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APPROPRIATE TECHNOLOGY FOR THE MANUFACTURE OF PULP AND PAPER PRODUCTS

STRATEGIES FOR DEVELOPING PULP AND PAPER INDUSTRIES IN DEVELOPING COUNTRIES

Background Paper

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STRATEGIES FOR DEVELOPING PULP AND PAPER INDUSTRIES IN DEVELOPING COUNTRIES

by

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INTRODUCTION

1. Due to manual work being substituted by mechanical and electrical aids at a much faster rate in the West, the developed countries in the last two centuries have gone much ahead of the developing countries in technology. After the second world war, due to a sudden spurt in technology development, the per capita income has increased by such an extent that the developed countries had to develop more and more sophisticated technology to cut down the cost by reducing the number of labour employed per unit of production leading to capital intensive industries and high labour wage. As a result the gap between the rich and poor in the standard of living and level of technology is ever widening. The developing nations now have the option of selecting the appropriate technology for any product without having to go through expensive and time consuming process of developing these technologies as they are readily available with the developed nations and some of the developing nations. For selecting the appropriate technology a 'taker' has to keep in mind its own stage of development, percentage of unemployment, capital required and the volume of market it can cater to. The purpose of this forum is to find out the appropriate technology for an industry which can be adopted without creating any problem with the 'taker' and the 'giver' of the technology. We will deal in this paper with the appropriate technology for the pulp and paper industry with specific reference to India being a developing nation.

2. Since the days of the invention of the printing press in Germany, the consumption of paper in the developed nations has gone up tremendously. Today the consumption of paper in developed countries is about 200 kgs. per capita compared to 2 to 3 kgs. per capita in the developing countries.

3. Originally when the demand of paper was not sufficient even in developed countries, the mixed textile wastes were the main raw material for making of paper. As the demand of paper increased, the technology had to be changed to some other raw materials with assured availability. Therefore, cellulosic raw materials which were available in nature became the main source. Most of the large capacity pulp mills in the world are concen-

trated in countries like U.S.S.R., Sweden, Norway, Finland, Japan, Canada and U.S.A. as these countries have the coniferous raw materials in sufficient quantity. More and more developed countries are going to depend on imported pulp from the major producers of pulp where coniferous raw materials are still available in sufficient quantity, as some of the developed countries are no longer finding it economical to make their own pulp due to the high cost of raw materials.

4. Although Sanskrit is one of the oldest languages and mother of many modern languages of the world, the script in written form did not reach the masses because it was written on special bark and leaves of trees, copper plates and stones. The use of paper, therefore, in India has been introduced very slowly. India entered the pulp and paper industry in an organized manner only towards the end of the 19th century and the mills which were set up during that time were of all integrated type utilizing bamboo as the main raw material.

5. With the increased production from 150,000 tons in 1950 to 960,000 tons in 1977, there are visible signs of less and less availability of raw materials like bamboo at an economic rate. In the last ten years the price of bamboo per ton has gone up by more than twice. Due to less and less availability of bamboo many integrated mills have started increasing their use of more and more mixed hard wood available in the country. A number of small mills have been built in various parts of the country based on agricultural residues like rice straw, wheat straw, Kenaf, bagasse, Jute cuttings and such other seasonal materials. In India there are about 25 paper mills of capacities 10,000 tons and above and about 50 mills of capacities ranging between 1,000 tons to 10,000 tons per annum.

6. Compared to capacities in developed countries which may be as high as 1,000 tons a day, even these 25 big mills in India would be considered as small mills by international standards. The products manufactured with the technology currently available in India is good enough to meet the standard of domestic consumers. As such, there does not seem to be a case of increasing capital investment per annual ton of production any higher than what it is by trying to acquire more sophisticated technology, since the

more sophisticated a technology the less is the employment and the more is the investment. In a country where labour wages are relatively low there does not seem to be a case of trying to cut down the cost by increasing capital investment and reducing labour.

7. In India, therefore, technology in paper industries are available from capacities of 3 tons a day to 200 tons a day using materials like agricultural residue, bagasse, bamboo and mixed hard wood. As such, a wide range of technology is available in the country and to a great extent the technology available in India may be the appropriate ones for adoption in the rural areas of this country and also in some of the developing countries where similar raw materials are available.

8. The employment per 1,000 tons of production was as high as 75 in mills set up earlier than 1950 in India. For mills which are being currently established this figure has come down to 35 per 1,000 tons of production. In developing countries we think that one needs not try to achieve an employment lower than this figure. However, an appropriate technology in some particular sections will always be introduced from the developed countries from time to time without effecting the employment to capital employed ratio. This will be necessarily of small magnitude as it would be only in selected areas.

9. In India, forest operations are mostly done manually. As such, a lot of people are employed in cutting, felling of the raw materials in the forest areas and transportation of the same to the factory site. We have found that it creates employment of five persons in the forest (rural) area for every person employed in the factory. Therefore, this type of industry creates a sound base for development of rural economy. The growing of bamboo or hard wood by the agriculturists in the unused land near their fields gives them a source of income making bamboo or hard wood as if it is a cash crop. The agricultural residue utilization definitely gives extra money to the farmer without his having to go out of the area for jobs in the period when he has not much work in the field.

10. For rational use of raw materials and for sustained growth of paper mills in the developing countries, both promotional and regulatory policies shall have to be framed at the national, international and regional level.

As there is more potentiality in the increased volume of trade between developing nations, the utilization of existing technology already available to them with some modernization here and there from the developed countries can go a long way in the development of the pulp and paper industries in the developing nations making a base of rural development at least in some selected areas.

SUMMARY AND CONCLUSIONS

1. For developing countries, the most difficult problem for the transfer of technology is the selection of the appropriate one. The various technologies suggested in this paper are on the basis of experience taking into consideration the level at which the country is in its technological development.

2. Eight technical options have been suggested. The option I, is for a chipping plant located at a place where bamboo/wood is available in plenty but the cost of transport of other inputs for further processing to pulp and paper in situ is uneconomical. A capacity of 80 tons per day is suggested. The per capita investment is minimum for this option and a plant of this magnitude is expected to give gainful employment to 70 people in the factory and about 300 people in the forest. The Chips produced will be of standard quality. Depending on the size of the market and availability of other inputs, it can be linked with the option III.

3. The option II, split into two sub options A and B, is for a sun-dried pulp sheet and common paper or board from agricultural residues, respectively. This is suitable for an area having surplus agricultural residues. The capacity suggested is 25 tons per day. The lower capacity suggested is mainly because of the uneconomical handling of agricultural residues and bagasse over a long distance. It has been found that fertile agricultural land of 10 sq. kms. growing two crops per year, can sustain a mill of this size. If an efficient transportation network exists, the capacity can be higher. The chemicals recovery unit has not been taken into consideration with an idea that the effluent shall be used for irrigational purposes. For making pulp sheet, it has been assumed that sun-drying is possible for

250 days in a year. The employment is 450 in the factory and about 500 in the field.

4. The option III, which has been subdivided into four sub-options A, B, C and D, is for an integrated paper plant from bamboo chips - the first one, MG Kraft; the second one MG White; the third one MF Kraft; and the fourth one MF White. A capacity of 25 tons per day is suggested for all these sub-options. These options will have a chemicals recovery unit and hence the effluent will be of a quality allowing its disposal on surface water.

5. The option IV, is for a paper plant from purchased pulp - indigenous or imported. The capacity suggested is 25 tons per day. Depending on the per capita consumptions, standard of living, availability of various inputs, the capacity of 25 tons per day can be higher. The fourth alternative is mainly for a port area where pulp can be imported and converted into paper, and then can be consumed near the port itself. It can be located in the market centres of the country.

6. To promote the successful application of these aforementioned technological options in developing countries it is suggested that national governments should formulate policies as mentioned in Section IX to ensure growth of paper and pulp industries. These are:

(i) For area planning, reliable estimates of wood, bamboo, agricultural residues, bagasse and other potential raw materials should be available at regular intervals. Scientific plantation of fast growing species yielding good quality pulps should be taken up expeditiously. National policy has to be formulated for rational usage of different raw materials.

(ii) Since the price of paper is dependant on factors like the cost of labour, expenditure on air and water pollution, cost of chemicals and utilities, interest on borrowed capital, infrastructural facilities, etc., it can only be controlled when there is a control on the above mentioned items. National policy has, therefore, to be formulated on the control of these variables.

(iii) National policy has to be such that industries producing paper products are only categorized under small industry.

(iv) Adequate infrastructural facilities, such as development of road and railway network, housing facilities, water supply, power supply, hospital, school, etc., which are sin-qua non for the integrated development of rural industry is to be provided by the national government.

(v) Being a power intensive industry, the tariff should be at a concessional rate.

(vi) Certain fiscal incentives in terms of exemption of taxes are recommended.

(vii) Entreprenal assistance in terms of supplying a rural trained force is a prerequisite for the setting up of an industry. The training of these rural people should be organized and financed at a national level.

(viii) Finance has to be provided to the potential entrepreneur in liberalized terms and at low rates of interest from financial institutions.

(ix) There has to be a sustained availability of labour and power.

(x) On a regional level, there should be transport subsidy in respect of setting up industries in certain areas.

(xi) Finally, it is suggested that the developing nations should have intimate cooperation in the following major matters:

(a) Earmarking of good to be manufactured by the developing nations.

(b) Relaxation of tariff barriers in respect of goods and services from one to the other.

(c) Preference on buying machinery from developing nations if an appropriate one is available.

