board material for Manufacture in Swaziland

45. Wood based sheet material manufacture in Swaziland is presently restricted to the manufacture of block board, at Swaziland Plantations (Pty) Limited, in the Piggs Peak district, using pine corestock and surfaced with indigenous pine or imported Okumé Veneer. The production capacity is some 250 boards per day (4,000m^3/annum) and the product is marketed principally in RSA. A small quantity of concrete shuttering board and decorative venner board is sold in Swaziland.

46. The choice of additional capacity and product manufacture in Swaziland is conditioned by the availability of raw materials and the markets available for the product.

47. Section A of this report presents a bleak outlook for the marketing of conventional particle board if manufactured in Swaziland. Other wood based panels might be considered but most present problems associated with marketing or the technology of manufacture.

Fibre building board: Marketing problems accrue to this product in all its grades and qualities. RSA is a major producer of hardboard and softboard and is a net exporter of both those products. Although there is no manufacturing capacity for medium density fibreboard in Southern Africa the product is a major competitor to standard grade uncoated particle board and its manufacture in Swaziland would face intensive competition from the entrenched particle board industry in RSA.

Plywood: The plywood industry is capital intensive and has recently been subject to sustained technological advance leading to single plant diversification into a range of markets, principally based on decorative veneer to (e.g. concrete shuttering) grades. Although Swaziland has abudant plantation softwood resources the Kingdom does not possess a broadleaved resource of decorative veneer species.

Thus the manufacture of plywood in Swaziland would present problems of technology and marketing as well as implying the import of decorative species in log or veneer form.

48. Among the more recent developments in wood based sheet materials, two products are considered relevent to the internal needs of Swaziland, particularly in relation to the requirements for housing.

Wafer Board: This product is manufactured from thin wood flakes bonded with a thermo-setting phenolic resin to form an exterior grade board used for external cladding in building construction. The product was developed in North America in the 1950's but achieved prominence only in the mid 1970's as its requirement for phenolic resin is considerably less than that of exterior grade particle board, but the product has yet to be manufactured in developing countries.

Cement bonded Particle Board: Exterior grade particle board, using phenolic resins have long been known and are finding increasing use in construction. However the product has a number of restrictions.

(a) because of the high cost of phenolic resin when compared with urea formaldehyde (cost ratio UF:PF = 1:4)
(b) water absorption and swelling cannot be completely controlled unless resistant paints laminates and edge sealants are used. Some risk accrues if these surface coats are damaged.
(c) Exterior grade particle board has limited fire resistance.

Cement bonded particle board is manufactured by the addition of wood particles prepared to size specifications close to those of convensional particle board but without the need to dry to low moisture content. They are mixed with dry Portland cement, to the mixture is added water at a rate determined by the moisture content of the wood particles. The whole is formed into a board mat by a modified particle

board forming machine. Boards are cold pressed and clamped for a period to allow the cement to set. Finally each board is conditioned to the required moisture content and trimmed using conventional hardened steel saws. The resultant board is dimensionally stable, fire proof and resistant to biodegradation hazard. The board can be nailed, screwed, lipped, sawn and glued.

49. Cement bonded particle board is a recent product. It was developed in 1962 by Elmendorf Research Inc. of Palo Alto, California, U.S.A. as a high density compressed wood based particle board with good weather and fire resistant properties. A full scale production plant was built in Japan and the board, trade named Century Board, quickly gained acceptence. Between 1966 and 1970 the Swiss company Durisol A.G. continued development on the Elmendorf concept, gaining experience in application to prefabricated building components. A full scale automated production line was designed and built at Dietikon in Switzerland by the Bison-Werke organisation on behalf of Durisol. A second unit was commissioned at Wunstorf in the Federal Republic of Germany by Fulgit, a major asbestos-cement producer. By 1977 a 100m^3 per day capacity plant had been commissioned in Hungary and this has now been expanded to 150m^3 per day production. Experience in developing countries began when the original Durisol plant was transferred and rebuilt in Vietnam with assistance from the Swiss authorities. In 1978 six plants were commissioned in developing countries, among them are three small scale plant in West Africa, Asia and Central America. As well as a successful introduction into the European market cement bonded particle board has shown good performance in tropical and subtropital climates in Turkey, Iraq, Tunisia, Saudi Arabia, West Africa, Indonesia, Brazil and the Caribbean.

50. Cement bonded particle board has a particular relevence to Swaziland.

(i) In relation to the specific needs for low and middle

income housing the local availability of a weather resistant board which is also fire and biohazard resistant is of special significance to meet demands for buildings accross the entire spectrum of climatic zones within the Kingdom.

(2) The product can be manufactured on a small enough scale to be marketable entirely within the country. A 25m^3 daily capacity will supply the need for 9 houses of 35m^2 living accommodation of single skin construction, or 4 houses of double skin construction.

(3) At a small scale production level the manufacturing technology is relatively simple and can utilise labour intensive methods.

(4) Expansion of installed capacity is flexible and can take the form either of a simple addition to production or the addition of prefabrication facilities for systems building components.

(5) The raw materials are all available locally.

E. Manufacture of Cement Bonded Particle Board in Swaziland

51. In the manufacture of cement bonded particle board, the raw materials required are wood or bagasse and cement together with mineralising chemicals, e.g. water glass ($Na_2 SiO_3$) aluminium sulphate ($Al_2 (SO_4)_2$) and sometimes calcium hydroxide ($Ca(OH)_2$) to increase cement plasticity. The factory must be located on an industrial site serviced with water, electricity and industrial sewage disposal.

Technological limitations of raw materials

52. Wood: The wood species and the particle geometry are the important factors which influence the properties of the finished product. There are two wood characteristics which inhibit the setting of cement - tannins and low molecular sugars. Experience within the industry has shown that where these are present in low concentrations and in soluble form, air seasoning to 30-40 percent moisture content will remove the debilitating influence on cement curing. The principal species available in Swaziland are, Pinus patula, Eucalyptus grandis/saligna, and various species of wattle (Acacia Sp). Of these only wattle is unsuitable, because of its high extractive content.

53. Cement. High initial strength is one of the principal attributes of the cement used in the process. Portland Cement grade 450 F is the preferred material in Europe. This is equivalent to DIN 1164, yielding 450 kp/cm^2 after 28 days, or BS 12,1958, rapid hardening cement. Equal strength properties can be obtained with lower grades provided that a longer curing time is used. Experience in developing countries has shown that blast furnace slag type cements can be used successfully. Type II Portland Cement (South African Bureau of Standards) is available in Swaziland, equivalent to grade 35 on the DIN standard. This will be a satisfactory raw material for the product.

Mineralising Agents

54. Although not manufactured locally the mineralising agents (para 51) are all available from RSA via chemical wholesalers within the Kingdom.

55. Bagasse. There has been little experience in the use of bagasse as the ligno-cellulose raw material for the product, except at an experimental level. The fibre preparation is more complex than that of wood, involving both pith removal and the essential removal of all residual sugars - which are prent at about 5 percent of wet bagasse at mill site. On the other hand difficulties assocated with particle geometry, which often cause problems with convensional particle board manufacture, are not - as a far as is known - a debilitating influence on cement bonded board. Bagasse is available in quantity in Swaziland.

Availability and costs of raw materials

56. Swaziland has a thriving sugar industry, with almost 21,000 ha of cane harvested in 1978/79, (equivalent to some 2.3 million m.t green bagasse) at two sugar mills situated in the Low Veld region of the country. A third sugar mill will begin production in 1980/81 based on an additional 9,000 ha of cane planted in the Low veld. The forest resource is located at three principal centres in the high veld . Over 97,000 ha have been planted of which 71,386 ha are coniferous (75 percent Pinus Patula) and 26,622 ha are broadleaved species (87 percent Eucalyptus grandis/saligna). In 1977 the annual yeild of roundwood wes over 1 million m^3, the principal products are unbleached sulphate pulp and sawnwood form the conifers and sawn mining timber, poles and fencing from the broadleaved woods. There is also a cement factory at the Matsapa industrial estate located close to Manzini in central Swaziland which obtains its raw material as clinker from Maputo, Mozambique. The factory has an installed production capacity of 78,000 mt per annum.

Bagasse

57. There are two sugar mills in Swaziland.
Ubombo Ranches is situated at Big Bend in the south east and the principal share holder is the Lonrho Corporation.
Mhlume Sugar Company is situated at Mhlume in the North East, and is a Commonwealth Development Corporation enterprise.
Production statistics for the two mills are shown in Table 6 for the period 1971/72 and 1977/78. A 26 percent increase in sugar output has taken place in the six year period arising from additional areas under cane cultivation. Correspondingly the yield of bagasse has risen from 454 thousand mt to 597 thousand mt in the period. Each mill has undergone considerable expansion in the last 5 years. At Mhlume a E20 million improvement programme began in 1977 and includes additional refiner and boiler capacity.

TABLE 6

PRODUCTION STATICTICS : SUGAR MILLS

1971/72 AND 1977/78

(units x 1000 metric tons).

