AN APPRAISAL OF RAW MATERIAL RESOURCE POSITION FOR MEETING THE DEMANDS OF THE INDIAN PULP AND PAPER INDUSTRY WITH EMPHASIS ON INTENSIVE MANAGEMENT OF BAMBOO FORESTS IN ANDHRA PRADESH

by

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ABSTRACT

Andhra Pradesh is one of the seventeen states of India, occupying about 8.5 per cent of the total geographical area of the nation and supporting the same percentage of population and forests. The per capita consumption of paper and paper products in India was 1.5 kg in 1965 and was planned to be raised to 7.0 kg by the end of the sixth five-year plan (1980-81). The expected growth of the pulp and paper industry appears to be much less than the probable future demand will be. This industry has grown slowly because of inadequate profit margins and lack of an assured supply of raw material. Although bamboo is the conventional raw material used for making writing paper in India, it is possible to produce a satisfactory grade of writing paper with a 20:80 mixture of bamboo and hard wood pulp.

The provincial government (through its Forest Department) should attract capital and stimulate growth in the pulp and paper industry by offering incentives such as long leases on bamboo forests and tax concessions for improved utilization of land and raw material. The Forest Department also should initiate large scale bamboo plantations to bridge the widening gap between supply and demand. All the budget allotment towards plantations of quick growing species would have to be devoted to bamboo plantations to achieve the provincial targets of the fifth five-year plan in the state of Andhra Pradesh.

INDEX OF CONTENTS

Index of Contents (continued) Page

Index of Contents (continued) Page

LIST OF TABLES

LIST OF TABLES (continued) Page

LIST OF FIGURES

LIST OF MAPS

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CHAPTER I

INTRODUCTION TO INDIA AND THE STATE OF ANDHRA PRADESH

1.1 General

India is a sovereign, democratic republic with a president as the executive head. The people of India belong to six races and about 85 per cent of them follow Hinduism. Though there are 845 languages and dialects over 90 per cent of the population speak one of the fourteen languages specified in the constitution. There are seventeen states (created on the basis of language) and six union territories. A governor is the executive head of each state and is assisted by the chief minister and his council of ministers. The union territories (Manipur, Tripura, Andaman, Nicobar Islands, etc.) are under administrators who are directly responsible to the Parliament.

India is a peninsula with the Bay of Bengal on the east, the Indian Ocean on the south, and the Arabian Sea on the west. On the north, the Himalayas spreading 250 to 300 km wide form the border with China. The land can be divided into three main topographical regions, the Himalayan region, the Indo-Gangetic plain, and the Deccan plateau which is separated from the Indo-Gangetic plain by Vindhyan and Satpura mountains. The general climate is of the tropical monsoon type and

85 per cent of the precipitation comes from the southwest monsoon. Based on rainfall four zones are recognized. Andhra Pradesh is in a dry zone with mean annual rainfall of about 1000 mm.

Over 80 per cent of the population is rural with agriculture as its main occupation. Of the total cultivable land only 20 per cent is under irrigation and the rest has to depend upon the monsoons. Rice accounts for half of the cereal output and the other half is wheat, millet, and barley. Among the important cash crops are jute, tea, ground nuts (peanuts), sugar cane, tobacco, and cotton. India's cattle population is one fourth of the world's cattle population. Buffalos are reared for milk and as draught animals; sheep and goats are raised for meat.

1.2 Introduction to Andhra Pradesh

The state of Andhra Pradesh (A.P.) is situated approximately between 77°E to 86°E longitude and 12°N to 18°N latitude. The state has a significant role in the agricultural economy of the nation and is virtually the granary for south India (Map 1). The official language of the state is Telugu, the population is predominantly Hindu, but there is a fair proportion of Urdu speaking Muslims. This bilingualism places additional demand on the use of paper.

The Bay of Bengal forms the eastern boundary and the Eastern Ghats run all along the coast and also form the border in the north and northeast. In the southwest, the Dharwar (oldest rock formations of the world, similar to the Canadian shield) forms a plateau with an average elevation of 620 meters[1].

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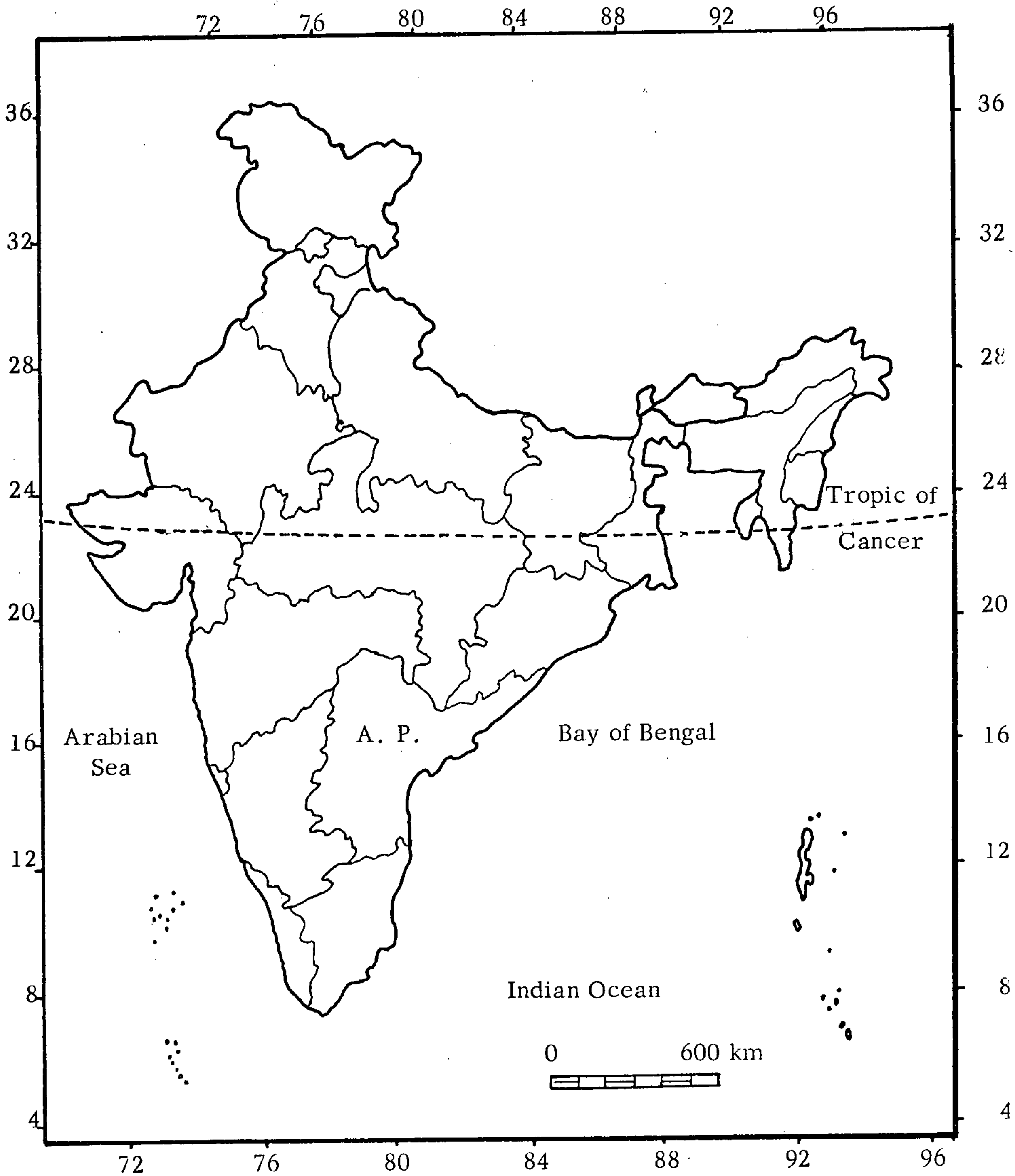
[1]Prior to 1963 the foot, pound system was in vogue, but later India switched over to metric system by an Act.



Map 1. Andhra Pradesh - India.

Detailed land maps are available for areas bordering the state of Andhra Pradesh. The highest peak is in the Horseley hills and is only 1,200 meters above mean sea level.

1.3 Drainage

Two main rivers, the Godavari and the Krishna, which originate in the Western Ghats flow into the Bay of Bengal forming large deltas where agriculture is intensively practiced. A number of tributaries to the main rivers help in draining the run-off water very rapidly.

1.4 Geology and Soil

The main geological formations are given below in chronological sequence along with their distribution (Our Forests, 1968).

1. Recent and sub-recent alluvium: These are the clays and alluvial soils formed by the river deposits and are found in the coastal deltas.

2. Tertiaries: These are limestone and sandstone deposits occuring in the Godavari Valley.

3. Deccan traps: During the Eocene Epoch, large scale volcanic eruption took place all over the world due to geotectonic movements. These volcanic outbursts formed into step like structures (hence the name 'trap') and the basic rocks are known as basalts. These formations occur in the Deccan plateau region (north-western part) of the state.

4. Gondwanas: These are the coal bearing formations formed during the carboniferous period of the world. The formations comprise coal bearing shales and sandstones, occuring in the Godavari Valley.

5. Cuddapahs and Kurnools: These are the oldest rock structures comprising schists, granites, gneisses, marbles, etc. They are found all over the state as an underlying rock base except in the coast due to the fault line along the coast.

Different geological formations resulted in different soil types. The six recognized soil groups are (1) alluvial soils, (2) saline and alkaline soils, (3) Regur or black cotton soils, (4) red soils, (5) lateritic soils, and (6) skeletal soils. Agriculture is intensively practiced in alluvial and black cotton soils, though some dry crops are grown in other soil types as well. Each soil group supports a particular forest type in a given climate zone. The forest types in relation to soils is discussed under forest types.

1.5 Climate

The most powerful influence exerted on the climate of the Indian subcontinent are altitude, distance from the sea, and the disposition of mountain ranges in relation to the prevailing winds. The temperature in the coastal area is more equitable than in the western plateau. The day temperature in summer may go above 48^{o}C (120^{o}F) and in the winter nights the temperature may be as low as 7^{o}C (45^{o}F). In midwinter, fog may be experienced in the valley regions where the rainfall is heavier compared to other areas. In the west and northwestern parts of the state precipitation from the northeast monsoons is more than the precipitation from the southeast monsoon. About 90 per cent of the 1,000 mm mean annual rainfall of the state is from the southeast monsoons.

1.6 Seasons

There are three distinct seasons in A.P.

1. Summer season: The four months of March, April, May, and June constitute the hot summer season when the temperature is well above $43^{o}C$ ($110^{o}F$) reaching the peak temperatures of $48^{o}C$ ($120^{o}F$) in the middle of June.

2. Rainy season: Monsoon showers bring relief from the heat, in the last week of June. The rains continue intermittently till the end of October.

3. Winter season: From November to February the temperature drops considerably and the weather is dry and pleasant except for the rains from the retreating monsoons.

1.7 Distribution of Forests

The forests of Andhra Pradesh are widely scattered. Compact blocks are found only in the Eastern Ghats, the Nallamalais, and the Seshachalam hill ranges of Andhra region and the Godavari and Krishna river valleys of the Telangana[2] region. The percentage of forests in the hilly tract is about 48 per cent, whereas in the plains it is hardly 5 per cent. Of the total forest area of 66,500 sq. km. (25,675 square miles) less than 2 per cent is under communal ownership and the rest is owned by the State.

The position of Andhra Pradesh in India can be visualized from the statistics given in Table I. India's forests contribute less than 1 per cent to her national income (Mohanty, 1968). The average annual increment of forests is 0.5 cu.m. per hectare but the potential productivity of Indian forests has been estimated at ten times its existing production. The low productivity is due to low investment of

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[2] Telangana region is the erstwhile Hyderabad State ruled by H.E.H. Nizam. This region was added to Andhra region to form Andhra Pradesh in 1956.

TABLE I

RELATIVE POSITION OF ANDHRA PRADESH IN INDIA

(FROM OUR FORESTS, 1968)

	Andhra Pradesh	India	A.P. as % of India
1. Total land area	275,280 sq. km	3,263,000 sq. km	8.44
2. Forested area	66,506 sq. km	784,000 sq. km	8.48
3. Forest as % of land	24	24	
4. Annual harvest of wood (1965-66)			
Industrial wood	0.5 million cu.m	506 million cu.m	0.10
Fuel wood	0.7 million cu.m	11.7 million cu.m	6.00
5. Out turn per hectare of forest			
Industrial wood	0.075 cu.m	6.45 cu.m	1.16
Fuel wood	0.105 cu.m	0.149 cu.m	70.47
6. Revenue from forest (1965-66)	Rs 51.774 million	Rs 857.533 million	6.03
7. Expenditure on forests	Rs 20.628 million	Rs 433.123 million	4.76
8. Head of livestock per hectare of forest area	5	5	
9. Forest area per capita	0.18 ha.	0.22 ha.	
10. Density of population	130 per sq. km	162 per sq. km	80.25

Rs 12 per ha. on forest development (Mohanty, 1968). The forests of India are shown in Map 2.

1.8 Forest Types

Over 75 per cent of the forests of Andhra Pradesh are of the mixed dry deciduous type, classified as "southern tropical dry deciduous forests" (Champion, 1961). The forests are further subdivided into three groups:

1. Dry teak (*Tectona grandis*, Linn.[3]) forests.
2. Red sanders (*Pterocarpus santalinus*, Linn.) bearing forests.
3. Dry mixed deciduous forests.

The forest types are briefly discussed below.

Southern Tropical Dry Deciduous Forests:

Top height varies between 15-20 meters. The top storey consists of a few species each tending to dominate in a suitable locality. However, pure patches are due to edaphic factors. The temperature varies from 10^{o}-15^{o}C in winter and 40^{o}-45^{o}C in the hot summer months. The mean annual rainfall varies from 800 mm to 1150 mm, received mostly from the southwest monsoon. Teak is the most important species in most of the forest area while red sanders and sandalwood (*Santalum album*, Linn.) are important in the south and southwestern parts of the state (*i.e.* the ceded districts, comprising Chittoor, Ananthapur, Cuddapah and Kurnool districts).

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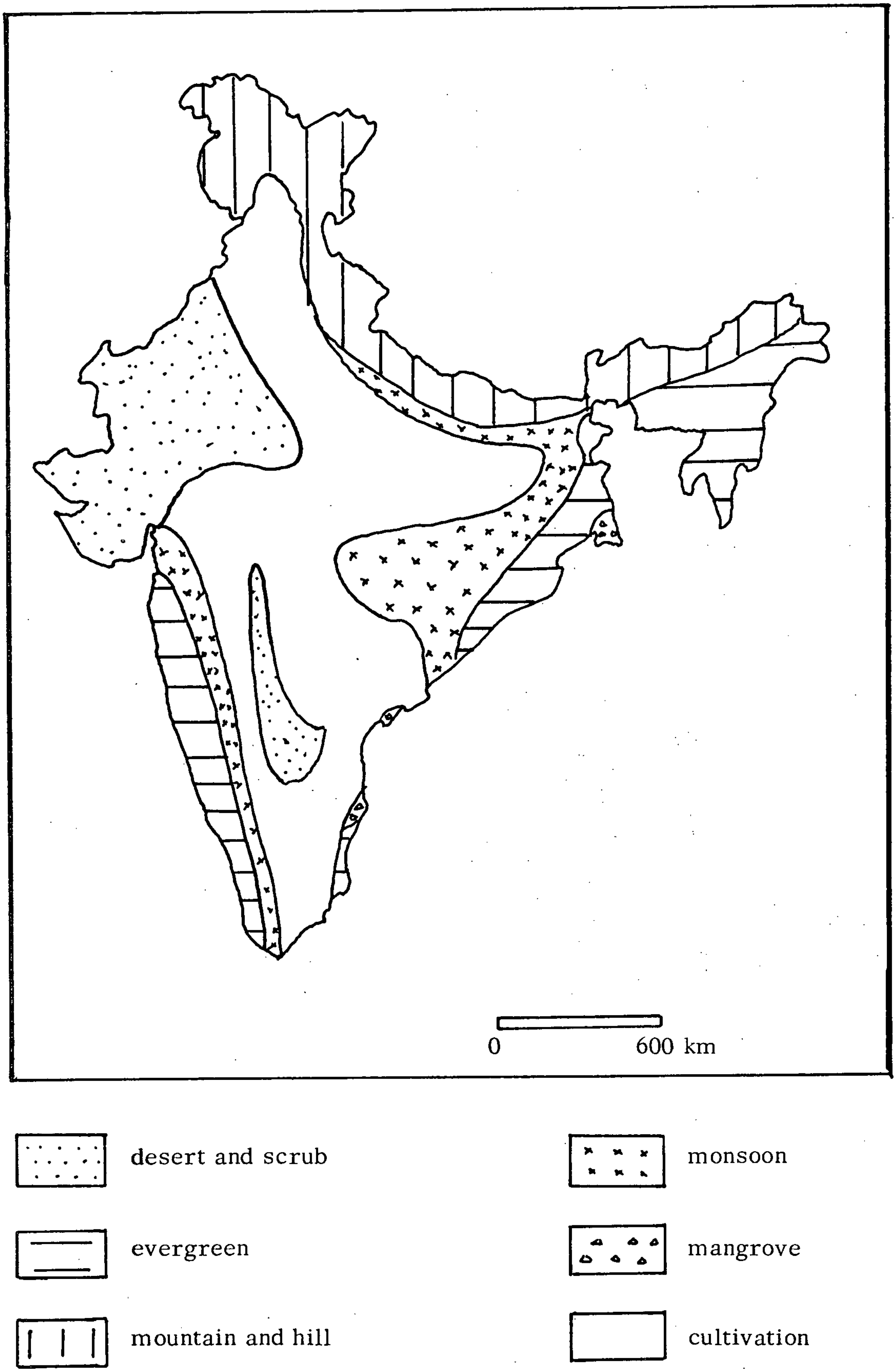
[3] The authority of the botanical names, wherever not given, is according to the codes of the Indian Forest Research Institute, Dehra Dun, India.