(d) Facility of transport of goods, through adjacent countries.

(e) Economic cooperation among developing nations through bilateral and multilateral arrangements for efficient utilization of resources.

I. APPROPRIATENESS OF TECHNOLOGY

1. The Pulp and Paper Industry, as has been mentioned in the introduction, has been developed through centuries according to the necessity. Because of sudden increase of consumption after the Second World War and due to scarcity of labour in the developed countries and because of high consumption economy, there has been a revolution in the technology increasing capital cost per ton of production and decreasing the employment. Improvement of technology after the Second World War has become necessary to some extent for economy on raw materials and reduction of waste. These technologies concerned may be necessary to adopt, even if they are something of a sophisticated nature, so that it saves imputs and also avoids the danger of pollution. For example, the Recovery Boiler for use of waste chemicals is now included in the technology not only for economy of chemical inputs but also for reduction of effluent disposal problems. The various technologies that we have suggested in this paper are on the basis of our experience and the stage of present technological development.

2. We have taken various technical options:

(i) The first option is for a Chipping Plant installed at a place where bamboo/wood is available but its distance from other inputs are uneconomic for conversion of the bamboo into pulp in situ whereas the chips produced can be easily transported to a place where there is a ready market within an economic distance.

(ii) As there are agricultural residues available all over the country and as there is a shortage of bamboo in the country, the second option has been given using agricultural residues as raw material. This second option has been split up into two by giving a choice of making sun-dried pulp for sale to a paper plant or making a common variety of paper.

(iii) The third alternative, is divided into two sections, i.e. MG varieties and MF varieties. Each of the sections again has got two sub-options, i.e. unbleached and bleached. The third category has to be linked with the first option in (i) because option III can be sited at a place, which is nearer to the other inputs like coal, lime and alum but away from the bamboo plantation so that an optimum cost advantage is achieved in the cost of transport of inputs and raw material.

(iv) The fourth appropriate technology suggested is for an independant paper machine by bringing pulp from either an imported source or from a mother pulp mill. The capacity, which has been suggested, can be economic only if it makes high value paper or if there is a protection of the market around it to give promotional advantage in the first few years or by creating a tariff barier either for the country or for a particular area.

3. In suggesting the various options the minimum capacity has been considered. If the market or the availability of raw materials is higher, then the capacity can be of the magnitude to suit the market whichever is the limiting factor. If bagasse is available at a reasonable rate, the second alternative can use it instead of agricultural residue.

4. One or the other of these options should be viable in most of the developing countries with modification in the capacity of the plant on the higher side depending on raw material source and market.

II. GENERAL OUTLOOK ON PULP AND PAPER INDUSTRIES IN DEVELOPING COUNTRIES WITH PARTICULAR REFERENCE TO INDIA.

Raw materials

1. Traditionally softwood was the preferred raw material for making paper grade pulps. Most of the developing countries are, however, devoid of softwoods. Hence the technology has to be oriented for hardwood, bamboo, agricultural residues and similar raw materials.

2. Bamboo is the principal raw material used for paper-making in India. However, in the context of depleting resources of this raw material, with the suitable technology for pulping hardwoods and agricultural residues, their use in the paper industry is gaining momentum. With the use of agricultural residues, available in the rural area and presently being used as cattle feed or fuel by the rural people there is bound to be some amount of resistance from the rural population or the prices of these raw materials are bound to shoot up very steeply rendering them uneconomic as raw material for the manufacture of paper and paper board. Bagasse has long been used in sugar mills as the only source of fuel. Use of bagasse eliminates harvesting and collection problems associated with many other fiber sources. Bagasse is found in good supply in areas where little or no native wood supplies for paper-making is available.

3. However, although bagasse is plentiful and available, it cannot, in any sense of the word, be regarded as a free material. This is the main fuel used to supply heat for sugar mill operations. Based on heat requirements for the mill and assuming good furnace efficiencies, an efficient raw sugar mill should be able to operate on about two thirds of the bagasse produced, leaving the other one third as surplus bagasse. The setting of a monetary value on bagasse is a complex subject but any realistic evaluation of the material must take into account such factors as current sugar mill practices particularly regarding surplus bagasse, heat value of bagasse, bagasse furnace efficiencies, heat value of alternate fuel, furnace efficiencies with alternate fuel and of course the monetary value of alternate fuel.

4. The table below will give an idea of the trend in consumption of different raw materials for the manufacture of pulp and paper in India over the period of fifteen years.

	1958-59	1975-76
Bamboo	70	51
Hardwood	4	28
Softwood	6	3
Agricultural residues and grasses	16	12
Waste Paper	4	6

The comparison of the figures of 1958-59 to those of 1975-76 reveals that utilization of hardwood has increased manifold during the last fifteen years.

Paper Production

5. The planned development of paper industry was taken up in 1951 when there were about 20 paper mills with their total installed capacity being about 150.000 tons per year. Since then there has been rapid progress, especially in the second and third five-year plans. There are now about 25 mills having capacity of more than 10,000 tons per annum and about 50 mills having capacity of less than 10,000 tons per annum, with a total installed capacity of about 1.100.000 tons per annum. The small mills account for 20 per cent and the big mills 80 per cent of the total production. With an average growth of 7 per cent per annum, it is now estimated that by 1985 the installed capacity should be about 2.000.000 tons and that by 1990 the installed capacity should be 2.700.000 tons.

6. It may be seen from Table I that 80 per cent of the production is from developed countries whereas the developing countries account for 20 per cent only.

TABLE I. PAPER AND PAPER BOARD PRODUCTS BY CONTINENTS AND WORLD TOTAL

(on thousand of tons)

	1956	1960	1970	1971	1972
North America	36226	38917	58914	60881	65325
Europe	19621	25634	45159	45351	47970
Asia and Oceania	4961	7861	20621	20998	22462
Latin America	1192	1656	3712	3835	4252
Africa	178	288	892	943	1017
World Total	62179	74355	129298	132008	141026

7. Following the oil crisis in 1973 there had been a strong recession in the paper market. For the last few years there is even a buyer's market in the paper industry.

8. Table II will give an idea of the present world production of paper and paper board from different quality of pulp.

TABLE II. WORLD PULP, PAPER AND PAPERBOARD VOLUME ESTIMATES (REF. PAPER VOL. 182 NO. 6, 1974, PAGE 314)

(Million Metric tons)

	1963	1968	1973	1974	1975	1976	1977	1978
Paper and Paper Board:								
Total -	96.3	127.5	160.6	167.8	175.9	182.5	188.5	192.9
News Print	17.5	22.2	24.7	25.3	26.2	27.2	28.0	28.7
Writing and Printing			35.6	36.8	38.6	40.2	41.6	42.6
Other Paper and Paper Board	78.8	105.4	100.3	105.6	111.1	115.2	118.9	121.7
Paper Pulp Total	77.5	104.5	128.1	133.8	138.6	143.5	148.2	151.7
Mech. Wood Pulp	21.7	25.2	28.9	29.9	30.7	31.4	32.3	32.9
Semi-mechanical/Semi-chemical wood pulp	50.3	71.9	10.0	10.4	10.9	11.5	11.9	12.2
Chemical Wood pulp			81.0	84.8	87.8	91.0	94.1	96.3
Other Fiber Pulp	5.5	7.4	8.3	8.8	9.2	9.5	9.9	10.3
Dissolving Pulp	4.6	5.1	5.9	5.9	5.1	6.3	6.4	6.5

Paper consumption

9. A developing country starting with a large population base and a massive illiteracy problem has an inbuilt growth of demand for paper, arising mainly from educational needs. The demand for newsprint also goes up with the spread of literacy. Moreover, with progressive diversification of industries and requirements for various types of packaging materials as the economy expands, the overall demand for paper are bound to go up.

10. Per capita consumption of paper for some of the developed and developing countries are given below. It is evident that there is a wide gap in per capita consumption of paper between developing and developed countries indicating the huge potential market that awaits in the developing countries.

U.S.A.	=	267 kg.	India	=	2 kg.
U.K.	=	140 kg.	China	=	10 kg.
Sweden	=	202 kg.	Malayasia	=	20 kg.
			Indonesia	=	2 kg.

International trade in paper

11. Pulp as an important world-wide commodity is a business approaching around US$ 8.5 billion. The lion's share of the world trade in paper of nearly 40 million tons goes to Sweden, Canada, Finland and the U.S.A. The Table IIIA and IIIB will give an idea of international trade in paper and paper board and pulp as in 1972.

Table IIIA. INTERNATIONAL TRADE IN PULP IN 1972

(In thousand tons)

Country	Production	Import	Export
U.S.A.	46604	3733	2237
Canada	19091	106	6102
Sweden	8308	37	3741
Finland	6284	4	1611
Norway	1976	210	785
U.K.	357	2190	3
Japan	9458	807	47
India	747	15	16
Malaysia	n.a.	9	Nil
Indonesia	34	2	Nil
Iran	26	13	Nil
Singapore	n.a.	11	7
Phillipines	63	31	Nil
Brazil	1029	146	139
U.A.R. (Egypt)	86	35	Nil
Kenya	Nil	9	Nil
Nigeria	10	1	Nil

n.a. - Not available

Table IIIB. INTERNATIONAL TRADE IN PAPER AND PAPER BOARD IN 1972

(In thousand tons)

Country	Production	Import	Export
U.S.A.	59310	7993	2940
Canada	12699	347	9515
Sweden	4562	129	3164
Finland	4965	27	4302
Norway	1348	98	958
U.K.	4338	3054	247
Japan	13648	143	503
India	846	173	25
Malaysia	18	179	11
Indonesia	35	144	Nil
Iran	143	142	Nil
Singapore	5	135	Nil
Phillipines	287	127	Nil
Brazil	1367	250	8
U.A.R. (Egypt)	145	75	6
Kenya	8	71	Negligible.
Nigeria	10	41	Nil

12. From the above tables it is evident that there is a hugh potential in paper trade that can develop amonst the developing countries due to the low per capita consumption and low level of production.

