Trends And Prospects of Forest Products In India - Implications For Sustainable Development of Forest Resources

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DECLARATION

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Certified that the dissertation entitled "**TRENDS AND PROSPECTS OF FOREST PRODUCTS IN INDIA - IMPLICATIONS FOR SUSTAINABLE DEVELOPMENT OF FOREST RESOURCES**", submitted by Surender Kumar in fulfillment for the award of the degree of M.Phil of Jawaharlal Nehru University, is his original work and may be placed before the examiners for evaluation. This dissertation has not been submitted for the award of any degree in this or any other University.

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CHAPTER I

INTRODUCTION

PROBLEM

Environmental degradation associated with economic development is visible in almost all the places in the world. The change in the quality of land, air, water as well as in the loss of some flora and fauna make one concerned about such costs of development. The initial reactions to questions about the desirability of such development elicited the response that "poverty is the worst pollutant. In the recent Earth Summit, the world recognised both the factors that development cannot be sustained without protecting environment and environment cannot be protected in the absence of development.

Based on present technology, the developmental efforts have not only beneficial consequences, but also pregnated with undesirable results which has given encouragement to deforestation. Deforestation is a major problem particularly in third world. According to Brundtland Report, "the mature tropical forests that still exist cover only 900 million hectares, out of the 1.5 - 1.6 billion that once stood. Between 7.7 to 10 million hectares are eliminated outright each year, and at least further 10 million hectares are grossly disrupted each year". Our country, according to Agarwal and Narain (1985) report, has lost 1.3 million hectares of forest every year in 1970's and early 1980's. Total forest cover is down about 14 percent in 1980-82 as compared to almost 17 percent in 1972-75.

The results or problems created by deforestation can be known from the two successive reports of Centre for Science and Environment (CSE). CSE says that when the trees disappear the local tank silts up, the village-well dried-up, and the perennial stream gets reduced to a seasonal one. In countries like India where monsoon climate which is highly uneven over the year, the meaning of destruction of vegetation is to give encouragement to drought and water scarcity in the dry season. The results of deforestation in India are these (L.C. Jain 1988).

- Between 100 million to 150 million hectares of India's land area is rapidly turning barren and one million hectares of croplands and grazing lands are badly affected.
- On an average, every hectare loses 20 tonnes of top soil a year. Every six months, more top soil gets washed away than has been used to build all the brick houses across the country.
- Four million hectares have already been swallowed up by the ravines. In the famous Chambal Vally more than 10 percent of the villages are completely depopulated.
- Most of the national mining comes from 40 contiguous districts of central and eastern India, the tribal heart

land of the country. Several million hectares of good crop and forest lands have been destroyed in this tract by mining operations and hundreds of villages have been depopulated.

- The Green Revolution pulls out more plant nutrients from the soil than it puts back. Ludhiana district, which records the highest yields of many crops, now also records the highest deficiencies of plant nutrients in its soil. Many farmers have already started applying zinc. Iron, copper and manganese deficiencies are not for behind.

-Seventy percent of all available water in India is polluted. Even the high altitude lakes are dying because of pollution. In many places group and group water is going down leaving the poor persons' dug-well high and dry. In many other places, the water table is going-up creating serious problems of water logging.

- Between a quarter to a half of the lands brought under irrigation can go out of cultivation permanently because of soil salinity and water logging.

- The flood-prone area has doubled over the last ten years from 20 million to 40 million hectares. And millions of people have been displaced and uprooted.

All this is due to systematic character of the functioning of land, water and atmosphoric and biological ecosystem, deforestation, decrease in wildlife resources, the explosure of river basins, sedimentation of dams and river bed, and in addition atmosphoric pollution does not occur in separate compartments (Bustamante et. al 1991). The problems are not exhaustive and they have aggregative effect on the quality of life for both present and future generations.

The deteriorating environmental capital stock puts the question marks on development - a process using fully all the natural and human resources of a given society while maintaining an ecological balance of nature and in which the benefits of growth first to the most needy, and in which overtime there is a reduction in all forms of inequalities. The limit of natural resources would limit human population and their capacity to produce is a widely held idea. From Malthus to Club of Rome confidently forcasted a shortage of all raw materials under the pressure of exponential economic expansion. So, according to Club of Rome and its Malthusian predecessors, growth cannot go on. The Brundtland commission does not agree with idea. Brundtland says that economic production must increase even faster than the growth in world population, so, as to overcome the poverty, we must do it while reducing our demands in natural resources. In nutshell, it raises the demand for economic growth and environmental improvement which is not only possible but also essential - this idea is popularly known as "Sustainable Development" - the development that meets the goals of the present generation without compromising the ability of future generations to meet their own needs (WECD 1987), besides it is very difficult to live in a world which is not able to sustain the lives of our families, our neighbours and the generations to come.

2. **The Concept of Sustainable Development:-**

The sustainable development concept finds its intellectual heritage in the progressive conservation movement of the 1890s and 1920s. There are many similarties and differences between the advocates of progressive conservation and sustainable development. Their differences include differing concepts of sustainablility, differing concepts as limits to growth and differing ideologies as a source of value. The differences in values are important in helping us to understand the implications of sustainable development (Batie, 1989).

Progressive conservation alleviate waste through proper pricing and regulation (O Ricordan, 1988). They (progressive conservationists) believed in technical efficiency and when had option, they preferred that renewable rather than non-renewable resources be used. For example scientific forestry that included not only reforestation but also sustained yield forestry management to produce a continues flow of timber resources (Hays, 1987). Sustainable development also alleviate waste, but alleviation according to the Gospel of ecology not the Gospel of Efficiency (Nash 1989). The difference between the sustainable development and progressive conservation can be understand by one example. To protect forest diversity by allowing and encouraging minority cultures to use the forests in traditional ways is one example of sustainable development. In constrast, proposing parks to protect the forest resources in order to practice expert-managed optimal forest rotations and to take sustained yield harvests (Booth 1989) So, the philosophy of sustainable development embraces concepts of ecology and rejects the concepts that are exempted from ecological constraints.

At the same time that progressive conservationists were influencing development and conservation policy, economists were expanding the implications of the "Hicksian" or ordinalist revolution of the 1930s (Cooter and Peter 1984). Members of the earlier school of economics were concerned with material welfare, income distribution, and alleviating poverty. Thus, we find that much of conventional natural resource economics focuses on optimal rate of exploitation for a natural resource where primary value is as a productive input into the economic process (Barbier 1989). Even environmental economics, which tends to address the environmental services of natural resources, has paid little attention to the trade off between economic activity and natural resource quality (Barbier, 1989).

Neoclassical circular flow analogy links natural resources with production and consumption goods and is rarely portrayed as influencing or being influenced by the natural environment - thus there are no constraints on economic growth" (Pearce 1987). In neoclassical economics physical units are not the ultimate limits to growth that occupy the minds of sustainable development advocates. "Rather their advocates are concerned with limits to growth posed by the pollution of the environment. In this context even if a particular scarcity index trends down word, the trend matters little if it comes at the expense of environmental quality. Thus the sustanable development concept directly challenges the neoclassical and progressive conservationists' faith in expert management of technology to offset resource depletion"(Batie 1989).

Sustainable development is much recent developmental thinking (WECD (1987); Repetto (1986); Redcliff (1987); Turner(1988); Stockhalm Group (1988); Pearce, Barbier and Markandya (1990); Brookfield (1991) etc.) The term development emphasis on the quality of life educational attainment, nutritional status and access to basic freedoms and spiritual welfare, and sustainability suggests policy measures aimed at the attainment of developmental achievement last well into the future (Pearce et. al 1990). According to world conservation strategy sustainable development emphasis on "management of human use of all biosphere so that it may yield the greatest sustainable benefit to present generation while maintaining its potential to meet the needs and aspirations of future generation" (IUIN 1980). It is impossible to analyse economic, social, cultural and ecological transformations separately from one another because the quantitative dimensions" associated with increase in the material means available to those in poverty" and the qualitative dimensions of "ensuring the long-term ecological, social and cultural potential for supporting economic activity and structural change" are mutually reinforcing and inseparable (Barbier, 1989).

Repetto (1987) has defined the concept in this fashion "sustainable development is a development strategy that manages all assets, natural resources and the human resources, as well as financial and physical assests for increasing long-term wealth and well being". Sustainable development as a case rejects policies and practicies that support current living standard by depleting the productive base, including natural resources and that leaves future generations with poorer prospects and greater than our own". Pearce et. al have emphasised on the maintaining of stocks of natural capital and this is more realistic point in a developmental situation, Pearce and Turner has said that it involves maximising the net benefits of economic development subject to maintaining the services and quality of natural resources overtime. Here 'maintainance' involves the utilisation of renewable resources at a rate not more than equal to the natural rate of regeneration or reproduction, and optimizing the efficiency and substitutability of non-renewable resources. According to Brookfield (1991) the essence of sustainable growth is seen in the application of conservation rules to maintain the regenerative capacity of renewable resources to guide technological change so as to switch from non-renewable to renewable resources wherever physically possible, and to develop a phasing policy for the necessary use of non-renewable resources".

Martin - Brown have projected both the environmental and minority cultures as goals, economic growth is either constrained by these goal or antithetical to these goals. According to them every development policy must be scrutinized to determine whether it is fundamentally supportive to the natural environment:

-evaluates the demands on limited global resources;

-considers alternative resources which are local and renewable;

-encourages an improved standard of living for those existing in degrading conditions;

-encourages self-sufficiency;

-requires the protection of life from toxic and carcinogenic substances; and

-respects the dignity and intrinsic worth of all life.

Thus the sustainable development is "co-operation and co-existence" from "conquenst and exploitation" about the relationship of humans to their environment.

3. Aims of the Study:

The general aim of this study can be stated simply; it is undertaken to provide a basis of information for decisions by planning agencies, forest producers, forest industries. The hoped for results be achieved if the information presented here helps the forests to contribute better to a rapid and sustainable economic development.

Viewed more narrowly, the study has the following aims:

1. To present quantitative estimates of present forest product consumption and corresponding estimates of the wood supplied by the forests and forest resources for the manufacture of these products.

2. To present estimates of future requirements for forest products, based on probable economic changes and corresponding future supply of forest products based on current trend.

3. To apply a two sector dynamic model (Ehui & Hertel 1989)in Indian conditions to see how much forest stock is required to sustain agriculture productivity.

4. To analyse the opportunities of substitution of forest products by non-renewable resources.

5. To offer recommendations regarding forest products valuation which include pricing system for forest products and the role of natural resources stock in national income which is assumed as a measures of well-being.

One should not conclude from this, that all the information needed to formulate detailed plans will be found in the chapters which follow. This study will present the broad outline of the problems, indicate their scope and derive magnitude and in some cases suggest possible lines of action. To this extent it will help provide a basis for national planning of forest activities.

Planning is an essential part of any forestry programme since the nature of tree growth forces foresters to look to future markets for the raw materials they produce. But the production period is long and the economic variables offering the future are so many and complex that foresters tend to confine their planning activities to things concerned with tree growth and thereby to separate forestry oriented activities from the rest of the economic world. Estimates of future requirements for forest products based on economic factors (rather than the biological ones of tree growth and reproduction) will help the forestry and wood-based industries to integrate their programmes more closely with the economy of the nation. Such integration is not only desirable but absolutely necessary if the forest resources are to contribute their share to sustainable development.

4. Time Spans:

4.1 Observation Period

A critical step in the study was choosing the length of the observation period, a topic with which Klien (1956) deals briefly. The choice should be between annual or quarterly data since sufficient observations would not be available for other length of time (McKillop, 1967). The greater yield of information and the greater degrees of freedom associated with an analysis using quarterly data held strong appeal, but the difficulties of such a study appeared too great and so annual data were used. Lengthy lags are necessary to depict correctly influences in the demand for certain of the wood products studied and this required the use of a long sample period. Moreover, the investigator has sufficient information at his disposal to specify reaction to prices and other influences over a twelve month span but had insufficient information to do this for shorter spans. Ideally the investigation would have had an intensive field work phase in which market behaviour was examined, but certain limitations made this impossible. The only alternative would have been an empirical determination of variables and lags, but with only one set of observations available this approach descarded as being statistically work.

4.2 Sample Period:

With choosing of a year long observation period the need for a 20 or 30 year sample period become evident and 1962 is taken as the starting year as it was the earliest one, for forest products, for which observations were generally available. The longer the period the more difficult it is to deal with structural change, but the presence of potential structural change is welcomed because the receiving of its presence is seen to be a useful part of the study. At the inception of the study the latest year for which data is available is 1988, so that the years 1962 to 1988 are taken as the sample period.

4.3 Prediction Period

Predictions were made to the year 2000. Klien (1956) says "extrapolations should not be carried too for into the future perhaps not more than two years" clearly, the prediction period in this study was of ambitious length, but it should be recognised that its choice is suggested by need rather than by statistical considerations.

5. Study Methods

The detailed methodology is presented in each chapter, a brief description is presented here. The necessary methodology became quite narrowly prescribed both by the objectives themselves and by the sources, quality and availability of data. The methods adopted can be described like this:

Data gathered for a reasonably accurate description of the existing situation of the forest resources and the consumption and production of forest products. Considerably information is already available as a result of FAO's preparation of the annual year book of forest product statistics. Additional data were obtained from Indian forest statistics and Indian Agricultural Statistics - the annual publications, part of economic data is already available in economic surveys; the annual publication of finance ministry. Statistics on the prices of wood and its substitutes were obtained with the help of India-data-base the Economy and Statistical Abstract of India.

Using the information on historical forest product consumption and anticipated rates of economic growth, estimates were made of the changing consumption of various categories of forest products on the assumption that raw material supplies will be forthcoming without any increase in relative price. This gave the estimated future requirements for forest products. These future requirements were compared with the yields the forests can be expected to produce under existing plans for management and exploitation and with the changes in forest area that can be expected and intensified agricultural activities and bringing the new forest areas into production. This comparison provided the basis for an opportunity to find substitutes of forest products on the basis of cost conscious and non-cost consciouos factors, and the basis for an assessment of present and planned forestry activities that may be expected.

As the forests are basis of maintaining agriculture productivity, two sector dynamic model is applied to Indian conditions which is based on control theory.

The aim of this study is estimation of current trend and an additional aim is to estimate future consumption levels. Mood (1950) indicated unbiased estimates are not uneqvivocally better than biased ones, nor are consistant ones necessarily better than in-consistant ones. However, in the absence of information on the magnitudes of biases and variances the problem is one of choosing estimates with known, rather than unknown properties. Accordingly, unbiasedness or consistency of unbiasedness was not attainable, was set as a goal in estimating parameters and future magnitudes. Additional goals of minimum variance with respect to unbiased estimates, and efficiency with respect to consistant ones, are also specified.

For estimation purpose classical least square method is used. As Gold Berger (1964) demonstrates, for a classical regression model, least squares estimates of coefficients are in general, biased and inconsistant if variables are omitted from unless the coefficients associated with these variables are zero. The same is true for the the predicted variables. This emphasized the need for careful construction of economic model so that chances of excluding important variables would be minimized. The proper consideration is given, so the choice of model also in estimating the demand functions. From this analysis stem the conclusions of the study.

6. Plan of Presentation:

The study is presented in six chapters including the present one. Chapter 2 is devoted to a description of forest resources and production, and also deals with future estimation of major forest products supply. Chapter 3 describes historical wood consumption patterns in quantitatives terms and then develops the estimates of future requirement. Considerable attention is paid to choice of model for estimation purpose. Chapter 4 deals with forest products substitution by non-wood substitutes opportunities and describes the extent to which market failure are responsible for over exploitation of forests; and the estimation of national income when the capital stock (forests) is depleting, chapter 5 deals with the problem of deforestation and agricultural productivity with Ehui. and Hertel model, Chapter 6 provides summary and conclusions.

7. Limitations of Study:

Difficulties due to lack of basic information were particularly severe in this study which limits the reliability of the study. The major statistical problems encountered are discussed in this way.

Information on the area under forest cover, the composition of forest types, the density of growing stock, and the annual growth of the stand is best provided by systematic forest inventories. Many problems of definition arises in establishing an inventory procedure and in interpreting its results.

Data on forest removals is particularly scanty, because of the wealth of forest resources. The three main sources of difficulties are removals for fuel, removals from trees outside the forests, and felling due to shifting cultivation. So, the figures reported in this study are therefore estimates which have substantial margins of error.