Map 2. Forests of India

Dry Teak Forests

These forests are distributed in Telangana, in the Papi hills of Godavari valley, and in the Nallamalais of Andhra region. Three local subtypes are recognized based on the proportion of teak. The pure teak type has over 60 per cent of teak, the intermediate type has 30-60 per cent, and the mixed type has 10-30 per cent of teak (this is based on the number of trees above the pole stage). The teak forests are found on gentle slopes with deep alluvium and good drainage. The trees become stunted, develop forks and low spreading crowns wherever the edaphic factors are unsuitable. Regeneration of teak is conspicuously absent except in remote, favourable localities.

The associates of teak in the upper canopy are *Pterocarpus Marsupium*, Roxb., *Terminalia tomentosa*, W. and A., *Anogeissus latifolia*, Wall., *Dalbergia latifolia*, Wall., *Boswellia serrata*, Roxb., *Cleistanthus collins*, Benth., and *Lagerstroemia parviflora*, Roxb. The second storey comprises of *Butea monosperma*, Roxb., *Diospyros Melanoxylon*, Roxb., *Acacia Sundra*, DC, syn. *A. catechu*, Willd., *Bridelia retusa*, Spreng. syn. *Cluytia Spinosa*, Willd., *Cassia Fistula*, Linn. and *Emblica officinalis*, Gaertn. syn. *Phyllanthus Emblica*, Linn. *Dendrocalamus strictus*, Nees, *Bambusa arundanacea*, Willd. and other grasses are common.

Red Sanders Bearing Forests

These forests are distributed in the ceded districts and Nellore District, on dry hill slopes often on quartzite formations receiving a rainfall of 900-1,000 mm. This forest type occurs with pure patches of *Pterocarpus santalinus*, and is also associated with *Anogeissus latifolia*, *Hardwickia binata*, Roxb., Chloroxylon Swietenia, DC. syn. Swietenia chloroxylon. Red sanders grows better on well drained deep soils and on cooler aspects of hill slopes.

Southern Dry Mixed Deciduous Forests

This is the main type found all over the state and comprises the major forest tract, on low hills and undulating terrain with shallow soils. The average height of the tree vegetation varies from 10-15 meters with thorny species in the upper canopy. These thorny scrubs are usually fuel forests, often subjected to maltreatment viz. theft, fires, and grazing due to the nearness of habitation. Anogeissus latifolia, Albizzia Lebbeck, Benth., Soymida febrifuga, Adr. Juss., Xylia dolabriformis, Benth., Zizyphus species, Strychnos species are the predominant trees. Bamboos and grasses are common.

Besides the above major forest types the following two groups are also found to a limited extent.

1. Dry evergreen forests: These forests are confined to the coastal belt along the Bay of Bengal with characteristic species like Memecylon edula, Maba buxifolia, Mimusops hexandra, Roxb. Introduction of exotics like Casuarina equisetifolia, Forst; and Anacardium occidentale, Linn. (cashewnut) is very successful in these areas.

2. Tidal forests: These are confined to the heavy alluvial deposits of the Krishna and Godavari river estuaries. The important littoral species are Avicennia species, Sonneratia species, Excoecaria species, etc. The natural regeneration does not establish itself unless helped by silvicultural treatment and inadequately reforested openings to the extent of 15 per cent of total area in mangrove forests have been already created.

CHAPTER II

CURRENT CONSUMPTION AND FUTURE DEMAND FOR PAPER AND PAPER PRODUCTS IN ANDHRA PRADESH AND INDIA

India produces a variety of papers and boards. They are grouped as writing and printing papers (including newsprint), absorbent papers, and boards. Excepting certain specialty papers, all papers made in India have some bamboo pulp in the furnish. Newsprint forms the bulk of the imports in the pulp and paper sector.

2.1 Consumption of Paper and Paperboard

The apparent consumption of paper and paperboard can be obtained by adding imports to indigenous production and subtracting exports from it. The consumption of paper and paperboard for the past five years (1963-1967) is shown in Table II. Since the quantity of paper exported is very small, and in any case data are not available for all the years, the apparent consumption can be safely taken as shown in the table.

2.2 Capacity and Production of Paper Mills in India

The capacity and production of the paper mills in various states from 1964-1967 is given in Table III and the location of the paper and board mills is shown in Map 3.

2.3 Classification and Pattern of Consumption of Papers

The papers and boards in use may be grouped into two categories

TABLE II

PATTERN OF PAPER AND BOARD CONSUMPTION IN INDIA FROM 1963 TO 1967

(Based on Indian Pulp and Paper, 1964, 1965, 1966, 1967a and 1968)

Year	Cultural Papers Writing & Printing (Metric Tons)	(%)	Industrial Papers: Kraft & Wrapping (Metric Tons)	(%)	Industrial Papers: Boards (Metric Tons)	(%)	Industrial Papers: Specialty Papers (Metric Tons)	(%)	Total (Metric Tons)
1963	308,571	64.50	83,143	17.38	70,878	14.82	15,792	3.30	478,384
1964	326,703	63.36	91,582	17.76	81,548	15.82	15,775	3.06	515,608
1965	349,061	61.80	94,631	16.75	107,432	19.02	13,686	2.42	564,810
1966	390,266	64.50	100,967	16.70	101,794	16.80	12,063	2.00	605,090
1967	382,210	61.50	121,198	19.50	106,168	17.10	12,081	1.90	621,657

TABLE III

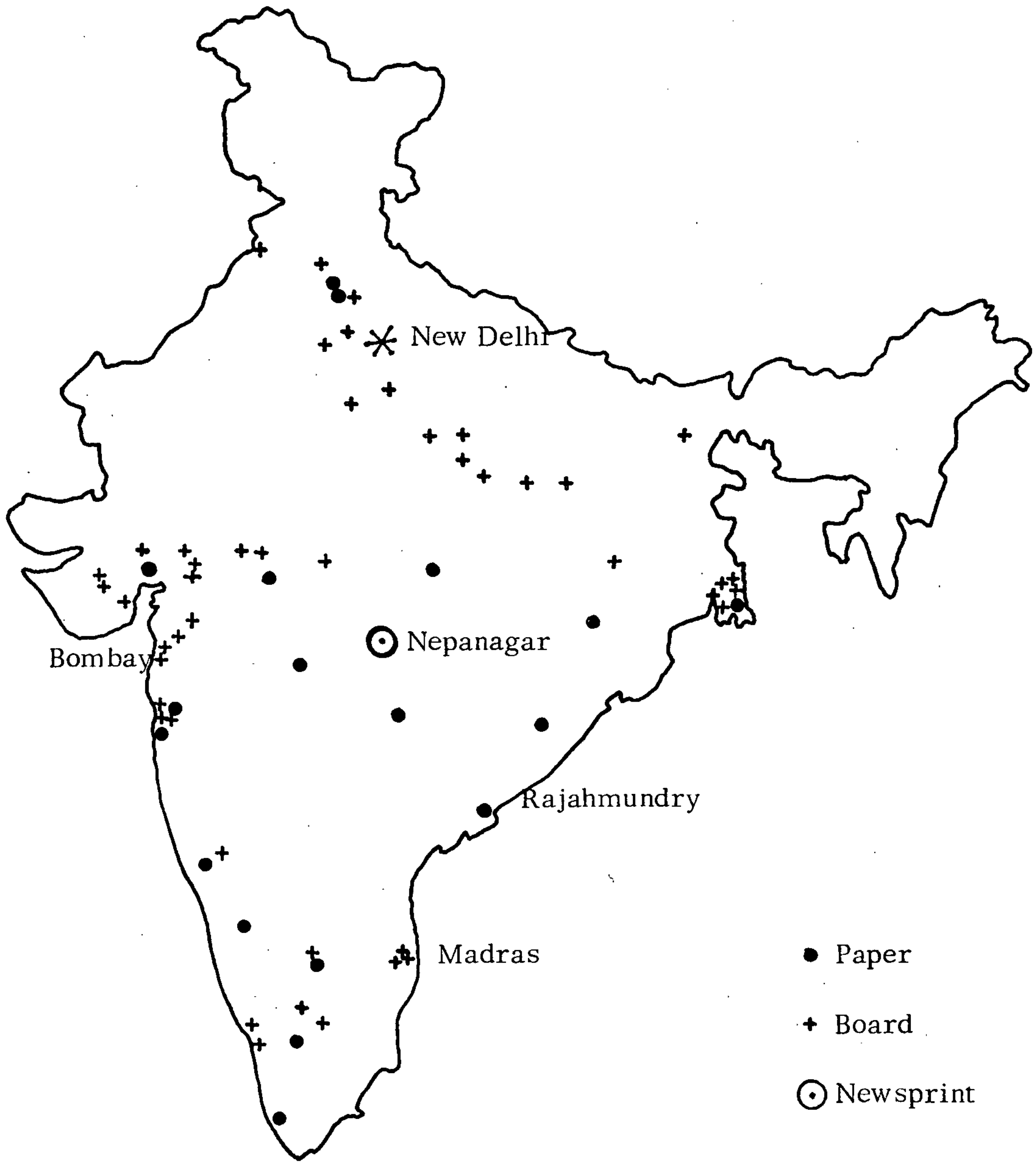
INSTALLED CAPACITY AND PRODUCTION–PAPER MILLS OF INDIA

(Based on Indian Pulp and Paper, 1965, 1966, 1967a, and 1968)

State & No. of Mills, 1968	1967 Capacity	1967 Production	1966 Capacity	1966 Production	1965 Capacity	1965 Production	1964 Capacity	1964 Production
Andhra Pradesh (2)	64,000	51,091	52,000	32,507	43,000	35,646	43,000	34,630
Bihar (2)	63,000	43,743	63,000	43,885*	63,000	53,684	63,000	51,612
Gujarat (6)	20,490	10,287*	20,490	10,494*	18,390	12,070*	15,050	13,499
Kerala (2)	14,340	6,477	14,340	8,463	14,340	9,678	8,640	7,830
Madhya Pradesh (4)	77,200	75,682*	77,200	59,210	57,200	18,844*	9,200	6,423
Madras (3)	26,000	19,362*	26,000	23,920	26,000	19,990*	23,000	17,760
Maharashtra (14)	83,210	57,907*	76,710	72,975*	73,110	52,696*	49,810	42,921*
Mysore (5)	69,700	55,999*	69,640	58,080	66,640	56,886*	53,640	51,640
Orissa (2)	90,000	81,823	90,000	83,060	90,000	82,691	90,000	82,234
Punjab (2)	45,800	36,801*	45,760	39,901	45,760	36,536*	45,760	39,541
Uttar Pradesh (2)	34,200	27,183	34,200	29,865	34,200	30,315	34,200	31,398
West Bengal (10)	142,080	130,860*	141,880	132,157*	133,560	118,116*	127,630	111,095
Total No. Mills (56)								
Total	730,000	598,841	711,200	585,051	665,920	536,992	562,930	490,654

Notes: The figures in parentheses are the number of mills in 1968. Capacity and production quantities are given in metric tons.

*Production figures for some mills are not available.



Map 3. Paper, Board and Newsprint Mills in India. (From Indian Pulp and Paper, 1969)

(Bhargava, 1964).

1. Cultural papers which include writing and printing papers of all kinds and newsprint. These are usually made from long fibred raw material.

2. Industrial papers which include wrapping and packing papers and all kinds of boards. In temperate regions long fibred conifer woods are used as the raw material, but they could also be made from short fibred hardwoods.

The pattern of consumption of various types of papers in 1967 is as follows:

1.	printing and writing papers	61.5%
2.	packing and wrapping papers	19.5%
3.	paperboard	17.0%
4.	specialty papers	2.0%
		100.0%

2.4 Factors Influencing the Consumption of Paper

From global studies by the Food and Agriculture Organization of the United Nations, it has been observed that there is a marked positive relationship between the per capita consumption of paper and paperboard and per capita income. However, the relationship is not uniform, and it was seen that income elasticity declines with rise in income. The range of elasticity of consumption of paper and board (including cultural and industrial papers) for different income levels is given below (F.A.O., 1967).

Per Capital Income Level	Elasticity of Consumption
< $ 100	2.5–3.0 (e.g. Asia except Japan)
$400–$ 500	1.5–2.5
$500–$1000	above one (e.g. Europe)
> $2000	< 1 (e.g. United States)

2.5 Income and Consumption of Paper

Growth in consumption of each of the major categories of paper and paperboard decreases with rising income but not at a uniform rate. At per capita income of $150 or less the income elasticity of consumption of cultural papers is higher than that for industrial papers. As the per capita income rises above $800, the elasticity of consumption for industrial paper is higher than that for cultural papers.

Thus for a given rate of income growth, consumption of paper and paperboard rises much faster in the developing countries than in the developed countries. However, the bulk of the expansion in developing countries is in cultural papers. Paper is the only material to print or write on and has no direct competition from other materials. As income rises, literacy spreads and with it demand for newspapers, journals, books, writing and business papers. But competition arises from other communication media, notably radio and television.

India is a developing nation with the vast majority of the people illiterate and poor. Poverty is a cause of ignorance and also the result (Galbraith, 1964). Therefore, the surest way of tackling poverty is the spread of education. The Government of India has committed itself to technological advancement through improved education. A substantial proportion of the national and state revenues are allocated for the spread of literacy. The impact of literacy on the elasticity of consumption of cultural papers is important in lower income levels. The per capita consumption of paper is a function of literate populations and per capita income of the people (F.A.O., 1965). Initially it is the responsibility of the Government of India to supply an adequate quantity of writing and printing paper at a price within the reach of the common man.

2.6 Education and Consumption

In India education is free up to middle school for boys and girls and up to high school for girls. This is to encourage the participation of women in the democratic government. Hitherto the social system discouraged the education of women. Free education to everyone has attracted a great many students from the poorer sections of the society. People have realized the significance of education, and the number of school-going children trebled to seventy-five million during 1950-1967. The literacy per cent has risen from 9.5 percent in 1947 when India obtained her independence from the British to 30 per cent in 1967.

2.7 Population and Literacy

India has the second highest population in the world. She has 14 per cent of the world's population but only 2.4 per cent of the world's forests to meet her domestic requirements. Due to low literacy percentage and low per capita income, the per capita consumption of paper is much lower than the world's average. With increases in literacy percentage and in population, the total and per capita consumption of paper will increase manifoldly. With increased literacy there will be an increase in consumption of newsprint provided there is also a corresponding increase in income.

Nautiyal (1965a) has estimated the population of India by the turn of this century at 670 million, assuming the growth rate of population for 1951-1961, with 42.6 per cent of them literate. This is nearly half of the estimated population of the developed regions of the world (F.A.O., 1967). Demographic estimate of population by 1980 is 695 million. It is very difficult to visualize the supply of paper to such a vast population from indigenous resources. Viewed from the rapid popularity of birth control measures, the estimate of 695 million population by 1980 is unlikely. A higher rate of growth in gross national product with corresponding slower rate of growth in population would lead to increased per capita income and higher literacy percentage. The estimated literacy percentage by the end of the fourth five-year plan (1970-1971) is to be 40. Even to meet the requirement of cultural papers for such a population is a formidable task and the Government of India should take urgent steps to meet this potential demand.

2.8 Forecast of Future Consumption of Paper and Paper Products

The log normal projection method has been used for forecasting the consumption of paper and paper products in Andhra Pradesh and India. It is based on the study of Engel[4] curves relating to individual consumption of paper to individual income that the following formulae have been drawn up (F.A.O., 1960). Because the method also has been used for this thesis it will be helpful to outline its main features.

$$y = s_{\infty} \int_{-\infty}^{t} \frac{1}{\sqrt{2\pi}} e^{\frac{-t^2}{2}} dt \qquad (1)$$

$$t = b \log x - a \qquad (2)$$

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[4] Engel, Ernst (1821-1896) proposed a law stating that the proportion of expenditure on necessities will decrease with increasing income.

where

y = per capita consumption of paper and paper products

x = per capita income in constant rupees

s, a and b are saturation coefficients depending upon the type of paper and found to be valid for all the countries.

The per capita consumption (y_o) in any given year is obtained by dividing the total population (p_o) into the total consumption (c_o)

i.e. $y_o = c_o/p_o$

Then t_o can be obtained from equation 1 by use of Fischer and Yates normal probability integral tables. Equation 2 gives:

$$t_n = b \log \frac{x_n}{x_o} + t_o$$

where x_n is the per capita income n years hence. If r is the rate of increase of per capita income, it can be shown that:

$$\log \frac{x_n}{x_o} = n \log (1+r)$$

whence $t_n = b \; n \log (1+r) + t_o$.