III. RECENT TRENDS ON MODERN PULP AND PAPER INDUSTRIES

Present status and future trends

1. In the area of raw materials, coniferous wood like spruce, fir, pine, balsam, hemlock, etc. are still the principal source of raw materials in which the bulk world production of paper and paper board is mainly based. However, in the context of depleting resources and to cater to rising needs of the people, there is a gradual switching over to the hardwoods. Thus these hardwoods, once considered as short fibered and hence unsuitable for paper industry, have become an important source of raw material. Bamboo has for a long time been used as the principal source of raw material in many Asian countries. In India nearly 50 per cent of paper production is from bamboo only. Potentiality of bagasse is being realized in many countries. It is anticipated that utilization of bagasse and agricultural residues will play a vital role in the pulp and paper industry. There has been growing awareness in the utilization of waste paper. In many developed countries it is expected that the utilization of waste paper is going to be as high as 30 per cent.

2. As regards pulping, the draft process still dominates the area of chemical pulping because of its distinct advantages over the other processes. Continuous digesters have replaced the batch digesters in most of the large mills. High yield chemical pulping defined as being semi-chemical in type for producing paper grade pulps in yield range from 52 to 75 per cent with full substitution for conventional pulps made in 46 to 48 per cent, has aroused a keen interest in view of the depleting resources of raw materials.

3. There is a great interest in whole tree pulping as an important step to conserve fiber resources. The concept of severing the tree from the stump and processing every portion of the tree above the ground-bole, branches, twigs and leaves into a usable fiber source, has become a reality. When the Indian Paper Industry turns more and more to hardwoods, the whole tree pulping concept could be advantageously used from the fiber conservation view point.

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4. Polysulfide pulping has created a good deal of interest in that the yield is about 4 to 6 per cent higher than conventional kraft pulping.

5. In mechanical pulping the stone groundwood process is still the widely used process. Refiner mechanical pulping has, of late, gained considerable importance because of its much better strength properties than stone groundwood pulp. There are many mills in Europe and North America practising refiner mechanical pulping today. Yet another spectacular development in mechanical pulping is the thermomechanical pulping. Thermomechanical pulp has even better strength properties than refiner mechanical pulp. Single stage oxygen-alkali cooked thermomechanical pulp is expected to take over a considerable portion of production of writing and printing paper in the coming decade. Thermomechanical pulping for the production of newsprint is being practised in Europe and U.S.A. nowadays.

6. There had been considerable development in the bleaching of chemical and mechanical pulps. Multi-stage bleaching of chemical pulps with chlorination - Extraction - Hypochlorite - Extraction - Hypochlorite (CEHEH) is still there in many mills. With the advent of chlorine dioxide, hypochlorite stages are being mostly replaced by chlorine dioxide stages. What was not possible earlier to bleach kraft pulps by conventional CEHEH sequence over 85 degree brightness has now been possible with chlorine dioxide. In fact kraft pulps can now be bleached over 90 degree brightness by CEDED sequence (Chlorination - Extraction - Dioxide - Extraction - Dioxide). The use of chlorine dioxide bleaching calls for in situ generation of the chemical, as it is a hazardous compound as far as transportion is concerned. Although the initial cost of plant and equipment for chlorine dioxide plants are high but in the long run it does definitely pay for the higher initial cost. The operation of the dioxide generation plant, however, calls for a skilled and experienced crew. Peroxide bleaching is practised in some mills manufacturing high brightness pulps where brightness stability is very important.

7. Oxygen bleaching of pulp has become a big issue in connection with environment protection and is one of the biggest technical achievements

during recent years. The method has been adopted and planned at several places, although it is not yet fully developed especially from the economic point of view. The method is today considered as established in bleaching of sulfate pulp. Further experience will make it fully accepted by the early 1980's for fully bleached sulfate pulp and presumably also for semi-bleached kraft pulps. In this case one stage may be sufficient. For bleaching of mechanical pulps, the application of peroxide and hydrosulfite is quite common.

8. In chemical recovery section, considerable progress has been made. The two most popular recovery furnaces are - Combustion Engineering type and Babcock and Wilcox type. Several other processes, for example, treatment of black liquor with compressed air under high pressure and at a temperature of 200°C to 300°C and the other process of evaporating the black liquor to 30 per cent solids, heating to 330°C and then raising the pressure to 400 atmosphere, have been developed but its application is to be seen in the coming decade.

9. Stock preparation system has been revolutionized by better understanding of the bonding characteristics of the fiber. Pressurized refining and use of proper additives at correct points assure better formation of sheet and retention of fibers, fines, fillers and pigments. Excepting very special quality papers, beaters are almost completely replaced by conical and disc refiners. The design of these refiners are being increasingly modified so as to reduce the specific power consumption in stock preparation.

10. There has been spectacular development on the wet end of the paper machine over the past twenty years. Numerous developments in the design of headbox, slice, foil, table rolls and machine clothing have resulted in increasing the speed of the machine. High consistency forming has reduced the water handling in recycling. With the coming up of high speed twin wire formers, conventional fourdriniers will find it difficult to retain their existance in large capacity mills in developed countries. Fourdrinier is still the most common and widely used machine for manufacture of paper. Phosphor bronze wire is being substituted by synthetic wires. This has increased the machine running availability as the frequency of wire changing is reduced considerably.

11. Installation of fabric presses, combination fabrics, the uni-press venta nip presses and double felted press have resulted in substantial improvement in water removal and felt life. Multi nip presses have been developed and are being successfully used.

12. In the drying of paper, steam drying is still the practice. There have been a good deal of work in the condensate removal system. With the introduction of the closed hood system in the drying of paper, a considerable steam economy has been achieved. Madeleine blowing system is gradually replacing the conventional felt drying system. Technology has developed now for the intra red drying. To what extent this could be commercially employed is to be seen in the coming decade.

IV. TECHNO-SOCIO ECONOMIC BASE IN DEVELOPING COUNTRIES AS RELEVANT TO PULP AND PAPER INDUSTRY

1. In most of the developing countries agriculture is the main employment. The agricultural residues like rice straw, wheat straw, Kenaf, bagasse, jute cuttings and such other seasonal materials can be used for manufacture of pulp. In India as many as 50 small paper mills producing about 200,000 tons have been established using mainly such agricultural residues. One of the technical options given in this paper is for a 25 tons per day mill using agricultural residue. This mill will buy agricultural residue materials to the extent of Rs. 48 lakhs a year. If the mill takes the agricultural residue from agriculturists within 25 sq. km. of agricultural cultivation and taking the average holding per family being 4 hectares, the amount of money that will flow to the agriculturists will come to US$ 585. per year per family. This definitely gives an economic benefit to the people living in rural areas in agriculture. In a country like India where there is a big cattle population, it may not be possible to use all the agricultural residues for manufacture of pulp. It would be only possible in a few areas so that overall availability of fodder to the animal is not affected.

2. If bamboo or hardwood is used as raw material, for every employment in a factory the employment of five persons are created in the forest for cutting and felling of bamboo. As most of this employment for cutting, felling and handling of bamboo would be in rural areas, a big amount of money will flow to the rural people. For a 100 ton per day integrated mill as much as US$ 1,176,000 will flow to rural workers creating employment of nearly 10,000 people on whole-time basis or 20,000 people for six months. As the Pulp and Paper Industry creates direct employment in forest areas, it has an affect in a much bigger community covering an area where employment potentiality is least and where people are reluctant to leave their normal habitat.

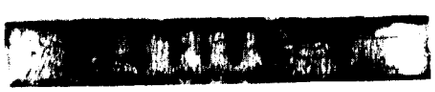
3. The developing countries, having the resources for production of pulp will earn more by manufacturing pulp and paper instead of sending the raw material outside the country. As has been seen in an area like the North-

Eastern Region of India, bamboo had no value as the bamboo in the forest was too expensive to be taken out for use in the mills situated in far away places. Due to a mill being set up near the raw material sources there has been a big spurt of activities in cutting and felling of bamboo both from the private forests as well as from government leased forest, thus creating a huge employment in the rural areas. The villagers, who grew bamboo for their own use for the making of houses and furniture are now getting a better price and cash money by selling bamboo to a pulp mill and thus it has become a cash crop to them. This has given an incentive to the villagers to grow more bamboo and thus making it a cash crop at a sustained basis. As bamboo grows in relatively inferior land and as it does not need much recurring care, it is becoming a definite source of income to agriculturists. A pulp industry, apart from the main raw materials like bamboo or agricultural residue, uses minerals like coal, lime stone and talcum powder. If these materials are available near the factory site, it creates another economic activity by ensuring inflow of money again to the rural people by exploitation of minerals like lime stone, coal and soap-stone.

4. In fact in developing countries where cellulosic raw materials along with coal, lime and soap-stone are available, it can form as a basis for industrial development bringing a series of economic activities, provided the other inputs like chemicals can be had at an economic price.