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CHAPTER II

FOREST RESOURCES AND PRODUCTION

1. INTRODUCTION

Forest are the greatest renewable resource that is available to mankind. By virtue of their biological characteristics they are able to produce while conserving and conserve while producing. They are not only the main source of raw material supply for various industries, but also help in maintaining ecological balances. They can be of tremendous economic value if exploited on scientific and rational basis. This chapter is divided into two parts, first part deals with forest area and second part will deal with forest production - environmental and material. The main stress will be on major forest products supply estimation and their future projections.

2. Forest Area

India consists of about 15 percent of world population with less than two percent of total forest area of the world. Due to population increase, the per-capita forest has declined from 0.20 hectare (h.a.) in 1951 to 0.0831 h.a. in 1986, while the minimum need is 0.44 ha. of forest land for every individual, as the current productivity of country's forest is only 0.7 m^3 h a^{-1} Y_r (J.B. Lal, 1990, p. 7). Further, the forest area is highly unevenly distributed in different states with 22 out of 32 states UTs having less than desired per-capita level of forest cover a dismal situation indeed (Table 2. 1.)

The other component of human demand for forest is on account of its large live stock. India has more than 13 percent of the world's domesticated animals, but it has less than Ø.5 percent of pastures of the world. The paucity of pastures has forced people to graze their animals in forests. And 47 percent of total land under agricultural cultivation donot satisfy the land hunger of people, as a result of which 4.35 million ha. of forest land is subject to shifting cultivation and Ø.7 million hactares have encroached for permanent cultivation of forest land. The pattern of land utilisation in country is presented in table 2.2.

2.1 The Spatio - temporal Shifts in Forest Area:

From the beginning of this century, the biotic pressure on forests had always been causing a contineous decline in the forest area over-time. Considerable area of reserved forests has been lost during the past four decades. According to the authorised and documented on forest area, during 1951-8Ø, about 4.31 million ha. of forests were lost to agricultural activities (6Ø.7 percent), industries and townships (3.Ø1 percent) and miscellaneous usages (2Ø.8 percent) (Kamath, 1985). Thus the decline in forest area has been estimated to the tone of Ø.14 million ha. (Kalla, 1988).

Dass and Vashisht (1983) study, reveals same pattern of temporal decline in forest area in states, such as Assam, Rajasthan (0.8 percent), Bihar and Madhya Pradesh (0.4 percent), Maharashtra (0.1 percent) during 1960-77 period.

Contrary to the overwhelming evidence of a decline in forest area, it has erroneously projected a gradual increase in forest area. With about 54 million hectares in 1961-62, the forest cover (area) continued to register an increase to 67 million hactares by 1984-85 (Table 2.3). The annual variation indicate that the area has increased at a decreasing rate of growth, the actual decline being since 1980-81, and the area on an average, over the period, has increased at a negligible rate of 0.49 percent per annum linearly and and 0.47 percent per annum geometrically. But, as the Indian forest Act, 1952, carries no guarantee of a uniform forest cover in the area, so, this apparent increase over time cannot be taken on its face value. Further a large portion of notified forest area includes waste lands, which added significantly to point a complecement 23 percent of the area under forests in 1986 (Sixth five year Plan). National Remote Sensing Agency (NRSA) estimated the forest area, based on their interpretation of land use imagery (1980-82), 46.347 million hactares. According to Dr. D.N. Rao (1990), this discrepancy may be of three reasons.

i) Some lands recorded as under forest may not contain enough vegatation to show up in satellite imagery.

ii) The records may be foulty and

iii) There may be problems of interpretation of satellite imagery.

The first reason seems considerable as the forests are not uniformly dense in vegation every where. In the 1989 assessment of FSI (FSI, 1989 p. 13), it was found that out of 64.01 million hactares, which is only 11.51 percent of country's geographical area, are under forest cover if sufficient density fo¬ environmental stability is met. (D.N. Rao , 1990 p.9)

3. Forest Production:

The production of forestry is conditioned by man made and natural determinants. The natural determinant include ecological security which meant climate-soil- environment mix and the man made determinants include the technology of exploiting forests for maximum material production which for household sector provides fuel, fodder and other domestic needs, and needs of wood based small and large scale industries.

3.1 Environmental Production:

It is clear that environment benefits of forests are widely perceived to be overwhelmingly more important than the conventional economic opportunity costs of use of that land. Environmental benefits are very hard to quantify, yet the researchers has started to work on this difficult problem. A seminal work in this area is that by Prof. T.M. Dass (1980), who has attempted to quantify all the environmental benefits that accrue to the society from a single tree which yields a biomass of 50 tons over a period of 50 years. His figures are presented in table 2.4. According to J.B. Lal, on the basis of the calculations of Prof. Dass, it works out that one ton of biomass is capable of yielding annual environmental services valuing Rs. 622/- (at 1980-81 prices), and at current prices value will be Rs. 1063/-. O.N. Kaul (1973), worked out the organic productivity of country's tropical, sub-tropical and temprate forests at 9.0, 8.2 and 6.2 tonns per hactare respectively. The combination of the figures of Kaul, Dass and of NRSA on the classification of forests, give an account of environmental services valuing Rs. 566.8 billion (Table 2.5.)[1]

J.B. Lal (1990) has estimated the annual rental earned by the forests to the country of various material goods and environmental services. The figures are presented in Table 2.6.

3.2 Material Production:

The second determinant of output of forestry is related to the technology of exploiting forests for maxmimum production. As above mentioned that forestry provides about more than a quarter of the gross domestic product, if environmental and material, both benefits are taken into consideration (J.B. Lal 1990). Even if we see the material benefits, taking from forests have been a good source to the public exchange (Table 2.7). The net revenue from forests has

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1. These figures do not include the annual rental from conservation of bio diversity and recreational services rendered by forests (J.B. Lal 1990).

steadily increased from Rs. 15 - 22 crores in 1951-52 to Rs. 202.08 crores in 1985-86. The material production can further be studied in two parts.

3.2.1 Minor Forest Products (MFPs):

From dawn of the day to dusk, MFPs play an important role throughout the entire cycle of man's life from birth to death. Honey is the first edible MFP given to human at the time of birth, and grasses and bamboos are the last of the MFPs put to their use for last journey of life on a pyre. During life-time variety of MFPs are consumed throughout and it is heartening to note that India earns a revenue about one third from MFPs out of total revenue from forests.

There are a number of minor forest products, like bamboo, fodder and grass, lac, honey, silks, fruits, seeds, edible oil, tendu leaves, gums and resins, tanning materials and dye stuffs etc., on most of which systematic quantative information is not readily available. Table 2.8 shows the trends in value of some of these minor products. Prof. Tirath Gupta and Amar Guleria (1982) worked out the potential production of various minor forest products. And if the annual production of MFPs attains full potential the annual rental on account of minor forest products will increase four times (J.B. Lal).

3.2.2 Major Forest Products:

In terms of value contribution major forest products account for about 70 percent of the total value added by the forest sector to the economy. Dass and Vashisht (1983) study reveals, for a period of 17years (1961-77), on the basis of a long-term state wise trend analysis, an increase in the production of timber at 4.36 percent per annum at the all India level. The production of fuel wood declined in almost states except Andhra Pradesh, Assam, Bihar, Haryana, Himachal Pradesh Kerala, Karnataka, Orissa, Punjab and Rajasthan, and in these states the growth rate remained only 1.92 percent per annum (Kalla, 1988).

The analysis of production performance for a long-term time-series data from 1962-88 reveals that the proportion of total wood used as raw material, as investment input for different wood based industries in India is quite low. It is assumed that the high proportion of industrial round wood to round wood is a welcome feature for the development of forest based industrial development (Mahendra and Maithani (1988). In 1962, India used 92.36 percent of total round wood as fuelwood and this ratio marginal increased in 1970 (90.64 percent), but it slightly declined to 91.12 percent in 1980 and to 90.84 in 1988, and the proportion of industrial roundwood to total round wood slightly increased from 7.36 to 9.16 percent in the same period, which is positive sign for forest based industrial development. But this ratio is very low in comparison to other countries, for instance, Japan used 98 percent of wood for industrial purposes.

The growth indices for major forest products during the period 1970-88 would be reveal a consistent increase without any dip. (Table 2.9). All these indices of wood products and wood increasing at a decreasing rate. The sawnwood sleepers indices wood based panel indices has grown upto 1985 and 1984 respectively, but after that they has become constant, this maybe due to data discrepancy. The wood pulp production indices has shown a dramatic increase (100-1136). The indices are 583 in 1981 and it has become 856 in 1982. This may be due to development of wood pulp industries in India, as in 1962 its production was only 20 thousand metric tonns, it has become 1000 thousand metric tonns in 1987. There is one more major forest product, that is paper plus paperboard, the growth indices of which also shows a consistent increase but only after 1974 (In 1974 = 104 to 1988 = 225). Obviously forest production, in India, has been consumption oriented, not productivity oriented without any strong forward and backward linkages with other sectors (Kalla, 1988).

Supply Estimation:

According to classical economic theory, the supply function for anygood i.e. jth good is (Allen, 1956)

$$g_{jt} = g_j(P_t, W_{it} \ldots\ldots W_{kt})$$

where

g_{jt} = quantity of good jth supply in year t.

P_t = Price of good is year t.

W_{it} = Price of factor i in year t.

Assuming that technology and prices are unaffected by the level of industry output, the aggregate supply function for the good may be written as

$$g_t = g(P_t, W_{it} \ldots\ldots\ldots W_{kt})$$

where

$$g_t = \sum_{j=1}^{n} g_{jt} = \text{Total supply in year t.}$$

The supply of forest products is mainly the out turn of forests. There is some problems in using the words supply and production interchangably, because the possibility of part accumulation of inventories of forestry product actually used in current period cannot be ruled out of the total supply and imports net of exports are also component of supply. So, here the problem arises of demand-supply dichotomy (Kalla). But in our etimates supply and production are used interchangeably and, it is assumed production is equal to supply.

Further, the production of forest products that are wood and wood products may be divided in two categories the primary products and secondary products. The production of primary products could be a function of actual forest cover, investment on forest management, the input of labour and the market prices of products under consideration, and the production of secondary products could be a function of the available technology, capital investment, market prices, prices of substitutes and their management etc.

Related Studies:

Major studies related to the present one in regard to objectives have been carried out by K.N. Rai et. al. (1983), Amar S. Guleria (1988), D.N. Rao (1990). All these studies deals with major forest products demand and supply. All these studies deals with long-run long term time series data (K.N. Rai, 1968; 1979; Amar Guleria, 1962-83; D.N. Rao 1976-87). The only difference with regard to these studies lies in the explanatory variables and the functional form of regression equations. For this purpose K.N. Rai (1983) treated production as supply and regress the supply in time with investment in forestry under transcendental specification; and compound growth specification ($S=ab^t$) the results of this study shows that the estimated production of roundwood, fuel wood + charcool, industrial roundwood, other industrial roundwood, paper + paperboard, Wrapping + packing paper + board, and fibre board and wood pulp production declined to actual by 1990.

Amar Guleria used the lineor function of time for estimating the supply function, but the functional form suffers from all weaknesses of arithmatic mean. Dr. D.N. Rao used the loglinear and log qudratic polynomial time trend to production series for this purpose. Rao's work is a valuable pioneering effort and he deserve much credit, be cause of the specification of function. As indicated above for an economic theorist supply could be explained as a function of price of product and price of factors of production. But for forest products this theory cannot work, because forests are under state regulation. Initially some difficulty may be experienced in conceptualizing a supply function for wood because of the features of allowable cut and appraised minimum prices associated with it. Eventually it may be thought that a supply schedule inelastic at price above the approved price, with zero supply at lower prices characterises the individual wood sale. It was observed that aggregate of such schedule wood lead to a discontinuous step like schedule to total supply, with discontinuities becoming less marked as the size of individual sales becomes smaller and approaised priced become more contineous (Mc Killop, 1967). so, it is noted that this total schedule will be subjects to shifts as the level of allowable cut was changed, and it is assumed that harvest from notified forests are treated as fixed and insensitive to prices and this seems reasonable in long-run, where harvest levels must equal, on average, the allowable cut and since the allowable is cut is determined by a harvest scheduling process that is largely independent of prices. So, we think, it will be better to take supply as a function of time (as the wood is extracted on a trend basis) because time is an indicator of all the major variations which are pertinent in influencing of forest products production.

For the estimation and projection purpose we have used the log linear and log quadratic polynomial forms of supply function with respect to time. i.e.

$$S_t = ab^t$$

or $\log S_t = \log a + (\log b)^t$ - (1)

and $S_t = ab^t C^{t2}$

$$\text{or} \quad \log S_t = \log a + (\log b)^t + (\log c)^{t2} \quad - (2)$$

where

S_t = production of forest product in year t.

t = time (1,......27)

a,b,c are prameters.

The result obtained by this evaluation are presented in tables 2.10, 2.11. Two basic results are abstracted from the tables for discussion. First, the high values of adjusted R^2 for all the 21 estimated apply functions seems to support the explanatory power of the models used in this study. Second all the (log b) coefficients are found to be significant at 5 percent level. The compound growth rates of supply of all the products are positive.

The highest compound growth rate remained for woodpulp (16.18 percent) and lowest for fibre boards (3.63 percent), the growth rate remained above 10 percent only for four products pulpwood + partides (11.53 percent), sawnwood + sleepers (10.05 percent), wood pulp (16.18 percent) and chemical woodpulp (12.62 percent); below 5 percent for seven products and for the remaining products the growth rates varied between 5 percent to 10 percent.

The results obtained on the objective of projecting the supply for forest products are presented in table 2.12. It may be revealed that the two approaches on based on log linear time trend equation and other based on log quadratic time trend equation.

4. Conclusion:

The above study of forest prouducts supply can provide information of sufficient precission to answer some questions such as

- How much land should be presently devoted to forests to make sure the timber needs of this and future generations are met so that the ecological balance can be maintained.
- Which industries can be developed with immediate or early prospects of industrial development based on forests raw material.
- How much silvicultural treatment is urgent to enrich the existing forests and economically justifiable and what kind of treatment should it be.

The present chapter helps to ensure these questions on the basis of the study of next chapter which deals with consumption forcasting which raises these questions.

Table 2.8

Outturn of Minor Forest Produce (Rs. 1000)

Year	Bamboos & Cones	Fodder & Grass	Gums & Resijms	Lac.	Drugst & Spices	Tanning Materials	Total
1951-52	12,490	15,321	7,468	3,265	720	1.701	70,558
1960-61	21,699	15,479	20,478	1636	807	896	111,395
1970-71	39,455	12,722	58,865	273	247	271	339,993
1975-76	118,879	31,700	148,460	738	3,073	1756	846,934
1979-80	222,433	24,976	260,719	47	7,183	10,622	1,363,373

Source: Govt. of India, Statistical Abstract 1987, Page 69.

Table 2.1.

States Classified on the basis of per capita Forest Cover (1985-87)

Per Capita forest Cover in ha.	States/UTs
Less than 0.05	Bihar, Gujrat, Haryana, Kerala, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal, Chandigarh, Delhi.
0.05 - 0.10	Andhra Pradesh, Karnataka, Maharastra
0.10 - 0.20	Asam Goa, Orissa, Dadra and Nagar
0.20 - 0.46	Haveli, Himachal Pradesh, J & K, Madhya Pradesh, Tripura.
0.47 - 1.00	Sikkim
1.00 - 5.00	Manipur, Maghalaya, Nagaand, Mizoram, Andman & Nicobar Islands
Over 5.00	Arunanchal Pradesh.

Source: FSI (1989), The State of Forest Report, Page 17 Cited from D.N. Rao (1990).

Table 2.2

Land Utilisation in India

Land Use	Area in Million ha.	Percentage of total area.
1. Agriculture (Cultivable land)	154.70	47.0
2. Forests (Area officially recorded as forest with or without free cover)	75.18	22.8
3. Permanent Pasture and other Grazing lands.	12.15	3.7
4. Lad under cultivable tree crop and gives	3.91	1.3
5. Cultivable waste land	16.64	5.1
6. Land under other non-agricultural uses	47.53	5.3
7. Barren and waste lands	24.60	7.5
8. Area for which no return exists	24.09	7.3
Total	32.80	100

Source: J.B. Lal, 1990.