Item of	Mhlume		Ubombo		Total	
Production	1971/72	1977/78	1971/72	1977/78	1971/72	1977/78
Sugar	86.6	109.9	90.5	114.5	177.1	224.4
Cane	720.8	974.8	794.2	1015.6	1515.0	1990.4
Green Bagasse	216.2	292.4	238.3	304.6	454.5	597.0
Dry, depithed Bagasse[1)]	77.2	104.3	84.9	108.7	162.1	213.0

1) estimated at 107kg per 1000kg cane produced.

Source. Company statistics and Swaziland. Sugar Association.

58. Further expansion of the industry is imminent with the advent of the Royal Swaziland Sugar Corporation mill. Government and the Swazi Nation each hold 32 percent of the equity and are the major share holders. The financial agreement was signed in 1977 with a capital investment of E5 million (at constant 1977 prices) and the company will operate 9,000 ha of cane at Malula and Ngomane, some 40 km from Mhlume. The mill is expected to come on stream in 1980 with a production of 47,000mt of sugar, rising at full capacity in 1973 to full capacity of 117,000 mt. of sugar. This implies a green bagasse production of 300-310,000 mt in 1983.

59. Since sugar milling began in Swaziland bagasse has been exclusively used in steam producing boilers to generate energy for both the mill operations and to provide electrical power to the irrigation schemes upon which cane production depends. Both sugar mills use boilers which can be fired either by coal or bagasse, and the boilers of the third mill will have the same facility. Bagasse is therefore only theoretically available for secondary industrial processing, and the key to its use is its energy substitution value.

60. Alternative forms of energy are available in Swaziland.
Coal. The Mpaka Mine is centrally located between the existing sugar mills and has an annual output of 120,000 mt per annum. The delivered cost to mill is presently estimated at E22 per m.t.
Electricity. The statutory authority for electrical power is the Swaziland Electricity Board (SEB) which was established in 1962. In 1964 SEB sold 17 million KWh, by 1977 200 million KWh were sold an important element of which was purchased from RSA via the South African Government Electricity Supply Commission (ESCOM). Sales are expected to rise to 350 million KWh by 1983 (a rise of 9 percent per annum) and SEB investment within the period is expected to contain the import of power rather than achieve self sufficiency. It is therefore most unlikely that purchased electrical energy will be available as an alternative the energy generated by burning bagasse.

Mill Site Costs for Bagasse

61. The cost of green bagasse purchased at the sugar mill is calculated as follows from information obtained from Ubombo Ranches.

Item	E
Equivalent cost of coal/tonne bagasse (basis 1 tonne coal = 4 tonnes bagasse)	5.5
Handling and loading charge	1.2
Additional boiler maintenance	0.5
Cost of green bagasse/tonne	7.3

Wood

62. The major characteristic of the use of wood in all sections of the particle board industry is the availability of residual raw materials arising from the forest (unallocated roundwood or unsalable small roundwood harvested in silvicultural operations) or residues arising from the industrial conversion of roundwood (sawmill and machining residues). In the manufacture of cement bonded particle board roundwood is the preferred type of raw material, this enables considerably more control to be exercised in particle size. Uncommitted roundwood is available at two locations in Swaziland, Piggs Peak in the north and Shiselweni in the South.

Piggs Peak Region

63. Peak Timbers. The company is a subsidiary of the giant Anglo American Corporation and is numbered among a group of companies integrated with South African Forest Industries (SAFI) which has interests in sawmilling, pulp and paper, wood based sheet materials and systems built housing. Table 7 indicates the extent of company activities both in 1978 and its plans for expansion to 1983 for which funds are already committed. It is estimated that the uncommitted roundwood resource will not exceed 7 to 10,000m^3 including forest residue, and most of thus resource will arise from the Eucalypt plantations.

TABLE 7

PRODUCTION STATISTICS PEAK TIMBERS

1973 1978 AND FORECASTS TO 1982/3

Total Estate Area	25,000 ha.
of which Pine	21,000 ha
of which Eucalypts	2,700
Pine Average annual increament	16m³/ha/annum
Potential Yield Pine	336,000m³/annum
Eucalypt Average annual increament	20³/ha/annum
Potential Yield Eucalypt	54,000m³/annum
All species, potential yield	390,000m³

Allocated roundwood

	1973	1978	1982/3
Structural mill	190,000	234,000	279,000
Industrial mill	52,000	75,000	105,000
Box wood mill	30,000	nil	nil
	272,000	309,000	384,000

Source Company statistics

Shiselweni District

64. Of the 21.5 thousand hectares of planted Eucalypt species more than 10 thousand hectares are located in the Shiselweni District in Southern Swaziland. Some 8,000 ha are owned by Shiselweni Forestry Company Limited, a CDC enterprise and the remainder comprises of small forest areas - rarely in excess of 100ha holdings - owned by numerous Title Deed farmers. To method of management is universal to the region, an 8 year rotation is planned followed by clear feeling and regeneration through the coppice system. Roundwood marketing is concentrated in two sectors, the Title Deed farmers sell to a mine-pack mill located at Nhlangano, the only town in the region, and Shiselweni Forests sell their produce as standing timber to a contractor operating for the particle board factory at Piet Retief.

Because of the recent recession in mining in RSA title deed holders are presently restricted to a quota of little more than 50 percent of their potential supply, and together with the unallocated roundwood at the CDC operation some 45,000m³ of roundwood, including forest residue is presently available; see Table 8.

TABLE 8

PRODUCTION STATISTICS	SHISELWENI DISTRICT
Total Afforested Area	10,900 ha
of which Shiselweni Forests	9,000 ha
of which Title Deed Farmers	1,900 ha
Total Eucalypt Area	9,800 ha
of which Shiselweni Forests	7,800 ha
of which Title Deed Farmers	2,000 ha
Eucalypt average annual yield	18.5m³/ha/annum
Total potential yield	182,000m³
of which Shiselweni Forests	144,000m³
of which Title Deed Farmers	38 000m³
Presently allocated Total	136,000m³
of which Shiselweni Forests	112,000m³
of which Title Deed Farmers	24,000m³

Mill Gate Costs of Wood

65. Wood costs are based on the presently unallocated reserves of roundwood and forest residue costed at 40 percent of the merchantable wood costs. Costing information has been obtained from the companies.

Cost of Merchantable logs (E/m.t)

Item	Peak Timbers *)	Shiselweni District *
Standing Timber	3.0	4.0
Harvesting	3.0	3.0
Transport to mill	7.0	5.0
Total cost at mill	13.0	12.0
Forest residue costed as harvested (40%)	5.2	4.8

Cement

66. The cost of cement in bulk deliveries from the Mantola factory to various locations, is as follows:

Nhlangano (Shiselweni)	E2.83/50 kilo	= E56.6/tonne
Mhlume	E2.76/50 kilo	= E55.2/tonne
Piggs Peak	E2.53/50 kilo	= E50.6/tonne
Ubombo (Big Bend)	E2.53/50 kilo	= E50.6/tonne

Location of Cement Bonded Particle Board Factory

67. The manufacture of cement bonded particle board requires and industrial site with suitable services (para 51) Among the areas considered for raw material supply the

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* Both sets of details derived from company information.

Shiselweni district has considerable cost advantages, and is adjacent to Nhlangano where an industrial site is located. Industrial development at Nhlangano is a specific target identified in the Third Five Year Plan with the declared objective of job creation in the region. The area is well serviced by roads, an improvement programme to link the region with a bitumen surfaced road to the Mbabane - Manzini industrial corridor will begin in 1980, and with budding community services.

68. The distances between Nhlangano and the various sites of raw material are as follows:

Location	Km
Nhlangano-Shiselweni	20
Nhlangano-Mhlume	200
Nhlangano-Piggs Peak	250
Nhlangano-Industrial Corridor	100

69. The cost of raw material delivered to Nhlangano is calculated using site location cost and transport costs which are quoted at E0.1/m.t/km

Delivered cost of raw material to Nhlangano Industrial Site

(Costs E/m.t)

Material	Location	Raw material	Transport	Total
Wood	Shiselweni	4.8	2.0	6.8
Bagasse	Mhlume	7.2	20.0	27.2
Bagasse	Ubombo	7.2	13.0	20.2
Wood	Piggs Peak	5.2	25.0	30.2
Cement	Matsapa	- inclusive -		56.6

Technical properties of Cement Bonded Particle Board

70. The product characteristics are summarised as follows:

(i) A homogeneous, single layer construction board

(ii) Board size 1,200 x 2,440 mm

(iii) Thickness range 8-40mm (16mm recommended)

(iv) Maximum density 1,250 kg/m^3. This corresponds to a wood: cement ratio (1:2.75). Lower densities are possible but fire resistance and biohazard increase and dimensional stability decreases as the wood ratio increases. As market acceptability of the panel increases the same plant can produce board of maximum density 1,000 kg/m^3 to a wood: cement ratio of 1:1.8. Such boards should only be used in interior situations eg lining and ceiling boards.