Section V. Alternative technologies available :

Technical option	Chipping unit from bamboo/ hardwood. (S)	Bleached pulp sheet from Agricultural residues. (IL.A)	MG White pulp board from agricultural residues. (IL.S)	MG Kraft paper from bamboo/ hardwood chips. (IIL.A)	MG White hardwood
5.1 Brief description of the process.	The bamboo/hardwood is fed to the conventional chipper, having versatility to use bamboo and hardwoods as well. The chips are then screened in a vibratory screen. The accepted chips are either directly loaded in the wagon/truck or stored in the open yard. The oversized slivers are fed back to the Rechipper and the undersized materials could be used as domestic fuel.	The agriculture residues are chopped and the chopped materials are cooked in rotary digester with 12% alkali (as NaOH on O.D.material) and 1.5% by weight of sulfur. The contents of the digester, after cooking at a certain temperature for a predetermined period of cooking, are dumped onto a tank after relieving the pressure. The stock suspension containing the spent chemicals are pumped into a drainer and the liquor drained out from the pulp. The stock is then transferred to a poucher where further washing is done. Approximate 5% available chlorine (on O.D. pulp) as bleaching powder is added to the stock and the stock mixed throughly and transferred to a retention tower. Retention time of about 2 hours is given depending on the development of brightness. The stock is then passed through a vibratory screen to remove shives and dirt and the accepted stock transferred to the poucher to wash the pulp free of chlorine and sent to decker, which will itself act like a cylinder mould and the sheet formed will be further dewatered in a series of two presses and cut into desired size and the wet sheets will be sun dried.	The bleached pulp from agricultural residues(Ref IL.A) from the poucher will be stored in a tower, acting as a buffer storage in between pulp mill and paper machine. The raw stock, from pulp mill, is refined in either beater or refiners. Sufficient amount of rosin, alum, dyes and various other additives are added to the stock at this stage, and sent to the centricleaners to remove dirt and shives. The stock is then pumped to the wet end of the multi vat MG machine. There are say be six vats thus giving six layers to the board. The first two vats will have good quality stock and the last vat will have good quality stock. The intermediate three vats will have inferior quality. Provision is kept for four Pre dryers and one MG cylinder, one reulinder and one cutter. The dried board/sheet will be rewound and cut into the standard size and marketed.	The purchased chips, stored in the open yard, are transported to the digester operating floor by a belt conveyor. The chips are cooked in vertical batch stationary type direct cooking digesters. About 16.0% chemicals (active alkali as Na_2O on O.D. bamboo/hardwood), as recovered white liquor, is added and the chips are cooked by direct steaming. The contents of the digester, after cooking at a certain temperature for predetermined period of cooking, are blown to a blow tank. The stock suspension containing pulp and spent cooking chemicals are taken to a vibratory knotter and the uncooked chips are seperated and recycled back to the digester. The pulp stock is next washed in a three stage counter current displacement type brown stock washers. The weak black liquor, containing the spent chemicals, at a concentration of 13.0 per cent solids are sent to soda recovery section for recovering the chemicals as discussed later. The unbleached pulp is passed through the centrifugal screens to remove the shives and stock dewatered to approx. 14% solids and stored in an unbleached high density tower. The raw unbleached stock is next refined in a beater or a conical refiner. Necessary amount of resin, alum and dyes are added and the stock pumped to the wet end of MG machine. The sheet formed on the wire, is further dewatered in a series of presses and partially dried on four pre dryers and finally dried on a MG cylinder.	The unbl density pumped is reac rims. a tower washed. pulp, c the stoc tained one or washed. bleach calcium added t ted pul tained about t is then rims an density The raw refined cal ref of rosin and oth to the s and pass stage co to remov to the h The shee is next of proce predryer dryer an reel. The sheet rewinder desired



...board from ...siduse.	MG Kraft paper from bamboo/ hardwood chips. (III-A)	MG White paper from bamboo/ hardwood chips. (III-B)	MF Kraft paper from bamboo/ hardwood chips. (III-C)	MF White paper from bamboo/ hardwood chips. (III-D)	MF/MG paper from indigenous/ imported pulp. IV
...in from agri- ...(Ref III-A) ...r will be ..., acting ...ane in bat- ...ed paper ... stock, ... is refined ... or re- ...nt amount ...yes and ...ditives ... stock at ...sent to ...ers to remove ... The stock ...p the wet ... vat MG ...are may be ...aving six ...oard. The ...will have ...ck and the ...ve good ...the inter- ...ets will have ...ty. Provision ... Pre dryers ...der, one ... cutter. ...sheet will ... cut into the ...and marketed.	The purchased chips, stored in the open yard, are transported to the digester operating floor by a belt conveyor. The chips are cooked in vertical batch stationary type direct cooking digesters. About 16.0% chemicals (active alkali as Na_2O on O.D. bamboo/hardwood), as recovered white liquor, is added and the chips are cooked by direct steaming. The contents of the digester, after cooking at a certain temperature for predetermined period of cooking, are blown to a blow tank. The stock suspension containing pulp and spent cooking chemicals are taken to a vibratory knotter and the unbooked chips are seperated and recycled back to the digester. The pulp stock is next washed in a three stage counter current displacement type brown stock washers. The weak black liquor, containing the spent chemicals, at a concentration of 13.0 per cent solids are sent to soda recovery section for recovering the chemicals as discussed later. The unbleached pulp is passed through the centrifugal screens to remove the shives and stock dewatered to approx. 14% solids and stored in an unbleached high density tower. The raw unbleached stock is next refined in a beater or a conical refiner. Necessary amount of resin, alum and dyes are added and the stock pumped to the wet end of MG machine. The sheet formed on the wire, is further dewatered in a series of presses and partially dried on four pre dryers and finally dried on a MG cylinder.	The unbleached pulp from high density tower (Ref.III-A) is pumped to a mixer where pulp is reacted with elemental chlorine. The stock is retained in a tower for 1 hour and then washed. About 3% by weight of pulp, caustic soda is added to the stock and the pulp is retained in a tower at 56°c for one or two hours and then washed. Necessary quantity of bleach liquor, containing calcium hypochlorite, is added to the caustic extracted pulp and the pulp is retained in a tower at 36°c for about three hours. The pulp is then washed free of chlorine and stored in a high density tower. The raw bleached pulp is next refined in a beater or a conical refiner. Necessary amount of resin, alum, dyes, talcum and other additives are added to the stock at this stage and passed through a multistage centricleaning system to remove the shives and pumped to the head box of the machine. The sheet, formed on the wire, is next dewatered in a series of presses and dried in four predryers followed by a MG dryer and reeled in the pope reel. The sheet is next rewound in a rewinder and cut into the desired size and marketed.	The raw unbleached pulp(Ref. III-A) is next refined in a beater or conical refiner. Necessary amount of resin, alum,dyes and chemicals are added to the stock and pumped to the head box of MF machine. The sheet formed on the wire is next dewatered in a series of presses and dried on steam heated drying cylinders. The roll is next rewound in a rewinder and cut into the standard size and marketed.	The raw bleached pulp(Ref.III-B) is refined in beater or conical refiner. Necessary amount of resin, alum, dyes, talcum powder and other additives are added to the stock and is pumped to the centriclesners to remove shives, dirt etc. and then pumped to the head box of the MF machine. The sheet of paper thus formed is further dewatered in a series of presses and dried on steam heated drying cylinders. The roll is next rewound in a rewinder and cut into the standard size and marketed.	The dried pulp is first made into stock suspension in a hydra pulper and then refined in beater or conical refiner. Necessary amount of resin, alum, talcum powder, dyes and chemicals are added to the stock and the stock is pumped to a multistage centricleaning system. The accepts from the first stage is sent to the head box of the machine. The machine should have the versatility to manufacture MF/MG variety as per the demand. The sheet formed on the wire, is next dewatered in a series of presses and dried either on a MG cylinder to manufacture MG variety or dried on steam heated drying cylinders to produce MF variety. The sheet is then rewound in a rewinder and cut into the standard size and marketed.

	I	II.A	II.B	III.A	III.B
				The sheet is next rewound and cut into the desired size and marketed. The weak black liquor produced at 13.0% solids is concentrated to about 38.0% solids in multiple effect evaporator and sufficient make up chemical, in the form of salt cake, is added to the concentrated liquor and sent to the reactor smelter. The heat in waste gas from the smelter is utilised for the production of steam. The smelt is dissolved in weak liquor to produce green liquor which is then causticised with lime in causticizing reaction to produce white liquor.	
5.2 Capacity, A.D. Tons/day	60 M/day	25 M/day	25 M/day	25 M/day	25 M/da
5.3 Input requirements.	i) Raw materials : Bamboo - 84000 ii) Other inputs : Chipper knives, diesel oil, lubricating oil and consumables.	i) Raw materials : Agricultural residues - 68990 ii) Other inputs : Caustic Soda - 8910 Sulfur - 890 Bleaching powder - 3380 Coal -18900	i) Raw materials : Agricultural residues - 78130 ii) Other inputs : Caustic Soda - 6430 Sulfur - 980 Bleaching powder - 3560 Resin - 375 Alum - 1280 Dyes - 2	i) Raw materials : Bamboo/hardwood chips - 64930 ii) Other inputs : Caustic Soda - 480 Salt cake - 3430 Lime - 9880 Coal -39400 Resin - 375 Alum - 1280	i) Raw materials Bamboo/hardwo chips - 5 ii) Other inputs Caustic Soda Salt cake Lime Coal Chlorine Resin Alum Talcum powder Dyes
5.4 Assumptions	i) Bamboo/hardwood, being surplus in the region, should be available at a cheap rate for the economic lifetime of the plant i.e. seven years. Plantation should be taken up if economic life time is to be extended beyond seven years. ii) A diesel generating set is planned to be installed. Economics would be better if power is available from public grid or from cheap rural energy source.	i) Surplus agricultural residues are available at a reasonable rate. ii) Sun drying is possible for 280 days. iii) A boiler with a matching back pressure turbine set is to be installed. The used set of this type, properly reconditioned, should be available from developed countries at very low cost. As an alternative cheap rural power is available.	i) Same as (i) and (iii) of option II.A. ii) Other inputs are available at a transport cost of 22.6 per cent of total cost of product.	i) Interlinked with option I. ii) Same as in (iii) of option II.A. iii) Other inputs are available at a transport cost of 18.8% of total cost of product. iv) The soda recovery section capable of recovering 80% chemicals with a reactor smelter unit. v) Reconditioned paper machine is available from developed countries at a cost such that interest and depreciation component per tonne of product does not exceed $ 70/82 per tonne of product, instead of $ 120/130 taking the component for new units.	i) Interlinked wi ii) Same as in (iii (x) of option I iii) Other inputs ar at a transport 19.7% of total product. iv) Same as in (iv) of option III.