Table 2.3

Area Under Forests in India

Period	Area (Million Ha.)	Percent Annual
1961-62	54.19	-
1962-63	60.54	11.72
1963-64	60.39	- 0.25
1964-65	60.35	- 0.07
1965-66	61.58	2.04
1966-67	63.48	3.08
1967-68	63.94	0.72
1968-69	64.70	1.19
1970-71	63.89	- 1.25
1971-72	63.83	- 0.09
1972-73	63.60	- 0.45
1973-74	65.43	2.88
1974-75	65.73	0.46
1975-76	65.87	0.21
1976-77	66.70	1.26
1977-78	67.16	0.69
1978-79	67.14	- 0.03
1979-80	67.46	0.48
1980-81	67.48	- 0.09
1981-82	67.42	0
1982-83	67.42	- 0.10
1983-84	67.35	- 0.03
1984-85	67.16	- 0.25
Mean	64.47	
S.D.	3.30	

Source: Govt. of India; Indian Agriculture in Brief, Directorate of Economics and Statistics, Ministry of Agriculture and Rural Development, New Delhi, various editions.

Table 2.4

Environmental Benefits from a Medium Sized Tree

No.	Benefits	Value in Rupees
1.	Production of Oxygen	250,000
2.	Conversion to Animal Protein	20,000
3.	Soil Conservation & Maintenance of soil fertility	250,000
4.	Recycling of Water and Controlling of humidity	300,000
5.	Sheltering of birds, Squirrels, insects and Plants.	250,000
6.	Controlling of Air Pollution	500,000
	Total	15,70,000

Source: J.B. Lal, 1990

Table 2.5

Annual Rental from Forests on Account of Environmental Services.

No.	Forest Type group	Area in million ha.	Average organic Productivity in tons.	Total organic productivity million tons
1.	Tropical	52.2	9.0	469.8
2.	Sub Tropical	5.7	8.2	34.2
3.	Temperate	4.5	6.0	27.0
4.	Alpine	1.8	1.2	2.2
	Total	64.2		533.2

Total annual value of Environmental Services = 533.2 x 1063
= 566.791 billion

Source: J.B. Lal, 1990

Table 2.6

Annual Rental From Forests for Various Material Goods and Environmental Services.

No.	Good/Services	Annual Rental in Billion Rs.
1.	Timber and Firewood	128.8
2.	Minor Forest Produce	10.9
3.	Grazing	22.0
4.	Environmental Services (other than Recreation and as harbours of bio-diversity)	566.8
5.	Biodiversity	66.0
6.	Recreation	1.0
	Total	795.5

Source: J.B. Lal, 1990

Table 2.7

Revenue from and Expenditure on Forests

Year	Gross Revenue	Expenditure	Net Revenue
1951-52*	255,358	103,111	+ 152,247
1961-62*	619,168	251,259	+ 367,909
1971-72*	1,533,082	788,898	+ 744,184
1985-86**	9,156,400	7,135,600	+2020,800

Source: * Govt. of India Statistical Abstract 1987

** India's Forests, Ministry of Forest and Environment, 1987.

Table 2.9

Major Wood and Wood Products in India

Year	Rural	Wood Industrial	Fuel	Wood Products Sown	Panel	Pulp	Paper + Paper Board
1970	173504 (100)	12765 (100)	160739 (100)	4361 (100)	173 (100)	88 (100)	861 (100)
1971	178269 (103)	13313 (104)	164956 (103)	4778 (110)	189 (109)	139 (158)	0 (95)
1972	183020 (105)	14064 (110)	169144 (105)	5126 (117)	180 (104)	215 (244)	885 (98)
1973	188120 (108)	14932 (117)	173188 (108)	5630 (129)	171 (99)	270 (307)	640 (97)
1974	193055 (111)	15825 (124)	177230 (110)	6212 (142)	186 (107)	350 (398)	893 (104)
1975	198235 (114)	16500 (129)	181375 (113)	6804 (156)	172 (88)	360 (409)	911 (106)
1976	202824 (117)	17071 (134)	185753 (116)	7507 (172)	187 (108)	409 (465)	934 (108)
1977	207361 (119)	17631 (138)	189730 (118)	8199 (188)	206 (119)	402 (457)	990 (115)
1978	211845 (122)	18253 (143)	193690 (121)	8999 (206)	226 (132)	479 (544)	998 (116)
1979	216680 (125)	18945 (148)	197735 (123)	10,000 (229)	232 (132)	483 (549)	1044 (129)
1980	221585 (128)	19684 (154)	201901 (126)	10876 (252)	252 (146)	483 (549)	962 (112)
1981	226678 (131)	20460 (160)	206218 (129)	12040 (276)	352 (203)	513 (583)	1266 (147)
1982	231981 (134)	21270 (167)	210711 (131)	13209 (303)	377 (218)	753 (856)	1288 (150)
1983	237527 (137)	22120 (173)	215407 (134)	14495 (332)	384 (222)	768 (873)	1491 (173)
1984	243322 (140)	23010 (180)	220312 (137)	15907 (365)	442 (255)	799 (908)	1557 (185)
1985	249387 (144)	23941 (188)	225446 (141)	17460 (400)	442 (255)	864 (982)	1590 (185)
1986	254389 (147)	24037 (188)	230352 (144)	17460 (400)	442 (255)	917 (1042)	1810 (210)
1987	2594071 (149)	24133 (189)	235268 (147)	17460 (401)	442 (235)	1000 (1136)	1910 (222)
1988	264412 (152)	24228 (190)	240184 (150)	17460 (400)	442 (255)	1000 (1136)	1940 (225)
Mean	184715	15877	167408	8264	243	397	1041
Simple G.R.	4.53	5.30	4.44	10.05	6.00	16.18	4.33
C.G.R.	7.18	9.38	2.48	29.5	13.86	188.46	11.73

Figures in parentheses are annual growth indices.
Source: Computed from FAO year books.

Table 2.10
Estimated Linear Exponemtial Trend Equations (S=ab^t)

Forest Product	log a	log b	Dum	$\bar{R}^2$	Growth Rate
Roundwood (A)	11.86	0.024	-0.446	0.999	2.39
	(2521)	(94.67)	(-105)		
Fuelwood+Charcoal	11.8	0.022	-0.461	0.999	2.23
	(4017)	(142)	(-174)		
Ind.Roundwood	9.16	0.037	-0.309	0.996	3.81
	(439)	(33.82)	(-16.35)		
Sawlogs+Vennerlogs	8.77	0.042	-0.389	0.997	4.28
	(412)	(37.10)	(-20.20)		
Pulpwood+Particles	4.85	0.109		0.711	11.52
	(22.35)	(8.059)			
Other Ind.Roundwoo	7.78	0.025	-0.322	0.949	2.53
	(110)	(7.09)	(-5.56)		
Sawnwood+Sleepers (A)	7.7	0.082	-0.297	0.989	8.55
	(126)	(25.3)	(-5.3)		
Woodbased Panels (A)	4.56	0.058		0.934	6
	(94.11)	(19.25)			
Plywood	4.261	0.061		0.923	6.3
	(77.12)	(17.73)			
Particle Board	1.713	0.073		0.619	7.54
	(9.67)	(6.58)			
Fibre Board	2.89	0.036		0.676	3.63
	(37.52)	(7.43)			
Woodpulp (A)	3.35	0.15		0.929	16.18
	(25.12)	(18.03)			
Mech. Woodpulp	2.81	0.075		0.633	7.78
	(14.74)	(6.78)			
Chem. Woodpulp	3.34	0.119		0.91	12.62
	(25.33)	(15.32)			
Other Fibrepulp	5.709	0.069		0.913	7.16
	(85.43)	(16.59)			
Paper+Paperboard (A)	6.214	0.047		0.95	4.83
	(183)	(22.26)			
Newsprint	2.84	0.089		0.766	9.3
	(18.53)	(9.28)			
Printing+Writing Paper	5.63	0.43		0.949	4.43
	(179)	(22.13)			
Other Paper+Paper Board	5.36	0.043		0.929	4.37
	(145)	(18.53)			
Packing+Wraping Paper+Board	4.295	0.066		0.942	6.84
	(83.59)	(20.65)			
Paper+Paperboard (NES)	4.77	0.024	-0.651	0.629	2.43
	(30.43)	(2.659)	(-3.28)		

Figures in Parentheses are t-stat.

Table 2.11
Estimated Quadratic Exponential Trend Equations ($S=ab^{t}c^{t^2}$)

Forest Product	log a	log b	log c	Dum	$\bar{R}^2$
Roundwood (A)	11.846	0.25	-0.00005	-0.439	0.999
	(1367)	(25.43)	(-1.91)	(-79.46)	
Fuelwood+Charcoal	11.786	0.023	-0.00004	-0.455	0.999
	(2254)	(38.82)	(-2.34)	(-137)	
Ind.Roundwood	9.054	0.052	-0.0004	-0.254	0.997
	(283)	(13.93)	(-3.93)	(-12.43)	
Sawlogs+Veneerlogs	8.724	0.048	-0.0002	-0.365	0.997
	(214)	(10.21)	(-1.324)	(-14.08)	
Pulpwod+Particles	6.302	0.029	0.0007		0.958
	(128)	(3.56)	(2.33)		
Other Ind.Roundwood	7.761	0.028	-0.00009	-0.313	0.947
	(69.95)	(2.4)	(-0.261)	(-4.54)	
Sawnwood+Sleepers(A)	7.87	0.06	0.0007	-0.384	0.999
	(69.07)	(4.53)	(1.75)	(-5.28)	
Woodbased Panels (A)	8.204	0.101	-0.0015		0.971
	(158)	(11.79)	(-4.932)		
Plywood	3.711	0.345	-0.008		0.923
	(21.33)	(12.06)	(-8.5)		
Particle Boards	7.312	0.067	-0.0009		0.905
	(107)	(5.934)	(-2.25)		
FibreBoards	11.222	0.089	-0.0016		0.935
	(189)	(9.14)	(-4.73)		
Woodpulp (A)	1.464	0.124	-0.002		0.624
	(5.288)	(2.729)	(-1.17)		
Mech. Woodpulp	2.928	0.028	0.0003		0.664
	(23.727)	(1.387)	(0.382)		
Chem. Woodpulp	3.407	-0.089	0.006		0.828
	(17.841)	(-2.86)	(5.4)		
Other Fibrepulp	2.714	0.219	-0.003		0.934
	(11.52)	(6.45)	(-3.007)		
Paper+PaperBoard (A)	5.813	0.048	0.0008		0.916
	(56.04)	(2.79)	(1.3)		
Newsprint	3.535	-0.054	0.005		0.89
	(21.35)	(-1.98)	(8.41)		
Printing+Writing Paper	5.601	0.049	-0.0002		0.948
	(112)	(5.89)	(-0.642)		
Other Paper+Paper Board	5.458	0.023	0.007		0.939
	(101)	(2.63)	(2.253)		
Wraping+Packing Paper+Board	4.291	0.067	-0.00003		0.94
	(52)	(4.94)	(-0.062)		
Paper+Paperboard (NES)	5.793	-0.131	0.006	-1.321	0.791
	(22.436)	(-3.69)	(4.44)	(-6.234)	

Figure in parentheses are t-stat.

Table 2.12
Projected Supply of Forest Product in India.

Forest Product	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Roundwood (A) I	274046	280590	287291	294151	301173	308365	315729	323269	330989	338890	346983	355269
'000m^3 II	272731	278898	285173	291558	298051	305656	311377	318207	325156	332216	339395	346691
Fuelwood+Charcoal I	246252	251747	257367	263111	268985	274987	281127	287403	293816	300316	307078	313985
'000m^3 II	245374	250622	255958	261914	266914	272532	278249	284059	289969	295978	302087	308297
Ind. Roundwood I	27147	28182	29257	30372	31530	32732	33980	35276	36621	38017	39466	40971
'000m^3 II	26172	26915	27655	28393	29126	29853	30674	31286	31988	32678	33356	34020
Sawlogs+Veneerlogs I	20838	21730	22661	23632	24644	25700	26801	27949	29146	30395	31697	33055
'000m^3 II	20514	21306	22121	22959	23821	24706	25614	26547	27504	28486	29492	30523
Pulpwood+Particles I	2720	3034	3284	3774	4209	4694	5236	5839	6513	7264	8101	9035
'000m^3 II	868	758	651	550	456	373	299	236	183	140	105	77
Other Ind.Roundwood I	5486	5722	5968	6225	6493	6772	7063	7367	7684	8015	8360	8720
'000m^3 II	4850	4965	5081	5199	5320	5442	5566	5691	5819	5948	6079	6212
Sawnwood+Sleepers(A) I	21968	23848	25888	28102	30508	33115	35948	39023	42361	45985	49918	54188
'000m^3 II	23282	25655	28308	31275	34599	38327	42512	47215	52508	58471	65197	72792
Woodbased Panels (A) I	491	521	552	585	620	657	696	738	782	829	879	932
'000m^3 II	559	610	665	727	797	876	964	1062	1173	1299	1440	1600
Plywood I	392	417	443	471	501	573	566	602	640	680	723	768
'000m^3 II	479	532	592	661	740	831	935	1056	1197	1360	1549	1771
Particle Board I	43	46	49	53	57	61	66	71	76	82	88	95
'000m^3 II	33	34	34	35	35	35	35	35	35	35	34	33
Fibre Board I	49	51	53	55	57	59	61	63	65	68	70	73
'000m^3 II	51	53	55	58	61	64	67	70	73	77	80	85
Woodpulp (A) I	1897	2204	2561	2975	3457	4016	4666	1321	6299	7318	8502	9878
'000mt II	995	1007	1009	1002	985	960	926	884	837	785	729	670
Mech. Woodpulp I	110	119	128	138	149	160	173	186	201	216	233	282
'000mt. II	245	313	405	531	703	942	1277	1753	2433	3418	4859	6986
Chem. Woodpulp I	785	884	995	1121	1263	1422	1601	1804	2031	2287	2576	2902
'000mt. II	553	572	589	602	611	613	618	616	609	599	585	516
Other Fibrepulp	2093	2243	2403	2575	2760	2958	3170	3397	3640	3901	4181	4460
'000mt. II	2323	2545	2793	3070	3380	3727	4116	4552	5043	5594	6216	6917
Paper+Paper Board I	207	227	248	271	296	324	354	387	423	462	505	552
(A)'000mt. II	414	525	672	870	1137	1501	2002	2698	3673	5052	7020	9856
Newsprint I	1875	1965	2060	2160	2264	2373	2488	2609	2735	2867	3006	3151
'000mt. II	2048	2189	2342	2508	2691	2890	3108	3347	3609	3897	4213	4561
Printing+Writing I	936	978	1021	1066	1114	1163	1215	1269	1325	1384	1445	1510
Paper '000mt. II	913	949	985	1023	1061	1101	1142	1183	1226	1270	1315	1361
Other Paper +Paper I	468	501	535	571	610	652	697	745	796	850	908	971
Board '000mt. II	.466	498	531	567	605	646	689	736	785	837	893	953
Wraping+Packing Paper I	272	284	296	309	322	336	351	366	382	399	416	434
+Board '000mt. II	272	284	296	309	322	336	351	366	382	399	416	434
Paper+PaperBoard (NES) I	232	238	243	249	255	262	268	275	281	288	295	302
'000mt. II	380	440	514	610	723	387	1057	1298	1608	2012	2542	3242

Fig. 2.1 Production of Roundwood in India (1962-88)