Obviously there is no use of absolute per capita income or coefficient a, only rate of increase of per capita income (r) is necessary (F.A.O., 1962). Having found t_n, by use of Fisher and Yates tables, y_n can be known. Then $c_n = p_n * y_n$ where

c_n is the consumption n years hence

p_n is the estimated population in that year and

y_n is the calculated per capita consumption of paper and other paper products.

For Andhra Pradesh it appears as if the log-normal demand function offers little advantage over the straight line logarithmic function when making projections for a limited change in income. Its usefulness lies mainly in its applicability over a wide income range and particularly for regions where historical data are either missing or distorted by abnormal developments (F.A.O., 1962). For these reasons, projection of demand trends by regression equations was not attempted.

Information regarding the per capita consumption of different kinds of paper and paper products is not available for Andhra Pradesh, but the per capita consumption of all paper products for India was 1.3 kg. in 1963 and the same figure was taken for Andhra Pradesh for the purposes of this projection method. From the mathematical point of view the forecast would be better if based on the sum of consumptions calculated for each kind of paper but practically speaking the figures for total consumption are more reliable since there is a wide disparity in customs classification or maker's specifications. Moreover the simple coefficient of determination R^2 for all kinds of papers is 99.7 per cent which is better than for the individual categories (F.A.O., 1962).

The annual growth rate of gross national product in real rupees (one Canadian dollar is equal to 6.94 rupees) for India is 5 per cent and the annual growth rate of population is 2.15 per cent (Progress Report, Government of India, 1968). The net per capita income growth rate is 5 - 2.15 = 2.85 per cent. Since the growth rate of population in Andhra Pradesh is only 1.9 per cent per annum, the per capita income growth rate can be safely taken as 3.1 per cent per annum. The per capita income growth rate is in conformity with most countries in Southeast Asia where it is in the order of 3 per cent (F.A.O., 1962). The calculation for the forecast are as follows:

Per capita consumption of paper and other products (y_o) in the year 1963	s*	y_o/s	t_o**
1.3 kg	620	0.00209	-2.045

*saturation coefficient for all paper and paper products
**obtained from normal probability integral tables

For this thesis the income growth rate of 2.85 per cent for India and 1.3 per cent for Andhra Pradesh, the values of n log (1 + r) for different year spans are given in Table IV and the final values of t_n and y_n/s are shown in Table V. The projected consumption for Andhra Pradesh and India is shown in Table VI, and presented in Figure 1. The forecast given by Muthoo (1965) is shown in Table VII for the sake of comparison. The forecast arrived at here is only rough and probably is conservative since the data used are not wholly reliable and secondary factors such as spread of education and expansion of industries are not taken into account. For this reason, the figures of Muthoo (1965) have been used in this study and, moreover, they now appear to be the basis for planning.

2.9 Meeting the Demand to 1980

In order to meet the demands of paper and paper products in the future, it is necessary to assess the raw material supply. The estimated requirements of raw materials as envisaged by Muthoo (1965) and Podder (1959) are given in Table VIII. They assumed that the supply of bamboo remains the same, the increased productivity due to intensification being absorbed by increasing population. Bhargava (1967) approaching the problem of bamboo supply more realistically has estimated an annual supply of three million metric tons of bamboo from the natural forests. The estimated future consumption of pulp and paper and the raw material requirement are

TABLE IV

VALUES OF n LOG (1 + r) FOR DIFFERENT YEARS

Year	Andhra Pradesh	India
	(R = 0.031)	(r = 0.0285)
1970 (n = 7)	0.09282	0.0854 (U1)
1975 (n = 12)	0.15912	0.1464 (U2)
1980 (n = 17)	0.22542	0.2074 (U3)

TABLE V

FINAL VALUES OF tn AND Yn/S

		b*u			tn = (bu + to)			Un/S		
	b	1970	1975	1980	1970	1975	1980	1970	1975	1980
INDIA										
All paper and paper products	1.6576	0.14155	0.24267	0.34378	-1.90345	-1.80233	-1.70122	0.00287	0.00359	0.0045
ANDHRA PRADESH										
All paper and paper products	1.6576	0.18385	0.26375	0.37365	-1.89115	-1.78125	-1.67135	0.00293	0.00375	0.00474

TABLE VI

FORECAST OF FUTURE CONSUMPTION OF PAPER AND PAPER PRODUCTS

IN ANDHRA PRADESH AND INDIA

	Andhra Pradesh			India		
	1970	1975	1980	1970	1975	1980
1. Population (Pn) (in millions)	43.32	49.18	57.46	550.51	625	695
2. Per capita consumption (Yn)* (in kg)	1.82	2.32	2.94	1.78	2.22	2.76
3. Total consumption** (Cn) (in millions of metric tons)	0.0788	0.1077	0.1273	0.9795	1.2253	1.5188

* Yn = Yn/S * S where S = 620

** Cn = Yn * Pn where Pn is the estimated population

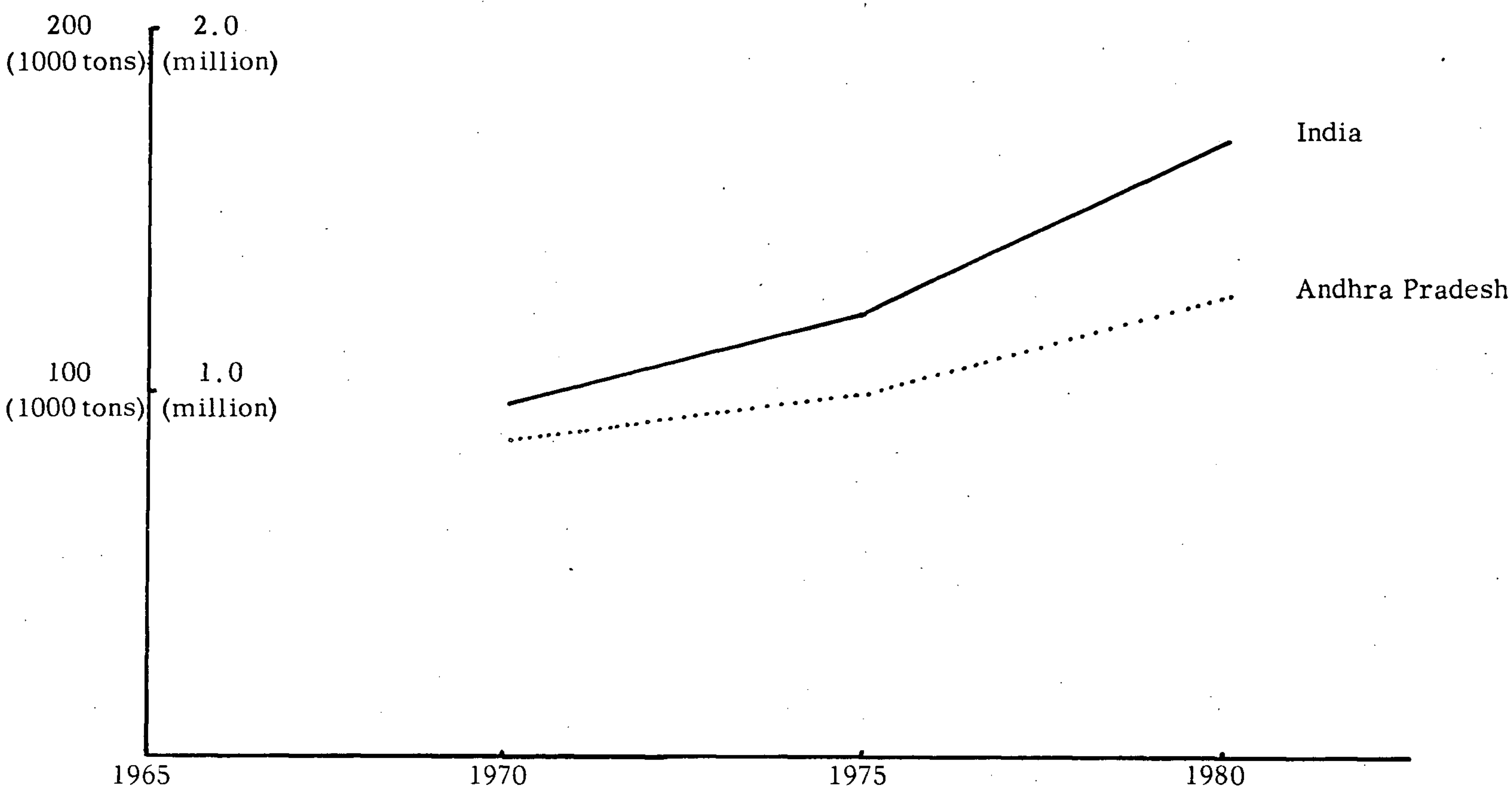

Figure 2. Demand projection of paper and paper products in Andhra Pradesh and India (in 1,000 tons for Andhra Pradesh and million tons for India).

TABLE VII

CONSUMPTION AND ESTIMATED DEMAND OF PULP AND PAPER IN INDIA

(Based on Muthoo, 1965)

	(in thousand metric tons)			
	1963-64	1970-71	1975-76	1980-81
1. Paper and paper board	493.6	1200	2000	3000
2. Newsprint	125.2	300	450	600
3. Rayon pulp	75.4	75.4	400	400
4. Other chemical pulp*	-	124.6	-	200
5. Population	470	560	630	695
6. Per capita consumption (in kg)	1.4	3.0	4.5	6.0
**		3.5	5.0	7.0
7. Total consumption or demand of all pulp and paper products	694.2	1700	2850	4200

* These figures are from Manmohan Singh and Mukherjia, 1965

**The figures are from Podder, 1959

TABLE VIII

PRESENT CONSUMPTION AND FUTURE REQUIREMENT OF FIBROUS RAW MATERIAL

AND FOREST AREA REQUIRED

(Based on Podder, 1959; Muthoo, 1965, and Shahi, 1964)

	Raw Material (in millions of tons)					
Year	Bamboo	Bagasse	Misc. fibres	Plantations (bamboo & eucalypts)	Total	% of forest area in India*
1965-66	2.0	0.22	0.18	—	2.4	5
1970-71	2.0	2.00	0.40	—	4.2	9
1975-76	2.0	2.50	0.70	2.0	7.2	15
1980-81	2.0	3.5	1.00	3.5	10.0	22

*Shahi (1964) suggested that if 10 per cent of the total forest area in India is dedicated for raising plantations, the 1981 targets of paper production can be achieved.

given in Table IX.

From the present day knowledge, the amount of different kinds of pulp required for a ton of finished product, the requirement of different types of pulps and the raw material required are worked out by Bhargava (1967) and presented in Tables X, XI, XII. The estimated raw material conversion factors are given in Table XIII. He concluded that unless active plantation programmes are undertaken right now, it will be difficult to meet the targets beyond 1980. Nautiyal (1965a) has arrived at a similar conclusion.

TABLE IX

ESTIMATED FUTURE CONSUMPTION OF PULP AND PAPER AND RAW MATERIAL REQUIREMENT

(Based on Manmohan Singh and Mukherjia, 1965 and Bhargava, 1967)

Item	1970-71	1975-76 (in million metric tons)	1980-81
Paper and paper board	1.20	2.00	3.00
Newsprint	0.30	0.45	0.60
Chemical pulp	0.20	0.40	0.60
Total	1.70	2.85	4.20
Per capita consumption	3.50 kg	5.00 kg	7.00 kg
Raw material requirement including bamboos, bagasse and other plantation wood	4.20	7.20	10.00
Requirement of bamboo alone	2.75	4.50	6.70
Supply of bamboo from forests	3.00	3.00	3.00
Supply of bamboo from plantations	—	0.23	0.46
Supply of pulp wood from plantations, particularly *Eucalyptus* spp.	—	0.35	0.42

TABLE X

ESTIMATED TONS OF PULP PER TON OF FINISHED PRODUCT FOR DIFFERENT VARIETIES OF PAPER AND BOARDS DURING 4th, 5th AND 6th V YEAR PLANS*

(From Bhargava, 1967)

Finished Product	Fine Paper 1st quality			Book Paper 1st quality			Boards			Newsprint			Wrapping and Packing Paper 1st quality		
Pulp Variety	4th Plan	5th Plan	6th Plan	4th Plan	5th Plan	6th Plan	4th Plan	5th Plan	6th Plan	4th Plan	5th Plan	6th Plan	4th Plan	5th Plan	6th Plan
Bamboo sulphate-bleached or unbleached	0.70	0.65	0.55	0.60	0.55	0.45	0.50	0.40	0.28	0.25	0.22	0.20	-	-	-
Hard wood sulphate bleached or unbleached	0.30	0.33	0.38	0.40	0.43	0.48	0.45	0.50	0.62	-	--	-	0.15	0.15	0.15
Hard wood chemiground-bleached (Salai)	-	-	-	-	-	-	-	-	-	0.82	0.85	0.87	-	-	-
Conifer sulphate-(Chirpine and fir) unbleached	-	-	-	-	-	-	-	-	-	-	-	-	0.90	0.90	0.90
Waste paper	0.03	0.05	0.10	0.03	0.05	0.10	0.20	0.25	0.25	-	-	-	-	-	-
Total per ton of finished product	1.03	1.03	1.03	1.03	1.03	1.03	1.15	1.15	1.15	1.07	1.07	1.07	1.05	1.05	1.05

*4th plan, 1966-70; 5th plan, 1971-75; 6th plan, 1976-80

TABLE XI

ESTIMATED REQUIREMENT OF DIFFERENT TYPES OF PULPS FOR EACH VARIETY OF PAPER AND BOARD*

(From Bhargava, 1967)

	← 4th Plan →				← 5th Plan →				← 6th Plan →			
	Bamboo Sulphate	Hard wood Sulphate	Hard wood Chemiground	Waste Paper	Bamboo Sulphate	Hard wood Sulphate	Hard wood Chemiground	Waste Paper	Bamboo Sulphate	Hard wood sulphate	Hard wood Chemiground	Waste Paper
Cultural papers	458.76	297.24	-	22.69	767.00	508.00	-	60.00	871.00	783.00	-	165.00
Newsprint	75.00	-	246.00	-	99.00	-	382.50	-	120.00	-	522.00	-
Wrapping and packing paper	111.60	93.60	18.00	-	168.00	204.00	33.00	-	196.50	436.50	57.00	-
Boards	120.00	108.00	-	48.00	172.00	215.00	-	107.50	201.60	446.40	-	180.00
Total	765.36	498.84	264.00	70.69	1107.00	927.00	415.50	167.50	1269.60	1665.90	579.00	345.00
Rounding up	766.00	499.00	264.00	71.00	1107.00	927.00	416.00	168.00	1270.00	1666.00	579.00	345.00

*in 1,000 metric tons

TABLE XII

ESTIMATED RAW MATERIAL REQUIREMENT FOR

DIFFERENT TYPES OF PULPS*

(From Bhargava, 1967)

Raw Material	End of 4th Plan	End of 5th Plan	End of 6th Plan	Yield of Pulp as %
Bamboo	2100	3000	3400	36
Pine & fir woods	38	62	93	58
Hard woods for sulphate pulps	1315	2440	4400	38
Hard woods for chemiground pulps	380	600	830	70
Waste Paper	95	225	460	75
Total hard woods	1700 (2.4)**	3050 (4.4)**	5250 (7.5)**	
Availability of Bamboo from natural forests	3000	3000	3000	
from plantations	30	230	460	
Total	3030	3230	3460	

*in 1000 metric tons
**figures in parentheses are in million cubic meters

TABLE XIII

ESTIMATED RAW MATERIAL CONVERSION FACTORS

FOR BLEACHED PULP—AIR DRY BASIS

(From F.A.O., 1962)

Raw material	% Moisture content	% Yield of pulp	% Cost of raw material per ton of bleached pulp**
1. Bamboo*	10	38.5	260
2. Wattle and bluegum	15	37.0	270
3. Bagasse	15	31.5	318
4. Grasses	10	30.0	333
5. Rice straw	10	40.8	245
6. Pine wood	15	40.0	250
7. Broad leaved pulp wood	15	39.0	250
8. Mixed hard woods	15	37.0	270

*Indonesian bamboo–G. niglociliata, Kurz. gave a yield of 49.9 per cent and B. polymorpha, Munro. of Burma gave 49.3 per cent yield (Ono, 1962).

**Cost of raw material multiplied by the given percentage gives the cost per ton of pulp (10 per cent moisture content basis).