(v) Moisture content 12% to 15%.

71. The specific properties of the board are determined by those of its who main components. Wood is light weight, elastic and has good workability. Cement is incombustible and is moisture, fungi and termite resistant. Other important characteristics are:

(i) The product can be glued to other materials

(ii) The surface can be overlaid with wood veneers, synthetic foils, ceramic tiles and mosaics.

(iii) The product has good elasticity under static loads and is resistant to impact loads, leading to a non brittle construction board.

72. As yet there are no internationally recognised standards for cement bonded particle board. This situation will soon be remedied as intensive work is now under way in

Switzerland:- EMPA Institute
Germany:- University of Hamburg
Great Britain:- Princes Risborough Laboratories of the Building Research Establishment.

73. In the meantime a number of properties of the board have been authenticated by independent testing institutions.

Physical Properties

74. Specific density 1,250 kg/m^3 (Wood: Cement Ratio 1 : 2.75 by weight for 16mm thick board).

Maximum swelling of thickness

- after 2 hours soaking in water - 0.8 to 1.3 percent
- after 24 hours soaking in water - 1.2 to 2.0 percent
- after 28 days soaking in water - I.2 to 2.0 percent

Linear expansion 0.3 to 0.4 percent

Weather and frost resistance (cylic temperature changes and soaking in water 150 cycles from - 20°c to + 20°c) No change in boerd strength.

Thermal conductivity 0.155 kcal/m^2 h °C.

Sound insulation

- single sheet 12mm. thick 30d8
- single sheet 14mm. thick 36d8
- double skin wall of 16mm

and 18 mm thick sheets, 50mm air space 45-50d8.

Mechanical properties

75. The following figures concern a board with specific density 1,250 kg/m^3 and a thickness of 16mm.

- banding strength 90-150kp/cm^2
- tensile strength (internal bond) perpendicular to surface of board 4-6 kp/cm^2
- compressive strength 150 kp/cm^2
- modulus of elasticity 30,000-50,000kp/cm^2
- screw holding (range 12-24mm board) 90-120kp/cm^2
- nail holding (range 12-24mm boards) 40-80kp/cm^2

Other properties

76 Fire resistance, is assessed as follows:

(a) ASTM (USA): rated as incombustible

(b) EMPA, (Switzerland): (class VI) practically incombustible.

(c) B.A.M, (F.R. Germany): (A2 Class).
A2 class material does not support combustion in any measurable way. All requirements for classification A2. (DIN 4102) are satisfied by the board.

(d) British standard BS 476 part 7: Flame spread, class 1.
Resistance against.
- fungal and termite attack. : highly resistant
- Toxicity : negligable. (no environmentally hazardous chemicals are released).
- Glueing : tested glued constructions with resorcinol and polyurethane glues show 100 percent adhesion.

Machining and Finishing

77. Cement bonded particle boards can be worked easily with standard wood working machinery, and the same standard carbide-tipped tools are used for cutting conventional particle board. Such tools show an extended life expectancy of 15-20 percent over conventional resin bonded board. Sanding is satisfactory with conventional sanding belts. Sawing, shaping, routing, drilling and lipping can be satisfactorily carried out with hand tools. Nailing and screwing do not necessitate pre-boring and can be satisfactorily carried out using hand tools.

Summary of technical characteristics

78. Table 9 shows a comparison between cement bonded particle board and other board products. Compared with urea bonded particle board, the product is heavier, has enhanced strength properties to water. Like urea resin bonded boards the product has excellent working properties and can be glued and attached with mechanical fastenings. Compared with asbestos cement boards the product is lighter, more flexible, has comparable insulation properties but is less strong in compression. Cement bonded particle board has considerably enhanced working properties.

Table 9

Comparison of Cement Bonded Particle Board Properties

Property	Particle Boards		Other Boards	
	Cement Bonded	Urea resin bonded	Asbestos Cement	Gypsum board
Density (kg/m^2)	1100-1200	600-700	1800	850-1100
Bending Strength (Kp/cm^2)	90- 150	120-200	170-180	60-110
Modulus of Elasticity ($1000kp/cm^2$)	30	24-30	158	-
Tensile Strength (Internal bond)	4-6	3-6	-	-
Thickness swelling				
2 hours %	0.8 - 2.0	2.0 -6.0	0.5-0.8	-
24 hours %	1.2 -2.0	12-16	0.5-0.8	-
Compression Strength (kp/cm^2)	150	100	500	-
Thermal conductivity ($kcal/m^2\ h°C$)	0.155-0.22	0.120	0.300	0.300
Behaviour in Fire	does not support Combustion	Burns	Does not Support Combustion	Does not Support Combustion
Machining performance (+ = good - = Poor)				
Sawing, milling	+	+	-	-
Sanding Screwing	+	+	-	-
Nailing	+	+	-	-
Painting, Plastering	+	+	+	+
Laminating	+	+	+	+
Veneering	+	+	-	-

Application of Cement bonded Particle Board

79. The board has considerable flexibility in application which may be summarised as follows:

(i) Low income housing, advantages include strength, fire, water, termite and fungi resistance. The most economical use is in total construction situations, but satisfactory applications are also in partially or fully load bearing panels in roof, wall and floor consturction with wood frames.

(ii) Agricultural storage units, dry storage facilities, bins, silos and boxes.

(iii) Components, numerous construction elements, especially where a machined weather resistant component is required, e.g.facades, roof sheathing, flat roof structures, balustrades, double and single skin wall units with inset window or door openings.

80. Ten years experiance in Europe has seen the successful introduction of the product in institutional buildings. (schools, offices, hospitals) and industrial and prefabricated buildings. In developing countries the product has been used in Indonesia (housing) Vietman (schools) Pakistan (housing) as well as prefabricated housing shipped to Saudi Arabia.

Investment costs for small-scale manufacturing capacity

81. The proposed manufacturing capacity is 25m^3/day, equivalent to 6750m^3/year. The plant will operate at three shifts per day throughout the year and in the calculation of full capacity production, a 10 percent down-time allowance is made.

82. A description of the process, together with a block flow diagram is given in Appendix I which also lists the equipment required using BISON production technology.

83. The investment required for the recommended capacity is E3,801,000, of which E2.72 million represents machinery and equipment, while land, buildings and overheads represent E466,000. In Appendix II a full economic analysis is shown together with a cash flow statement.
The investment requirements are summarised as follows:

	EX1000
Imported machinery (at site)	1633
Local equipment (at site)	459
Foundations, assembly, vehicles, offices	628
Total machinery and equipment	2720
Land, Buildings, including overheads	466
Preliminary expenses, housing	365
Working capital	250
TOTAL INVESTMENT	3801

84. The unit cost structure indicates a total manufacturing cost of E200.9/m^3 on the basis of costs of raw materials at the Nhlangano site. A decision in favour of wood rather than bagasse is taken on both technological criteria (para 55) and costs at the Nhlangano site (para68)
The unit cost structure is summarised as follows:

	E/m^3
Variable Costs	
Wood, cement, chemicals, water	53.64
Energy, electrical and thermal	9.16
Tools and maintenance	8.44
Sub Total	71.24
Fixed Costs	
Wages and salaries	44.96
Overheads, incl. sales expenses	17.43
Depreciation and interest	67.27
Sub Total	129.66
TOTAL UNIT MANUFACTURING COST =	200.9

Sales, profit and Return on Investment

85. Cement bonded particle board has not so far been manufactured in Swaziland, and the sales price for the product cannot, therefore, be absolutely fixed. The economics of the project show that a gross profitability of betwen 17 and 35 percent can be achieved at an ex-mill price of up to E300/m^3 Since the product is new to Swaziland the cash flow, break even analysis and returns on investment are calculated at an ex-mill price of E250/m^3 in Appendix II. For purposes of comparison the range E250/m^3 to E300/m^3 is used in this section, and Appendix III develops this theme using a sensitivity analysis to test the influence of changes in variable and fixed costs in association with ex-mill prices of the product.

86. Sales, profit and returns on investment are shown, using the same assumptious as those used in Appendix II, namely

- import duty is assumed to be zero.
- depreciation of equipment and buildings: NIDCS information.
- equity capital: 50 percent of investment
- investment loan 50 percent of investment
- wages and salaries: NIDCS information

Sales profit and return on Investment

Sales volume (m^3/year)	6750	6750	6750
Sales price (E /m^3)	300	275	250
Sales Revenue (Ex1000)	2025	1856.2	1687.5
Minus production cost, before Depreciation and interest (Ex1000)	902.1	902.1	902.1
GROSS PROFIT	1122.9	954.1	785.4
Total Investment (Ex1000)	3801	3801	3801
Gross Return on investment (%)	29.5	25.1	20.6
Minus depreciation and interest */	454.1	454.1	454.1
Net operating profit	668.8	500	331.3
Equity capital	1900.5	1900.5	1900.5
Net return on Equity Capital (%)	35.1	26.3	17.4

*/ Depreciation and interest are shown as applicable to the 5th and 6th operative year of production, i.e. year 7 and 8 in the cash flow Appendix II.