III-A	III-B	III-C	III-D	IV

he sheet is next reeled and cut nto the desired size and marketed.

he weak black liquor produced at 3.0% solids is concentrated to out 38.0% solids in multiple effect evaporator and sufficient ake up chemical, in the form of alt cake, is added to the concentrated liquor and sent to the ecovery smelter. The heat in waste gas from the smelter is utilized for the production of team. The smelt is dissolved in weak liquor to produce green liquor which is then causticized with lime in causticizing section to produce white liquor.

25 N/day

) Raw materials :

Bamboo/hardwood chips - 84930

i) Other inputs :
Caustic Soda - 490
Salt cake - 3430
Lime - 9800
Coal - 39400
Resin - 375
Alum - 1250

) Interlinked with option i.

) Same as in (iii) of option II-A.

) Other inputs are available at a transport cost of 18.8% of total cost of product.

v) The soda recovery section capable of recovering 92% chemicals with a recovery boiler unit.

v) Reconditioned paper machine is available from developed countries at a cost such that interest and depreciation component per tonne of product does not exceed $ 70/82 per tonne of product, instead of $ 120/130 being the component for new units.

25 N/day

i) Raw materials :

Bamboo/hardwood chips - 87680

ii) Other inputs :
Caustic Soda - 1155
Salt cake - 3870
Lime - 12740
Coal - 49040
Chlorine - 3668
Resin - 800
Alum - 1800
Talcum powder - 3000
Dyes - 2

i) Interlinked with option I.

ii) Same as in (iii) (iv) and (v) of option II-A.

iii) Other inputs are available at a transport cost of 18.7% of total cost of product.

iv) Same as in (iv) and (v) of option III-A.

25 N/day

i) Raw materials :

Bamboo/hardwood chips - 84930

ii) Other inputs :
Caustic Soda - 490
Salt cake - 3430
Lime - 9800
Coal - 49400
Resin - 375
Alum - 1250
Dyes - 5

i) Same as (i), (ii) and (iv) and (v) of option III-A.

ii) Other inputs are available at a transport cost of 17.1% of total cost of product.

25 N/day

i) Raw materials :

Bamboo/hardwood chips - 87680

ii) Other inputs :
Caustic Soda - 1155
Alum - 1800
Salt cake - 3870
Lime - 12740
Coal - 50040
Chlorine - 3668
Resin - 800
Talcum powder - 3000
Dyes - 2

i) Same as in (i),(ii) & (iv) and (v) of option III-A.

ii) Other inputs are available at a transport cost of 17.9% of total cost of product.

25 N/day

i) Raw materials :

Pulp - 25600

ii) Other inputs :
Resin - 800
Alum - 1800
Talcum powder 3000
Dyes - 2
Coal - 30000
Power, KWH/hr. - 1000

i) Interlinked with option II-A

ii) Same as in (iii) of Option II-A.

iii) Power is available from public grid. As an alternative cheap rural power is available.

		I	II-A	II-B	III-A	
		iii) The only essential to be brought in are chipper knives, diesel oil and lubricating oil and some consumable items. iv) Market is available within a radius of $ 11.00 per MT of chips.	iv) Other inputs should be available at the transport cost of 28.8 per cent of the total cost of product. v) Market is available within a radius of $ 21.00 per MT of pulpsheet on A.D. basis.			
5.6	Product quality standard.	Standard chips of following specifications : Sieve — Percent of total. + 28 mm — [illegible] -28 mm + 10 mm — [illegible] -10 mm + 4 mm — [illegible] - 4 mm — [illegible]	Comparatively weaker pulp than bamboo or coniferous wood pulp. To make white paper there should be atleast 20% of bamboo or long fibered pulp.	Standard MG pulp board for making corrugated boxes.	Standard MG Kraft paper of burst factor 20.	Stand
5.8	Manpower requirement.	Staff : Officer - 2 Supervisor - 3 Clerical - 2 Workers : Skilled - 9 Semiskilled - 5 Unskilled - [illegible] Total - 72	13 18 28 37 [illegible]	13 28 24 35 [illegible]	16 27 24 60 78 [illegible]	
5.7	Relative advantages and disadvantages of the alternatives covered under section outlining the flexibility of the technology to adjust different regional and economic constraints.					
	a. Interlinkages.	Could be interlinked with option III-A, III-B, III-C and III-D.	Could be interlinked with option II-B.	No interlinkages.	Could be interlinked with option I.	Coul opti

[redacted]

	III-A	III-B	III-C	III-D	IV
12	Standard MG Kraft paper of burst factor 2D.	Standard MG white paper.	Standard MF Kraft paper of burst factor 22.	Standard MF white writing and printing paper.	Writing printing and speciality paper.
	18 27 34 69 73 [illegible] [illegible]	18 27 34 83 83 [illegible] [illegible]	18 27 34 77 79 [illegible] [illegible]	18 27 34 91 97 [illegible] [illegible]	7 10 12 20 25 [illegible] [illegible]
	Could be interlinked with option I.	Could be interlinked with option I.	Could be interlinked with option I.	Could be interlinked with option I.	Could be interlinked with option III-A.

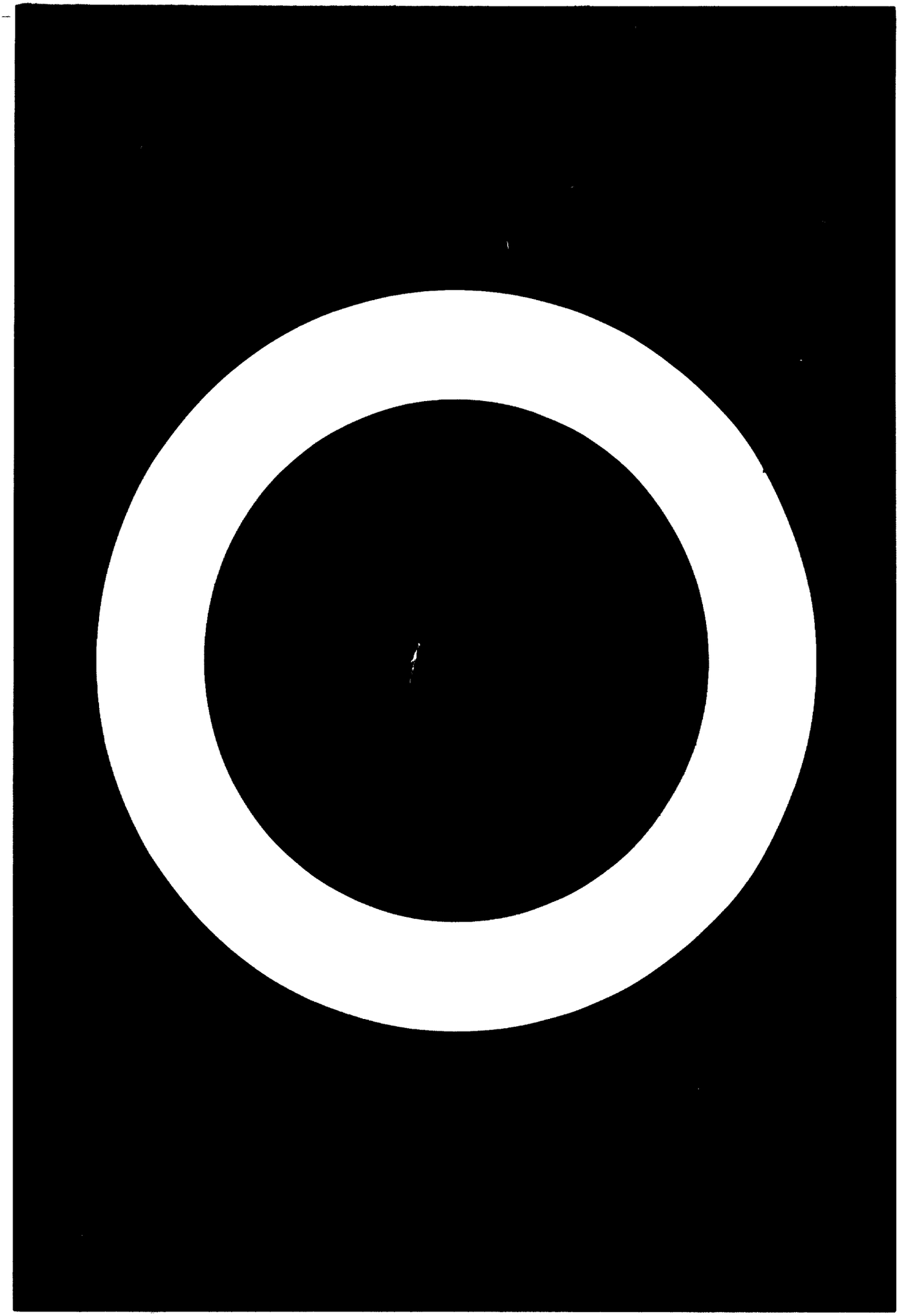
		I	II-A	II-B	III-A	
5.7	b. Flexibility of the technology under consideration to meet diverse sets of conditions for its applications.	Depending on the condition of the market, availability of input and proximity to market, it can be linked with appropriate options.	Depending the market size, the input cost at an economic distance, the technology can be improved with higher capacity by addition of balancing equipments, but keeping in mind the interest and depreciation component will be within the economic limit, so as to make the cost of product stand the market condition.	Same as in II-A	Same as in II-A	Same as i
	c. to utilise locally available materials.	The huge amount of forests which are decaying in situ due to lack of inaccessability, is a national waste. The option would utilise these raw materials for pulp and paper making.	Surplus agricultural residues, having potency of pulp and paper making would be utilised.	I n t e r l i n k e d w i t h O p t i o		
	d. to motivate and diversify the economy of the area.	This option would exploit the natural resources of the area and as such economy of the area would be improved.	By selling of surplus agricultural residue, the former would earn extra money over the normal sales of cereals. This will also give fillip to increase the yield of agricultural products and residues as well.	W i t h t h e c o m i n g u p o f i n t e g r a t e d d e v e l o p m e n t		
	e. to strengthen in other manners the areas development.	D e v e l o p m e n t o f b e t t e r c o m m u n i c a t i o n s y s t e m, r o a d a n d r a i l n e t w o				
	f. Indirect structural effects i.e. aspects of land use, replacement (or substitution) of other activities for e.g. ecological and socio-political effects.	Bamboo/hardwood will first be utilised from the natural growth. Better land use can be planned by scientific silvicultural operations. This will give extra income to the farmers provided there are unusable surplus land with these farmers as bamboo/ hardwood can be grown in relatively inferior soil. This will reduce destruction of natural forests which would otherwise create an ecological imbalance on the environment.	The existing land would be utilised for growing agricultural products. The surplus residues, which are decaying, will thus be a source of extra income over the normal sales of cereals. The effluent from this plant, which will be alkaline, can be used for growing agricultural crop in acidic soil. Thus, if proper arrangement could be done to utilise this effluent, there will be no adverse effect on the ecological balance.	Same as in Option II-A	The option will have a chemicals recovery unit to recover the chemicals used during cooking and as such effluent will not be toxic. This can be discharged on inland surface water without effecting the aquatic lives.	Same as i