CHAPTER III

REVIEW OF RAW MATERIAL SUPPLY SITUATION FOR PULP AND PAPER INDUSTRY IN INDIA

3.1 Classification of Raw Material for Paper Making

Theoretically any material capable fo yielding cellulose could be used for paper making. A classification of fibres used in making paper is given below (Muthoo, 1965):

A.	seed fibre	-	cotton	(Cochlospermum Gossypium, DC. syn. Bombax Gossipium, Roxb. or Bombax malabarica, DC.)
B.	stem fibre	-	hemp	(Cannabis sativa, L.)
			jute	(Corchorus capsularis, L.)
			sugar cane	(Saccharum officinarum, L.)
			bamboo	(Bambusaceae family)
			grass	(Eulaliopsis binata, (Retz.) C.E. Hubbard)
C.	leaf fibre	-	sisal	(Agave rigida, L.)
D.	fruit fibre	-	coconut	(Cocos nucifera, L.)
E.	wood fibre	-	1. Gymnosperms	Fir (Abies pindrow, Royle.)
				Spruce (Picea smithiana, Wall.)
				Pine (Pinus roxburghii, sargent syn. P. longifolia, Roxb.)
			2. Angiosperms	Poplar (Populus ciliata, Wall.)
				Eucalyptus (E. tereticornis, Baker and Smith)
				Casurina (C. equisetifolia, Forst)

The morphological and chemical properties of the fibres have a considerable effect on the properties of paper that is produced from them (F.A.O., 1953). Fibre length, fibre strength, and specific gravity are responsible for the paper strength (Dinwoodie, 1965). Conifer trees are a long fibred source of pulp with an average fibre length of about 3 mm. Broad leaved hardwoods have an average fibre length of 1 mm. The physical and chemical properties of some paper making fibres are given in Table XIV. In view of the shortage of conventional raw material for pulping, the cellulose and paper wing of the Indian Forest Research Institute has tested the suitability of certain relatively abundant hardwoods. The fibre properties, proximate chemical analysis, and the pulp yields are given in Table XV.

3.2 Choice of Raw Material

The important considerations for the selection of raw material for paper making are listed below (Srivastava, 1966; Atchison, 1969).

1. The amount of fibre that can be isolated from the plant must be high enough. It is desirable to have not less than 50 per cent of fibre yield.

2. The process of isolation should be easy and economic.

3. The raw material should have low extractive content.

4. The fibres must be of suitable size and character, preferably long fibres with thin cell walls (high fibre length to diameter ratio).

5. The plant must be plentiful.

6. There should be adequate and sustained supply of the raw material.

7. Collection of the raw material should be convenient and cheap.

8. Location of the mill should be close to the source of raw material in order to minimize transportation costs. The size of the mill is not only dependent upon the source of fibrous raw material but also upon the supply of water, power, labour at reasonable costs, and proximity to markets.

9. The raw material should not deteriorate in storage.

TABLE XIV

PHYSICAL AND CHEMICAL PROPERTIES OF SOME PAPER MAKING FIBRES USED IN INDIA

(From Muthoo, 1965)

Type of Fibre	Fibre Av. Length (mm)	Fibre Av. Dia. (microns)	Ash %	Lignin %	α-Cellulose %	Pentosans %	Texture
Rice straw	1.50	8.50	14-20	14-21	28-36	23-25	Open
Sugar cane bagasse	1.70	20	2	19-20	40-43	30-32	Open
Bamboos	3-4	14	1-3	22-30	50	16-21	Dense
Temperate conifers	2.70-4.16	32-43	1	26-30	40-45	-	Dense
Temperate broad leaved	0.70-1.60	20-40	1	18-25	38-49	-	Dense
Jute sticks	1.06	26	0.52-1.8	21-27	40-55	18-22	-
Sabai grass	2.23	12	1.65	25	57	19.7	-

Note: Properties of hard woods suitable for paper making in India are given in Table XV.

TABLE XV

PHYSICAL AND CHEMICAL PROPERTIES OF SOME IMPORTANT HARD WOODS OF INDIA

(From Man Mohan Singh and Mukherjia, 1965)

Name of Species	Average fibre dimension Diameter (microns)	Length (mm)	Proximate chemical analysis Ash %	Cellulose %	Lignin %	Pentosans %	Pulp Yield %
Acacia decurrens	14	0.86	0.36	63.10	21.20	19.30	53.0 (B)
(Wendl.) (Wild.)							
Ailanthus excelsa (Roxb.)	35	1.22	2.14	51.60	30.08	14.34	39.4 (B)
Albizzia lebbek (L.)(Benth.)	21	1.09	0.72	52.47	22.90	17.00	50.0 (B)
Boswellia serrata	24	0.88	1.80	50.70	27.30	13.00	41.9 (B)
(Roxb.)							85.2 (B)
Broussonetia papyrifera	30	0.82	1.08	59.18	23.26	16.43	48.3 (B)
(Vent.)							84.3 (U)
Casurina equisetifolia	11	1.08	0.90	56.70	23.20	19.20	50.3 (B)
(Forst.)							
Dalbergia sissoo (Roxb.)	18	1.10	1.07	54.26	24.20	14.93	52.7 (B)
Eucalyptus citriodora	14	1.03	1.45	57.90	22.99	16.75	42.0 (B)
(Hook.)							
Eucalyptus globulus (Labill.)	14	1.11	0.50	60.95	20.27	15.52	52.8 (B)
Gmelina arborea (Roxb.)	24	0.80	0.80	56.00	30.90	12.70	48.8 (U)
							39.8 (B)
Morus alba (L.)	11	1.02	1.20	57.40	24.70	16.30	42.2 (B)
Populus ciliata (Wall.)	24	1.14	1.24	62.76	25.31	17.80	52.1 (B)
*Cryptomeria japonica	38	2.18	-	-	-	-	56.9 (U)
(D. Don.)							

U = unbleached
B = bleached
*Temperate conifer, exotic to India

10. The raw material should be cheap at mill point. This is possible if there is no competition from other industries of secondary importance.

The consumption of different kinds of raw materials in the past by the Indian pulp and paper industry is given in Table XVI. Eberhardt (1968) has ranked the different kinds of raw material regarding their suitability and presented in Table XVII. With improved technology it is now possible to blend hardwood pulps with bamboo pulp in various proportions to make acceptable paper. The low ash content and the ease with which the lignin can be broken down compared to softwoods made broad leaved hardwoods acceptable as a raw material for pulping. Hardwood pulps can be used for making writing and printing paper where printability and ink absorption are more important than tearing strength. However, for running on high speed paper machines it is necessary to mix a small proportion of about 20 per cent of long fibred pulp.

3.3 Hardwoods as Raw Material for Paper Industry

On the basis of pulp yield and breaking length Guha (1969) has grouped some Indian hardwoods as below.

very good (over 48 per cent yield and over 6,000 m. breaking length)

1. Albizzia lebbek (L.), Benth.
2. Broussonetia papyrifera, Vent.
3. Dalbergia sissoo, Roxb.
4. Eucalyptus globulus, Labill.
5. E. grandis, Hill ex Maiden; Baker and Smith, 1920.
6. Trema orientalis (L.), Bl.

TABLE XVI

CONSUMPTION OF DIFFERENT RAW MATERIALS BY

THE INDIAN PAPER INDUSTRY IN THE PAST

(From Srivastava, 1966)

	Consumption in Tons			
Raw Material	1924-25	1936-37	1944-45	1958-59
Bamboo	5,830	57,840	187,000	450,000
Sabai grass (Eulaliopsis binata) (Retz) C.E. Hubbard	26,160	34,550	60,086	50,000
Imported wood pulp	7,976	10,976	7,206	30,000
Waste paper	-	5,908	17,400	25,000
Rags, hemp etc.	6,506	8,568	27,328	25,000
Bagasse	-	-	-	20,000
Spruce (Picea smithiana) (Wall.)	-	-	-	7,000
Sa lai* (Boswellia serrata) (Roxb.)	-	-	-	25,000

*Used for newsprint

TABLE XVII

SUITABILITY OF CERTAIN RAW MATERIALS OF INDIA FOR PULPING, YIELDS VS QUALITY

(From Eberhardt, 1968)

Yield Raw Material	85-90% Newsprint	70-85% Fluting	55-70% Middles	50-60% Liner	Bleached	50% Remarks
Mixed hard woods	Good*	Excellent	-	Good	Good	-
Eucalypts	Good	Excellent	-	Good	Good	Problem of corrosion
Bagasse	Good	Good	Good	Good	Good	Opacity poor
Bamboos	-	-	Fair	Good	Good	-
Grass, straw, reeds, etc.	-	Good	Fair	Fair	Excellent	-

*Depends upon species

good (over 45 per cent yield and over 5,000 m. breaking length)

1. Ailanthus altissima, Desf.
2. Albizzia procera, Benth.
3. Boswellia serrata, Roxb.
4. Casurina equisitifolia, Forst.
5. Populus ciliata, Wall.

fair (over 39 per cent yield and over 4,800 m. breaking length)

1. Ailanthus excelsa, Roxb.
2. Cassia siamea, Lam.
3. Eucalyptus hybrid - "Mysore gum"
4. E. robusta, Baker and Smith
5. Gmelina arborea, Roxb.

poor (under 39 per cent yield or under 4,800 m. breaking length

1. Cleistanthus collinus
2. Lagerstroemia parviflora

In the tropical forests of India, many broad leaved species are found but not one species occurs on an area large enough that the paper industry can profitably harvest the crop. Research work at the Forest Research Institute, Dehra Dun, India, has demonstrated the possibility of using mixtures of hardwoods for production of sulphate pulps for writing and printing papers. However, on fast running commercial machines, it is necessary to add long fibred pulp to the extent of 20 per cent to the furnish. The strength properties of pulp made from different proportions of bamboo and hardwoods are shown in Figure 2.

Bhargava (1969) considered that digesting a mixture of hardwoods and

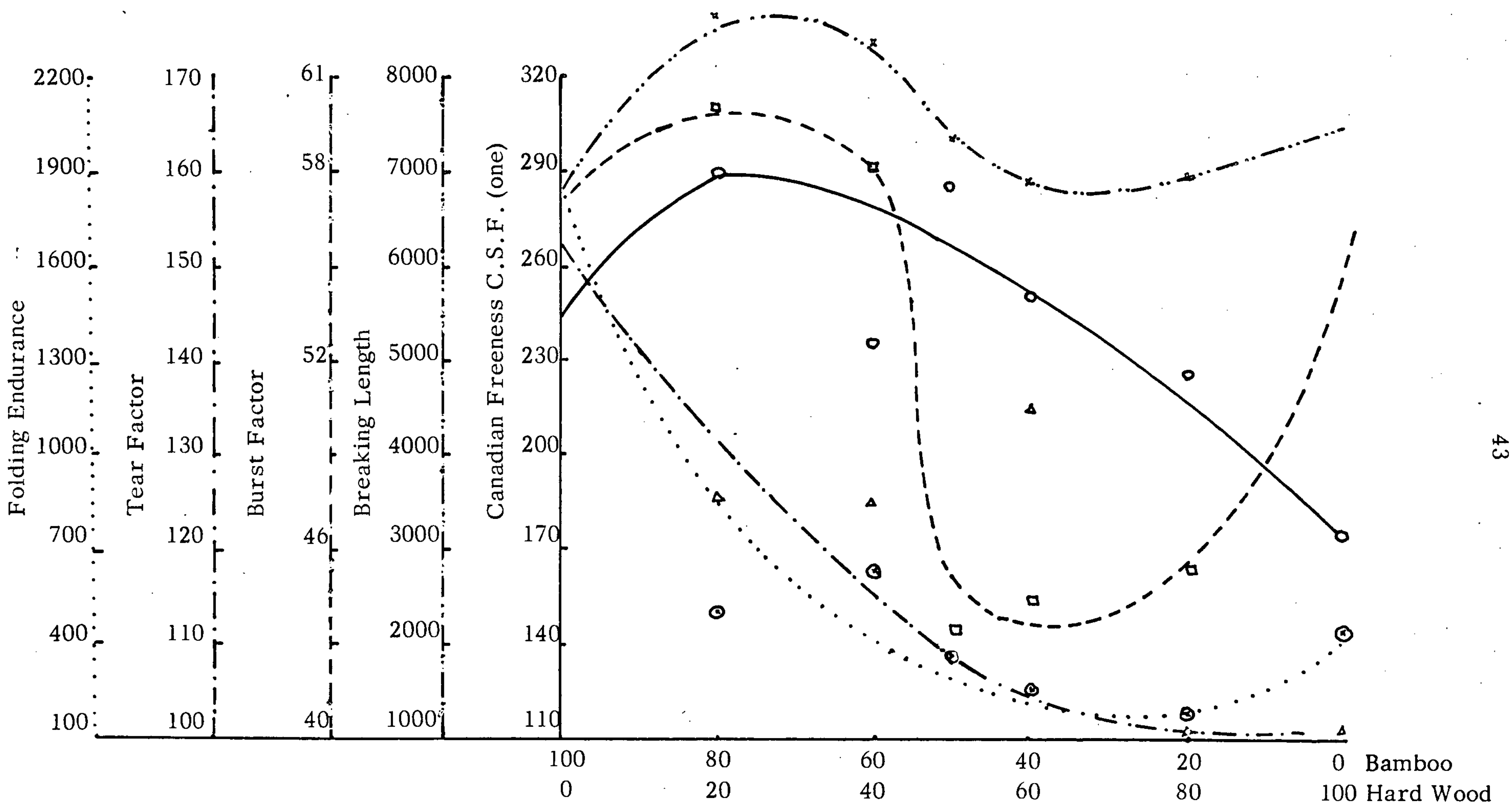

Figure 2. Mixture of Bamboo and Hard Wood Pulps (Beaten for 90 minutes) Vs Strength
(From Guha, S.R.D. et al. 1966)

bamboos is not satisfactory because of widely differing anatomical characters and the resulting pulp is non-uniform. The process involves wastage of raw material and chemicals. But the Bengal Paper Mill uses continuous pulping of a mixture of bamboo and hardwoods in the proportion of 70 to 30. The ratio will soon be brought to 50:50 with the installation of a new continuous digester (Guha, 1969). The Star Paper Mills, Saharanpur (U.P.), INDIA uses a mixture of hardwoods and pinewood (Pinus roxburghii).

3.4 Raw Material Supply

Bamboo

About 72 per cent of the present production capacity of Indian Paper Mills is based on bamboo as the staple raw material (Bhargava, 1964). Information about forest areas under bamboo and their potential yields is limited. Bhargava (1967) estimated an annual supply of 3 million metric tons from the bamboo forests. This is only 35 per cent of the total annual bamboo harvest, the balance being absorbed by the domestic and constructional requirements. The rayon grade pulp mill in Kerala (India) with an annual capacity of 54,000 metric tons uses bamboo as the raw material. Since rayon pulp can be made even from short fibred hardwoods, the paper industry urged the Government of India to establish priorities for the use of bamboo as a raw material for the paper industry. Sizeable supplies of raw material for the economic establishment of new pulp and paper mills are available only in Assam, Kerala, Madhya Pradesh, Mysore, and Orissa states.

Straw, Rags, and Waste Paper

Information about the actual consumption of each of the other raw materials viz. waste paper, rags, andhemp is not available but it has been estimated that about

100,000 metric tons of pulp is produced from those raw materials (Bhargava, 1964). The estimated availability of rice and wheat straw is 65 million metric tons of which 32 million metric tons is consumed on the farm (Manmohan Singh and Mukherjia, 1965). However, in India straw is not used for paper making because of the large costs involved in collection.

Coniferous Woods

Excepting chir pine, all other Indian conifers occur in the mountainous Himalayan region, at elevations greater than 300 meters above the mean sea level in the states of Jammu and Kashmir, Himachal Pradesh, Punjab, and Uttar Pradesh. Most trees are over mature and decay is common. Natural regeneration is inadequate. Removal of the crop poses a serious problem of soil erosion. It was estimated that about 0.4 million metric tons may be available annually (Bhargava, 1964). Increasing amounts of coniferous wood through improvized harvesting machinery and chip transportation through polyethylene pipes was suggested by Stracey (1968), but its feasibility in the capital starved Indian economy is doubtful.

Bagasse

Regarding the production of bagasse, the present annual production of 4.5 million metric tons is consumed in the sugar factories as fuel for steam and power generation. It can be released for pulping if an alternate fuel is made available to the sugar factories. Use of fuel oil is not only more expensive, but the boilers have to be modified accordingly at extra cost. However by improving the steam economy of the factory, some bagasse can be released for paper industry to the extent of 15-20 per cent of the weight of bagasse produced at each factory (Bhargava, 1964).

Depithing and baling equipment is necessary to make use of this surplus bagasse. At present bagasse offers the most promising raw material resource for meeting the short term crisis in paper production. The Simon-Cusi process for pulping bagasse is under active consideration by the Government of India.

Jute Sticks and Grasses

It has been estimated that over 4 million metric tons of jute sticks are produced annually in the states of Assam, Bengal, Bihar, Orissa, Uttar Pradesh, and most of it can be diverted to the paper making industry (Bhargava, 1966). Since cultivation of jute is confined to few localities, its collection is cheaper than bagasse but, because of its bulk, the transportation costs are high. Among grasses, Sabai (Eulaliopsis binata) was used to the extent of 25 per cent of the total fibrous raw material requirement in India (Manmohan Singh and Mukherjia, 1965). Due to increasing costs of collection and demand for domestic use such as thatching, the use of a single species of grass is found uneconomical. Though mixture of grasses, found in large scale mechanized plantations of tree species, can offer a potential source of raw material, the availability of the supplies is not known.