Estimated Wholesale price

87. To establish a market for the product a wholesale price must be calculated. This calculation has been based on the three ex-mill prices shown above and includes a considerable element for transport from Nhlangano to the industrial corridor between Mbabane and Manzini. The established transport costs is E0.1/km/tonne. Allowance is also made for damage in transport, expressed as a reject allowance at Wholesalers yard.

Estimated Wholesale Price

Ex-mill price (E/m³)	300	275	250
Wholesalers mark up (16%)	48	44	40
+ Sales expenses (4%)	12	11	10
+ Freight, 100km @ E0.1/km tonne	12	12	12
+ Transfer expenses (1%)	3	2.7	2.5
+ Reject allowance (7%)	21	19.3	17.5
Wholesale price (E/m³)	396	364	332
Wholesale price E/m² 16mm board	6.3	5.8	5.3

88. Finally, to establish the competitive position of the board its cost in use must be established. This element would most usefully be served by comparison of a complete house structure between conventional methods, e.g. cement block structures with currugated medium roofing and a complete house built from cement bonded particle board units fabricated using timber framing elements. At the present time such a comparison cannot be made. However from information supplied by the Bison Company on projects in Asian countries a calculation has been made on the unit cost of erection of walling units only.

The basis of this calculation is the on site fabrication of walling using cement bonded particle board, 16mm thick, nailed or screwed and glued to preserved timber frames consisting of 3 vertical studs and two horizontal rails (50x70mm) in assembled units of 1.25m x 2.30m. The wall panels are interconnected by galvanised bolts after elastic joint strips have been placed between stiles. It is assumed that interior facings of gypsum board will be used to complete a double wall structure. Local materials have been costed at Wholesalers yard prices, except the timber component which is costed on the information received from a local miller who manufactures preserved structural timber from indigenous softwood. Eighty five m^2 walling (interior and exterior) has been assumed for a low income house design based on 35m^2 living area.

Putative Cost of Wall Construction	E/m^2		
Cement bonded particle board	5.3	5.8	6.3
85 m^2	450	493	535.3
Interior gypsum board			
85,^{2} at E4.25/m^2	361	361	361
Lumber framing, preserved timber			
1.0m^3 at E110/m^3	110	110	110
Hardware, including joint strips	70	70	70
Exterior wall paint	38	38	38
Labour 6 man days, skilled			
labour rates + 30% supervision	40	40	40
Total	1069	1112	1154.3
Cost per m^2 E	12.6	13.1	13.6

In the Mbabane-Manzini industrial corridor the estimated cost of wall construction (150mm) is E14.3, from information received from the Buildings Section of the Ministry of Public Works and Communications (September 1979)

II CONCLUSIONS AND RECOMMENDATIONS

A Conclusions

The market for particle board in near neighbour countries

89. The market opportunities for resin bonded wood particle board identified in the 1973 report for project SI/SWA/71/804 cannot be substantiated in 1979.

(i) because the increasing demand forecast in 1973, a pre energy crisis era, has not materialised in near neighbour countries.

(ii) in the nearest neighbour country, R.S.A. the manufacturers have established an entrenched position and rationalised production towards considerable benefits in scale economics.

(iii) increased capacity in RSA is concentrated on the borders of Swaziland and, in the case of the largest manufacturer, drawing a high proportion of its raw material from the Kingdom. Thus the market for board produced in Swaziland is effectively sealed off.

(iv) the markets prospects for bagasse based resin board are particularly bleak.

Market opportunities in Swaziland

90. (i) Raw materials for board manufacture are abundant but there is an increasing awareness of their value. Bagasse is fully and efficiently utilised as a source of energy and will continue to be so used even with the advent of a third sugar mill. Increasingly wood is more fully utilised and unallocated resources are now concentrated on under used roundwood mostly in the form of that part of the felled tree which is presently not merchantable.

(ii) The market for wood based sheet materials in Swaziland is negligable if confined to interior grades.

(iii) Considerable market opportunities exist for an exterior grade board for cladding and sheeting.

Especially is this so in low and middle income housing sectors where the present need is great and demand is expected to burgeon.

(iv) Cement bonded particle board, a product new to Southern Africa, has considerable advantages in this sector. It is fire proof, weather proof and biohazard resistant, it can be manufactured by a small scale, labour intensive process and the product is competitive with conventional building materials.

8. Recommendations

91. A small scale (25m³ per day, 6,750m³ per year) labour intensive (154 employees) production capacity for the manufacture of cement bonded particle board is recommended. The investment cost is E3.8 million (at constant 1979 prices), the raw materials, wood, cement and mineralising chemicals are available locally. The proposed site is the Nhlangano industrial estate in Southern Swaziland. The technology recommended is that of the Bison, Bahre Gretan Company of F.R. Germany.

92. The product is new to Southern Africa and will present a challenge to successful marketing: however its potential use is not limited by technological restrictions, but rather by the conservative nature of the construction industry and its reliance on imports from RSA for much of its raw materials. Considerable effort is therefore recommended to establish the product in the eyes of the construction industry. Both Government and the International Agencies have a role to play.

It is therefore recommended

(i) That Government with the help of the International Agencies should obtain the product in sufficient quantity to manufacture 6 houses of low income hygenic standard, as determined by the best of the numerous design options presently discussed in the Kingdom. The Buildings Section of MWPC to be

the co-ordinating body responsible for the assessment of the characteristics of the product and its cost-in-use compared with other building materials.

(ii) NIDCS and SEDCO should serve as the base for promoting the product in the private sector of the building industry. NIDCS being responsible for education and promotion with architects, SEDCO with the education of contractors in the use of the material.

93. Co-ordination in the planning and execution of Government policy on low income housing is among the stated aims of the Third Development Plan. Such co-ordination will considerably enhance the climate for investment in the manufacture of indigenous building components appropriate to low income housing. Cement bonded particle board has a key role to play in this context.

It is therefore recommended

(i) that in association with the policy of co-ordination, representives of Government selected from MPWC, NIDCS, SEDCO or other appropriate institutions visit the manufacturers of such equipment in Western Europe to study the application of the product to the specific design criteria to be adopted in Swaziland and the raw materials available. UNDP assistance should be requested to fund this venture.

(ii) Investors with some commitment to Swaziland should be canvassed, among them CDC because the product will utilise part of the unallocated resource at Shiselweni, and it is also an international organisation specific interest in low income housing.

(iii) Government should commit loan funds up to a maximum of 50 percent of the equity but should not be the major shareholder in the venture.

(iv) A joint-venture approach is recommended with management in the control of the major equity subscriber.

Appendix I

THE MANUFACTURING TECHNOLOGY OF CEMENT BONDED PARTICLE BOARD

Introduction

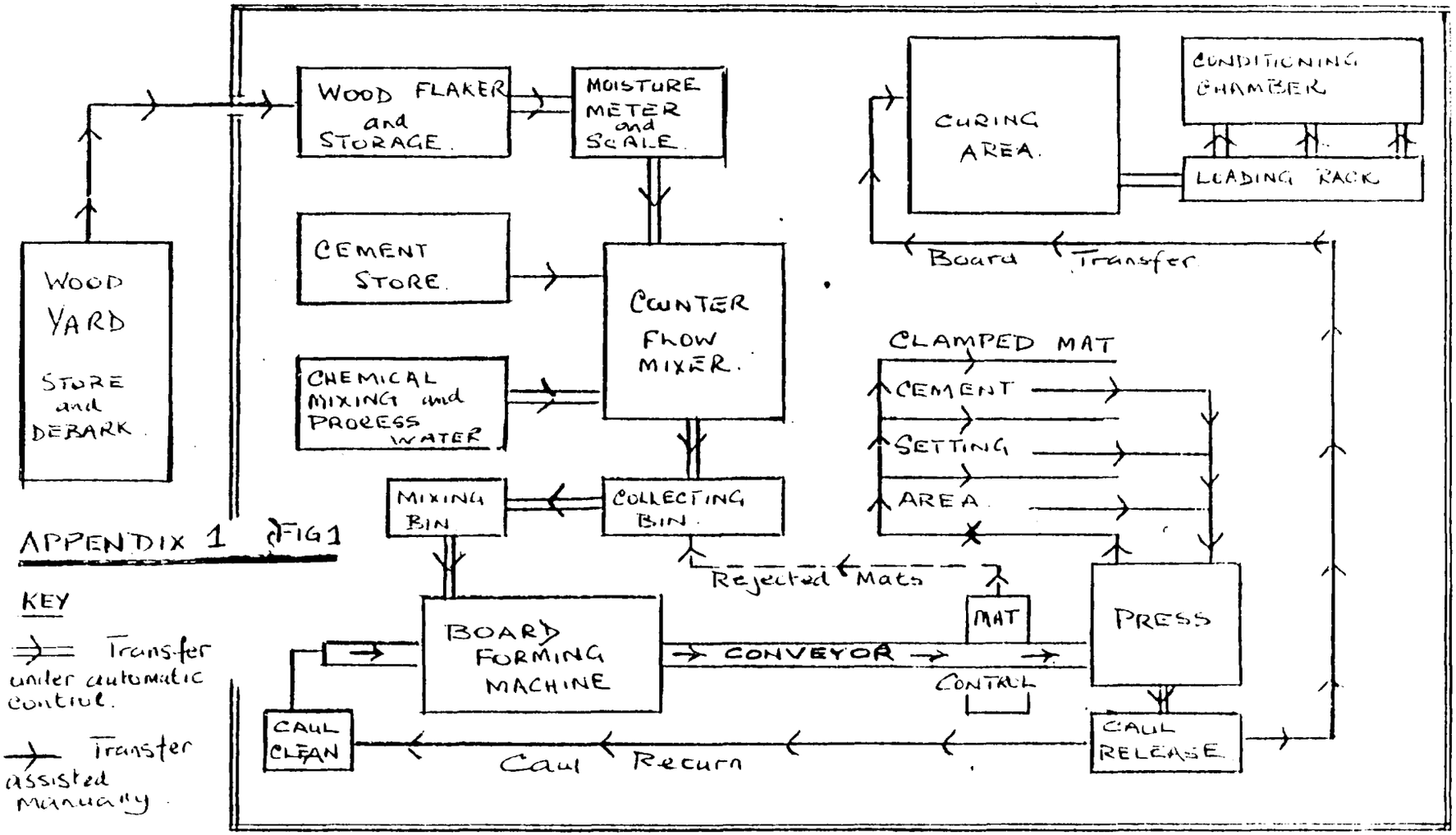
The technology of manufacture described in this appendix is that ascribed to the Bison Werke (Bahre and Greten) Company of the Federal Republic of Germany, the concept is based on the need of developing countries for small scale forest based industries which are self-sustaining in local markets. Thus the recommended manucturing procedure is both small scale, 25m^3 daily production, and labour intensive.