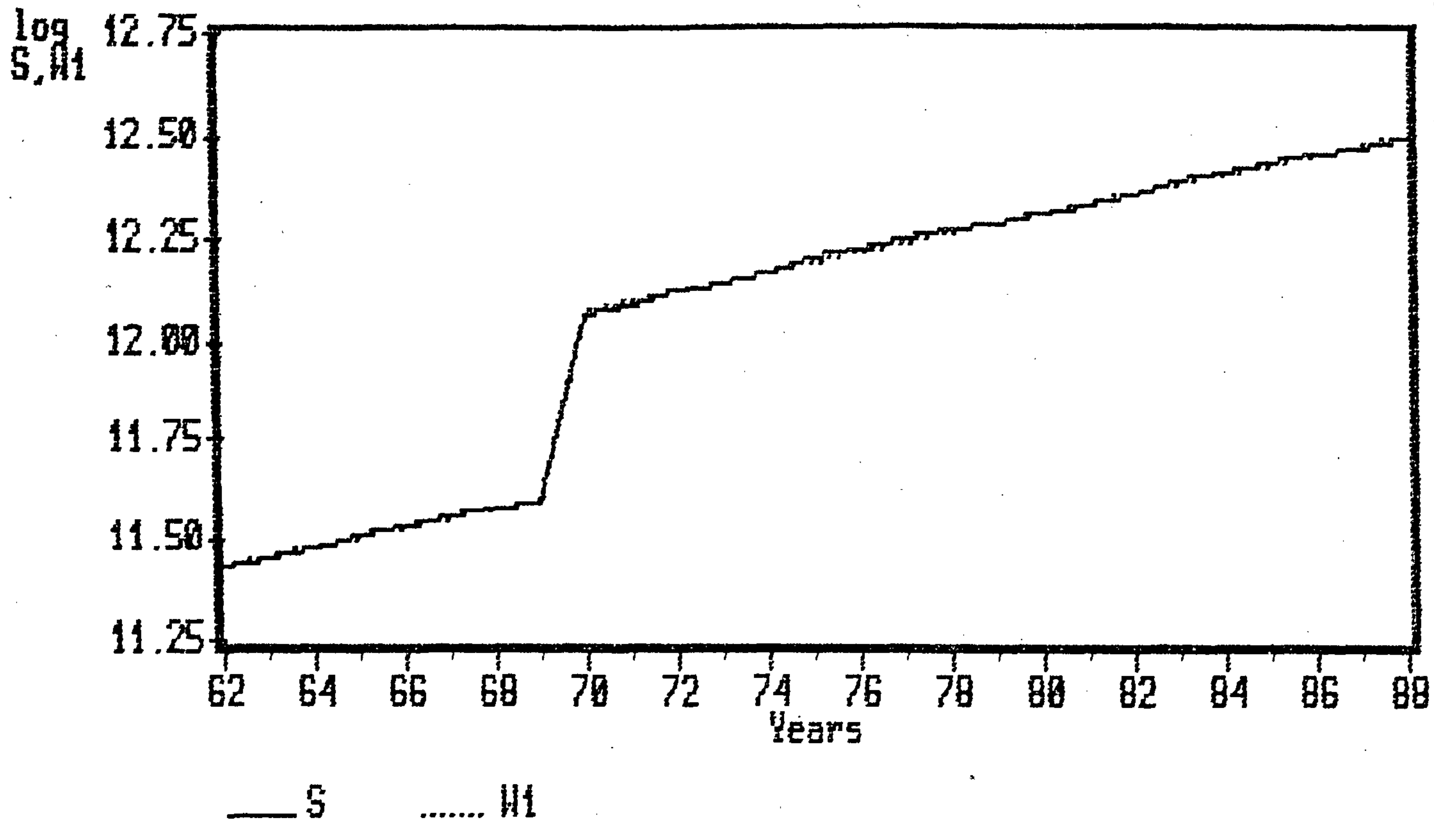


Fig. 2.2 Production of Roundwood in India (1962-88)

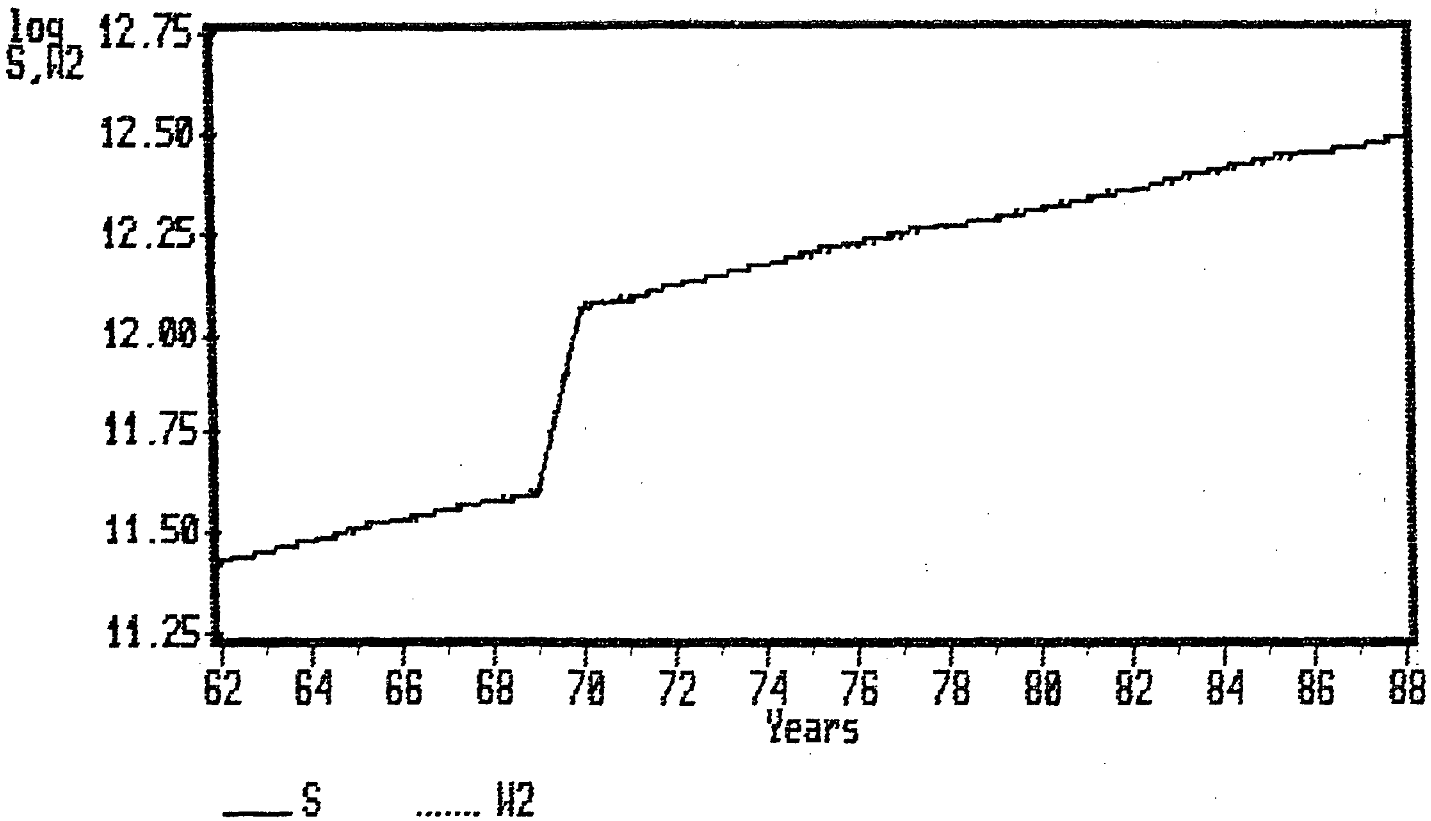


Fig. 2.3 Production of Sawnwood + Sleepers in India (1962-88)

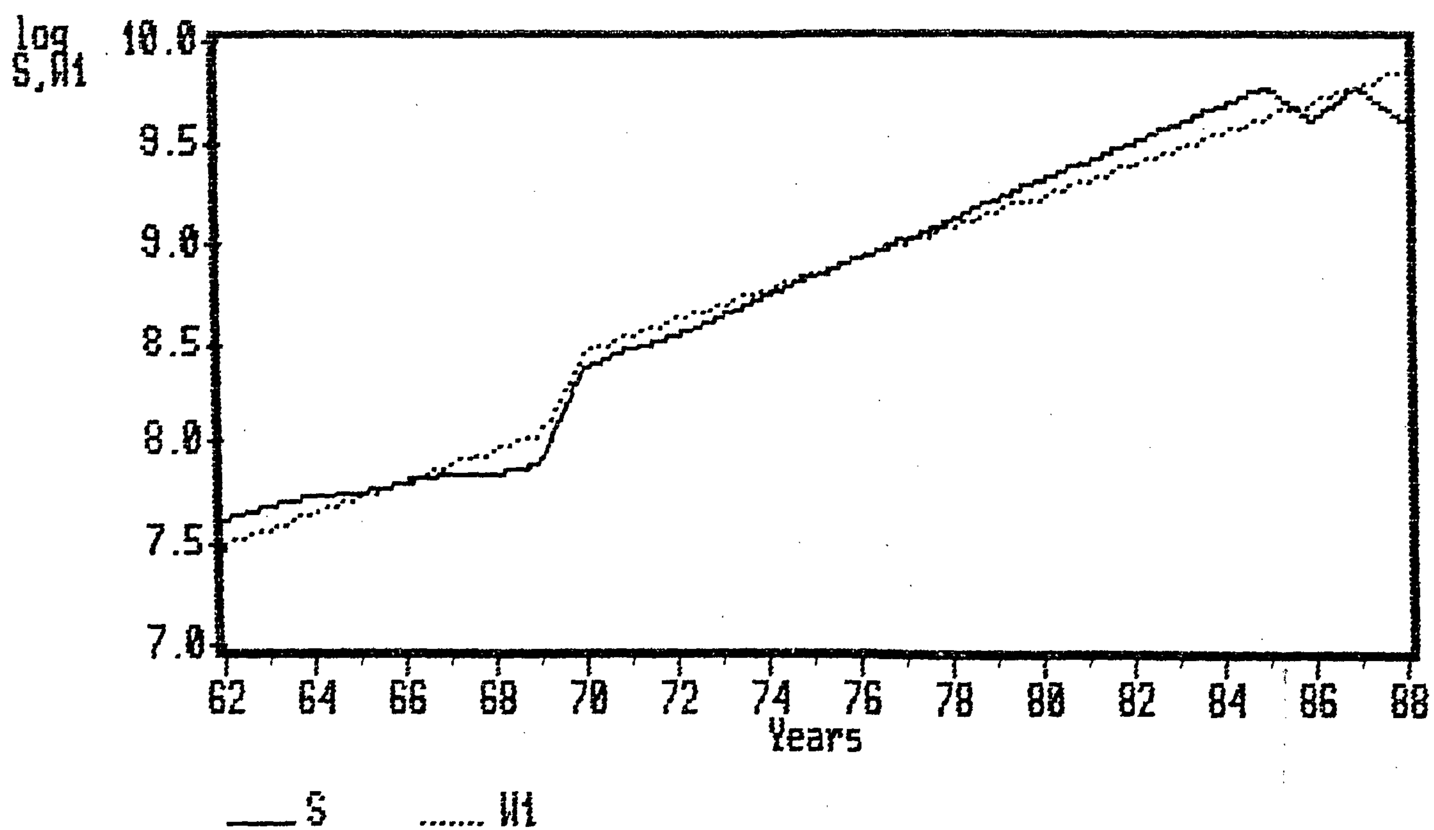


Fig. 2.4 Production of Sawnwood + Sleepers in India (1962-88)

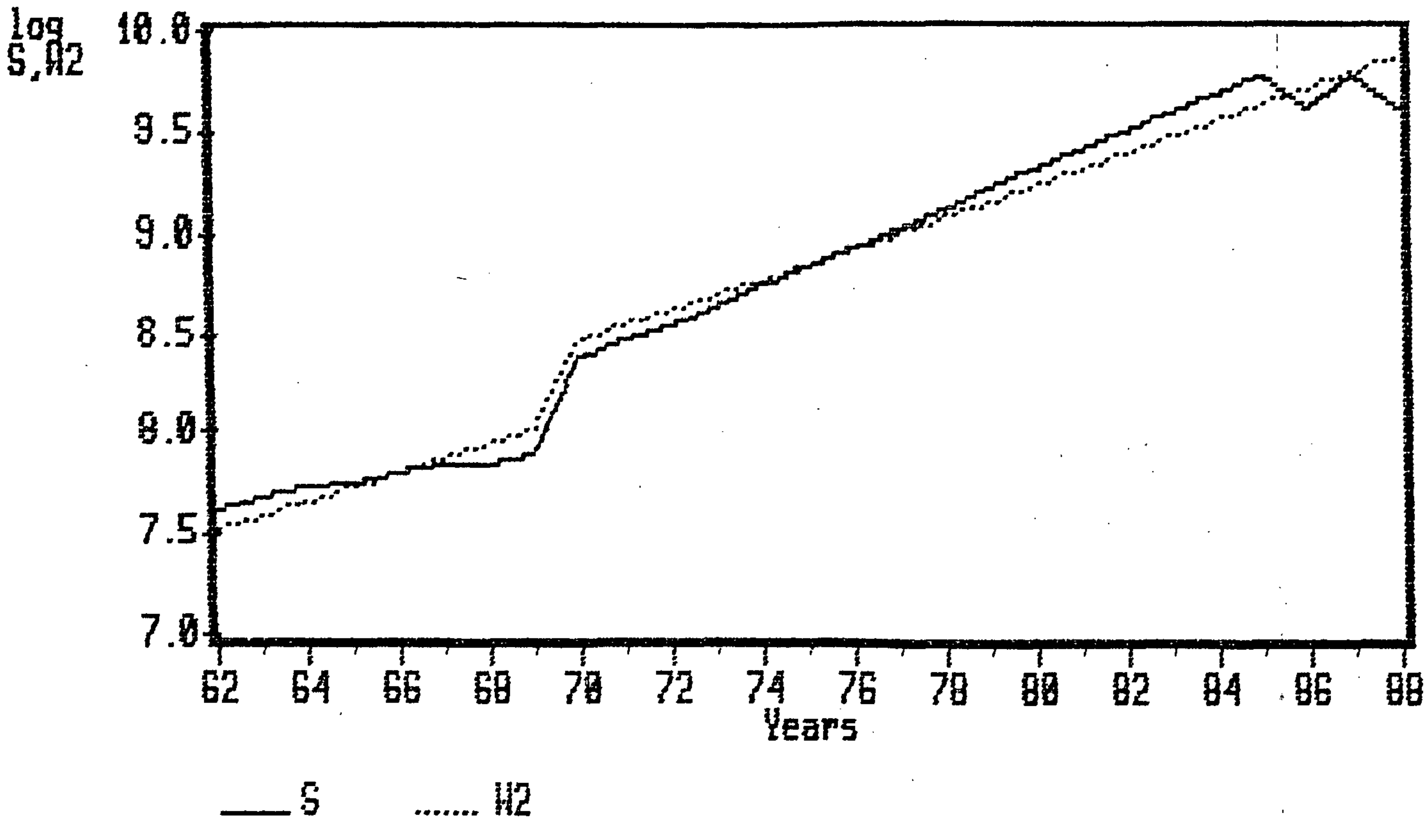


Fig. 2.5 Production of Woodbased Panels in India (1962-88)

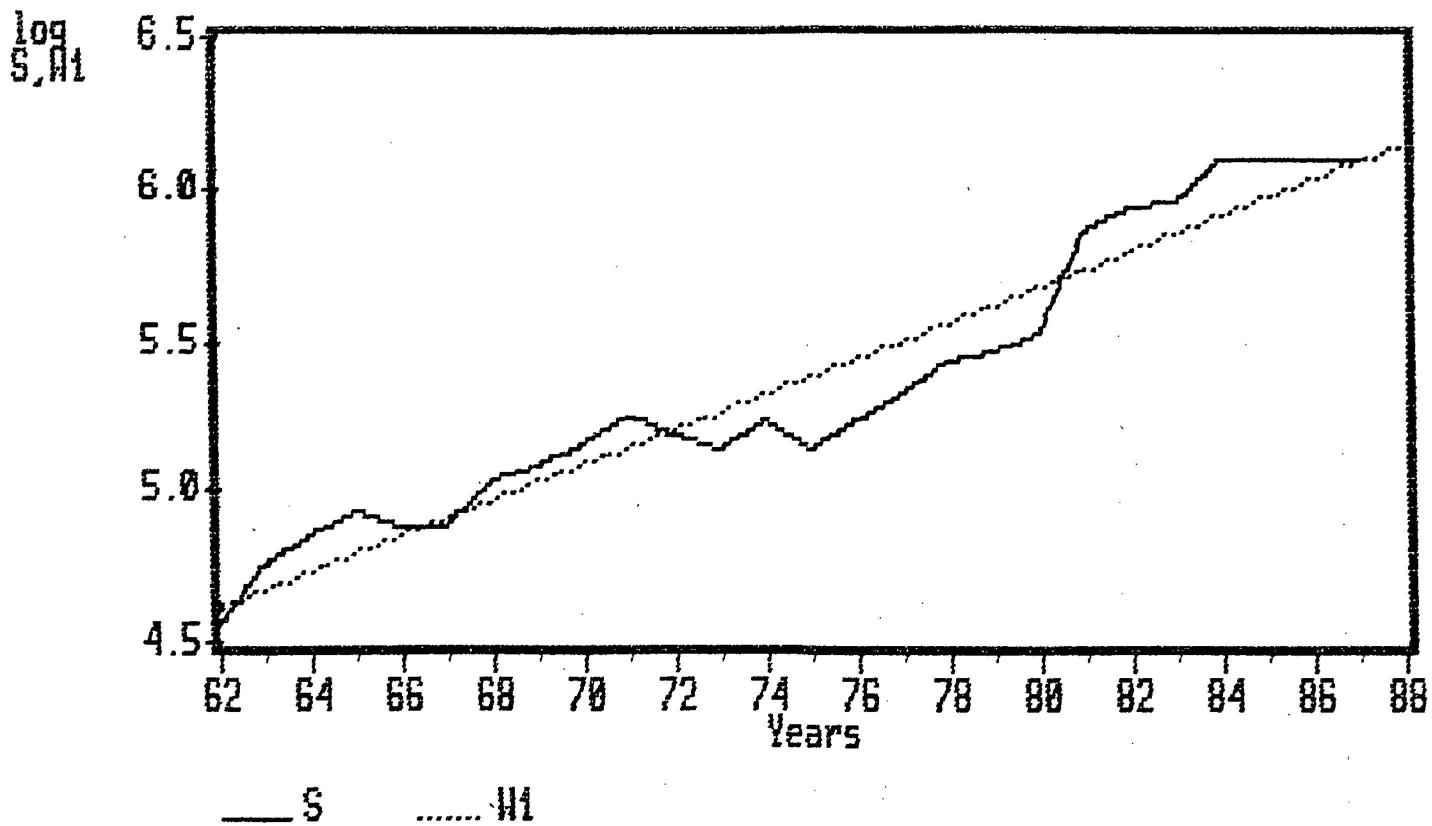


Fig. 2.6 Production of Woodbased Panels in India (1962-88)