Hard Woods

About 97 per cent of the Indian forests are comprised of hard woods of which 60 per cent by area is presently exploitable. Nearly 500 million cu.m. of industrial and fuel woods are extracted from these forests. This is only a fraction of available supplies. However, these raw materials are not suitable for the pulp and paper industry because of the extremely heterogenous mixture of the trees with different physico-chemical properties. Under the direction of the United Nations

Food and Agricultural Organization, a pre-investment survey is being carried out in India. It is being investigated to find a suitable mechano-chemical pulping process to utilize "Mysore hybrid" (E. tereticornis) plantation wood. Nautiyal (1965b) has made a study of the pulping of eucalyptus. There will be no dearth of short fibred raw material in the near future as most of the indigenous species are good coppicers.

3.5 Requirements of Raw Material

It is evident that there is a shortage of long fibred raw materials. At present, due to low level of industrial activity the percentage consumption of cultural papers has been higher than that of industrial papers. It may be seen from Table II there is a decrease in the relative consumption of cultural papers with a corresponding increase in industrial paper consumption. However, it is very necessary to increase the supplies of long fibred raw materials to meet the growing demands of cultural papers, particularly newsprint (India imports 60 per cent of her newsprint requirements). Nautiyal (1965a) and Bhargava (1967) have suggested that India will experience shortages in the supplies of long fibred as well as short fibred raw materials from 1980 onwards.

CHAPTER IV

FOREST RESOURCES AND DEVELOPMENT IN ANDHRA PRADESH FOR MEETING THE DEMAND FOR PULP AND PAPER

Forest products can be broadly classified as (i) fuel wood and (ii) industrial wood. The present consumption and future demand of industrial wood as estimated by Von Monroy (Forest Research Institute, 1961) is shown in Figure 3. The state of Andhra Pradesh occupies about 8.5 per cent of the total geographical area of India with a similar percentage of population and forest area. The relative position of Andhra Pradesh in India in supply and demand of fuel wood and industrial wood is shown in Figure 4.

Agriculture is the main occupation of the people of Andhra Pradesh, which constitutes 50 per cent of the provincial economy, and the main industries in the state are based on agricultural products. Intensive agriculture is practiced in the delta regions of Godavari and Krishna rivers. Rice, the staple food of the people, is grown over large areas. Cash crops such as tobacco, sugar cane, chillies (hot peppers), and pulses are also grown. Nearly 80 per cent of the population live in rural villages and raise large cattle herds. The impact of the human and cattle population on the adjacent forest areas is affecting the productivity of the forests. Heavy grazing by cattle in the forest areas impedes the growth and establishment of natural tree regeneration and also affects the soil structure. Indiscriminate felling of small trees for fuel and domestic requirements adds to the burden on the forests. Nearly 65 per cent of the total harvested bamboo is utilized as fuel and for building huts and agricultural implements.

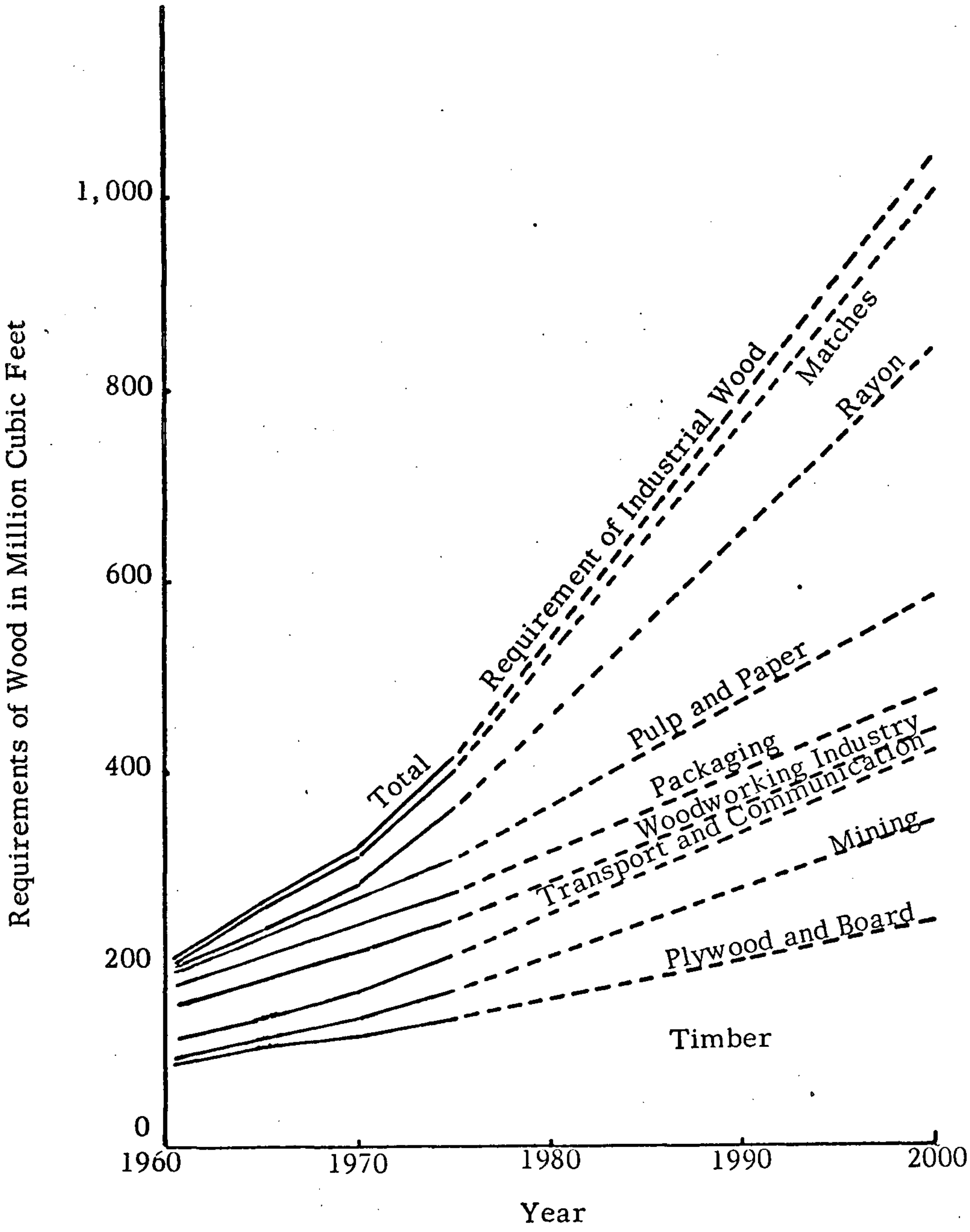

Figure 3. Expected requirements of industrial wood. (Based on von Monroy as given in Forest Research Institute, 1961).

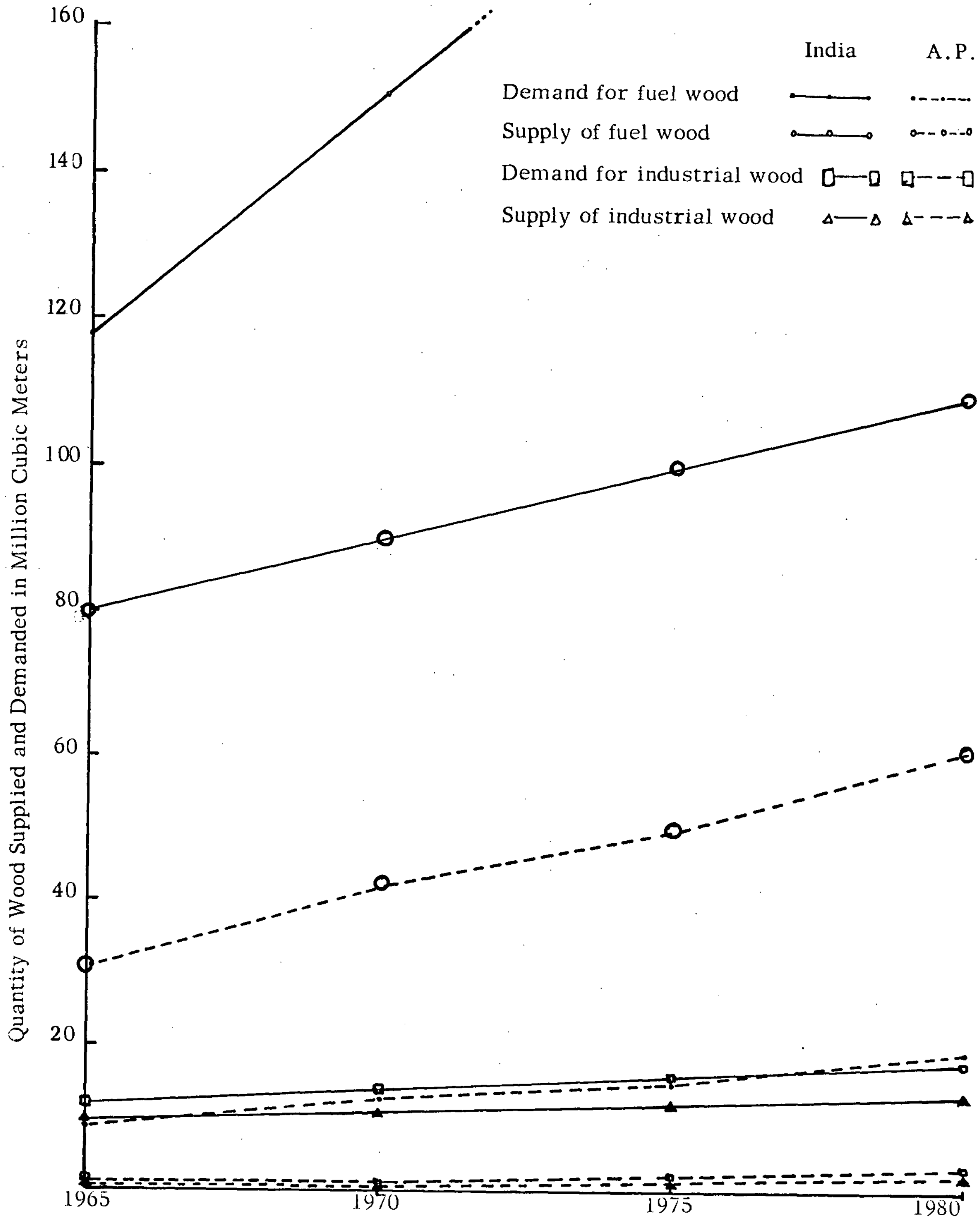

Figure 4. Supply and demand of fuel and industrial wood in Andhra Pradesh and India. (From Our Forests, 1968).

4.1 Forest Resources

There are a number of species of economic importance occurring in Andhra Pradesh. The principal tree species are listed below in the order of importance:

1. Teak (*Tectona grandis*, Linn.)
2. Red Sanders (*Pterocarpus santalinus*, Linn.)
3. Sandal Wood (*Santalum album*, Linn.)
4. Maddi (*Terminalia tomentosa*, W. and A.)
5. Tirman (*Anogeissus latifolia*, Wall.)
6. Yepi (*Hardwickia binata*, Roxb.)
7. Kodisa (*Cleistanthus collinus*, Benth.)

The principal tree species yielding construction timber are teak, maddi, and yepi. Though teak is in great demand for railway sleepers (ties), less important species like yepi and maddi are being supplied to the railways in increasing quantities. A number of other species are used in cottage industries viz. Sundra (*Acacia Sundra* syn. *A. Catechu*, Willd.) in the manufacture of katha and cutch. Katha is the heartwood extractive used for eating with betel leaves. Cutch is the secondary product, containing catechin, used in dyeing. Gutel (*Wrightia tinctoria*, R. Br.) is used in toy making, and rela (*Cassia Fistula*, Linn.) in tanning.

4.2 Forest Development

A century of scientific forestry practices have brought much of the forest area under systematic management. The setbacks due to two world wars and subsequent forest clearance under the "grow more food" campaign after independence have been only partly overcome. Special rehabilitation measures, afforestation and reforestation works were undertaken, but the budget provided was inadequate to meet the requirements. Development work in forestry started in 1951 with the commencement of the first five-year plan. Plantations of fast growing species, particularly of eucalyptus and bamboo, were started to meet industrial requirements. The extent of plantations of various species in Andhra Pradesh is given below:

Name of Species	During 1961 to 1966	During 1966-67
Teak	7,180 ha.	2,831 ha.
Casurina equisetifolia	3,124 ha.	651 ha.
"Mysore gum" (E. tereticornis)	2,093 ha.	1,554 ha. (Mysore gum and Bamboo combined)
Bamboo (D. strictus)	1,792 ha.	
Red Sanders	233 ha.	46 ha.

The overall financial activity of the Forest Departments of Andhra Pradesh and India can be visualized from Figures 5 and 6.

It has been made evident earlier in this thesis that steps should be taken to meet the growing demand for cultural papers by supplying suitable raw material to the industry. The low productivity of the forests is due largely to low investment in forestry and to the pressure of population. Though it is most economical in terms of financial returns to practice intensive forestry in areas of highest productive capacity (Bhadran, 1960), it is also necessary to raise the ecnomic value of the vast dry deciduous forests of Andhra Pradesh. It may be desirable to invest in plantations of quick growing species suitable for pulping in more favourable regions of India, manufacture the paper and distribute to the states which are in need of it. But forestry being the subject matter of the state, the Federal Government encourages the growth of the regional economy by providing funds for raising plantations of suitable species in the vicinity of the existing paper mills.

Figure 5. Revenue and Expenditure of Andhra Pradesh Forest Department in Millions of Rupees. (Based on Our Forests, 1968.)

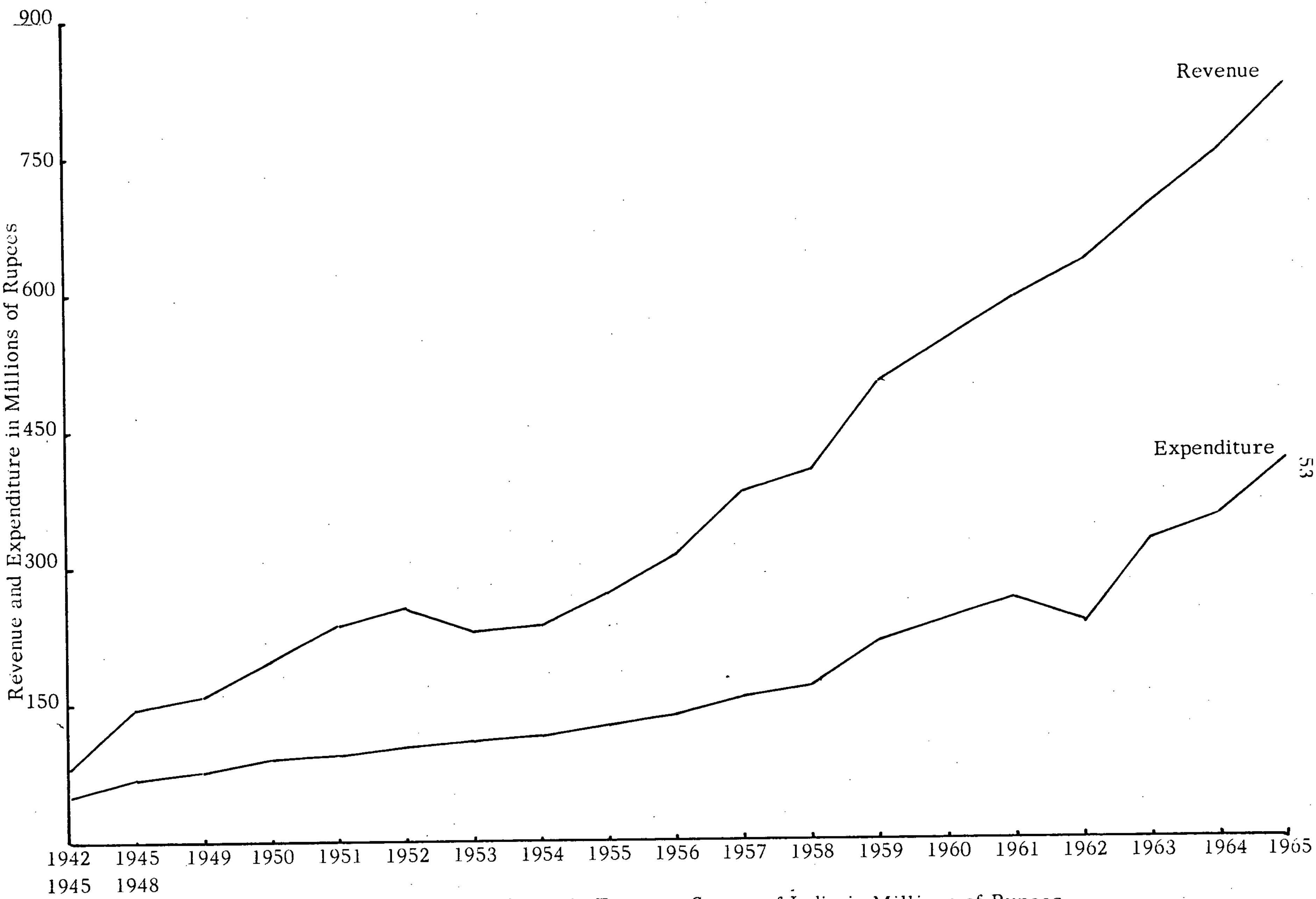

Figure 6. Revenue and Expenditure in Forestry Sector of India in Millions of Rupees.
(From F.R.I., 1961.)