The process used does not rely on high technology and except at the crucial mixing, forming, and to a lesser extent pressing stages there is a marked absence of automatic electronically based control. In marked contrast to convensional particle board manufacture the process is not energy hungry and the demand for electrical power is further reduced by the provision of a wood burning boiler in the conditioning stages of board manufacture.

At the proposed level of production the plant will employ 154 people using only 9 expatriate managers and technicians. Unskilled labour (63) semi -skilled labour (45) and skilled labour (23) from the bulk of the employment.

The manufacturing Process

The flow diagram, Fig.1, identifies 10 stages in the process. For the purposes ofdescription seven stages are identified.



APPENDIX 1 FIG 1

CEMENT BONDED PARTICLE BOARD FLOW SHEET

Flake preparation

In the logyard wood is debarked and open stacked for some 2 months to equalise the moisture content and at the same time neutralise the cement inhibiting substances. At a moisture content of between 25 and 30 percent logs and branches are cut by chainsaw into 50cm lengths and fed to a drum flaker by a manual operation.

The drum flaker reduces the roundwood to a flake size within the limits 0.2-0.3mm Thickness and 30-40mm length. The flaker is backed by a drop out screen to remove oversized flakes for recirculation. Acceptable flakes are pneumatically transported to a storage bin.

Moisture Control

The simple storage bin has an inclined base which enables the manual transfer of particles from store to the conveyor which feeds them to the surge bin of the automatically controlled metering scale.
At the metering scale the particles are weighed and their moisture content measured in an automatic and continually operating transfer system. Variations in moisture content are compensated by adding more or less water to the mixture of wood and cement which takes place at the next stage of the process.

Proportioning and Mixing

The preparation of the mixture is a manual operation.
Chemicals. For each of the chemicals used as mineralising agents a 300 litre plastic container is used. Chemicals are weighed and mixed with water to a prescribed formula conditioned by the species of wood used and the cement grade.
Cement. Cement is stored in 50 kilo bags and fed manually into the mixer from the bags.

Wood. The flakes are fed from the metering scale directly to the mixer.
The mixer is continously operating intensive counter flow model. The weighed and monitored flakes are fed by a screw feed mechanism into the mixer, a predetermined quantity of mineralising chemical is added and the whole mixed for several minutes. Next a measured quantity of cement is added and the mixing is continued to ensure an even distribution of ingredients. Finally an exact quantity of water is added predetermined by the moisture content of the wood flakes, and mixing continues. The mixing formula and times are controlled in a batch operation so that a control can be exercised with each mixture.. Once production has reached capacity level only minor variations in the formula and mixing times are anticipated.

The mixer discharges into a collecting bin from which the mixture is taken by conveyor belt into the surge bin of the forming station.

Forming

The heart of the process is the stationary forming station which spreads a symmetrical mat onto a series of caul plates moving on a conveyor belt underneath the forming head.
The caul plates are manually fed onto the conveyor belt in such a way that each caul has a small overlap with the following one. The quality of the forming, and particularly the density and tolerence of the final board, is conditioned by the accuracy of the spread of the mixture onto the caul plate. The mixture is heavy and viscous requiring a fine tolerance modification of the conventional particle board forming head, and it is on this modification, at present available only from the Bison company, that the success of the small scale manufacturing capacity depends.

The forming machine produces an endless mat of cement and wood flake mixture which is spread over the overlapping caul plates moving on a conveyor belt beneath the foming head. This endless mat is separated into individual gross sized boards, an accerlating release allows each caul to separate from its neighbour. After separation the cauls continues on another conveyor to the loading station. In so doing each caul passes under a contact roll which detects a badly spread mat. The conveyor is fitted with a dumping device which enables a badly formed mat to be deposited into a container from which it is transferred back to the main feeding conveyor between the mixer and forming machine and hence re-circulated.

After passing the control station the caul with mat is transferred by a short conveyor to a loading device consisting of a monorail and electric overhead sissor-hoist which grips underneath the caul lifting it into place on a stack of mats ready for pressing.

Pressing

A simple hydraulic cold press is used supported by an on-loading carriage. The on-loading carriage carries a stack of mats which are fed directly into the press. The press is closed, compressing the stack of mats to its final dimension. This is determined by the number of boards to be pressed, and the board thickness. The pressure applied will depend upon the final density required of the board.

The stack of mats is now clamped while under pressure, the press is released and the clamped stack removed via a winch onto a carriage which moves on rails to a storage rail track.

A series of storage rail tracks leave the press so that boards may be allowed to set while under restaint from the clamps attached at the press.

Setting Curing and Conditioning

The setting of cement is an exothermic reaction and setting usually requires no temperature conditioning provided that accerated setting is not required. In Swaziland conditions a setting time of some 14 hours will be necessary and as winter temperatures at night might be low facilities to cover the setting boards with tarpaulins will be necessary. Alternatively a simple well insulated chamber might be constructed over each rail track which might, in exceptional circumstances, be heated with a gas fired hot air dryer.

After setting the loaded carriages are transferred on their rails back to the press where the clamping device is removed. From here the unclamped carriage is removed to an unloading station where the boards are separated from their respective cauls by means of an electric suction hoist mounted on a monorail.

Panels are lifted from the cauls and placed on a pallet for transport to the storage department. Cauls are lifted in the same way and placed on a transfer truck and pushed to the caul infeed system where they are brought into circulation again after being brushed clean and coated with an oil-emulsion release agent.

Palletising the boards facilitates transport by forklift to the curing station. Curing is effected by stacking the pallets each holding its stack of boards in ambient factory conditions for 2 or 3 weeks.

Finally boards are conditioned to the required moisture content. For this each board must be separated. Boards are lifted by vacuum hoist and placed in a vertical position in racks at 50mm spacing. These are mounted on carriages that run on rails and are pulled by driven cable through a conditioning chamber which has a cross flow hot air circulation system. The hot air is provided from a wood fired boiler, approximate rating 0.66 cal/h.

The curing chamber, and setting chamber, if required, are constructed from cement bonded particle board obtained from first production output.

Panel sizing, storage and shipment

Sizing is effected by two double-end size saws in tandem. Standard carbide tipped saws are used and the machine is hand fed.

Cut to size boards are palletized for storage and shipment.