II-B	III-A	III-B	III-C	III-D	IV
II-A	Same as in II-A	Same as in II-A	Same as in II-A	Same as in II-A	Same as in II-A
inked with Option I					Interlinked with option II-A.
e coming up of integrated pulp and paper mill, there will begin siround development of general services.					
tem, road and rail network and other infrastructural facilities in the area.					
Option II-A	The option will have a chemicals recovery unit to recover the chemicals used during cooking and so such effluent will not be toxic. This can be discharged on inland surface water without effecting the aquatic lives.	Same as in Option III-A	Same as in Option III-A	Same as in Option III-A	There will be no adverse effect on ecological balance.

[redacted]

	I	II-A	II-B	II-A
6. Assessment of the applicability of the technology in area with different economic structures and different levels of per capita income.	The size of the plant will be directly proportional to the per capita income, standard of living and availability of raw material. This would be ideal for an area having vast forest resources, natural or man-made, and low per capita income with surplus available rural people.	This is suitable for the areas having surplus agricultural residues, which are more or less going to waste at the moment. Substantial money will flow into the farmer by sale of surplus agricultural residues. It will suitable for lower per capita income country/area.	Same as in option II-A	For higher per capita income, savings accrued on account of in rural areas, a policy dec wage structure to adopt the in the area.

II-B	II-A	III-B	III-C	III-D	IV
... as in option II-A	For higher per capita income, the capacity should be higher, unless there is definite advantage on the savings accrued on account of cost of raw materials and other inputs. If this industry is to be set up in rural areas, a policy decision shall have to be taken by the national government to have a lower wage structure to adopt the appropriate technology, provided there is unemployment/underemployment in the area.				The size of the plant will be directly proportional to the per capita income and standard of living.



VI. CASE STUDIES IN PULP AND PAPER PRODUCTION

1. An integrated pulp and paper mill, designed to produce 90 tons of paper and 30 tons of pulpsheet per day from bamboo, was set up in a rural area about 220 km. away from the nearest metropolitan city. The population of the locality before the setting up of the mill (1971) was 3000 in an area of 10 square km. The population of the district and State, in which the industry was located, was 2,225,000 and 14,626,000 in an area of 10,360 and 78,520 km. respectively. About eight per cent of the people of the State live in urban areas. The percentage of literacy of the immediate locality was about eight per cent and that of the district and State 22 and 28 per cent respectively.

2. Apart from some household cottage units and saw mills, there was no industrial activity. The population was entirely dependant on agriculture. The average household consists of eight members of which there are three earning members. About 80 per cent of the total income of the family was spent on buying of cereals, 10 per cent for groceries, 8 per cent towards clothing and 2 per cent on entertainment. It had been possible to cater to the basic needs of the people, although per capita calorie consumption was around the minimum requirement. The majority of the population were not exposed to urban atmosphere and the general level of ambition for betterment of material well-being was on the low side.

3. The area abounds in forest produce, the main items being timber of inferior grade and bamboo. Aforestation has of late been taken up to some extent. Other resources of the area include paddy, jute and other grains.

4. By the side of the mill flows a river, which is navigational throughout the year and having a strong current. The area was linked by a broad gauge railway line approximately 3 km. away from the mill site and also by feeder road to a national highway. Electricity had not yet reached the villages.

5. The construction of the project, costing rupees two hundred and twenty million, was completed in three years and the mill went into commercial

production in 1976. Today the mill has reached about 80 per cent of the installed capacity in two years of production. The mill has employed about 1400 people in unskilled, skilled, supervisory and managerial cadre. About 90 per cent of the people are from within the State and 50 per cent are from the immediate locality. The supervisory and managerial people are mostly from outside the immediate locality and is so because of the non-availability of the technically qualified personnel in the locality. The following table will give an idea of the employment by age group of the mill.

Table: EMPLOYMENT BY AGE GROUP

Age Group		No. of employees
18 - 23	-	398
23 - 28	-	540
28 - 33	-	255
33 - 38	-	100
38 - 43	-	65
43 - 48	-	20
48 - 53	-	18
53 and above	-	4

6. The first step in the paper-making process, as practised in this mill, is the chipping of bamboo. Conventional chippers are used for the purpose. The chips are then charged in a digester along with the necessary chemicals obtained, as recovered white liquor. Stationary vertical indirect cooking type batch digesters are used. After a predetermined period of cooking under controlled conditions of temperature and pressure, the contents of the digesters are blown to a blow tank. The pulp stock, containing the spent cooking chemicals, is next screened on an open vibratory screen to remove the uncooked and partially cooked chips and is than washed in a three-stage counter current displacement washer. Hot water is used in the last stage for washing. The pulp, from the last vat of washer, is next screened in a series of contrifugal screens, where the shives are removed. The liquor collected from the first stage brown stock washers, known as weak black liquor, is sent to the Soda Recovery Section for recovering the spent chemicals.

The accepted pulp from centrifugal screen is then dewatered and stored or directly sent to the bleaching section for production of bleached pulp.

7. The weak black liquor thus obtained is concentrated in multiple effect mixed feed type of short tube evaporators. The concentrated black liquor from the evaporators is further concentrated by allowing it to come in contact with hot flue gases from the recovery furnace in a venturi evaporator. The heavy liquor is then mixed with necessary amounts of salt cake, as a replenishment of the loss of chemicals during the recovery cycle, and fired in the recovery furnace. The heat value of hot flue gases produced is utilized for the generation of high pressure steam. The smelt left at the hearth of the furnace is dissolved with weak liquor, obtained from the subseuqnet causticizing section and the resulting liquor, known as green liquor, is reacted with lime in causticizers. The slurry, containing white liquor and mud, is then decanted in white liquor clarifier and the clear liquor from the overflow launder of the clarifier, known as white liquor, is sent back to the digester house.

8. The unbleached pulp produced, as described earlier, is then sent to the bleaching section. Multi-stage bleaching - Chlorination, Caustic extraction, Hypochlorite stage I, Hypochlorite stage II, is practised here. The bleached pulp from Hypochlorite stage II is screened in a multi-stage centricleaning system to remove dirt, shives, etc. and the cleaned bleached pulp is sent to the stock prepration section of the paper-machine.