4.3 Basis for the Choice of Species

The choice of a suitable species for supporting the pulp and paper industry, in a successful plantation programme should have the following requirements:

1. The species should be able to grow with minimum care in the climatic conditions of the state.

2. The whole process of harvesting, collection, transportation, and pulping should be economical and the pulp produced should be of the quality to make desired end products.

3. The species should come under the category of quick growing species as they alone can be harvested on a short rotation. The quick growing species meet the problem of raw material shortage and also give a reasonable return on the invested capital.

Quereshi (1968) suggested that for Indian conditions, the species might yield ten cubic meters per hectare (150 cu. ft/Ar) annually or in younger plantations the height increment should be 60 cm. per annum. In Tables XVIII and XIX a list of species which fall under the definition of quick growing species is given. A species which has a mean annual increment of ten cubic meters per hectare at an early age is decidedly preferable if the desired type of material is available at that age (Quereshi, 1968). For example chir pine (Pinus roxburghii, Roxb.) reaches 10 m^3 ha. at an age of 80 years while Gmelina arborea, Linn. attains double this increment at the age of six years.

Aung Din (1966) and Hughes (1968) suggested that Gmelina arborea is the best all round tropical pulpwood considering growth rate and fibre properties. Lamb (1966) suggested that Cedrela Toona, Roxb. is the most important fast growing

TABLE XVIII

AGE AND INCREMENT OF SOME FAST GROWING INDIGENOUS SPECIES

(From Quereshi, 1968)

Name of Species	Age Years	Stem & small wood Vol. per ha. (cu.m.)	M.A.I./ha. (cu.m.)
Alnus nepalensis, Don	22	357.907	16.269
Artocarpus Chaplasha, Roxb.	10	163.9	16.39
	14	276.6	19.76
	19	294.1	15.48
Casuarina equisetifolia, Forst.	5	75.3	15.06
	5	92.6	18.53
Cedrela Toona, Roxb.	9	139.2	15.47
	14	235.2	16.80
Chickrassia tabularis, Adr. Juss.	32	247.491	7.734
Dalbergia sissoo, Roxb.	11	-	33.73
Duabanga sonneratiodes, Ham.	47	889.484	18.925
	26	325.580	12.522
Gmelina arborea, Roxb.	3	64.7	21.57
	6	137.8	22.96
	11	168.7	15.34
Michelia Champaca, Linn.	8	146.0	18.25
M. oblonga, Wall.	14	245.0	17.50
Shorea robusta, Gaertn. (coppice)	30	-	10.99
Tectona grandis, Linn.	10	-	12.25
Terminalia myriocarpa, Heurck and Muell	8	122.7	15.34
Trevia nudiflora, Linn.	13	165.3	12.72
	18	175.1	9.73

TABLE XIX

RELATIONS OF CROP AGE, CROP DIAMETER AND VOLUME INCREMENT OF THREE FAST GROWING SPECIES

(From Quereshi, 1968)

Species	Crop Age (Years)	Average Crop Diameter (cm)	M.A.I. (Cu.m./ha.)
Bischoffia javanica, Blume	7	4.5	13.22
	10	5.6	12.10
Kydia calycina, Roxb.	10	10.0	10.50
Terminalia tomentosa, W, and A.	4	3.0	10.04
	7	4.8	14.95
	12	7.5	16.95

tropical hard wood. But unfortunately most of the species listed in the table were not found suitable for the climate of Andhra Pradesh. However,it is possible and even desirable to develop some kind of exchange economy with neighbouring states by investing in plantations of these species in favourable localities. Teak is too valuable to be used for pulpwood. Casuarina equisetifolia can be grown only in the coastal mangroves and is valuable as fuel. Maddi (Terminalia tomentosa) is found as a common associate of teak, but the technique of raising maddi plantations is not known. Maddi is well distributed naturally and is a good coppicer, hence there is no urgent need to investigate the plantation technique of this species.

The only two species that are suitable for pulp and paper industry and also comparatively easy to raise in large scale plantations are bamboo Dendrocalamus strictus) and "Mysore gum" (Eucalyptus tereticornis?). Bamboo is a long fibred raw material and hence its importance is obvious. A more detailed examination of bamboo is undertaken in the following chapters. Eucalypts are short fibred and relatively unimportant, but "Mysore gum" has a high ratio of fibre length to diameter compared to other eucalypts (Nautiyal, 1965a). Fast grown eucalypt wood gives the best chemical pulp with very high bursting and tensile strength, but the tear factor of pulp made from young fast grown trees is low.

There are a few broad leaved indigenous species with pulp properties comparable to that of "Mysore gum" (E. hybrid). Sizeable proportions of trees of Albizzia lebbek, Dalbergia sissoo, Boswellia serrata, Ailanthus excelsa, Cassia siamea, Cleistanthus collinus, and Lagerstroemia parviflora are found in the decidous forests of Andhra Pradesh. The characteristic associates of teak viz. Terminalia tomentosa and Anogeissus latifolia have been found suitable for pulping and are found in adequate quantities. The ranking of the above hard woods for pulping has been discussed in the previous chapter. All these species are good coppicers, particularly the associates of teak, but the technique of raising plantations of these species has not been seriously studied. Because it is desirable to have an assured supply of homogenous raw material "Mysore gum" has been extensively planted in this state. Its fuel value and fast growth potentially may add to the value of the otherwise inferior thorny scrub forests. The management costs for plantation are low compared to natural forests. However, the general climate of India and particularly of Andhra Pradesh is not favorable to the growth of eucalypts. There is considerable damage to the plantations by white ants which damage the root system but nevertheless it is an important species for plantation.

CHAPTER V

SUITABILITY OF BAMBOO AS RAW MATERIAL FOR PULPING

Development of uses of bamboo in paper making has been discussed in the Proceedings of the Food and Agricultural Organization of the United Nations (1962). Though paper was said to have been made from bamboo 2,000 years ago in China, it was only in 1875 that bamboo was discussed as a raw material for paper making in India, through an article by T. Routledge. Two stage fractional digestion for pulping bamboo was developed by W. Raitt during 1909-1915. By 1922 the India Paper Pulp Co. manufactured writing and printing paper from bamboo. Now India produces the highest quantity of bamboo pulp in the world. It is the cheapest raw material for making pulp and even more economical than bagasse (Streyffert, 1968).

5.1 Physico-Chemical Properties and Pulp Yields

Bamboo is the only long fibred raw material available all over India. The long fibred conifers, from which the bulk of the world's pulp is produced, can only be grown in the mountainous Himalayan region in India. Although a variety of bamboos are used for pulping, Dendrocalamus strictus and Bambusa arundanacea comprise the bulk of the raw material. The fibre length varies with species and within species as do the tracheids in the conifers. Bamboo fibres are round, short, and stiff. The fibre properties of different Indian bamboos, the proximate chemical analysis, and pulp yields are given in Tables XX, XXI, and XXII. The frequency distribution of fibres of five species is shown in Figure 7.

TABLE XX

FIBRE DIMENSIONS OF FIVE IMPORTANT INDIAN BAMBOOS

(Based on Ono, 1962; Ueda, 1960)

Name of Bamboo	Fibre length (in mm) Max.	Min.	Av.	Fibre dia. (in microns) Max.	Min.	Av.	Length (mm) / dia. (microns)
Dendrocalamus strictus, Nees.	5.5	1.0	3.06	35	5.5	19.8	100.5
Bambusa arundanacea, Willd.	4.05	0.67	2.73	55	16	30	-
Melocanna bambusoides, Trin.	4.75	1.0	2.72	-	-	-	115.2
Ochlandra travencorica (syn. *O. bradisii*)	9.0	1.00	4.03	-	--	-	-
Phyllostachys reticulata, C. Koch.	3.66	0.21	1.57	34.6	5.7	13.4	116.4

TABLE XXI

PROXIMATE CHEMICAL ANALYSIS OF BAMBOOS*

(From Ueda, 1960; Ono, 1962)

Name of the bamboo (place)	Ash	Silica	Coldwater Solubles	Hot water Solubles	Alcohol-Benzine Solubles	Ether Solubles	Caustic Soda 1% Solubles	Pentosans	Lignin	Cellulose
Dendrocalamus strictus	2.10	-	4.20	5.93	0.25	0.56	15.00	19.56	32.20	60.80
D. strictus (Bihar-India)	1.80	0.47	5.15	7.85	1.80	1.47	23.18	15.84	23.89	52.99
D. hamiltonii	1.80	-	2.47	4.42	0.28	0.27	20.81	21.49	26.21	63.26
D. longisphathus	2.45	-	2.30	5.07	1.22	0.80	19.76	19.47	24.54	62.96
M. bambusoides	1.87	-	3.26	6.48	1.43	0.81	18.97	15.13	24.13	62.25
B. arundanacea	3.26	1.79	4.59	5.95	1.32	0.82	19.35	19.62	30.09	57.56
Ochlandra travencorica	2.60	2.11	3.59	5.13	2.19	0.75	19.98	17.84	26.91	61.76
Gigantochloa a pus (Indonesia)	2.75	0.37	5.2	6.4	1.4	-	25.1	19.3	24.9	67.8
P. reticulata (Japan)	1.24	-	6.3	9.4	4.3	-	24.6	21.2	22.2	69.8
Cephalostrachyum pergracile (Burma)	2.51	-	9.8	11.8	6.7	-	29.3	17.5	19.8	66.5

*All results are expressed as a percentage of the oven dry weight of bamboo.

TABLE XXII

PULP YIELDS OF A FEW BAMBOOS

(From Inoue, Keijiro, 1962)

Species	Total NaOH per raw material %	Unbleached pulp %	Bleached pulp %
Phyllostachys reticulata, C. Koch	18	40.90	38.40
Dendrocalamus asper, Backer	18	45.70	43.00
Gigantochloa a pus, Kurz.	18	49.50	46.50
G. nigraciliiata, Kurz.	18	49.90	46.90
G. verticillata, Munro	18	45.40	42.70
Bambusa vulgaris	18	44.40	38.00
B. Bambos, Druce	18	44.10	41.50
Cephalostachyum pergracile, Munro.	18	44.80	42.10
Melocanna bambusoides, Trin.	18	42.50	-
Pinus densiflora	22	43.70	41.10

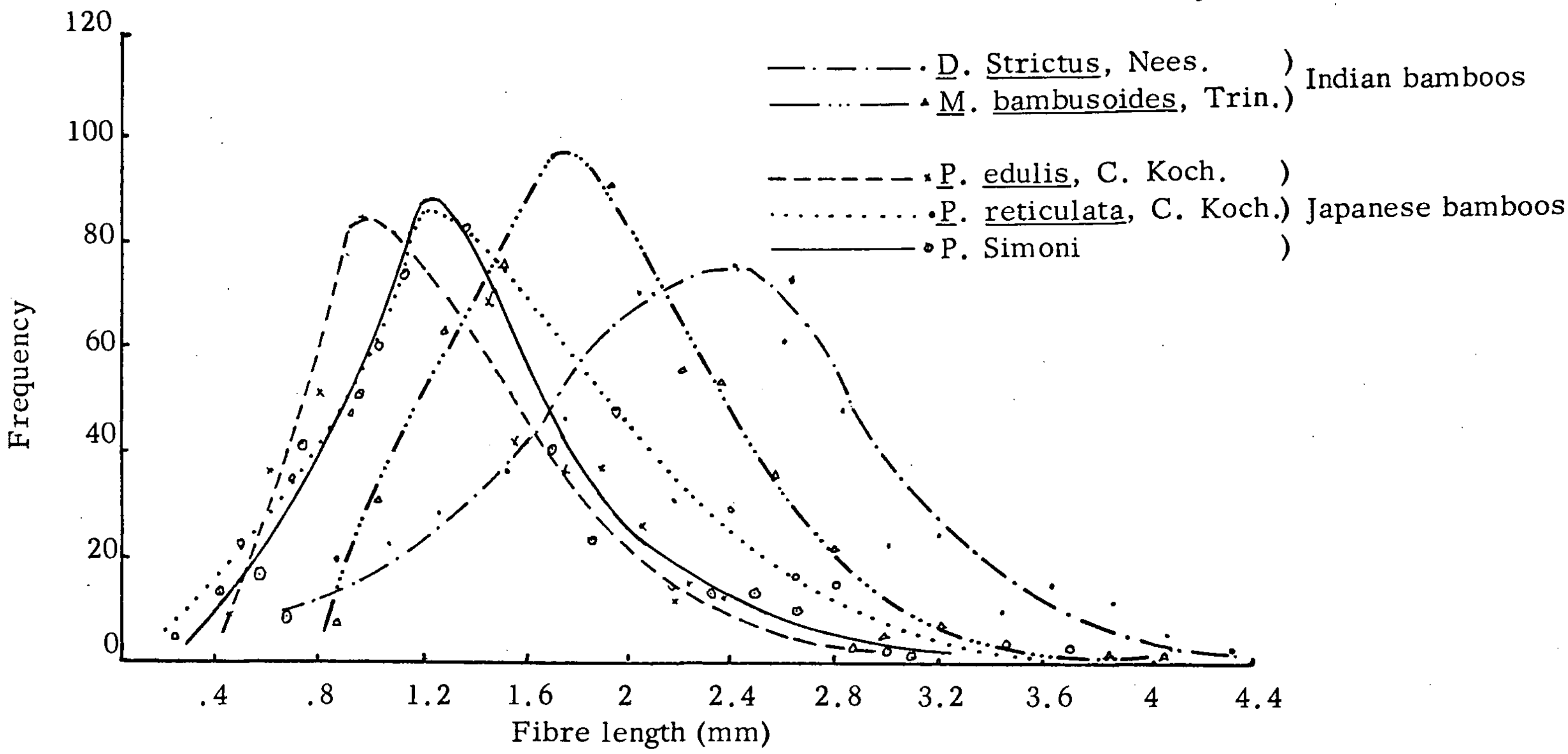

Figure 7. Frequency Distribution of Fibre Lengths of Five Bamboos. (From Ono, Kajuki, 1962)

5.2 Pulping of Bamboo

The arrangement of fibrovascular bundles influences the liquor penetration, yield, and quality of pulp. The strength of bamboo paper increases with the proportion of pentosan. In the bamboo nodes some of the fibrovascular bundles run perpendicular to the culm and the internodes, and this affects the pulping of the internode. Bamboo fibres also have pits which serve as lateral conduits. Contrary to the findings of Deshpande(1953), liquor penetration in bamboo chips is fairly satisfactory (Ono, 1962).

The Japanese bamboos have high hemicellulose content and hence high pulp yields. However, the tropical bamboos are superior in fibre content. The African bamboo Oxytenanthera abyssinica, Munro. has the highest yield of pulp (48 per cent). In conventional pulping the parenchyma cells were lost, hence bamboo fibres are separated mechanically and then pulped separately. The specific gravity of bamboo varies from 0.73 to 0.85 and since this is higher than conifer woods, the digester capacity is raised by 20 per cent. The yield of pulp from the several kinds of raw material which could be produced over one hectare in a year in Japan is as follows (Ono, 1962):

Spruce (on 50-year rotation) 0.3 to 0.5 metric tons of pulp/ha./year

Red pine (on 30-year rotation) 0.7 to 1.6 metric tons of pulp/ha./year

Bamboo 1.9 to 2.2 metric tons of pulp/ha./year or 7.5 to 9.6 metric tons of fresh bamboo/ha./year.

Bamboo consumes a low quantity of chemicals and the time required for digestion is also short. Delignification is easier compared to conifer woods, and the absolute quantity of alkali to be added is small. High silica content in bamboo is no longer a problem for recovering the alkali. Bleaching of bamboo pulp is easier than that of coniferous wood pulp (Inoue, 1962). It is desirable to use bamboo stored for two to three months since the soluble saccharides and moisture content is at the lowest after two months. Strength of paper made from decayed bamboo is lower but there is no appreciable difference in yields from fungus attacked bamboo (Bakshi et al., 1968). It is easier to chip mature bamboo and hence three to four year old bamboo is used.

Groundwood pulping of bamboo is not feasible. Bleached sulphate pulp from bamboo can be mixed with pulps of light coloured hard wood for making newsprint. Bamboo pulp is most suited for making high quality writing and printing paper with good ink absorbing property and print clarity. High α- cellulose pulp from D. strictus can be prepared by the water prehydrolysis sulphate process using a multistage bleaching process.

5.3 Research in Bamboo Pulping

Recent researches have shown that 75 per cent pulp yield can be obtained with satisfactory strength properties by steaming the bamboo chips before digestion (Mukherjea et al., 1967). Pande (1965) has shown a modified sequence producing bleached pulp with 98 per cent α-cellulose. Bamboo dust, produced at the time of making chips can be used for making wrapping paper by mechano-chemical process (Guha, 1966). However, bleachable grade pulps produced from bamboo dust have low strength. Continuous digestion of mixed hard woods and bamboos is carried out on a commercial scale in certain papermills. Newsprint was made in a pilot plant with 80 per cent eucalyptus groundwood pulp and 20 per cent bleached sulphate pulp from bamboo.

The distribution of polymerization degree of bamboo cellulose,which is a maximum at 2,000,is quite homogenous. This is the reason why bamboo promises a bright future as raw material for rayon pulp (Ono, 1962). However, in India, there are strong arguments against the use of bamboo as the raw material for rayon industry. The most important one is that as rayon can be made from short fibred hard woods; in the national interest long fibred bamboo should be diverted from rayon production to paper production. Secondly, with the advent of synthetic fabrics like terylene and nylon, there are no prospects for the rayon industry.