List of Equipment

This study is based on a production capacity of 25m^3/day, using equipment lists supplied by:

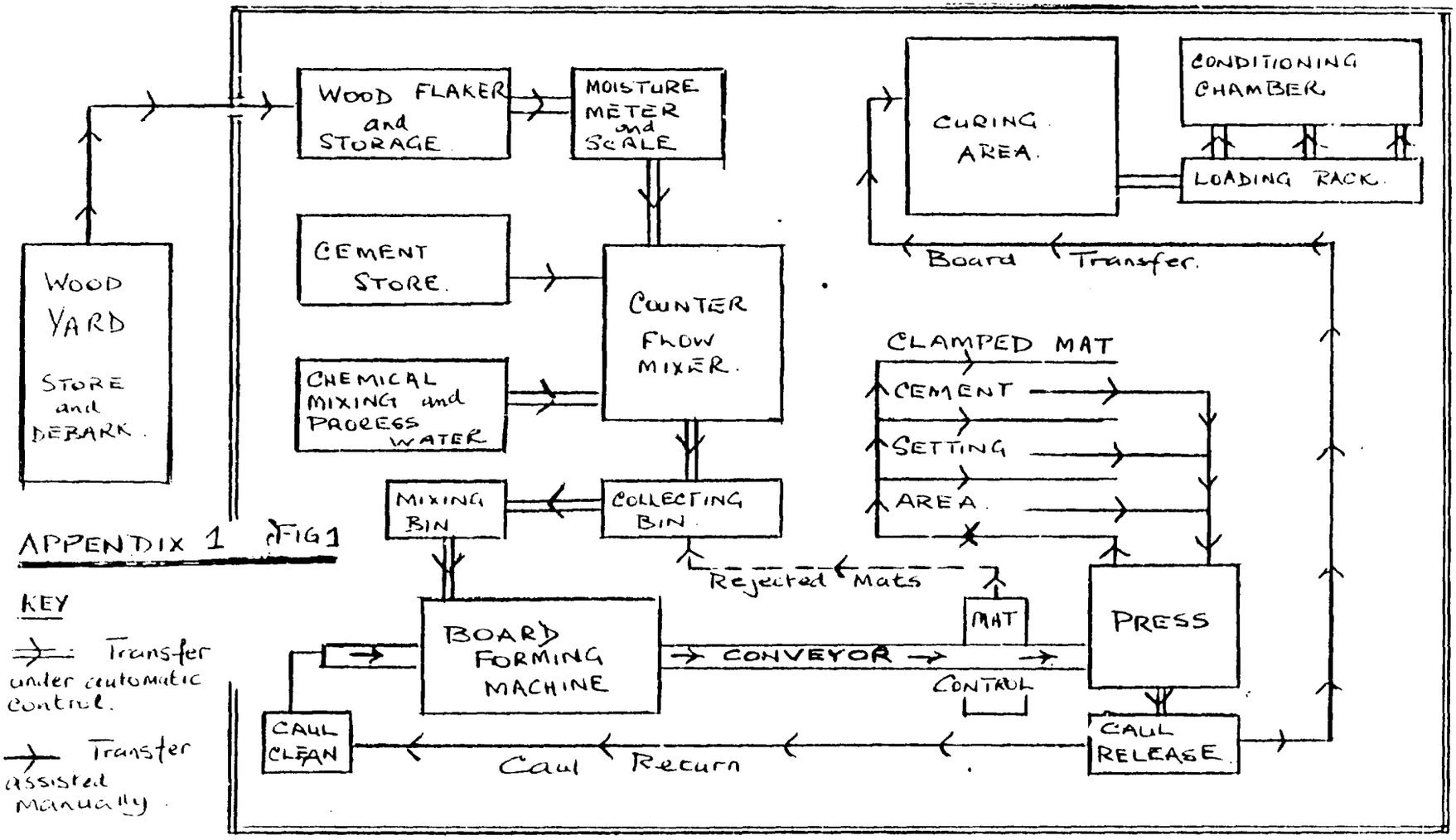
Bison Werke Bahre and Greten Company,
3257 Springe 1.
F.R. Germany.

Appendix I Table 1 lists the locally provided equipment.

Appendix I Table 1

List of facilities and equipment to be supplied locally

1. Debarking tools
2. Log splitting equipment
3. Wet flake storage bin (wood or concrete)
4. High voltage electrical switch gear: low voltage distribution, cables, limit switches and mounting materials
5. Basic electrical installations of factory building 220/380 volt supply
6. Ventilation of building: chimney stack.
7. Pipelines and fittings for;
   compressed air, process water, waste water and usual offices
8. Supporting structures for mechanical and pneumatic conveyors, installations, gangways machinery foundations etc.
9. Compressor, capacity approximately 2N/M^3/min operating pressure 6at,
10. Fork lift truck (6 tonnes)
11. Fire precaution and protection equipment
12. 600 caul steel plates
    1,400mm x 2,800mm x 4mm
13. Maintenance and workshop equipment
14. Quality control equipment, general control of wood, cement, and chemicals.
15. 200 transport pallets 1250mm x 3,200mm
16. Flake bin 25m^3 capacity
17. 20 rack carriages for conditioning channel.



APPENDIX 1 FIG 1

CEMENT BONDED PARTICLE BOARD FLOW SHEET

APPENDIX II

ECONOMICS OF CEMENT BONDED PARTICLE BOARD MANUFACTURE IN SWAZILAND

Introduction

The proposed manufacturing capacity is small scale, 25m³ per day, but a capital intensive operation is avoided by reducing automation within the process to a minimum.

This Appendix is presented in 5 tables, with commentary as appropriate.

1. Investment costs
2. Materials and Energy Costs
3. Wages and Salaries
4. Manufacturing Costs
5. Unit Cost and break even analysis
6. Cash Flow

All tables relate to a plant with an installed capacity of 6,750m³ per year, equivalent to 25m³/day (operating 300 days - 10 per cent).

A. COST STRUCTURE

Investment Costs Table 1

(i) Costs are based on manufacturers information supplied by Bison, Werke Bahre and Greten of the Federal Republic of Germany, in June 1979.

(ii) Imported machinery quoted in US $ has been converted to Emalangeni at the rate E1 = US $ 1.2.

(iii) Local costs are estimates only supplied by building contractors. However as Appendix I shows local equipment is not difficult to obtain.

(iv) Costs of buildings and land are based on the NIDCS publication "A Guide for Investors in Swaziland" published in November, 1978.

(v) Pre operational start up expenses include a substantial element E200,000 for housing. This is based on the probable requirement for management housing.

Materials and Energy Costs Table 2

(i) All costs are based on the assumption that the manufacturing capacity will be based at Nhlangano in Southern Swaziland.

(ii) Mill gate costs are included throughout.

Wages and salaries Table 3

(i) Wages and Salaries are based on the NIDCS publication, and increased by 10 percent to allow for increases in the past year.

(ii) A wages supplement of E5.0 per week has been allowed in lieu of the alternative provision of rations.

Manufacturing Costs and Unit Costs. Table 4 and 5

(i) Both these tables are derived from Tables 1-3 in the calculations of raw materials costs.

(ii) Depreciation and Interest are calculated from the cash flow, presented in Table 6 and are averages of the 5th and 6th operating year (7th and 8th years respectively)

Summary of Raw Material and Labour requirement

1. Wood and cement are the major raw materials requirements. At 25m^3 production per day, 6750m^3 per annum the wood requirement is as follows, oven dry wood basis

Board manufacture	=	1,890 mt/annum
Thermal Energy	=	900 mt/annum
Total (Oven dry basis)		2,790 mt/annum

Total requirement from the forest, (green wood basis, units m^3) is estimated as 6,000m^3

Cement, annual consumption 5,198 m.t

2. Labour requirements are summarised as follows

	Total	Day Shift	Evening Shift	Night Shift
Skilled	23	9	7	7
Semi skilled	45	20	13	12
Unskilled	63	21	21	21

A three shift per day operation is proposed.

Table 1: Investment Costs

1. Investment Costs		Ex1000
Imported machinery f.o.b. (incl. 1 yr. spares)		1496
Freight and Insurance (7%)		105
	C.I.F. Value	1601
Clearing and transport to site (2%)		32
	Cost at site of imports	1633
Local equipment (estimated)		450
Transport to site, insurance (2%)		9
	Cost of local equipment	459
TOTAL EQUIPMENT COST at site		2092
Foundations/assembly (20%)		418
Office, equipment/vehicles		30
	Sub Total	2540
Engineering		50
Mill contingencies (5%Sub Total + engineering)		130
TOTAL MACHINERY AND EQUIPMENT		2720
Land and Site preparation (7ha) NIDCS		21
Buildings (120 x 32m @ E100/m² NIDCS)		384
Overheads and contingencies @ 15%		61
TOTAL CIVIL ENGINEERING WORKS		466
Construction costs, housing for executives		200
preliminary start up costs		165
Preliminary Expenses Total		365
Working Capital		250
	TOTAL INVESTMENT	3801