9. Conical and disc refiners are used for refining the pulp. Alum, rosin, talcum powder, dyes and other necessary chemicals are then added to the refined pulp and the stock. Before finally going to the headbox of the paper-machine, it is screened in a three-stage centricleaning system. The accepted stock from the first stage is then diluted with white water and via pressure screen and manifold enters the headbox of the paper-machine. The paper-machine installed in this mill is of fourdrinier type with closed headbox and with a suction pick up arrangement. The wet sheet is next dewatered in a series of plain and fabric presses and is dried in conventional steam

drying cylinders with a closed hood system. The dried sheet is then rewound and cut into the desired size and marketed. The product of the mill is well appreciated by the market and is selling at US$ 540. per MT on an average.

10. The quality control system adopted by the mill is quite simple. To give an idea, the quality of pulp is controlled by a number called Kappa no. which is an indication of whether it will be easily bleachable or not. The experiement takes about an hour. The quality of cooking liquor is measured as active alkali, sufidity and causticity and takes about 10 minutes. The quality of bleached pulp is measured as brightness for which a brightness tester is needed. The experiement takes about 15 minutes. Quality of boiler water is also controlled. All these experiments except the brightness tester do not call for any expensive equipment. A control laboratory with laboratory wares and necessary chemicals is all that is necessary to perform the test and control the quality accordingly.

11. For testing paper there is a Control Laboratory installed in the Paper Machine Building itself. It determines basis weight and certain strength properties. For common variety of paper an elaborate testing facility is not required. A tensile, mullen and caliper tester is necessary to control the quality. Most of this equipment is available indigenously in the country.

12. To give an idea about the economies of the plant the cost of production and profitability at hundred per cent capacity utilization is given below:

Basis: One ton of writing and printing paper.

Variable cost	Rs. 2200	$ 259.
Fixed cost	Rs. 1000	$ 118.
Total ex-factory cost	Rs. 3200	$ 376.
Less incentives in excise duty	Rs. 200	$ 24.
Net ex-factory cost	Rs. 3000	$ 353.
Interest and depreciation	Rs. 1100	$ 129.
Selling cost	Rs. 350	$ 41.
Cost of sales	Rs. 4450	$ 523.
Selling price	Rs. 4600	$ 541.
Profit	Rs. 150	$ 18.

13. With the application of incentives, as suggested in Section IX, the economics would be even better. Besides, the socio-economic benefits that have resulted with the setting up of such a labour intensive industry in a rural area where there is umemployment and where the standard of living is low, will justify setting up such units in rural areas of developing countries.

14. The visible benefits which are seen in this locality are given below:

(i) The villagers have found an extra source of income by selling bamboo to the mill which was being used only for roofing and other domestic purposes before the mill was set up. The per capita income of the locality has gone up by about US$ 2.40 alone on account of selling of bamboo.

(ii) Villagers have started plantation of bamboo and are taking greater care for growing more bamboo.

(iii) The civil construction of the colony was given to contractors of the locality who had no or little previous experience. This project has enabled them to acquire more expertise and they are now going out of the locality to take up similar new or allied works in other industries that are coming up in the State.

(iv) There has been development of transportation network in the area.

(v) Gradually people are getting used to industrial culture and as a result some of them are coming forward with signs of entrepreneurship.

(v) Indirect employment to about 4000 people in trading and transportation has resulted in the mill area.

15. The capacity of this unit is higher than what is offered in the technological options in this paper. But a similar smaller unit would be feasible and profitable provided the interest and depreciation component does not exceed US$ 94 per ton for an integrated mill.

VII. CASE STUDIES IN DECENTRALISED PULP AND PAPER PRODUCTION

Chip Production

1. A scheme of chipping units, prepared by the author, is under the active consideration of the Government of Mizoram.

2. A hugh forest of untapped bamboo resources in Northeastern region are going to decay for want of adequate infrastructural facilities required to exploit these resources. In fact when the river routes were open for tariff through East Bengal before the creation of the then East Pakistan and now Bangladesh, the bamboo from Surma Valley region and from Brahmaputra Valley region used to go by river on large rafts at a reasonably low cost to the pulp and paper mills in Calcutta. This position has somewhat changed after 1947 and the bamboo from these areas have become more expensive to be carried outside the areas than before.

3. To generate employment in the forest operation for which the required skills are available in this area and also to gradually develop the bamboo areas with proper silvicultural operation and accessible roads to make the bamboo available at an economic rate at the nearest point of good communication, it is suggested that one can start the first stage of an integrated pulp and paper mill in some selected areas.

4. This scheme envisages setting up a Chipping Unit of 80 tons per day capacity. The capital cost, estimated at about US$ 141,000,000, will generate a gainful employment to 70 persons in the factory and 300 persons in the forest operation. With a 15 per cent return on investment, the landed cost of chips in a pulp mill situated 800 km. away from the Chipping Unit, works out at US$ 29 per ton of chips.

5. From the above it would be seen that if we want to utilize the bamboo resources with maximum employment potentiality in the rural area, the most logical step would be to set up a chipping unit in a modest way and then gradually expand to pulp and paper. By doing this one would be able to see the actual economy of a paper mill and also to train the local people for various jobs as the other sections are added one by one.

6. Taking into consideration the various regional factors, the author has suggested to set up one unit in each of the following States of the Northeastern region keeping in view the distance to a nearby pulp mill:

a. Arunachal
b. Mizoram
c. Meghalaya
d. Tripura

Pulp Production

7. A pulp mill was set up in a rural area of Gujrat for producing 135 tons per day of bleached dried pulp from bamboo/wood. The area abounds in forest resources. By the side of the mill is located a big river. The project, costing rupees 170 million (US$ 20 million), went into commercial production in 1967. It has employed 600 people in the factory.

8. From the cost analysis it appears that the cost of sales of pulp is very high. This is because of the high incidence of interest and depreciation on the cost component. This is, in fact, the problem faced by any mill which has come into production from 1967-68 onwards.

9. It has been found that by conventional steam drying of pulp and then subsequently slushing the pulp for production of paper, the cost is very high. This is the reason why in India most of the mills have an integrated pulp plant with a paper-machine. This mill has also, in fact, installed a paper machine recently to offset this disadvantage. If the pulp could have been dried by some other method the story probably would have been different.

Paper Production

10. A paper plant was set up in an industrially under-developed area of the State of Bihar and at a distance of about 230 km. from the nearest metropolitan city for producing 45 tons per day of speciality paper from purchased pulp. The area lacks in adequate infrastructural facilities. People in general have a low standard of living. Availability of surplus rural labour in the area was high.

11. This plant was originally planned for an integrated pulp and paper mill from bagasse. Later on this idea was dropped as bagasse could not be made available from the existing sugar mills in the region. It was, therefore, decided to set up a paper plant only from purchased pulp. The project, costing rupees eighty million (US$ 9.4 million), went into commercial production in 1976. The power required is taken from the public grid. The mill has provided a gainful employment to 800 people in the factory.

12. To give an idea about the economics of the operation, the cost of production and profitability at hundred per cent capacity utilization is given below:

Basis: One ton of speciality paper.

Variable cost	Rs. 3200	$ 376.
Fixed cost	Rs. 500	$ 59.
Total ex-factory cost	Rs. 3700	$ 435.
Less excise subsidy	Rs. 400	$ 48.
Net ex-factory cost	Rs. 3300	$ 389.
Interest and depreciation	Rs. 900	$ 105.
Selling cost	Rs. 400	$ 48.
Cost of sales	Rs. 4600	$ 541.
Selling price	Rs. 5000	$ 590.
Profit	Rs. 400	$ 49.

13. It has been observed that the mill can produce at the designed rate without any problem. However due to some extraneous factors like interruptions in the power supply, the mill has experienced a tremendous set back in production for the last two years. We feel if this industry was set up near a port or in an area having good transportation facilities, the economics would have been better.

Paper Product Production

14. There are numerous paper products industries in the country producing corrugated containers, box board, exercise books, paper bags, paper plates, etc. These are mostly located in the urban areas where there is a ready market of the products.

VIII. CASE STUDIES IN UTILIZATION OF BAGASSE FOR PRODUCTION OF PULP AND PAPER

1. There is a mill in India producing 35 tons per day of paper from bagasse. Wet bagasse, as obtained from sugar mills, is depithed first. Both dry and wet depithing methods are used. The yield of depithed bagasse is around 70 - 75 per cent. Depithed bagasse is then cooked in Pandia continuous digester with 10 to 15 per cent caustic soda at a cooking temperature of 160°C for about 15 minutes. The unbleached pulp at 45 per cent yield is next washed in a two stage countercurrent washer and bleached in conventional C.E.H. (Chlorination - Extraction - Hypochlorite) sequence. The bleached pulp is then centricleaned and sent to the stock preparation section and then to the paper machine.

2. With certain minor modifications in the paper machine it has been possible to run the machine using hundred per cent bagasse pulp.

IX. IMPACT OF NATIONAL POLICIES AND PLANNING ON STRATEGY FOR DEVELOPMENT

Policies relating to utilization of raw materials and industrial wastes

1. For broad area planning purposes, reliable estimates of hard wood, surplus agricultural residues like rice straw, wheat straw, Kenaf, bagasse are not available. In absence of this data, an entrepreneur finds it too risky to go in for non-conventional raw materials. It is, therefore, suggested that there should be regional wide surveys of various accessible and inaccessible raw materials and agricultural residues. In planning a mill based on agricultural residues, allocation of these residues should be kept for the cattle population of the country.