CHAPTER VI

GROWTH, YIELD, AND MANAGEMENT OF BAMBOOS

There is much of value in the literature although many seemingly original papers offer little more than a restatement of facts published previously (Robert, 1963). Much of this chapter is from the report made by R.R.Yeada (1969).

6.1 Growth and Habitat

Bamboos are a group of perennial giant grasses belonging to the family *Graminae* and tribe *Bambusoidae*. Though bamboos are distributed over much of the world, they are natural to South East Asian countries, flourishing in monsoonic climates with average annual rainfall of 1016 mm and mean annual temperature of 36^{o}C (Raizada and Chatterji, 1956; Hubermann, 1959). The various species of bamboo have well defined habitats, following the distribution of rainfall, often forming excellent indicators of forest types. Bamboos are usually found associated with tree species, but pure bamboo forests occur only due to edaphic or biotic factors.

Bamboo propagates asexually but it flowers either sporadically and/or gregariously. Bamboo seedlings develop an underground rhizome where the manufactured food is stored. The rhizome spreads outward from the centre and with advancing age tends to proceed in one direction only which is that most favourable to the growth. Two kinds of buds appear on the rhizome, the scaly pointed buds which appear before monsoon remain underground as rhizome and the culm buds, which appear in winter, emerge in early rains as a culm (Krishnaswamy, 1956). The rate of emergence and the total height reached within a few days of monsoon showers depend upon the clump size or the age of the rhizome. A group of culms attached to a rhizome is called a clump.

The bamboo culms grow by elongation of the internodes and the growth is nearly complete within 8 - 12 weeks from the date of emergence. The rate of growth is rapid when the culm reaches a height of 1.5 to 2.0 meters. The greatest elongation of the internode is in the lower middle portion of the culm and within the internode the maximum growth is at the basal portion (Tomar, 1963a). There is no secondary or radial growth due to the absence of cambium. For temperate bamboo like Phyllostachys edulis, C. Koch. a maximum length increment of 87 cm. per day was reported (Tomar, 1963a). The erect bamboo in India (Dendrocalamus giganteus, Munro.) grows up to 30 meters in height and 18 cm. in diameter. The age of the culm is known from the colour of the sheath or from the bloom on the culm. The life of the culm varies from 7 to 10 years.

Dendrocalamus strictus, Nees. and Bambusa arundinacea, Willd. are the two clump forming bamboos which are of economic importance to India. Melocanna bambusoides, Trin., the runner type is found in heavy rainfall zones and is an important bamboo in the north eastern region of India. D. strictus is the most widely distributed bamboo in the vast dry deciduous forest of India and is also the most thoroughly studied species among bamboos. The optimum number of clumps per hectare in natural conditions was found to be 150-200 and each clump gives out 10-20 new culms during the growing season. The diameter and height of the culms depend upon the size and vigour of the clump and also the timing and intensity of rainfall.

6.2 Protection Against Injury, Insects, and Fires

Cattle and wild animals, particularly elephants, cause considerable damage to bamboo forests. Because of the subterranean rhizome, bamboo clumps are not killed by bush fires. On green bamboo insect attacks are not noticed except those caused by Chrysomelid borers. Dinoderus species may attack felled bamboos and render them useless (Ahmed, 1954). Spraying of D D T and Gammaxene would prevent the damage from Dinoderus on stored bamboo.

6.3 Flowering in Bamboos

Gregarious flowering in bamboo is considered to be physiological when the entire bamboo area flowers irrespective of age, then seeds and dies. The physiological flowering cycle of bamboo varies with species and for the same species in different climatic zones. For D. strictus, the flowering cycle is 21 years in Maddhya Pradesh, 28 years in Madras, and 28 years in Uttar Pradesh (Krishnaswamy, 1956). Sporadic flowering is either confined to few clumps or to a few culms in the clump. Sporadic flowering of D. strictus is more common on dry, coarse grained soils while gregarious flowering is regular in fine textured soils (Yadav, 1963). Krishnaswamy (1956) reported the flowering of seedlings in the nursery along with the gregarious flowering of the bamboo forest from where the seed was collected. For this reason precautions should be taken in raising large scale plantations by raising nursery stock with seed obtained from different geographical regions. There is apparently no difference in growth rates or in clump formation of the bamboos so raised, but further study of provenance effects may be needed.

6.4 Physical and Mechanical Properties and Economic Uses of Bamboos

Bamboo has high strength values relative to weight and size. The mechanical properties of important bamboos of India have been studied by Limaye (1952) and discussed by Sekhar and Bhartari (1960). There is a strong correlation between specific gravity, lignification with age, and strength properties of D. strictus bamboo. The culm attains mechanical maturity within 2 1/2 years, and lignification is complete within four months. These two factors are very important in pulping of bamboo.

Bamboo is said to be poor man's timber as it not only meets the domestic needs for wood, the bamboo seed also has food value. Though a number of bamboo cottage industries are developed in Japan to make products such as slide rules, gramaphone needles, bamboo curtains, the only cottage industry of any importance in India is wicker work. Use of bamboo springs in making furniture for low income groups, use of bamboo rejects in making pencil slats and in match industry, was demonstrated by Rao (1961). Because of its shallow rooted rhizome network, bamboo was found suitable for soil conservation work.

In the South East Asia, the greatest industrial use of bamboo is in the pulp and paper industry, including a limited use in making rayon grade pulp. Bamboo is the only long fibred raw material available all over the deciduous forests of India, which comprise about 80 per cent of the Indian forests. The yield and quantity of pulp is satisfactory and best suited for writing and printing paper. Though adequate quantities of bamboo are found in many countries, pulping of bamboo is done in only a few countries. The Karnaphuli paper mill in East Pakistan produces 100 tons per day using 300 tons of air dry bamboos (McClure, 1956). In Thailand bamboo pulp is blended with straw pulp for making paper, and Cambodia produces 5,000 tons of pulp from bamboo and straw.

6.5 Bamboo Potential Surveys in India

In view of the increasing demand by pulp and paper industry, it was necessary to assess the bamboo resources of the nation. Bamboo potential surveys have been carried out in most of the states in India and All India Cooperative Investigations were conducted to arrive at a satisfactory felling cycle and cutting intensity. The demand for bamboo is of three kinds viz. (1) local demand, (2) commercial requirement, and (3) industrial demand. Only 35 per cent of the total bamboo harvested annually is used in industry. The survey used the statistical technique of stratified systematic line plot sampling with a random start. The results of a few surveys are given here to indicate the yields from natural forests. The yield position in Gujarat and Mysore states is given in Tables XXIII and XXIV.

In the state of Madhya Pradesh, a forest rich state, bamboo is found as an associate of teak, with luxurious growth. Two quality classes have been recognized. Bamboo Quality I has a merchantable length of 15'-20' with 5"-6" basal girth, while Quality II has a length 12'-15' and basal girth of 2"-4". The average number of clumps per acre for Quality I bamboo is 132 and for Quality II bamboo is 35. The lower number of clumps per acre for Quality II bamboo is apparently due to the unsuitability of the site for bamboo growth. Bamboo bearing areas are defined as those which produce 125 culms per acre per year. They are further classified as moist and dry types, receiving 45 inches or more rainfall and less rainfall respectively. In each type two classes are distinguished. Heavy yielders are those producing 250 culms per acre per year and poor yielders are producing 125-250 culms per acre per year.

One acre of moist type heavy yielder is taken as standard area (= half ton

TABLE XXIII

RESULTS OF BAMBOO ENUMERATION IN FORMER BARODA STATE, GUJARAT

(From Chaudhari, 1956)

Locality	Total acres	Net bamboo acres	Av. no. clumps/acre	Av. no. culms/clump	Total per acre No. culms	Total per acre Tons	Girth 1.5 ft above ground	Av. lbs per culm
Tapti	118,673.5	71,196	125.25	12.04	1508	5.219	4.3	7.75
Vajpur	167,254.5	93,466	115.10	13.41	1544	5.338	4.3	7.75
Nanchal	164,286.3	30,600	62,33	16.06	1001	3.349	4.4	7.50
Nessu	196,668.0	16,881	109.50	15.10	1654	5.525	4.1	7.50
Sadadwal	115,630.5	27,625	138.77	14.60	1426	4.760	4.2	6.25

TABLE XXIV

YIELD OF BAMBOO IN ADJOINING BELGAUM AND DHARWAR DIVISIONS–MYSORE STATE

(From Chaudhari, 1956)

Locality	No. of green bamboos/clump Age			Annual increment per clump (numbers)	Green wt. of increment per 1000 clumps (tons)	Dry wt. of increment per 1000 clumps (tons)	Name of species
	1 season	2 seasons	mature				
Virnoli and Kugli	2.33	4.14	6.73	3.24	88	59	*B. arundanacea*, Willd.
(Belgaum Division)	(3.42)	(5.87)	(8.28)	(4.65)	(15)	(10)	*D. strictus*, Nees.
Dandeli	4.19	3.93	3.34	4.06	44	29	*B. arundanacea*
(Dharwar Division)	(4.72)	(5.48)	(8.82)	(5.10)	(16)	(10)	*D. strictus*

of air dry bamboo). To this standard, all the bamboo areas are reduced. The standard area in square miles multiplied by 320 gives the annual production in tons of air dry bamboo (Mishra and Chakravarti, 1961). Yields in three felling series in Raigarh Division (Madhya Pradesh) worked on 6-year felling cycle are as follows:

Felling Series	1st Felling Cycle No.	1st Felling Cycle Wt. (in tons)	2nd Felling Cycle No.	2nd Felling Cycle Wt. (in tons)
Taraimal	197	0.39	394	0.79
Gajmar	240	0.84	564	1.13
Bargarh	365	0.73	294	0.59

The overall increase in yield in the second felling cycle is attributed to systematic fellings in the previous felling cycle.

In Madras state (now known as Tamilnadu) four density classes were distinguished according to the number of clumps per acre (John, 1961). Ranging from dense or pure class including areas with more than 50 clumps per acre to the poor class including areas with less than 10 bamboo clumps per acre. Four quality classes based on length and girth of culms were recognized and the results of a pilot survey are given in Table XXV.

In Maharashtra state two density classes based on the number of culms per clump and two quality classes were recognized. Quality Class I includes culms with over 1.5" in diameter and over 35' in length, while all those culms inferior to the above belong to Quality Class II. The average weights of D. strictus culm in three quality classes and three different conditions are given below:

TABLE XXV

RELATION OF QUALITY TO WEIGHT IN TWO LOCALITIES IN MADRAS STATE

(From Andiappan and Wilson, 1963)

Name of Species	Quality	Tirupattur Length (ft)	Tirupattur Girth (inches)	Tirupattur No. of bamboos per ton	Coimbatore Length (ft)	Coimbatore Girth (inches)	Coimbatore No. of bamboos per ton
Bambusa arundanacea	I	30-40	10 -12	90	45-55	12 -15	50
	II	25-30	7 - 9	150	35-45	9 -12	95
	III	20-25	5 - 7	320	30-33	8 - 9	160
	IV	15-20	3 - 5	1120	20-30	4.5- 7	320
Dendrocalamus strictus	I	15-20	5 - 6	260	20-40	5 - 6.5	450
	II	12-15	2 - 4	1120	13-15	3 - 5.5	750
	III	8-12	1.5- 2	2990	10-13	3 - 4.5	1000

Quality	Green Weight (in lbs.)	Dry Weight (in lbs.)	Weight of Dead Bamboo (in lbs.)
Super I	18.60	8.91	9.00
Average	9.54	5.45	4.80
Quality II	5.20	3.28	3.26

In summary, the yield of bamboos from natural forests in India is as follows (Ueda, 1960):

Species	Average No. / Hectare Clumps	Culms	Av. Dry Wt. Per Culm (kgs)	Yield/Hectare Per Year (tons)
D. strictus, Nees.	280	5,000	3.5	3.25
B. arundanacia, Willd.	250	5,000	10.0	5.00
M. bambusoides, Trin.	-	14,5000	5.0	5.75

No information is available regarding the yields from plantations as the bamboo plantations have been started only in this decade. The yields vary with the number of clumps per hectare. Bamboo plantations in Congo (Brazzaville) yielded 22 tons per acre after 4 1/2 years (Groulez, 1966). The species planted is Bambusa vulgaris.

6.6 Management of Bamboo Forests

The management of bamboo forests is beset with many practical difficulties, chief among them is the difficulty of supervision of felling according to rules. The size of the clump depends upon the species and locality factors rather than age. The number of new culms produced bears a linear relationship to the number of mature culms in the clump. The production of new culms as a percentage of old culms is higher for small clumps, probably because of the availability of more area and increased nutrient supply. However, the production of new culms increases with clump size and the optimum clump size is 60 culms (Tomar, 1963).

Two major considerations for the management of bamboos are (1) felling cycle and (2) cutting intensity. (Cutting intensity is the relation of mature culms to be removed to the total number of culms in the clump. Felling cycle is the period between two successive fellings in the same bamboo clump.) The considerations for felling cycle are (a) the minimum age at which a culm is exploitable, (b) age of full maturity of the culm, and (c) life period of the culm. For D. strictus bamboo, they are found to be 1, 5 to 6, and 7 to 8 years, respectively, and the felling cycle, obviously, should be 2 to 6 years (Seth, 1954). It was known from experience that the clumps worked under too short a felling cycle deteriorate quickly, and too long a felling cycle results in overcrowding and reduction in production. In India, for D. strictus bamboo, the felling cycle is three years in moist localities and four years in dry hilly tracts. A particular set of felling cycle and cutting intensity may not be best for all areas since the life cycle for the same species varies from place to place.

6.7 Felling Rules

Several decades of observation and experience have led to the formulation of detailed cutting rules for increased yields. It is very necessary to follow these felling rules carefully for sustained yield management of bamboo forests. The salient features of the rules are given here (Gupta, 1964):

1. The exploitation of the clump is from the side opposite to where the maximum production of culms is observed. Following a horseshoe pattern, the mature culms are removed.

2. All old, dry, and rotten culms are removed leaving only one year old

straight and vigorously growing culms and an equal number of straight and evenly spaced mature culms, if available.

3. In carrying out thinning on the periphery, all one year old culms are retained unless they are crooked.

4. At least 5-8 well spaced mature culms are left in the clump.

5. Sharp knives should be used in felling to avoid splitting of bamboo.

6. The culms are cut as low as possible, above the node to avoid collection of rain water and subsequent rotting.

7. Digging up of a clump for rhizome is forbidden. (Bamboo rhizomes make good walking sticks and are used for making polo balls, so their removal must be carefully controlled.)

8. Dressing (debranching and topping) of the culm should be done away from the clump to avoid fire hazard.

There is no specific season for felling bamboos for pulp and paper industry. However, no felling in the growing season (corresponds to rainy season in India) is allowed because of likely damage to the clump.

6.8 Yield Prescription

For sustained yield management, the yield should be independent of the new culms produced and Mathauda (1960) suggested prescribing the cyclic yield as a percentage of old culms. However, the maximum size of the clump should be economically workable and should not contain dead, broken, and unmerchantable culms (Tomar, 1963b). From an experiment conducted in bamboo forests of Andhra Pradesh by Raghavan (1964), it was observed that the yield of bamboos from well managed forests is thrice the yield from natural unmanaged forest.

Using the linear relationship of the new culms producted to the initial clump size (Yeada, 1969) has suggested a cutting intensity of thrice the number of new culms, on a four-year felling cycle for clump size of 30 culms, for maximum yield of bamboos during the entire life cycle of the clump. It is understood that management of the forests should carefully follow the felling rules. The felling cycle and cutting intensity are well suited for plantations where harvesting can be commenced no sooner than the clump attains the size of 30 culms. The annual yield per hectare with 150 clumps of that size is calculated to be 2.5 metric tons, without any intensive forestry practices.

6.9 Factors Influencing the Growth and Yield

Growth and yield of bamboo plantations are influenced by the following factors:

1. Site quality. This can be improved by (a) fertilizers, (b) irrigation, and (c) tilling of soil.
2. Spacing.
3. Tending and cultural operations.
4. Mixtures.
5. Felling cycle and cutting intensity combination.

Of the above, fertilization of bamboo plantations and raising of bamboos with eucalypts has promise and is economically feasible. Successful plantations with a mixture of bamboos and eucalypts have been raised in Dandeli (Mysore) to supply the West Coast Paper Mills. Fertilization of industrial plantations is rewarding because it increases the yield per unit area, lowers the transportation costs, reduces supervision costs and land taxes. By proper cultural operations and harvesting on scientific principles, an annual yield of ten tons of bamboo per hectare could be obtained from bamboo plantations.