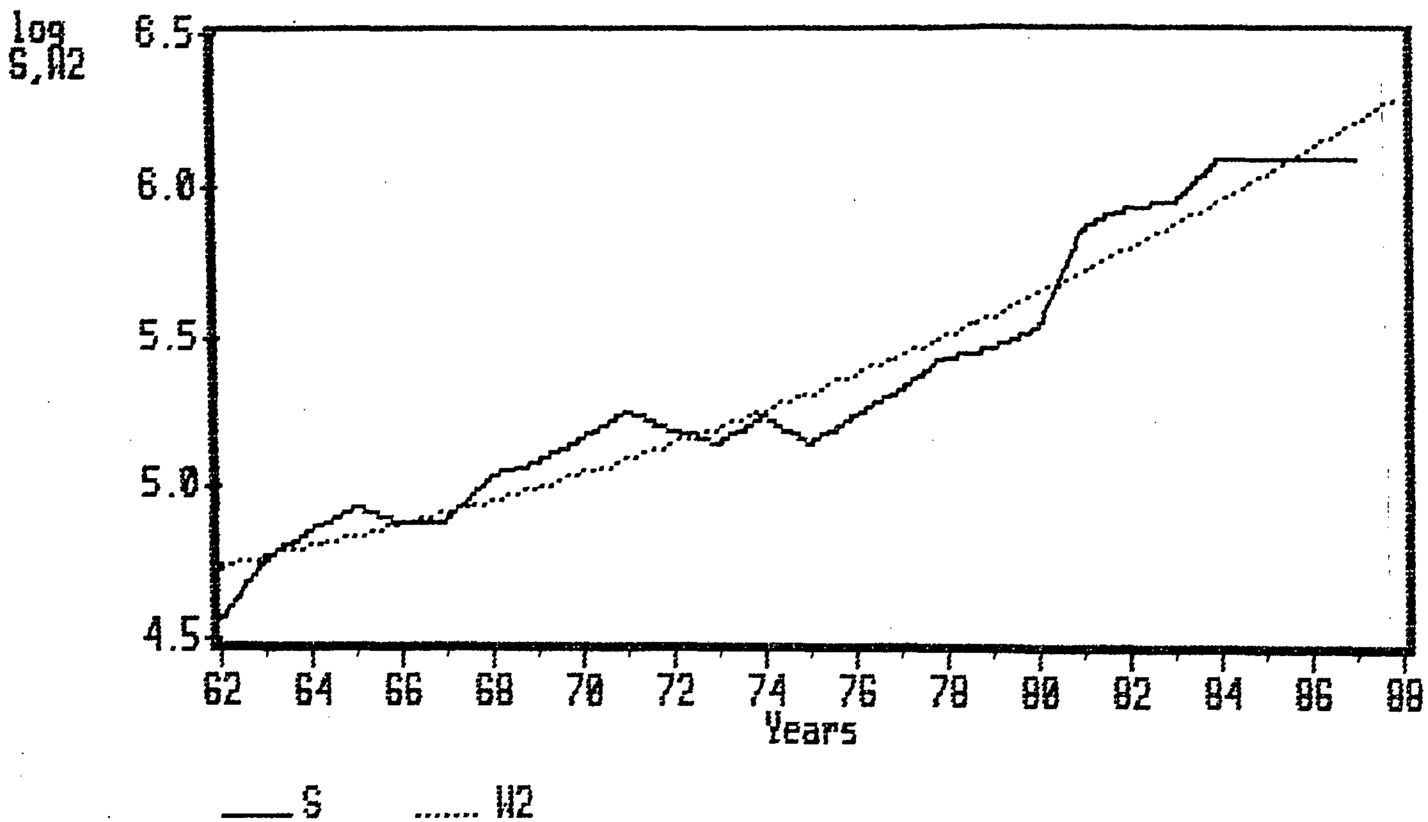


Fig. 2.7 Production of Woodpulp in India (1962-88)

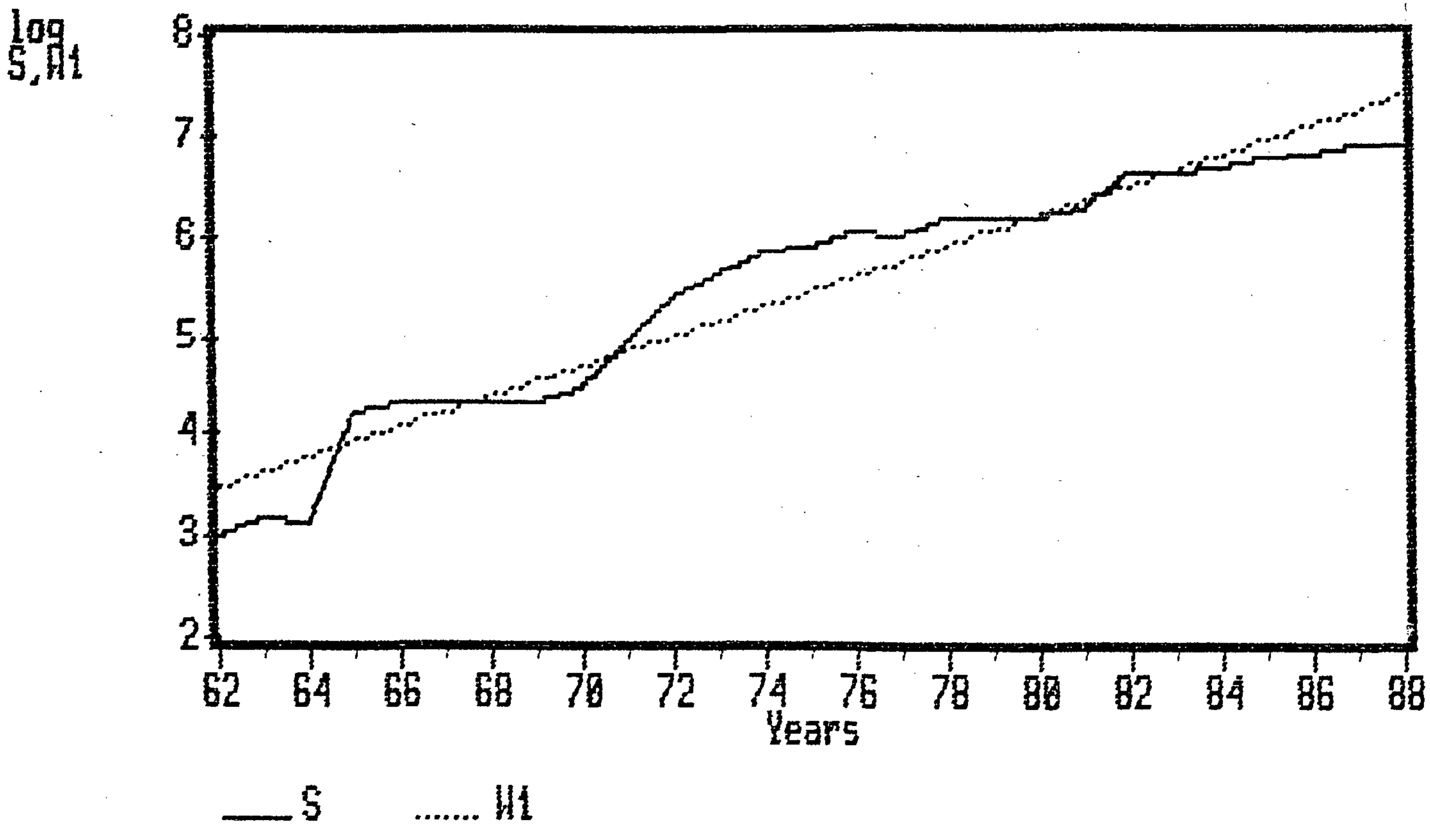


Fig. 2.8 Production of Woodpulp in India (1962-88)

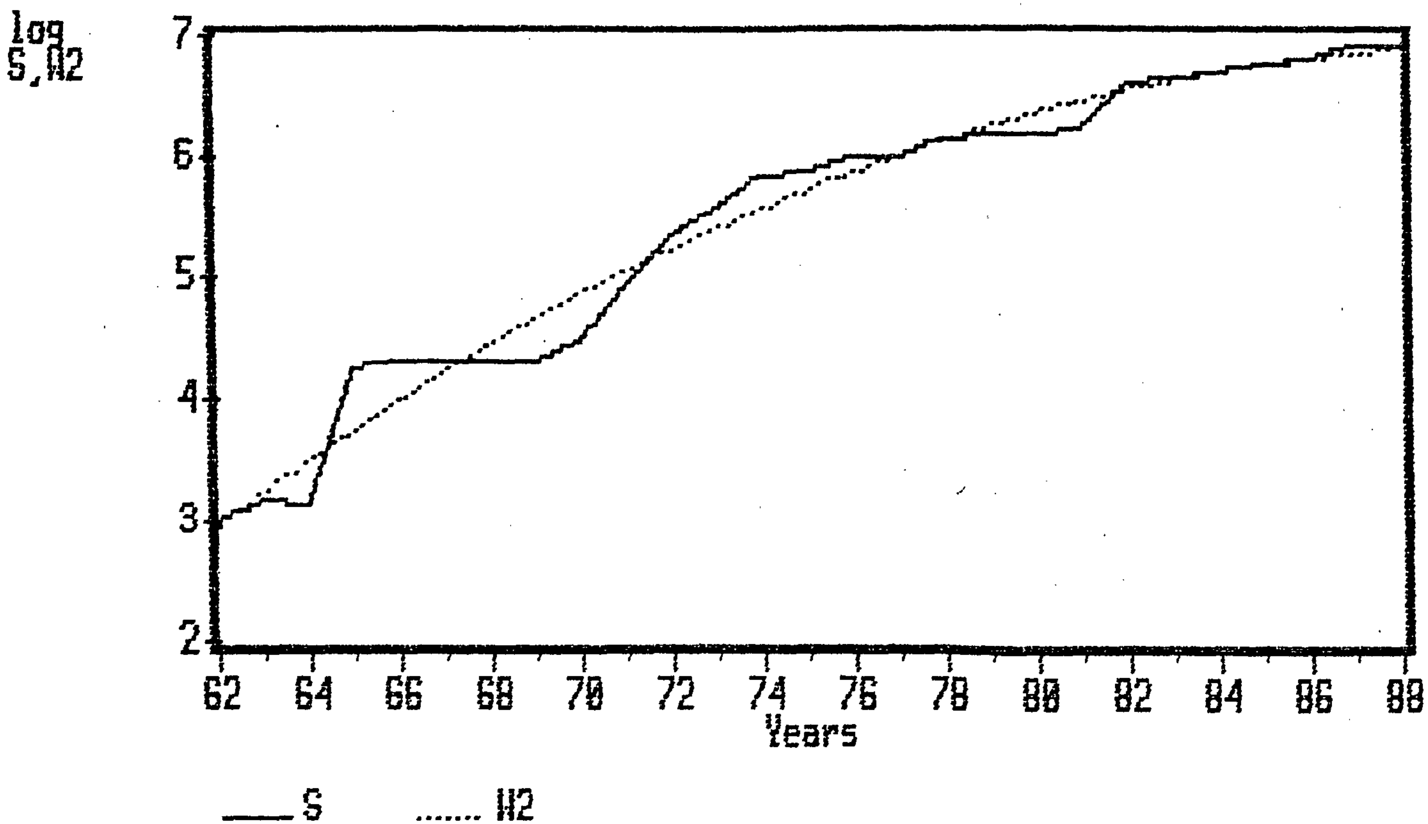


Fig. 2.9 Production of Paper + Paperboard in India (1962-88)