2. Scientific plantation of bamboo and wood has to be taken up expeditiously at three times the rate of felling.

3. Bagasse has so long been unproductively used in sugar mills as the only source of fuel. National policy has to be formulated for its rational usage. The value of bagasse thus released by sugar mills may be taken at par with the value of a alternate fuel and the capital investment required for modification of the existing bagasse fired boilers to coal fired ones should be subsidized by the national governments. The sugar mills should be assured of the adequate supply of a alternate fuel in a phased manner. To begin with we can have a system introduced to dry the bagasse before firing into the boiler. By these processes about one third of the bagasse should be available for paper industries.

4. Although deinking of waste newspaper is a technically feasible idea, its successful application in a developing economy appears bleak at this stage as the waste newspaper has a ready market and is being sold at a high price. To give an idea of the inappropriateness of this technology, in India old newspapers are sold at a price of Rs. 3000.00 per ton. However, in a country where it is just being disposed of as a waste material and if a mill has only to pay the collection charges, the economy may be in favour of the setting up of a waste paper reclamation unit.

Policies relating to pricing of paper

5. The price of paper depends on the following factors:

(i) Infrastructural facilities

(ii) Government duties like excise duty, sales tax, import duty on plant and machineries, etc.

(iii) Cost of raw materials and utilities

(iv) Labour cost

(v) Capital and revenue expenditure on air and water pollution control

(vi) Rate of interest on borrowed capital.

The price of paper can be controlled only when there is control on the price of the above mentioned items.

Policies relating to growth of paper machinery

6. Most of the developing countries did not have the facilities for the manufacture of pulp and paper equipments and as a result these were being imported from U.S.A., U.K., France, Germany and other developed countries where these machineries were developed for the type of raw materials available in those countries. Now some of the developing nations have manufacturing capacity of pulp and paper machinery for mills with a capacity from 5 tons per day to 200 tons per day, for the type of materials available in most of the developing nations.

7. The pulp and paper equipment manufacturing industry in Europe was developed considering the world as the market, whereas the market for the developing nations will be amonst themselves. Hence a close understanding amongst developing nations is required so that these countries will buy their requirements of plant and machinery from the developing countries only. To promote the development of the trade of paper machinery the developing nations may formulate a tariff policy favouring the import of machinery from developing nations; a reduction in import duty for the import of machinery from developing nations.

Policies relating to paper products

8. National policy has to be such that industries producing paper products are only categorized under small scale industry.

9. The paper mills should be advised to release the base paper to the conversion industry directly. The inherent shock absorbing capacity of small industries being limited, these industries will need to be supplied with paper and boards at the mill price.

Policies relating to incentive and taxes

10. Adequate infrastructural facilities, which are sin-qua-non for the integrated development of the region, should be provided by the national government.

11. Community development facilities such as housing, schools, hospitals, water supply, etc. are also to be provided by the State or National government, as otherwise the rural industry will find it extremely difficult if not impossible to set up an industry in a rural area. In an urban area, the population of which constitutes even less than 20 per cent of the country's population, if these facilities are available from governmental subsidised prices, it is natural that the rural people also should get the same benefits if not better.

12. Being a power intensive industry, tariffs should be low or else some cheap rural power source has to be identified.

13. In many developing countries a good fraction of plants and equipment is imported. If import duty on these indispensable plants and equipment are not minimized, the incidence of interest and depreciation on the cost of production becomes prohibitively high. Hence, there should be a reduced import duty on the machinery not available in the country with further liberalisation in import policy by preferring import of plants and machinery from developing nations.

14. Since the paper industry is a highly capital intensive industry with a long gestation period, certain fiscal incentives in terms of tax exemptions are recommended:

a. No sales tax on raw materials during the first five years of production.

b. Excise relief to be considered as follows:
   (i) full relief for the first two years
   (ii) 80 per cent relief for third and fourth years
   (iii) 60 per cent relief for the fifth year

c. No corporation taxes for the first five years.

Policies relating to entreprenaurial assistance

15. Entreprenal assistance in terms of supplying rural trained forces is a prerequisite for setting up an industry. The training of these people should be organized and finanoed on a national level.

16. Long term loans have to be provided in liberalized terms and at low rates of interest from financial institutions.

17. There should be sustained availability of labour and power.

Policies relating to construction industry practioes

18. Restriction has to be imposed on certain construction materials when a substitute material of construction is available in the country; for example, fiberglass can be substituted by oonventional stainless steel, for transportation of processed pulp. This would reduce the import of stainless steel to the extent that it could be substituted and at the same time the indigenous manufacturer can find an extra market.

X. GUIDELINES FOR STRATEGY DEVELOPMENT

National level

1. The following action is suggested to be taken at the national level to encourage the search and development of the aforementioned new technological options:

a. Identification of areas with surplus labour.

b. To have a wage policy fixing lower wages in a rural area compared to an urban area, depending on the level of employment and per capita income.

c. Professional consultancy services for identifying appropriate technologies in these areas.

d. Training of workers of all categories at the cost of national government.

e. Training and making available dedicated competent managers by the national government even by going to the extent of expenditure on training at national and international levels and paying the difference in salary for a similar manager/supervisor/highly skilled worker between an urban area and rural area.

f. A constant liaison and rapport at national level for obtaining or developing some of the processes for the adoption of appropriate technology for, e.g. the development of high yield pulping, modification of the wet end of the paper machine or even the entire process of making paper from pulp.

Regional level

2. On a regional level the following action is suggested:

a. Transport subsidy in respect of setting up industries in certain areas, for example Northeastern region in India.

Co-operation among developing countries

3. a. Earmarking manufacture of processed and semi-processed goods by the various developing countries.

b. Relaxation in movement of materials from one country to another by better utilization and development of land rules.

c. Preferential tariffs for the purchase of goods and equipment from developing countries.

d. Technical and economical cooperation amongst the developing countries through bilateral and multilateral agreement by efficient utilization of resources and for the expeditious development of the paper industry.

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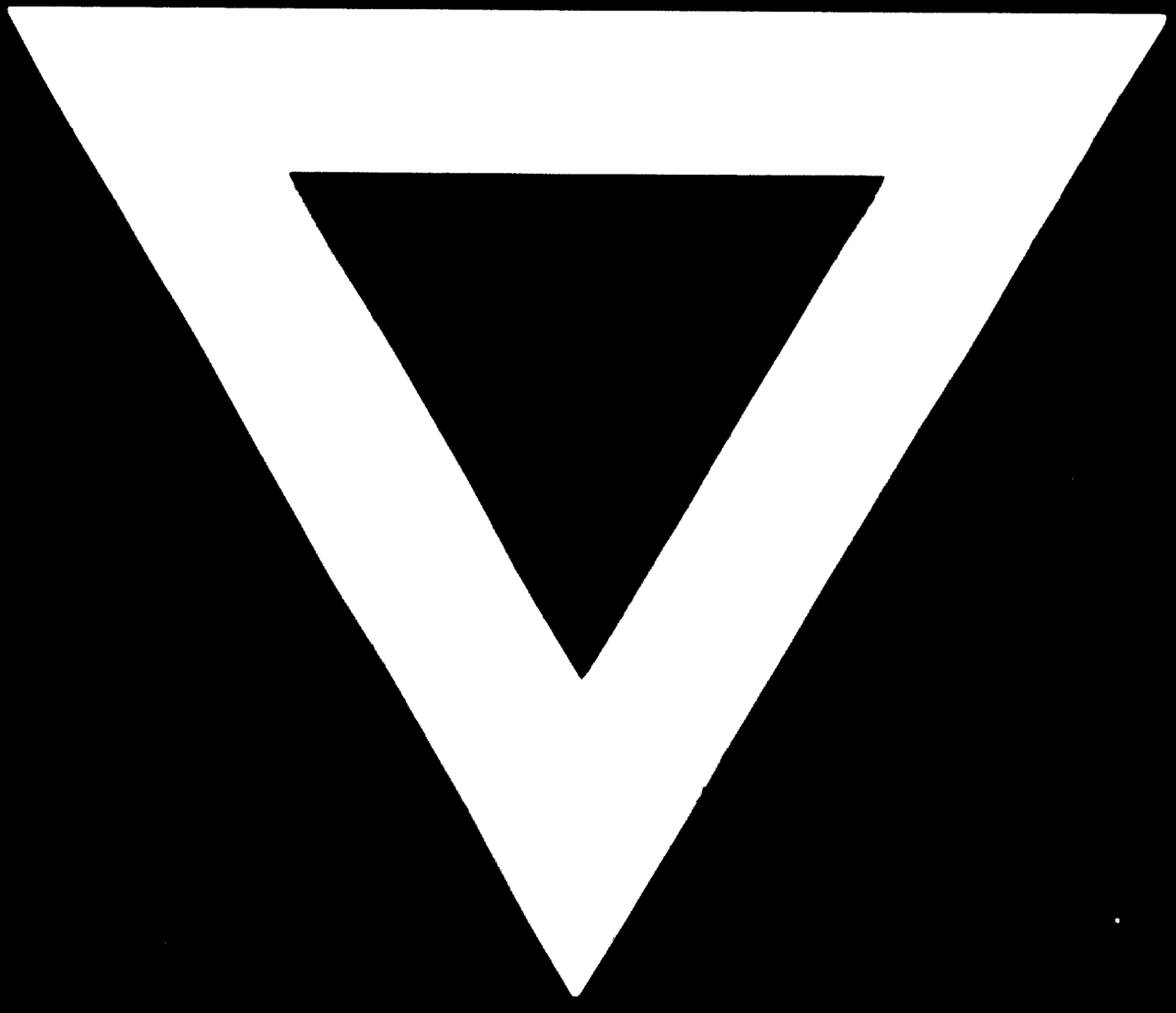

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