Table 2. Material and Energy Costs

Wood	Unit	
Consumption of ovendry wood	kg/m^3 board	280
Unit price (green wood)	E/ton	7
Annual consumption (ovendry wood)	tons/year	1,890
Annual wood costs (allow 2 ton green = 1 ton dry)	E/year	26,460
Cement		
Consumption of cement	kg/m^3 board	770
Unit cost (basis E2.85/50 kilo bag)	E/ton	57
Annual consumption	ton/year	5,198
Annual cement costs	E/year	296,285
Chemicals		
12% of cement cost	E/year	35,554
Water		
Consumption of water	m^3/m^3 board	2.0
Unit price	E/m^3	0.28
Annual consumption	m^3/year	13,500
Annual water cost	E/year	3,780
TOTAL MATERIALS COST	E/year	362,079
Electrical Energy		
Installed Power	KVA	417
Load Factor	0.7	
Consumption/annum	1000 KWH	1,655
Unit price	E/1000 KWH	28
Annual cost	E/year	46,340
Thermal Energy		
Consumption	Kcal/m^3 board	0.4
Thermal energy consumption/annum	million Kcal	2,700
Calorific value of fuel wood used (O.D. basis)	Kcal/kg	3,000
Consumption of Fuel wood	tons/year	900
Unit Cost	E/ton	15
Annual cost	E/year	13,500
Additional fuel oil consumption 15% of fuel wood costs		2,025
Total fuel costs		15,525
Tools (lump sum)		
Consumption of knives, sawblades, chain saws	E/year	16,000
Maintenance (lump sum)		
Consumption of spares, oils, greases, cleaning materials and sanding belts	E/year	41,000
TOTAL ENERGY AND MAINTENANCE COST	E/year	118,865

Table 3: Wages and Salaries

Wages	Unit	
Skilled labour (23)	E18.5/week	425.5
Semi skilled labour (45)	E18.5/week	742.5
Unskilled labour (63)	E14.5/week	913.5
Total 131. @ E5 supplement	5.0/week	655.0
Total Weekly wages		2736.5
10% Social security etc		273.5
Total. Wages per week		3010
Total wages per year	Ex1000/annum	156.5

Salaries: Management & Technical	Unit	
General Manager	E1800/month	21 600
Production Manager	E1500/month	18 000
Technical Manager	E1500/month	18 000
Sales Manager	E1500/month	18 000
Chief Engineer	E1500/month	18 000
Production	E 400/month	4 800
Assistant engineer	E 400/month	4 800
Chemist	E 400/month	4 800
Assistant Chemist	E 300/month	3 600
3 Foremen	E 250/month	9 000
Total Management & Technical	Ex1000/annum	120.6
Administrative personnel		
Office Manager	E 400/month	4 800
2 Accounting Clerks	E 250/month	6 000
2 Administrative clerks	E 250/month	6 000
2 Secretaries	E 200/month	4 800
1 Driver	E 100/month	1 200
3 Security Officers	E 100/month	3 600
Total Administration Salaries	Ex1000/annum	26.4
TOTAL WAGES AND SALARIES		303.5

Table 4: Manufacturing costs

Item		25m³/day
Capacity	m³/	6 750
Raw Materials		
- Wood	E/annum	26 460
- Cement		296 285
- Chemicals		35 554
		358 299
Energy and other manufacturing Costs	E/annum	
- Electrical energy		46 340
- Thermal energy		15 525
- water		3 780
- Tools		16 000
- maintenance materials		41 000
		122 645
Wages and Salaries		
- Wages		156 500
- Salaries		147 000
		303 500
Overheads		
- general overhead @ 10%		78 444
- Sales and promotional expenses 5%		39 222
		117 666
Production Costs		
- before depreciation and interest		902 110
- depreciation and amortization		331 762
- interest on loan (11 1/2%)		122 350
		454 112
Total manufacturing cost		1 356 222
Cost per m³ board		200.9

Table 5: Unit Costs break-even point and safety margin

		Unit	
Capacity		m^3/year	6,750
Variable Costs	Cost From Table 2	E/m^3	
- Wood	E 26,460		3.92
- Cement	E296,285		43.89
- chemicals + water	E 35,554 + 3780		5.83
- electrical energy	E 46,340		6.86
- thermal energy	E 15,525		2.30
- tools & maintenance	E16000 + E41000		8.44
- materials	Sub Total		71.24
Fixed costs	Costs from Table 4	E/m^3	
- wages and salaries	E303,500		44.96
- general overheads	E 78,444		11.62
- sales expenses	E 39,222		5.81
- depreciation	Average year 7 and 8 from cash flow		49.15
- interest	= 5 + 6 operative year		18.12
SUB TOTAL	E/m^3		129.66
TOTAL MANUFACTURING COST	E/m^3		200.9
Estimated Selling Price	Em^3		250.0
Minus variable costs			71.24
= Unit contribution			178.75
TOTAL FIXED COST	Ex1000		875.2
Break Even Point			4,900
Safety Margin	% Capacity		28

PROJECT ECONOMICS

Profit and Loss Estimation and Cash Flow Table 6

The following assumptions apply.

(i) Import duty on equipment = 0

(ii) Depreciation on machinery and equipment = 10 Years

(iii) Depreciation on buildings = 20 years

(iv) Depreciation of preliminary expenses = 5 years

(v) A scheme of equal instalments was used with cash flow.

(vi) Equity capital = 50 percent of investment
Investment loan = 50 percent of investment

(vii) A scheme of loan repayments was used beginning in year 5 of the cash flow with 16% repayment, and then by 2% increments to year 9 when the final 24% payment is made.

(viii) Plant delivery will take no more than one year. (Year 1) from the date of ordering

(ix) Erection and installation will be completed within one year (Year 2).

(x) Production will begin in the last quarter of Year Two.

(xi) Production schedules as follows:
Year 2 - start up
Year 3 - 50 percent capacity
Year 4 - 75 percent capacity
from Year 5 - 100 percent capacity

(xii) Unit variable costs will be
- during Year 3 = 120 percent
- during year 4 = 110 percent
- during year 5 = 105 percent
- from year 6 = 100 percent

(xiii) The minimum calculated ex-mill price of E250/m^3 has been used throughout the cash flow.

(iv) No allowances are made for tax liability.

Summary and Conclusions of Cash Flow Analysis

1. The calculations show that a small scale labour intensive plant for the production of cement bonded particle board can be a viable operation.

Table 6. Profit and Loss Estimation and Cash Flow. ($25m^3$ per day) (Units E x 1000)

YEAR CAPITAL (Units x E1000)	1	2	3	4	5	6	7	8	9	10
Funds - equity	1425.4	475.1								
- loan		1805.5	95.0							
Funds subscribed total	1425.4	2280.6	95.0							
CAPITAL EXPENDITURE										
Equipment and Engineering	992.4	1727.6								
Land, Buildings, foundations	350.0	116.0								
Pre-operational & start-up costs	83.0	282.0								
Working capital		155.0	95.0							
TOTAL INVESTMENT EXPENSES	1425.4	2280.6	95.0							
OPERATING SCHEDULE										
Income Sales & Boards (E/m^3 250)			843.7	1265.6	1687.5	1687.5	1687.5	1687.5	1687.5	1687.5
Minus production costs (before depreciation)			499.1	712.5	926.0	902.0	902.0	902.0	902.0	902.0
GROSS PROFIT			344.6	553.1	761.5	785.5	785.5	785.5	785.5	785.5
Minus - Interest charges (11.5%)			218.6	218.6	218.6	183.5	144.2	100.5	52.4	-
- Depreciation			368.3	368.3	368.3	368.3	368.3	295.3	295.3	295.3
NET PROFIT (LOSS)			(-242.3)	(-33.8)	174.6	233.7	273.0	389.7	437.8	490.2
Plus - Depreciation			368.3	368.3	368.3	368.3	368.3	295.3	295.3	295.3
= Cash generated			126.0	334.5	542.9	602.0	641.3	685.0	733.1	785.5
Minus = Loan repayments			-	-	304.1	342.1	380.1	418.1	456.1	-
= Nett cash flow			126.0	334.5	238.8	259.9	261.2	266.9	277.0	785.5
CUMULATIVE CASH FLOW			126.0	460.5	699.3	959.2	1220.4	1487.3	1764.3	2549.8

2. The net return on equity capital (before taxes) has been shown. (para 86 to be 17.4 percent at the minimum estimated ex-mill price of E250 /m^3 rising to 35.1 percent if the maximum ex-mill price of E300/m^3 is used).

3. A low market price has been chosen for the cash flow analysis to allow maximum penetration into the market against existing building materials (para 88).

4. At the modest ex-mill price and the conservative repayment schedule shown, the complete loan repayment is made in Year 9, and by year 10 the cumulative cash flow has covered the initial equity commitment.

5. By Year 6 a modest return on equity of some 13.5 percent can be made, at this time there is an option either for expansion or, with the build up of the market for the product, diversification into building component manufacture associated with prefabricated house construction.

APPENDIX III

SENSITIVITY ANALYSIS

INTRODUCTION:

Cement bonded particle board is a new product in Swaziland and there is no experience of the effect of changes in costs of manufacture or established market price in the Kingdom. A sensitivity analysis has therefore been prepared on the basis of the assumptions used in Appendix III, and particularly the Cash Flow Analysis, (Table 6 of Appendix II).

Using the basic ex-mill price of E250/m^3 as the basis the following analyses have been attempted.