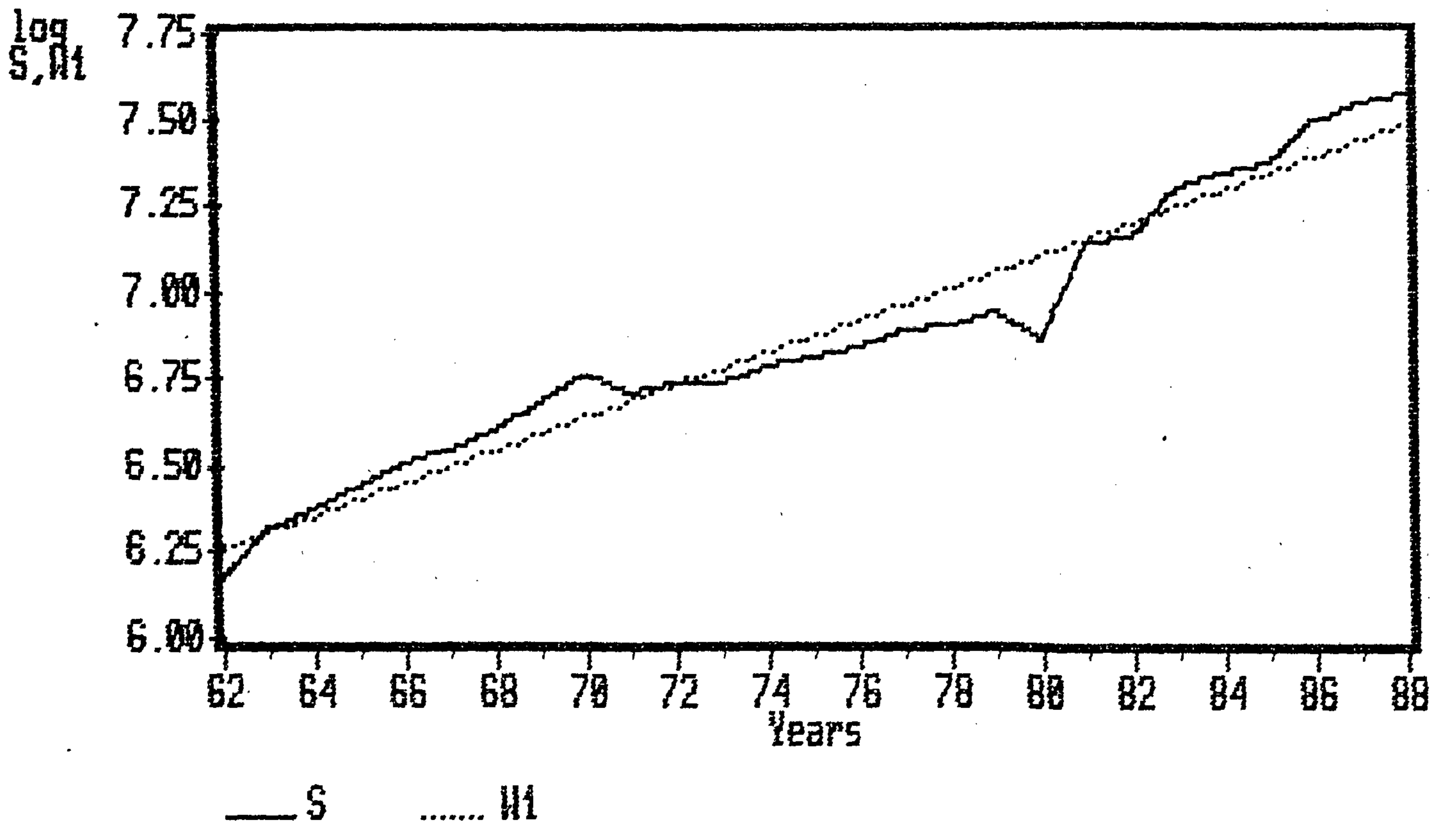
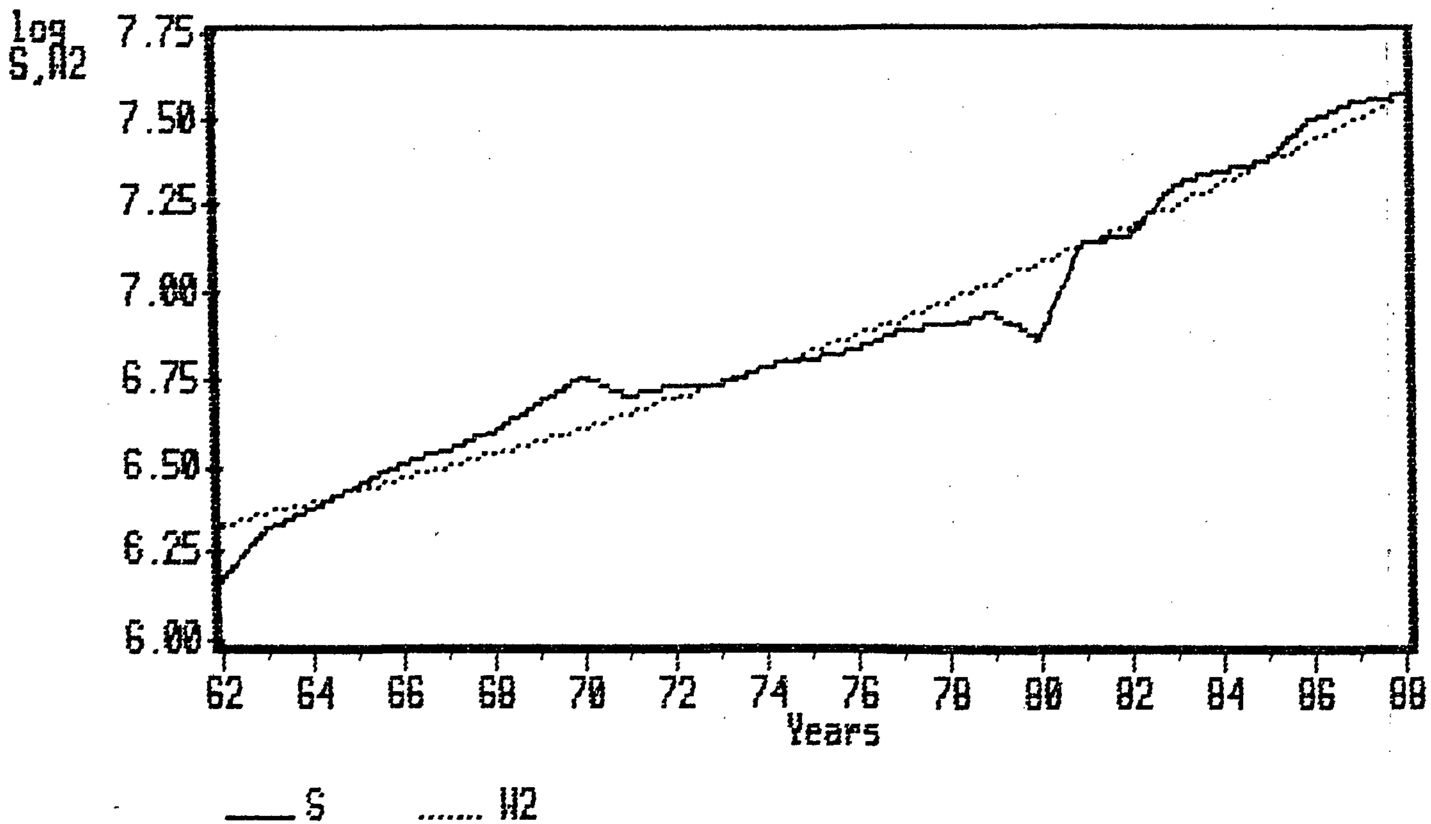


Fig. 2.10 Production of Paper + Paperboard in India (1962-88)



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CHAPTER III

The Consumption of Major Forest Products

1. Introduction

The present chapter is entirely devoted to the estimation of consumption of major forest products. In planning for economic development a clear idea must be had of quantities of various goods which will be required or consumed by the inhabitants of a country in the future. These must necessarily be estimates and their value will be dependent largely on the basis which is used in making them. A logical basis for such thinking may be the consumption pattern of the existing population. As everything is almost certain to change with time, it becomes necessary to know what happened in the past. Trends in any thing cannot be projected blindly into future, but when careful allowance is made for over - all changes in the economy, they can provide a useful basis for future estimation.

Wood is used in great variety of products. Many of these are of relatively minor importance and the quantity of wood used in them is small compared to total, while it might be interesting to see how wood goes into each of these products, but such detailed information is not needed as the minor forest products are not cause of deforestation. In this present chapter we shall study first of all some related studies, then methodological problem in detail. The last portion of the chapter throws light on econometric results of estimates and projections.

2. **Related Studies:**

Major studies related to the present in regard to objectives have been carried out by Govt. of India (1976), Chandrakanth et. al. (1979), K.N. Rai et. at (1983), D.N. Rao (1990) etc. These studies have used the projected income data derived through the estimated compund growth rate equation of income to project the aggregate national demand for forest products. For this purpose, theyhave used the compound growth rate function and franscendental functions (Chandrakanth et. al and K.N. Rai et.al) which have property of varying elasticity, where as Dr. D.N. Rao have used the Cobb-Douglus type functions for this purpose, which have constant elasticity property. On these macro level studies Kalla (1988) has made two basic objections, firstly that these donot take into consideration the changes in stocks of forest products which are durable, because there are possibilities of consumption of stocks that is accumulated in due course of time as this may be the case for durable goods. Secondly, he points out that these studies have taken into account only national income as the sole determinant of consumption, ignoring all other deterimnants of demand.

On micro level a few studies have been carried out and most of these studies relate to fuel wood, (Maithani et. al, 1986, Mathur et. al, 1984; Negi et. al, 1986; Govt. of India, 1982). These studies also taken basically income as the sole determinant. The consumption of fuel wood may be conditioned with the size of family, availability of substitutes, the distance from the availability of fuel sources etc. The effect of fuel wood prices relative to alternative fuels prices may be a sole determinant of fuelwood consumption (Kalla, 1988).

3. Methodology:

Statistics on consumption may be developed along two lines. The first approach is to obtain independent estimates of the actual consumption of individual products. But this type of data is not published. The second approach is based on production and international trade statistics. For each product domestic production (X) plus the amount imported (M) minus the amount exported (E) give the figure for apprarent consumption (C). i.e. $C = X + M - E$. But an accurate estimate of consumption by this methods would require a consumption for the stock on hand at the beginning and end of the period. Data on stocks are not available and such a correction is not attempted. It is assumed that failure to correct for stocks does not effect the usefulness of consumption estimates.

3.1 Model Specification:

There are two important aspects of model specification (a) functional form and (b) relevant variables.

(a) **Selection of functional form :** Because of the nature of problem under study three functional forms can be selected

1. $Y = \alpha X^{\beta}$

   or $\log Y = \log \alpha + \beta \log X.$

2. $Y = \alpha X^{\beta} e^{rX}$

   or $\log y = \log \alpha + \beta \log X + rX$

3. $Y = \alpha e^{\beta(x)t}$

   or $\log Y = \log \alpha + \beta(x)t.$

The important properties of these three functional forms are as follow:

The functional from (1), which is a cobb-Douglus type function, provides a direct test on the existence of rational behaviour, this is because it represents the so-called second stage of neo-classical functions. Furthermore this type of function completely disregard the existence of third stage which is characterised by zero or negative marginal productivity utility.

The •(2) and (3) functional forms from the point view of production/consumption theory incorporate all the three stages of neo-classical functions. However, theory says that economic decision lie only in the second stage of production/consumption function. Of course, this is true only under perfect competition, the assumption that is most unlikely to hold in our data. So, one may like to impose certain restrictions in estimating these functions, provided one has a prior sound knowledge needed to develop the restrictions. We have, therefore, not imposed any restriction on the estimation of these functional forms except some econometric restrictions.

Moreover, equation (3) has varing parameters throughout the observations, as the parameters are multiple of time, so as time increase the value of parameter also increases, whereas the (1) and (2) equations have constant parameters.

Thus, the use of the three functional forms mentioned above implies examining the basic hypotheses there are:

(i) that the marginal productivity/utility of function are increasing, decreasing or negative (2 & 3) or it is just decreasing (1).

(ii) that the consumption/production elasticities are constant (1) or varing (2 & 3) and

(iii) that the structural parameters are constant (1 and 2) or varing (3).

Which one is the best:- The problem of choice of functional forms is by no means simple. It has been widely discussed in econometric literature. It depends on purpose of study. If the purpose of study or model is to obtain as accurate as possible values of the individual structural or reduced form co-efficients, the choice has conventionally been based on the statistical properties - unbiasedness and minimum variance. In the case of small samples writers have used a combination of bias and varience of estimates as criteria for their 'goodness' i.e. mean square error. And for functional forms, when attempting ranking, the most common measure of forecasting performance has been the root of mean square error (RMSE).

$$RMSE = \sqrt{\frac{\Sigma (F_i - A_i)^2}{n}}$$

where F_i = forecasted value of variable i.

A_i = Actual value of Variable i.

n = no. of observations.

The virtue of RMSE, on a prior ground, is that it is simple function of the bias and variance of the frequency function and therefore, its sampling distribution is relatively simple (R. Summer, 1965).

__(b) Selection of Variables:-__ In our context, the discussion of this aspect of model specification involves some question (Desai, 1973).

i) Are the variables selected relevant ?

ii) Have we selected all the relevant variables ?

iii) What is the degree of multicollinearity among the variables ?

(iv) What is the degree of aggregation ?

These questions should be raised because of their bearing on both economic and statistical analysis. Thus, omission of a relevant variable would bias the estimate of the regression coefficients associated, with the variables included in the model, against this, although, the inclusion of an irrelevant variable does not bias the estimate of the regression coefficient, but it is unsatisfactory for two reasons:

(i) it does not satisfy a criterion of logic behind selecting a variable, (ii) it reduces the degree of freedom and also increases, the possibility of multi-collinearity besides possibly including auto residuals. A high degree of multi-collinearity leads to imprecise estimates of the parameters.

For an economic theorist, the consumer demand function for an individual consumer j, in year t for ith product, having a disposable income ejt, may be written in this fashion (Allen, 1956).

$$q_{ijt} = f_j(P_{it} \ldots\ldots P_{mt},\ e_t)$$

where q_{ijt} = qnantity of good i demanded,

P_{kt} = Price of good k in year t, (k = 1 ....m)

and aggregate demand

$$q_{it} = f\ (P_{it} \ldots\ldots\ldots P_{mt},\ e_t)$$

where $q_{it} = \sum_{j=1}^{n} q_{ijt}$, $e_t = \sum_{j=1}^{n} e_{jt}$

But allowing for the influence of change in population over-time via some theoretical derivation was felt too complicated (McKillop, 1967), yet it was apparent that changing population might both shift the demand schedule and change its scope.

So at theoretical level the demand function can be written in this form.

$$q_{it} = f(P_{it} \ldots\ldots\ldots P_{mt},\ e_t,\ N_t)$$

where N_t = population in year t.

The variation in the consumption of forest products can be explained by three major factors income, price and population. But wood as it grows in forest is not consumer product (except fuelwood). It is converted in form and made into useful products to satisfy human desire to use it. So, the consumption depends on finished products made available to the consumers. Facilities for processing the wood are as important in determining consumption as is the source of forest raw materials. Wood using industries in developing countries, such as India, are generally under developed and that the factories to make products such as paper + paper boards are under developed in these countries, for instance, particle boards have hardly been used in Latin America because there has been almost no domestic manufacture (FAO, 1963). Many wood products such as sleepers, fence posts , mine timbers, sownwood etc. are secondary products and used in packing and in the construction of boat and buildings (FAO, 1963). So the amount of wood used for such purposes depends on the development of other sectors of the economy such as agriculture, industry, transport, mining and construction etc. But, in India none of these sectors have been as active as in the developed nations. Therefore, the amount of wood products consumed is closely limited to the condition of the general economy of a country and may be expected to follow a pattern of development similar to that the whole economy therefore, we are assuming, here that the national income (GNPFC) may be the best indicator of overall development of the economy.

In the present study, three conceptual frameworks are used for a quantitative assessment with the following objectives.

(i) determine the nature and magnitude of the relationship between the cosumption of forest products and the real national income and to derive the income elasticity of demand for various forest products.

(ii) To project the demand for forest products. The functional forms are as follow:

(1) $C_{it} = \alpha\, y_t^{\beta}\, e^{rt}$

or $\log C_{it} = \log \alpha + \beta \log y_t + rt$

(2) $C_{it} = \alpha\, y^{\beta}{}_t\, e^{ryt}$

or $\log C_{it} = \log \alpha + \beta \log y_t + ry_t$

and $C_{it} = \alpha\, e^{\beta(y)t}$

which for estimation purpose can be expanded in this way

(3) $C_{it} = \alpha\, e^{(\beta to + \beta 1\ (y)t)}$

or $\log C_{it} = \log \alpha + \beta ot + \beta_1 (y)t$

(4) $C_{it} = \alpha\, e^{\ (\beta ot\ +\ \beta 1(y)t\ +\ \beta_2 (y^2)t}$

or $\log C_{it} = \log \alpha + \beta_{ot} + \beta_1 (y)t + \beta_2\ (y^2)t.$

where y_t = GNP at factor cost in year t.

α, β's and r are parameters.

The expression for the income elasticity of consumption (demand) η_j for the jth product- from equation (1) the parameter of y_t is the elasticity which remains constant ovetime. From equation (2) the expression is as follow

(5) $\eta_j = \beta + ry_t$

and from equation (3) and (4) the expression is derived in this fashion respectively,

(6) $\eta_j = \beta_1 (y)t$ and

(7) $\eta_j = \beta_1 (y)t + 2\beta_2 (y^2)t$

in equation (5) $_j$ depends upon income in each year, but in equation (6) and (7) depends upon income in each year multipled by the time.

The second objective is to estimate growth rate for this purpose, we use the compound growth rate function, in which consumption is defined as a function of time-time trend is an indicator of all the major variations in population, income tastes and preferences prices and availability of substitutes which are pertinent in influencing of forest products consumption.

(8) $C_{it} = ab^t$

$$\text{or } \log C_{it} = \log a + (\log b)t$$

The compound growth rate is obtained by subtracting one from b. i.e. (b-1).

Our third objective is to forecast the demand for forest products. For this purpose we have used the structural equation (3) and (4).

4. Estimates of Consumption:

A long term trend analysis for a 19 year period (1970-88) revealed an increase in the consumption of wood estimated at 4.52 per cent per annum at all India level. The long term analysis (1962-83) of forest produce (Table 3.1,3.2) indicates that roundwood, other industrial roundwood, fibre board, paper + paperboard, printing + writing paper and wraping + packing paper + board has less than 5 percent growth rate in consumption over the period where as only pulpwood + particle, sawnwood + Sleepers and wood pulp has more than 10 percent compound growth rate and in remaining products growth rate in consumption varies between 5 percent to 10 percent per annum. The lowest growth rate is in the consumption of fibre board (3.63) and the highest growth rate is in the consumption of pulpwood + particles. The compound growth rate in the consumption of fuelwood is 5.34 percent per annum, whereas the compound growth rate in consumption of industrial roundwood is about 5.86, which is slightly above the fuelwood consumption. Moreover, the share of fuelwood + charcoal in total roundwood consumption has slightly increased over this long period i.e. in 1962 the share was 92.38 percent and in 1988 it remained 90.54 percent (1970 = 92.65, 1980 = 91.12) and the share of industrial roundwood over the period has slightly increased i.e. from 7.62 percent in 1982 to 9.5 percent in 1988 (1970 = 7.39, 1980 = 8.81). The growth indices for major forest product during the period 1970-88) would reveal a cosistent increase.