Nitrogen is the most required element followed by potassium and phosphate and when used together in Japan the results are encouraging (Ueda, 1960). In Japan it was found that the maximum quantity of nitrogen that can be safely applied is 23 kg. At 35 kg. the culms become soft and to avoid this silica has to be added to the fertilizer (Numata and Ogava, 1959). The suggested dosage per hectare in Japan was N 100 kg to 200 kg (depending upon the quality of the soil), P_2O_5 50 kg to 100 kg and K_2O 50 kg to 100 kg. In India N:P:K is used in the proportion of 150 lbs:130lbs:25 lbs. per acre. The fertilizer is spread around the clump and covered with soil after the premonsoon showers. The cost of labour and fertilizer commensurates with the economic benefits accrued. Fertilizer application is carried out along with the first weeding and soil working in the plantation and the additional labour cost is not very high. Fertilization of bamboo plants boosts the growth rate, overtopping the grasses and weeds, thus reducing the costs of weeding.

6.10 Raising of Bamboo Plantations and Cost Per Ton of Bamboo

Bamboo plantations are usually raised by use of two-year old nursery seedlings. Rhizomes and polythene bag plants are used when the plantation site is far away from a nursery. Direct seeding is never done because of the low germination and plant per cent. The seedlings are planted in 30 cm. cube pits or in 90 cm. x 30 cm. x 30 cm. trenches at an espacement of 5 m. x 5 m. or 7 m. x 7 m. At the time of harvesting after 10 years, it is expected to have 150-225 seedlings per hectare. One hundred fifty clumps per hectare is considered to be optimum for good culm production in monsoon conditions. One kilogram of fresh seed will give enough seedlings for planting five hectares at 5 m. x 5 m. including the replacement of casualties.

The breakdown of the cost of planting is given in Table XXVI. On a large scale plantation programme, with a well established central nursery, the cost per hectare will be well under Rs500/. Since the rate of return is sensitive to the capital invested at the beginning, attempts should be made to keep the initial costs low. The cost of raw material delivered at mill site could be minimized by intensive management practices, a well laid out network of roads, and improved transportation techniques. Since bamboo is worked on a short felling cyle the cost of road per ton of bamboo removed will be reasonably low.

6.11 Need for Research

Research in the use of bamboo as a raw material for industry could involve either short term or long term projects. Under short term programmes, the possibility of releasing more bamboo from domestic consumption for industrial use exists by supplying alternate raw material for house construction and also by improving the life and utility of bamboo through chemical treatment. Suitable combinations of felling cycle and cutting intensity for all the bamboo areas have to be worked out. Under long run projects, choice of suitable species for different types, genetical and provenance studies and the relation of age to lignification for maximum cellulose extraction have to be studied. The possibility of introducing exotics _viz._ _Oxytenanthera abyssinica_, Munro. (African bamboo) and _Guadua angustifolia_ (Central America) to India should also be explored. Mechanization and use of various labour saving devices in harvesting also deserve study.

TABLE XXVI

ESTIMATED COSTS OF RAISING A BAMBOO PLANTATION

Item	Cost/ha. (in Rupees)
Survey and demarcation of planting area	0.15
Digging 60 cm. cube pits at 5m x 5m (400 pits)	70.40
Cost of two year old nursery seedlings (400)	400.00
Transport of seedlings to the site (400 seedlings)	18.75
Unloading and transport to planting spot	35.00
Cost of planting after puddling	7.00
Weeding and soil working	33.60
Replacing casualties (10%)	20.00
Miscellaneous viz. inspection paths, fire breaks, plantation boards, etc.	15.10
Total	600.00

CHAPTER VII

MEASURES TO STIMULATE THE GROWTH OF PULP AND PAPER INDUSTRY

7.1 Performance of the Industry in the Past

It has been shown that there would be an increase in demand for cultural papers with the spread of education. To meet this demand, the targeted capacity of the Indian paper mills by 1965-66 was 820,000 metric tons with a production of 700,000 metric tons. The actual production was only 560,000 metric tons with an installed capacity of 669,000 metric tons, indicating a fall of 23 per cent from the targets (Ghosh, 1967). The estimated demand of 1.2 million metric tons for paper and paper board by 1970-71 was based on annual growth rate of 12.5 per cent. In reality the annual growth rate is about 10 per cent, and at this rate the demand would be 800,000 metric tons (Ind. Pulp and Paper, 1967).

The importation of paper and paper board has been reduced because imports were allowed only if equalled in value by exports. For the production of export quality paper it is necessary to add imported pulp to the extent of 10 per cent to the stock and the economics of such export is hardly justified (Ghosh, 1967). The anticipated deficit from the targeted capacity by the end of 1970-71 is about 270,000 metric tons (see Table XXVII). From this it is apparent that the future targets can not be achieved unless remedial measures are taken to promote the growth of the paper industry.

7.2 Reasons for the Shortfall in Targets

Various reasons were given for the slow progress in pulp and paper industry.

TABLE XXVII

SHORT FALL IN CAPACITY IN THE PULP AND PAPER INDUSTRY-INDIA

(From Indian Pulp and Paper, 1966)

	Metric Tons
Capacity at the end of third five-year plan (1965-66)	679,220
Substantial expansion licensed	205,836
New large units in construction	15,000
	890,056
Substantial expansion approved in principle with letters of intent issued	86,800
New small mills licensed	50,000
	1,027,616
Targeted capacity for the fourth five-year plan (1966-71)	1,300,000
Capacity visualized	1,027,616
Deficit	272,384

The total eclipse of enterpreneurial interest in the paper industry was attributed to the following reasons (Ind. P. and P. 1967b):

1. An unrealistic price policy developed because selling prices of paper and board were fixed by Government. The production costs have been increasing continuously and the average price of industrial raw material rose by 29 per cent during 1966-1967 alone, while the price of paper was allowed to increase by only 10 per cent during 1966 to 1968. The control on selling price of paper was lifted in May, 1968.

2. A drop in profitability resulted from levies by Government, increased freight rates, and rising costs of power and fuel. The ratio of profits to net worth in paper industry as a whole after tax according to a Reserve Bank of India study for 1964-65 was 3.34 per cent as compared to the average ratio of 9.4 per cent for all industries (Ind. P. and P. 1967d). The ratio of profits to net worth during 1967 was 5.1 per cent compared to 10.8 per cent for all industries (Singhania, 1968). Though profitability is a desirable index of entrepreneurial activity, analysis of the industrial activity in the world during 1950-60 indicated that the average annual rate of change in industrial production in paper industry is lower than the aggregate of all industries (F.A.O., 1967). This is probably due to the high bulk and low value of the product as well as due to relatively slower growth rate in literacy and economic progress.

3. Doubts were raised as to the adequacy of supply of cellulosic raw material. If continuous digestion of mixed hard woods is adopted by the industry, there is no immediate dearth of raw material. However, to plan expansion it is necessary to have an assured source as the design and construction of the mill and equipment must provide for optimum utilization of the raw material. It may be too

expensive to modify or change the equipment for using different kinds of raw material every time.

4. There is difficulty in importing machinery in view of the stringent foreign exchange requirements. Lack of adequate domestic consulting engineering services in the pulp and paper industry and difficulty in procuring equipment and spares from indigenous sources are also responsible for the shortfall in targets.

7.3 Requirement of Capital

The demand for paper and paper board of 900,000 metric tons by 1970-71 represents a rise of 50 per cent over the 1967 production of 600,000 metric tons. The estimated capital requirement for achieving the additional capacity is Rs 900 million on the basis of a conservative estimate of Rs 3,000 per metric ton. The present level of activity indicates a possible increase of 150,000 metric ton production by 1970-71. It is necessary to accelerate the activity in pulp and paper industry to increase the capacity and total production to meet the targets. This is only possible by attracting capital by offering incentives so that the industry can earn a reasonable profit.

7.4 Bamboo Leases in Andhra Pradesh

Concessions to the industry can be given either at stumpage level or at the income level depending upon the conditions. In addition to centrally controlled imports protecting the price, power and raw material are supplied to the pulp industry at a concessional rate. In the state of Andhra Pradesh bamboo forest areas are leased out to the industry for twenty-one years charging only royalty on the quantity of bamboo removed. Royalty in India usually includes both stumpage and royalty as referred to in Canada. The lease period of twenty-one years is in conformity with the physiological life cycle of bamboos. Leases are granted to the paper mills which are within the geographical boundaries of the state. This, at times, leads to the shortages in raw material supply for the expanding paper mill. However, the mill can secure its additional requirement of raw material through negotiations with the forest contractor who holds a bamboo contract in the neighbouring state or the mill representative can bid for bamboo area in open auction. The cost of raw material excluding the costs of harvesting in such cases will be many times the royalty paid from the lease area of the mill.

7.5 Royalty

In Andhra Pradesh royalty per ton of bamboo is based on air dry weight at the final loading point. Moisture content of each load is determined by random sampling and then converted to air dry weight by a suitable conversion factor for the determination of royalty. Though the royalty paid by the industry to the forest department is only a fraction of the market value, the way the royalty is levied discourages the incentive for intensification of bamboo management. A suitable procedure has to be evolved to provide a fair return to all agents of production.

The lessee (paper mill) has to spend more money to employ skilled labourers and to follow the felling rules carefully. The harvested bamboo has to be removed from the forest area promptly to prevent forest fires. It is necessary to set up a transit depot near a railhead before the produce is finally removed to the mill. The lessee has to establish a network of roads at considerable expenditure to work the entire lease area systematically. The present system of collecting royalty ignores all this expenditure and reduces the incentive given by way of low royalty.

7.6 Return on Capital

The return on the capital invested by the Government of India in public sector industries was 3.6 per cent in 1965-66 and 2.8 per cent in 1966-67 (Ind. P. and P., 1969). Forest Department of Andhra Pradesh earns 4 per cent by levying a royalty of Rs 5/ per ton of air dry bamboo. The calculation assumes the cost of plantation at Rs 500/ per hectare, without cost of land and the annual yield at two metric tons per hectare. The author considers that a fixed amount should be collected from the lessee for the entire lease area instead of royalty on the quantity of bamboo removed.

Two important stipulations or contractual obligations should be incorporated in the agreement. Firstly, all felling rules should be followed including the necessary fire prevention measures, such as regular maintenance of fire lines and prompt removal of felled bamboos outside the forest area. Secondly, the area should be worked on an approved felling cycle. Removal of dead and dying bamboos from the whole area may however be allowed. By this it is hoped the industry or the lessee in this case will make the best use of the leased area.

7.7 Tenure

A better form of tenure is necessary for improved land use. In order to develop forest based industries, the nature of tenure should be as such to justify heavy investments by the industry for the development of the area. The original grant of a lease area should be large enough to supply the annual raw material requirement of the mill. Areas also should be earmarked to meet the additional raw material requirement of the mill due to mill expansion. Wherever no such bamboo forest areas exist, steps should be taken to raise large scale bamboo plantations.

Gregarious flowering and subsequent dying of whole bamboo forests may take place due to drought or physiological life cycle of bamboo. In order to meet such an eventuality it is necessary to raise well planned bamboo plantations within the region of the paper mill. Grants of additional areas or renewal of the lease should be conditioned by the past performance and fulfilment of contractual obligations, however.

7.8 Concessions for Research

Further incentives can be offered by way of tax concessions based on the expenditure on research and creation of employment opportunities. There was little or no organized research in the industry in the past. The cellulose and paper section of the Forest Research Institute, Dehra Dun can no longer carry out the research demands of the pulp and paper industry. The pulp and paper industry in India has resolved to set up a research institute by raising funds from the major paper mills (Ind. P. and P., 1967c). It would be in the interests of the industry to undertake research in marketing the products and studying consumer tastes for total utilization of bamboo and other raw material.

7.9 Problems in Raising Large Scale Plantations, Government Budget, and Plantation Scheme

In order to meet the growing demands for long fibred raw materials, it is necessary to raise large scale bamboo plantations. Von Monroy (F.R.I., 1961) and Sharma (1968) suggested an annual plantation programme of about 60,000 hectares with quick growing species in suitable localities. During the third five-year plan the Government of India made a provision of Rs 500 million towards plantation programmes including soil and moisture conservation schemes. During the fourth five-year plan the budget provision is Rs 1,200 million of which Rs 280 million will be spent on raising 560,000 hectares of plantation with quick growing species. The planning commission has suggested raising 20,000 hectares of bamboo and 60,000 hectares of eucalypts plantations every year.

By 1975 there is expected to be ten paper mills in Andhra Pradesh producing 400,000 metric tons per year consuming 1,200,000 metric tons of air dry bamboo (Rao, 1966). This anticipated production is nearly four times the earlier estimated demand and contrasts remarkably with the 1967 production of 50,000 metric tons in two paper mills, consuming 1500,000 tons of bamboo obtained from natural forests. The raw material consumption is based on one third pulp yield.

From India's plantation target for the fourth five-year plan the state of Andhra Pradesh can claim its share of 8 per cent in the budget for raising an annual plantation of about 9,000 hectares ($560,000 \times \frac{8}{10} \times \frac{1}{5} = 8,900$). Assuming the plantation programme during the fifth five-year plan also to be the same, the total area under plantations of quick growing species would be 90,000 hectares. This entire area would have to be planted with bamboo alone to make 20 per cent of the pulp and mixed with 80 per cent of hard wood pulp in order to meet the ambitious target of 400,000 metric tons of paper by 1975 in Andhra Pradesh.

In fact hard woods are not being pulped in Andhra Pradesh. The Bengal Paper Mill, West Bengal, is leading in pulping a mixture of bamboos and hard woods. With the installation of a continuous digester, the mill proposes to reduce the current proportion of bamboo and hard woods of 70:30 to 50:00. Even hoping that the paper industry in Andhra Pradesh will use equal proportions of bamboo and hard woods, the shortage of bamboo by 1975 will be in the order of 350,000 tons. The annual area required for obtaining this yield is 140,000 ha. or a total bamboo plantation area of 560,000 ha. worked on a four-year felling cycle.

It is thus evident that the funds allocated for a plantation programme fall short of the proposed production targets. Unless steps are taken, giving incentives to promote the growth of industry and to intensify the management of bamboo forests, the targets cannot be achieved. The industry should rise to the occasion by adopting the latest techniques for pulping a mixture of hard woods and bamboos and try to win concessions from the government.

7.10 Labour Organization

Large scale plantation programmes are beset by a number of practical problems. The most important of them all is the organization of labour. Bamboo plantation success depends upon the timely planting of seedlings or rhizomes which usually is at the commencement of monsoons. Most of the precipitation is during three months, June to August. This is also the time for planting of agricultural crops. Thus there is a conflict in the demand for labour. The forest department engages labour on contract (piece rate basis) only at the time of planting and cultural operations. Uncertainty of employment and insecurity handicaps labourers working for the forest department. Labour cooperatives are being organized in certain states of India to overcome this problem.

7.11 Nursery

In order to supply the required seedlings for the plantations, central nurseries have to be established. Since the areas are earmarked for developing the paper industry, there should not be any difficulty in selecting the area for the nursery. Because of the problem of gregarious flowering and dying of seedlings in the nursery, every possible care should be taken to obtain seed from different zones. The nursery should be established separately for each of these seed collections. Since the viability of bamboo seed is short and plant per cent low, adequate quantities of seed should be collected from sporadically flowered bamboo clumps, treated with fungicides and stored in air tight containers.

Other problems of plantations such as transportation of labour, fertilizers, tools for planting, etc., have to be faced, depending upon local conditions. Since the object is commonly to harvest maximum possible yield, measures to achieve this objective most economically should be worked out.

CHAPTER VIII

CONCLUSIONS

The Government of India has committed the nation to technological progress through higher levels of education. With growing population and increasing literacy, there is a growing demand for writing and printing paper. With rise in per capita income and growing industrial activity the demand for newsprint and industrial papers is also rising. The demand for cultural papers in 1980 both for Andhra Pradesh and India has been estimated. Bhargava (1967) has shown that the projected demand by 1980 can be met then through application of present day technology. Nautiyal (1965) and Bhargava (1967) strongly expressed the need for raising large scale bamboo plantations for the supply of long fibred raw material.

The actual growth in pulp and paper industry is falling short of the projected demands. The reasons for slow growth have been discussed. In order to stimulate growth in the paper industry and attract capital, the Government has to offer incentives to allow the industry to make a reasonable profit. With improved technology it is possible to pulp a mixture of hard woods and blend with long fibred pulp or pulp a mixture of hard woods and bamboos to obtain a satisfactory grade of writing and printing paper. The pulp and paper industry with its proposed paper research institute should be able to learn how to pulp indigenous hard woods and bamboos on a commercial scale and thereby increase its profit. The Government should offer tax concessions to stimulate research and development by industry. In the long range interests of the industry, forest areas are leased out to the paper mills on royalty basis and the nature of tenure should be such as to attract large capital investment. The industry should earn concessions with improved utilization of land and raw material.

The widening gap between supply and demand of long fibred raw material can be bridged by raising bamboo plantations as bamboo can be harvested on short felling cycle of three to four years. As the onus of responsibility for meeting the future demands of raw material rests upon the forest department, it has been suggested that the Government should undertake large scale bamboo plantations. The problems of labour organization and raising of nursery stock have been discussed. In order to achieve the target in Andhra Pradesh all the plantation budget should be allocated for raising bamboo plantations and the industry should be able to produce satisfactory writing paper with 20 per cent bamboo pulp and 80 per cent miscellaneous hard woods. Since the present proportion of bamboo to hard woods, adopted by industry is only 50:50 (one to one), the need for raising large scale bamboo plantations is obvious. Intensive economic analysis to refine the issues discussed should be undertaken for the long term development of pulp and paper industry in Andhra Pradesh and India.

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