A. Effect of increasing ex-mill price

Assumption 1. Basic calculations Appendix III
Assumption 2. Increase in ex-mill price to E275/m^3
Assumption 3. Increase in ex-mill price to E300/m^3

B. Effect of increases in Manufacturing costs

Assumption 4. 10% increase in variable cost using ex-mill price of E250/m^3
Assumption 5. 10% increase in fixed costs using ex-mill price of E250/m^3
Assumption 6. 10% increase in total costs, using ex-mill price of E250/m^3

C. Effect of increases ir interest rate

Assumption 7. increase in interest rate tO 13%. using ex-mill price of E250/m^3
Assumption 8. increase in interest rate to 15% using ex-mill price of E250/m^3

The effect of these assumption are shown in three tables for comparison.

APPENDIX III TABLE 1.

EFFECT OF INCREASING EX-mill PRICE

SALES PROFIT AND RETURN ON INVESTMENT

	Assumptions		
	1	2	3
Sales price (E/m³)	250	275	300
Sales volume (m³/year)	6750	6750	6750
Sales revenue (Ex1000)	1687	1856	2025
Minus Prod. Cost (Ex1000)	902	902	902
Gross Profit (Ex1000)	785	954	1123
Investment (Ex1000)	3800	3800	3800
Gross Return (%)	20.6	25.3	29.5
Minus depreciation and interest (Ex1000)	454	454	454
NET PROFIT	331	500	669
Equity capital	1900	1900	1900
NET RETURN	17.4	26.3	35.2

COMMENTARY:

The effect of increasing ex mill price by progressive stages of 10 percent from E250/m³ to E300/m³ is to dramatically improve profitability. This will enable the loan repayment period to be decreased or higher dividends to be paid on equity capital.

However as shown previously in this report, (Part I section c) the construction industry in Swaziland is characterised by high materials cost and a conservative approach to building methods. As the product is new to Southern Africa, and the market is local, the lowest ex-mill price will have positive advantages in market penetration.

APPENDIX III TABLE 4

EFFECT OF INCREASING MANUFACTURING COSTS

SALES, PROFIT AND RETURN ON INVESTMENT

	Assumptions			
	1	4	5	6
Sales price (E/m³)	250	250	250	250
Sales volume (m³/year)	1687	1687	1687	1687
Minus Prod Cost	902	950	945	992
GROSS PROFIT	785	737	742	695
Investment	3800	3800	3800	3800
GROSS RETURN	20.6	19.4	19.5	18.3
Minus depreciation and interest (Ex1000)	454	454	454	454
NET PROFIT	331	283	288	41
Equity capital	1900	1900	1900	1900
NET RETURN	17.4	14.9	15.2	12.7

COMMENTARY:

As might be anticipated by the distribution of unit costs between the fixed and variable elements, the effect of increasing either groups of costs is more or less the same. There is a significant negative effect of an overall production cost increase of 10 percent on the profitability of the enterprise at the most modest ex-mill price considered for the product.

Most vulnerable to cost increases at the present time is cement which is in short supply from time to time because of production and shipping difficulties at Maputo.

This analysis indicates that any production cost increase must result in ex-mill price increase if a modest level of profitability is to be maintained.

APPENDIX III TABLE 3

EFFECT OF INCREASING THE INTEREST RATE

SALES PROFIT AND RETURN ON INVESTMENT

	Assumptions		
	1	7	8
Sales price (E/m³)	250	250	250
Sales volume (m³/year)	6750	6750	6750
Sales revenue (Ex1000)	1687	1687	1687
Minus Prod Cost (Ex1000)	902	902	902
GROSS PROFIT (Ex1000)	785	785	785
Investment (Ex1000)	3800	3800	3800
GROSS RETURN (%)	20.6	20.6	20.6
Minus depreciation and interest (Ex1000)	454	470	490
NET PROFIT	331	315	295
Equity capital	1900	1900	1900
NET RETURN	17.4	16.5	15.4

COMMENTARY:

The present rate of interest charged to investors in Swaziland is 11.5%, an attractively low rate. A more general rate in developing countries is 13 percent (assumption 7), but as far as the present project is concerned a rate of 15%. (assumption 8) would be prohibitive at an ex-mill price for the product of E250/m³.

It is likely that even a rise to 13 percent would precipitate an increase in ex-mill price. To retain the profitability of the enterprise the ex-mill price would need to rise only modestly to E254/m³ at 13% and E257 @ 15%.

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M. Dlamini - Project Officer

UNDP

A. Eidhammer - Junior Project Officer
A. Lavenon - Expert attached to MPWC

The Sugar Industry

K.S. Smith - Secretary Swaziland Sugar Association
J. Wevers - General Manager, Mhlume Sugar Company
R.F. Burns - Managing Director Ubombo Ranches
G. Szokolay - Managing Director Royal Swazi Sugar Company
J. Ranger - General Manager Royal Swazi Sugar Company.

Swaziland Electricity Board

K. Thompson - General Manager

The Forest Industry

J. Taylor - Former General Manager Shiselweni Forestry Co.
P. Massey - General Manager " " " "
J. Rushin - Manager, Resin Products Limited Matsapa
A. Jacob - Production Manager Swazi Pine
P. Foster - Manager, Tyrone Timber Company Mbabane
D. Heenam - Forester Swaziland Plantations Limited
A. Van der Merve - Sawmill Manager Swaziland Plantations Ltd
R. Alder - Blockboard Production Manager "
R. Binns - General Manager Peak Timbers Limited
R. Laburn - Production Manager Bison Board Piet Retief
R. Hubbard - Manager Mankanana Sawmills Limited
A. Belsham - General Manager Usuthu Pulp Company Limited
P. Garmishuisen - Forest Manager " " "
S. Brook - Operations Manager

Architects and Quantity Surveyors

J. Gravelle - Summerley Brown, Architects
S. Hynes - Architect

K. Van Zyl - Long and Van Zyl Quantity Surveyors
R. Gardner - Murdoch Green Partnership Quantity Surveyors
G. Barns - MPWC Quantity Surveyor
P. Base - " Architect
Ms Miller Williams - Project Co-ordinator P.E.S.E. Architect

Wholesale Suppliers

Swazi Warehouse - Mbabane
Builders Place - Mbabane
Factory Supplies - Mbabane
Matola Cement Factory - Matsapa

UNITED NATIONS

Appendix IV

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

UNIDO 2 November 1979

Request from the Government of the Kingdom of Swaziland for Special Industrial Services

INTERNAL

JOB DESCRIPTION
SI/SWA/79/801/11-01/31.7.A

POST TITLE	Expert in the Production and Marketing of Wood Based Panels
DURATION	Two months
DATE REQUIRED	As soon as possible
DUTY STATION	Mbabane, with travel within the country and to neighbouring countries
PURPOSE OF PROJECT	To update and complete, wherever necessary, the study prepared by a UNIDO consultant in September 1973, to the point where it becomes a bankable project and include in an annex detailed technical specifications for the equipment which could be the basis for a call for tenders.
DUTIES	The expert will work with the staff of the National Industrial Development Corporation and staff of the existing two sugar mills in the country, and will update the study prepared by a UNIDO expert in the marketing of wood-based panels in 1973. In updating and complementing this study the expert will specifically be expected to cover the following topics:

1. Availability of bagasse and other raw materials (plantation softwoods)
2. Cost at mill site of bagasse and other ligno-cellulogic raw materials (plantation softwoods).
3. Storage problems for bagasse.
4. Availability and costs of other inputs (resins, etc.)
5. Present markets for particle boards and other wood based panels in the country and in neighbouring countries. and development trends of these markets.

.../..

Applications and communications regarding this Job Description should be sent to:
Personnel Services, UNIDO, P.O. Box 707, A-1010 Vienna, Austria

6. Availability and cost of labour and capital.

Based on the above compilation of data the expert shall prepare a complete techno-economic feasibility study, indicating the proposed specifications of the products to be manufactured, the capacity, raw materials, technology proposed, putative production and investment costs and profits to be expected. The expert shall also include a simple sensitivity analysis for such parameters as raw material, labour costs, selling price, interest rate, etc.

The expert will also be expected to prepare a final report, setting out the findings of his mission and his recommendations to the Government on further action which might be taken.

QUALIFICATIONS — Economist or Engineer with extensive experience in the preparation of feasibility studies for wood-based panels industries. Experience in marketing of panels and in developing countries desirable.

LANGUAGE — English

BACKGROUND INFORMATION — In 1973, UNIDO assisted the country by appraising the possibility of producing particle board from bagasse through the provision of the services of an expert in the marketing of wood-based panels.

The assignment originally foresaw the utilization of bagasse as raw material, but the findings turned out to be somewhat negative because the local sugar mills - then two mills - were, at that time, not willing to secure the supply of the bagasse raw materials on a long-term basis. Their unwillingness was largely attributable to the fact that, coupled with the steeply rising sugar price on the international market, their sugar production was so lucrative that they were less concerned about assuring a more economic utilization of bagasse as particle board instead of its traditional usage as fuel. No action had been taken by the Government on the project until recently when it requested UNIDO's Investment Co-operative Programme Office to assist it in finding a potential joint-venture partner with whom it can implement the bagasse particle board project.

NO CANDIDATES REQUIRED AT THIS TIME