As mentioned above for the purpose of estimation of consumption of forest products, we have used the three type of models in four functional forms, and as for as matter of choice is concerned we have used the RMSE the function which provides least is considered the best for the purpose of forecasting (Kout, 1977, p. 505). The structural equation (4) gives the least RMSE in comparision to other structural equation forms. Only in the case of industrial roundwood the structural equation (2) gives least RMSE (Table 3.3). But for uniformity for the purpose of estimation of income elasticity and future consumption we have used the equation (3) and (4).

The results obtained in the evaluation of the first objective, namely nature and magnitude of the relationship between the consumption of forest products and income are shown in table 3.4,3.5,3.6,3.7 for the four functional forms respectively. Two basic results are abstracted from the tables for discussion.

1. The high value of adjusted R^2 for all the 21 consumption functions and the value of RMSE for all products almost around zero i.e. less than one support the explanatory power of the model used in this study.

2. In the case of structural equation (3) only for seven products β_1 are significant, but in the case of structural equation (4) for 12 products β_1 are significant and for II products β_2 are significant. When β_1 and β_2 both are significant being positive and negative, they support the basic hypothesis of varing elasticity of the model used. In computing the income elasticities the values of both β_1 and β_2 are used. In the case of structural equation (3), 12 products have negative sign and out of these 12 only three are significant. In the case of structural equation (4) only five products have negative sign for β_1 and only three β_1 of this type are significant, whereas for five products β_2 sign is positive and only for two product is significant.

The estimated income elasticities are presented in table 3.8 which are based on equation (6) and (7) respectively. Before evaluating these results, it is necessary to justify the importance of this exercise of computing income elasticities. These values of income elasticities could provide an empirical basis for identifying priority items of wood products and thereby for planned production programmes. Products with increasing income elasticities will be needed more in the economy than that with decreasing income elasticities. Siphoning off investments from the products with increasing income elasticities and investing there resources in the products with decreasing income elasticities would lead to a back of adequate demand for these products as income increases. And at the same, there will be a shortage in the case of products with increasing income elasticities. The effects in terms of expansion of production stabilisation of existing production, investment, research, training and creation of additional infrastructural facilities for production and marketing of increasing income elastic products should always be assigned high priority. In the case of products with negative (decreasing) elasticity i.e. for inferior goods proper care will have to be taken in assessing priority for their production. (Chandrakanth, 1979).

With the preceding discussion on hand, the 21 forest products are classified broadly into four categories. (Table 3.8 - II). Further in these categories products can be broadly classified into luxury necessity and inferior[1] as

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1. Economic Theory says that for η 71, the product in question is a luxury; for $\emptyset < \eta < 1$ the product is a necessity and for $\eta < \emptyset$, the product is an inferior good.

time and income changes, based on the value of income elasticities varies from point to point.

Products in group I belong to those products whose income elasticities increase as income and time increases, in group II, whose income elasticities decrease with increase in income and time, in group III, whose income elasticities first increase and after same time decrease as income and time increases, which is one of the basic properties of neo-classical functions. In group IV, there is only one product, particle board, whose elasticity first decreases and then increases as time and income varies in the same direction.

In the first group the income elasticity for sawnwood + sleepers and paper + paper board (NSE) after a point became elastic, and for the remaining products it remains less than one, in other words we can say that, in India, paper + paperboard, Newsprint, printing + writing papers are still necessities and income elasticities of these products increase as income and time increase, so these products demands much further attention.

In group II, as mentioned above, consists of products where elasticity decreases as time and income increases the elasticities of these products are negative from the beginning, so, these products can be put into the catagory of inferior products.

The negative and declining income elasticity for fuelwood may be due to the reason that as income increases fuelwood is substituted by fossite fuel[2].

To see the variation in income elasticities of forst products at various points it is necessary to known the end use of those projects, especially which need explanation.

As for as particle boards are concerned their elasticities first decreases and than increases, it may be due to that in the beginning the consumption of particle boards was not readily available to all the population[3] (FAO - 1963) or it may be that as the standard of living has increased and its availability to general people made possible its domestic consumption increased.

The demand for roundwod and wood products are for construction, container, manufacturing, furniture and fixtures manufacturing and other manufacturing, and made for households. Some products are primary products and some are secondary. The industrial roundwood consists of sawlogs + veneer logs, pulpwood + particles and other industrial roundwood. The paper + paperboards are major wood pulp products. So all these products demand and supply in influenced by the demand and supply of other products.

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2. In developing regions it is expected that as in come increases fuel wood is substituted by fosil fuels - for detail see - World Forest products. Demand and Supply 1990 & 2000. FAO (1982)

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3. In Latin America, as there is 1960s manufcturing was not developed and the particle board consumption was negligible and it increased with the development. For detail see - Latin American Timber Trends and Prospects FAO(1963).

In the beginning the demand for sawlogs + Veneer logs, wood panel, industrial round wood increased and after same time started to decrease i.e. the elasticity started to decline as lumber and plastics has come as their substitutes. And the income elasticity for wood pulp has become negative as the begasse straw waste paper and similar materials are used for paper + paper board manufacturing.

But positive and increasing income elasticity for industrial roundwood and paper products, and positive and elastic income elasticity for sownwood + sleepers proves the validity of the model, which assumes that the forest products consumptions is determined by the development of economy i.e. on national income since sownwood + sleepers are used in construction etc. activities.

5. <u>Predictions:</u>

Future consumption cannot be measured, it can only be estimated. The level and even the pertinence of such estimates depends on the assumption on which they are based. The actions of the potential consumers of a product at any particular time are influenced by many factors. In the case of forest products, these are disposable income, the availability of products itself, its prices, the prices of competing products, the existing state of technology, consumers tastes, habbit pattern etc. Even if the future condition of all these factors were known, future consumption would still be uncertain because their effects are not constant. All estimates of future consumption are therefore, useful, but this does not diminish their importance for planning.

So, the future estimates requires some assumptions. The assumptions should be careful estimates of what these levels might actually to be. The assumptions are:

(i) The forest products supply will be as abundant in the future as they are today, which depends on the availability of wood as a raw material. The availability of raw material, in turn, depends on the rate of which forests are harvested and in which they are managed.

(ii) The price of forest products in relation to competing materials will remain unchanged over the period in question.

(iii) The income in the question period will increase at the compound growth rate which has increased in the sample period.

Because of these assumptions, the figures in this chapter are not forecasts of what the future consumption actually will be; instead they are estimates of what the future consumption would be under specified conditions of abundence, prices and income assumed above.

For the predicting purpose, as clearly mentioned, we have used the structural equation (3) and (4). And for this purpose we have used the least square regression analysis which is called the ratio method also.

Forecasting equations had good explanatory power with the squarred multiple correlation coefficient never less than Ø.95 (McKillop, 1967). The estimated relationship are presented in table (3.6,3.7). The results obtained by these two structural equations are presented in table 3.9(I,II). Twelve products has increasing trend, whereas with 9 products have decreasing trend. The highest growth rate is for particle goods and lowest growth rate is for pupwood + particles in the forecasting period. For some products, in forecasting period, the consumption increase upto a certain point and after that started to decline, such that the consumption forecast for other industrial roundwood and wood based panel increase upto 1991 for fibre board upto 1993, for mechanical wood pulp 1996, and for other fibre pulp upto 1994 and after that started to decline.

6. Market Equilibrium:

To see the percent imbalance in forest products demand supply we have used the following expressions:

$$\text{percentage imbalance} = \frac{S_t - D_t}{D_t} \times 100$$

we take the available data as an indicator, the demand for roundwood which represent the total wood remains greater and it tends to be in equilibrium, subject to present rate of deforestation/afforestation remains constant. Excluding round wood, for eight forest products demand exceeds supply but in the remaining products supply will exceed the demand. The data of market equilibrium is presented in table 3.10.

7. Conclusion:

Past phenomena were well explained by the estimated equations. In no instance, the obtained value of multiple correlations coefficient is insignificant. According to Klein (1956) " .....the real test of the validity and usefulness of any theory is its ability to predict". Estimated structural equations may be regarded as theories as to how people behave and how prices and consumption levels are generated. The results of the study with regard to forecasting indicate that these theories and their associated premises stood up well under test.

Further the market equilibrium show the trade prospects in forest products.

Table 3.1

Estimated Consumptions Fuction

Forest Product	log a	log b	$\bar{R}^2$	Growth Rate
Roundwood '000m^3 (A)	1.439	0.0442	0.879	4.52
	(222.79)	(13.80)		
Fuelwood + Charcoal '000m^3	11.198	0.052	0.7	5.35
	(105.57)	(7.85)		
Ind.Roundwood '000m^3	8.888	0.057	0.467	5.86
	(47.727)	(4.87)		
Sawlogs+Veneer logs '000m^3	8.392	0.061	0.951	6.29
	(193.41)	(22.502)		
Pulpwood+Particle '000m^3	4.853	0.109	0.711	11.52
	(22.372)	(8.059)		
Other Ind.Round-wood '000m^3	7.43	0.042	0.889	4.29
	(159.38)	(14.479)		
Sawnwood+Sleepers 000m^3	7.424	0.096	0.977	10.07
	(161.528)	(33.324)		
Woodbased Panel '000m^3	4.518	0.057	0.887	5.86
	(70.901)	(14.35)		
Plywood '000m^3	4.209	0.061	0.856	6.29
	(53.798)	(12.483)		
Particle Board '000m^3	1.785	0.062	0.537	6.40
	(10.02)	(5.58)		
FibreBoard '000m^3	2.789	0.038	0.645	3.83
	(32.173)	(6.943)		
Woodpulp '000mt(A)	4.51	0.097	0.957	10.19
	(70.148)	(24.085)		
Mech.Woodpulp '000mt	2.714	0.08	0.709	8.32
	(17.022)	(8.026)		
Chem.Woodpulp '000mt	4.233	0.078	0.902	8.08
	(52.821)	(15.528)		
Other Fibrepulp '000mt	5.707	0.07	0.914	7.17
	(85.726)	(16.675)		
Paper+Paperboard '000mt (A)	6.396	0.047	0.966	4.77
	(232.77)	(27.152)		
Newsprint '000mt	4.619	0.057	0.885	5.85
	(71.785)	(14.178)		
Printing+Writing -paper '000mt	5.614	0.046	0.949	4.66
	(168.39)	(21.927)		
Other Paper+Paper Board '000mt	4.292	0.067	0.943	6.93
	(83.236)	(20.787)		
Wraping+Packing Paper+Board '000mt	4.292	0.067	0.943	6.92
	(83.236)	(20.787)		
Paper+PaperBoard (NES) '000mt	4.41	0.045	0.536	4.59
	(34.151)	(5.567)		

Figures in parentheses are t-statistics.

Table 3.2
Growth Indices of Major Wood Products in India

Year	Wood 'Round	'Fuel	Industrial	Wood Products Sawnwoo	Woodpanel '	Pulp	Paper+P.Board
1970	100	100	100	100	100	100	100
1971	103	103	104	109	115	123	103
1972	105	105	110	117	109	172	101
1973	108	108	117	129	89	201	96
1974	111	110	124	142	108	245	104
1975	114	113	129	156	98	256	102
1976	117	115	134	172	96	272	107
1977	119	118	138	188	119	288	117
1978	122	120	143	206	133	338	125
1979	125	123	148	230	144	381	131
1980	128	126	154	252	153	381	125
1981	131	128	160	276	212	390	162
1982	134	131	167	303	231	529	170
1983	137	134	174	332	236	539	171
1984	140	137	181	365	273	559	181
1985	144	140	188	400	273	600	184
1986	147	143	191	400	267	635	204
1987	150	146	196	400	274	688	214
1988	153	149	198	400	274	688	217
'Mean	183357	167406	15946	8270	230	463	1233
Simple G.R.	7.22	6.99	9.94	29.25	13.26	25.26	10.13
C.G.R	4.52	5.34	5.86	10.07	5.86	10.19	4.77

Table 3.3

Root of Mean square Error of Different Fuctional Forms

Forest Product	C=ab^t	C=aY^(b)e^(rt)	C=aY^(b)e^(Y)	C=ae^(bot+b₁(Y))	C=ae^(bot+b1yt+b2y^2t)
Roundwood (A)	0.125467	0.115255	0.096073	0.0052	0.005179
Fuelwood+Charcoal	0.25765	0.224645	0.22091	0.199801	0.193168
Ind. Roundwood	0.452701	0.452348	0.417315	0.429264	0.425319
Sawlogs+Veneerlogs	0.105473	0.104594	0.230175	0.018215	0.016132
Pulpwood+Particles	0.527304	0.527273	0.568468	0.527293	0.299108
Other Ind.Roundwood	0.113327	0.105206	0.10794	0.076425	0.072794
Sawnwood+Sleepers (A)	0.11172	0.107251	0.117664	0.076375	0.03163
Woodbased Panel (A)	0.154849	0.146019	0.139024	0.133976	0.121779
Plywood	0.125467	0.115255	0.096073	0.092924	0.089711
ParticleBoards	0.432992	0.430007	0.420512	0.42127	0.409284
Fibre Boards	0.210745	0.204383	0.201065	0.201058	0.199022
Woodpulp (A)	0.156275	0.150667	0.187283	0.155903	0.138814
Mech. Woodpulp	0.387576	0.33041	0.260954	0.254287	0.244433
Chem. Woodpulp	0.194807	0.194806	0.205495	0.19011	0.167278
Other Fibrepulp	0.16182	0.160602	0.16534	0.156457	0.154138
Paper+Paperboard(A)	0.066798	0.065596	0.063692	0.065794	0.059457
Newsprint	0.156413	0.154824	0.152404	0.155047	0.14925
Printing+Writing Paper	0.081049	0.080894	0.083335	0.080894	0.080599
Other Paper+Paperboard	0.087666	0.08644	0.080306	0.086799	0.069816
Wraping+Packing Paper+ Board	0.125342	0.123219	0.123824	0.123345	0.1236
Paper+Paperboard(NES)	0.313931	0.304572	0.305817	0.189353	0.187085

Table 3.4
Estimated Consumption Functions

Forest Product	log a	b	r	$\bar{R}^2$
Roundwood	28.223	-1.521	0.102	0.892
	(3.544)	(-2.107)	(3.7)	
Fuelwood+Charcoal	42.908	-2.872	0.158	0.718
	(2.207)	(-1.631)	(2.417)	
Ind.Roundwood	2.843	0.543	0.036	0.445
	(0.091)	(0.193)	(0.333)	
Sawlogs+Veneerlogs	8.763	-0.034	0.062	0.95
	(14.98)	(-0.637)	(19.091)	
Pulpwood+Particle	4.705	0.013	0.108	0.699
	(1.682)	(0.053)	(6.071)	
Other Ind.Roundwood	21.69	-1.293	0.091	0.9
	(2.984)	(-1.962)	(3.631)	
Sawnwood+Sleepers	18.013	-0.96	0.132	0.978
	(2.431)	(-1.429)	(5.161)	
Woodbased Panel	-11.436	1.446	0.002	0.896
	(-1.242)	(1.734)	(0.078)	
Plywood	-22.219	2.396	-0.03	0.875
	(-1.855)	(2.206)	(-0.717)	
Particle Board	18.965	-1.557	0.121	0.524
	(0.638)	(-0.578)	(1.18)	
Fibreboard	-14.607	1.577	-0.022	0.652
	(-1.034)	(1.232)	(-0.453)	
Woodpulp	8.554	-1.273	0.145	0.958
	(1.782)	(-1.349)	(4.033)	
Mech.Woodpulp	-65.864	6.216	-0.155	0.78
	(-2.885)	(3.004)	(-1.971)	
Chem.Woodpulp	3.962	0.024	0.077	0.898
	(0.294)	(0.02)	(1.654)	
Other Fibrepulp	-1.001	0.608	0.046	0.912
	(-0.09)	(0.605)	(1.21)	
Paper+paperboard	6.716	-0.029	0.048	0.966
	(19.713)	(-0.942)	(22.492)	
Newsprint	5.183	-0.051	0.059	0.883
	(6.445)	(-0.703)	(11.778)	
Printing+Writing Paper	5.741	-0.011	0.046	0.947
	(13.665)	(-0.303)	(17.67)	
Other Paper+Paperboard	4.584	0.067	0.03	0.919
	(4.463)	(0.794)	(2.529)	
Wraping +PackingPaper+ Board	3.709	0.053	0.065	0.943
	(5.796)	(0.913)	(16.243)	
Paper+Paperboard (NES)	6.34	-0.174	0.052	0.545
	(4.008)	(-1.224)	(5.271)	

Figures in parentheses are t-stat.

Table 3.5
Estimated Consumption Functions

Forest Product	log a	b	r	$\bar{R}^2$
Roundwood	-28.629	3.742	-0.000023	0.926
	(-5.627)	(7.79)	(-5.474)	
Fuelwood+Charcoal	-50.001	5.737	-0.000041	0.771
	(-3.808)	(4.619)	(-3.549)	
Ind.Roundwood	-53.039	5.793	-0.000039	0.528
	(-2.396)	(2.773)	(-2.081)	
Sawlogs+Veneerlogs	20.023	1.15	0.000023	0.757
	(8.046)	(4.75)	(7.498)	
Pulpwood+Particles	-34.041	3.565	-0.0000073	0.65
	(-5.715)	(6.753)	(-5.325)	
Other Ind. Roundwood	-23.571	2.886	-0.000016	0.895
	(-4.118)	(5.341)	(-3.365)	
Sawnwood+Sleepers	-46.21	4.967	-0.000022	0.974
	(-7.405)	(8.431)	(-4.251)	
Woodbased Panel	-0.661	0.424	0.0000098	0.906
	(-0.09)	(0.609)	(1.576)	
Plywood	5.63	-0.205	0.000016	0.896
	(0.671)	(-0.259)	(2.327)	
Particle Board	-51.105	4.935	-0.00003	0.545
	(-2.291)	(2.344)	(-1.598)	
Fibreboard	2.342	-0.002	0.000009	0.663
	(0.22)	(-0.002)	(1.005)	
Woodpulp	-37.253	0.643	-0.000012	0.938
	(-3.751)	(4.099)	(-1.436)	
Mech.Woodpulp	41.092	-3.726	0.000053	0.863
	(2.969)	(-2.852)	(4.55)	
Chem.Woodpulp	-16.426	1.867	0.0000015	0.887
	(-1.507)	(1.814)	(0.16)	
Other Fibrepulp	-12.953	1.687	0.0000012	0.907
	(-1.477)	(2.037)	(0.16)	
Paper+Paperboard	-11.594	1.649	-0.0000038	0.968
	(-17.144)	(27.5)	(-23.196)	
Newsprint	-17.471	2.025	-0.0000047	0.886
	(-10.797)	(14.115)	(-11.997)	
Printing+Writing Paper	-11.886	1.604	-0.00000376	0.943
	(-13.434)	(20.447)	(-17.054)	
Other Paper+Paperboard	-10.785	1.484	-0.0000034	0.938
	(-12.643)	(19.631)	(-16.663)	
Wraping+Packing Paper+	-21.094	2.325	-0.00000515	0.942
Paperboard	(-16.044)	(19.952)	(-16.16)	
Paper+Paperboard (NES)	-13.508	1.645	-0.0000041	0.541
	(-4.16)	(5.713)	(-5.231)	

Figures in parentheses are t-stat.

Table 3.6
Estimated Consumption Fuctions

Forest Product	log a	Bo	B1	Dum	$\bar{R}^2$
Roundwood	11.85	0.03	0.00	-0.44	1.00
	(2273)	(39.05)	(-3.23)	(-119.63)	
Fuelwood+Charcoal	11.79	0.02	0.00	-0.46	1.00
	(2563)	(40.484)	(-2.308)	(140.71)	
Ind. Roundwood	9.06	0.05	0.00	-0.25	1.00
	(467.656)	(20.745)	(-4.979)	(-18.387)	
Sawlog+Veneerlogs	8.71	0.05	0.00	-0.35	1.00
	(348.97)	(15.451)	(-1.56)	(-20.129)	
Pulpwood+Particles	4.85	0.11	0.00		0.70
	(21.817)	(7.137)	(-0.033)		
Other Ind. Roundwood	7.92	0.02	0.00	-0.42	1.00
	(408.38)	(9.268)	(-0.233)	(-33.376)	
Sawnwood+Sleepers	7.72	0.08	0.00	-0.31	0.99
	(72.068)	(5.823)	(0.287)	(-4.051)	
Woodbased Panels	4.69	0.18	0.00		0.91
	(61.05)	(1.22)	(2.84)		
Plywood	4.42	0.00	0.00		0.90
	(50.511)	(0.227)	(3.59)		
Particle Board	1.60	0.11	0.00		0.54
	(6.64)	(2.502)	(-1.164)		
Fibre Board	2.91	0.01	0.00		0.66
	(25.365)	(0.25)	(1.54)		
Woodpulp	4.49	0.10	0.00		0.96
	(50.487)	(6.109)	(-0.338)		
Mech. Woodpulp	3.27	-0.07	0.00		0.87
	(22.526)	(-2.535)	(5.6)		
Chem. Woodpulp	4.31	0.06	0.00		0.90
	(39.781)	(2.748)	(1.096)		
Other Fibrepulp	5.79	0.05	0.00		0.92
	(64.826)	(2.875)	(1.294)		
Paper+Paperboard	6.40	0.05	0.00		0.99
	(31.207)	(24.59)	(-0.859)		
Newsprint	4.62	0.06	0.00		0.88
	(70.83)	(12.85)	(-0.652)		
Printing+Writing Paper	5.61	0.05	0.00		0.95
	(165.078)	(19.43)	(-0.304)		
Other Paper+Paperboard	5.41	0.04	0.00		0.93
	(148.28)	(16.74)	(-0.702)		
Wraping+Packing Paper+ Board	4.29	0.07	0.00		0.94
	(82.811)	(18.158)	(0.884)		
Paper+Paperboard (NES)	5.42	-0.10	0.00	-1.11	0.82
	(28.87)	(-3.358)	(4.39)	(-6.297)	

Figures in parentheses are t-stat.

Table 3.7
Estimated Consumption Functions

Forest Product	log a	Bo	B1	B_2	Dum	$\bar{R}^2$
Roundwood	11.85	0.03	0.00	0.00	-0.44	1.00
	(1918)	(13.875)	(-0.485)	(0.817)	(-113.092)	
Fuelwood+Charcoal	11.79	0.03	0.00	0.00	-0.46	1.00
	(2200)	(15.42)	(-1.989)	(0.888)	(-135.158)	
Ind. Roundwood	9.09	0.04	0.00	0.00	-0.26	1.00
	(430)	(6.121)	(1.252)	(-2.007)	(-19.421)	
Sawlogs+Veneerlogs	8.77	0.02	0.00	0.00	-0.37	1.00
	(495)	(3.291)	(5.868)	(-6.28)	(33.418)	
Pulpwood+Particles	3.99	0.36	0.00	0.00		0.90
	(22.30)	(9.707)	(-6.95)	(6.96)		
Other Ind. Roundwood	7.91	0.04	0.00	0.00	-0.43	1.00
	(482)	(7.079)	(-3.297)	(3.288)	(-39.688)	
Sawnwood+Sleepers	8.00	-0.07	0.00	0.00	-0.39	1.00
	(152)	(-4.63)	(10.303)	(10.309)	(-11.89)	
Woodbased Panel	4.79	-0.09	0.00	0.00		0.92
	(52.83)	(-1.774)	(2.53)	(-2.199)		
Plywood	4.61	-0.16	0.00	0.00		0.93
	(48.268)	(-3.005)	(3.637)	(-3.186)		
Particle Board	1.37	0.31	0.00	0.00		0.55
	(4.483)	(1.79)	(-1.293)	(1.169)		
Fibre Board	2.97	-0.05	0.00	0.00		0.66
	(19.983)	(-0.599)	(0.853)	(-0.688)		
Woodpulp	4.65	-0.04	0.00	0.00		0.96
	(44.8)	(-0.604)	(2.395)	(-2.452)		
Mech. Woodpulp	3.43	-0.20	0.00	0.00		0.87
	(18.742)	(-2.005)	(2.007)	(-1.375)		
Chem. Woodpulp	4.52	-0.12	0.00	0.00		0.92
	(36.119)	(-1.697)	(2.71)	(-2.59)		
Other Fibrepulp	5.85	0.00	0.00	0.00		0.92
	(50.73)	(-0.056)	(0.973)	(-0.835)		
Paper+Paperboard	6.45	0.03	0.00	0.00		0.97
	(182)	(4.177)	(2.185)	(-2.272)		
Newsprint	4.70	0.03	0.00	0.00		0.89
	(52.885)	(1.821)	(1.288)	(-1.35)		
Printing+Writing Paper	5.63	0.04	0.00	0.00		0.95
	(117)	(4.176)	(0.384)	(-0.411)		
Other Paper+Paperboard	5.51	0.01	0.00	0.00		0.96
	(133)	(1.438)	(3.457)	(-3.543)		
Wraping+Packing Paper+ Board	4.30	0.06	0.00	0.00		0.94
	(58.635)	(4.086)	(0.256)	(-0.183)		
Paper+Paperboard (NES)	5.58	-0.18	0.00	0.00	-1.21	0.81
	(18.794)	(-1.546)	(1.19)	(-0.733)	(-5.408)	

Figures in parentheses are t-stat.

Table 3.8
Estimated Income Elasticities of Forest Products.

Year	Roundwood I	Roundwood II	Fuelwood+Charcoal I	Fuelwood+Charcoal II	Ind. Roundwood I	Ind. Roundwood II	Sawlogs+Veneerlogs I	Sawlogs+Veneerlogs II	Pulpwood+Particles I	Pulpwood+Particles II	Other Ind. Roundwood I	Other Ind. Roundwood II
1962	-0.0006	-0.0007	-0.0004	-0.0013	-0.004	0.004	-0.001	0.019	-0.00006	-0.09	-0.0001	-0.0106
1963	-0.0013	-0.0015	-0.0008	-0.0026	-0.008	0.008	-0.003	0.038	-0.00014	-0.2	-0.0003	-0.022
1964	-0.0022	-0.0024	-0.0014	-0.0042	-0.012	0.013	-0.005	0.06	-0.00022	-0.32	-0.0005	-0.0346
1965	-0.0029	-0.0031	-0.0017	-0.0054	-0.016	0.017	-0.006	0.079	-0.00028	-0.41	-0.0006	-0.045
1966	-0.0035	-0.0039	-0.0022	-0.0068	-0.02	0.021	-0.008	0.099	-0.00035	-0.51	-0.0008	-0.0566
1967	-0.0045	-0.005	-0.0028	-0.0087	-0.026	0.026	-0.01	0.124	-0.00046	-0.66	-0.001	-0.0714
1968	-0.0054	-0.006	-0.0034	-0.0103	-0.031	0.03	-0.012	0.148	-0.00055	-0.79	-0.0012	-0.0847
1969	-0.0066	-0.0073	-0.0042	-0.0124	-0.038	0.035	-0.015	0.175	-0.00067	-0.95	-0.0015	-0.1005
1970	-0.0078	-0.0086	-0.0049	-0.0144	-0.045	0.04	-0.018	0.202	-0.00079	-1.15	-0.0018	-0.1162
1971	-0.0088	-0.0097	-0.0055	-0.0161	-0.051	0.044	-0.02	0.226	-0.00089	-1.25	-0.002	-0.1298
1972	-0.0096	-0.0106	-0.006	-0.0177	-0.055	0.049	-0.022	0.248	-0.00097	-1.37	-0.0022	-0.1425
1973	-0.011	-0.0121	-0.0069	-0.02	-0.063	0.053	-0.025	0.277	-0.00111	-1.56	-0.0025	-0.1594
1974	-0.0121	-0.133	-0.0076	-0.0219	-0.07	0.057	-0.028	0.302	-0.0012	-1.71	-0.0027	-0.174
1975	-0.0142	-0.0156	-0.0089	-0.025	-0.082	0.061	-0.033	0.338	-0.0014	-1.98	-0.0032	-0.1951
1976	-0.0154	-0.0169	-0.0097	-0.027	-0.089	0.065	-0.036	0.364	-0.0016	-2.14	-0.0035	-0.2102
1977	-0.0177	-0.0193	-0.0111	-0.0301	-0.102	0.067	-0.041	0.398	-0.0018	-2.42	-0.004	-0.2303
1978	-0.0198	-0.0216	-0.125	-0.033	-0.115	0.069	-0.046	0.429	-0.002	-2.68	-0.0045	-0.2489
1979	-0.02	-0.0218	-0.0126	-0.0339	-0.115	0.075	-0.046	0.449	-0.002	-2.73	-0.0045	-0.2595
1980	-0.0226	-0.0247	-0.0142	-0.0373	-0.131	0.076	-0.052	0.482	-0.0022	-3.04	-0.0051	-0.2797
1981	-0.0252	-0.0274	-0.0159	-0.0405	-0.146	0.076	-0.058	0.512	-0.0025	-3.35	-0.0057	-0.2979
1982	-0.0271	-0.0295	-0.0171	-0.0431	-0.157	0.076	-0.063	0.539	-0.0027	-3.58	-0.0062	-0.314
1983	-0.0307	-0.0332	-0.0193	-0.0468	-0.177	0.068	-0.071	0.565	-0.0031	-3.97	-0.007	-0.3304
1984	-0.0333	-0.036	-0.0209	-0.0498	-0.192	0.065	-0.077	0.589	-0.0034	-4.26	-0.0076	-0.3408
1985	-0.0362	-0.039	-0.0228	-0.0527	-0.209	0.059	-0.084	0.609	-0.0037	-4.58	-0.0082	-0.3408
1986	-0.039	-0.042	-0.0246	-0.0556	-0.225	0.052	-0.09	0.627	-0.0039	-4.88	-0.0089	-0.3778
1987	-0.0423	-0.0454	-0.0266	-0.0586	-0.244	0.041	-0.098	0.641	-0.0043	-5.22	-0.0096	-0.3696
1988	-0.0486	-0.0519	-0.0306	-0.0622	-0.281	0.002	-0.112	0.617	-0.0049	-5.78	-0.011	-0.03789

Contd.

Year	Sawnwood+Sleepers		Woodbased Panel		Plywood		Particle Boards		Fibre Boards		Woodpulp	
	I	II	I	II	I	II	I	II	I	II	I	II
1962	0.001	0.099	0.015	0.068	0.02	0.09	-0.02	-0.11	-0.002	0.04	-0.002	0.06
1963	0.002	0.206	0.032	0.139	0.05	0.2	-0.04	-0.23	-0.004	0.08	-0.004	0.13
1964	0.004	0.324	0.051	0.213	0.07	0.31	-0.06	-0.35	-0.007	0.12	-0.007	0.19
1965	0.005	0.421	0.066	0.282	0.09	0.4	-0.08	-0.46	-0.009	0.16	-0.009	0.25
1966	0.006	0.53	0.09	0.359	0.11	0.51	-0.1	-0.58	-0.011	0.2	-0.012	0.32
1967	0.008	0.67	0.099	0.424	0.15	0.62	-0.14	-0.7	-0.015	0.25	-0.015	0.38
1968	0.01	0.795	0.129	0.504	0.18	0.72	-0.16	-0.82	-0.018	0.29	-0.018	0.43
1969	0.012	0.944	0.157	0.578	0.22	0.82	-0.2	-0.93	-0.022	0.33	-0.022	0.48
1970	0.015	0.093	0.185	0.648	0.27	0.92	-0.23	-1.04	-0.026	0.37	-0.026	0.53
1971	0.016	1.222	0.208	0.72	0.3	1.02	-0.26	-1.15	-0.029	0.42	-0.029	0.58
1972	0.018	1.341	0.228	0.792	0.33	1.12	-0.29	-1.27	-0.033	0.46	-0.032	0.64
1973	0.02	1.503	0.261	0.856	0.37	1.21	-0.33	-1.36	-0.036	0.5	-0.036	0.67
1974	0.022	1.641	0.287	0.924	0.41	1.3	-0.36	-1.46	-0.04	0.54	-0.04	0.71
1975	0.026	1.846	0.337	0.957	0.48	1.33	-0.42	-1.49	-0.047	0.57	-0.047	0.67
1976	0.029	1.989	0.366	1.018	0.52	1.41	-0.46	-1.58	-0.051	0.6	-0.051	0.7
1977	0.033	2.186	0.419	1.022	0.6	1.4	-0.53	-1.55	-0.058	0.62	-0.058	0.62
1978	0.037	2.368	0.47	1.016	0.67	1.37	-0.59	-1.5	-0.065	0.62	-0.065	0.53
1979	0.037	2.463	0.474	1.145	0.68	1.57	-0.6	-1.73	-0.066	0.69	-0.066	0.69
1980	0.042	2.664	0.537	1.102	0.77	1.48	-0.68	-1.61	-0.075	0.68	-0.075	0.53
1981	0.047	2.847	0.598	1.041	0.86	1.36	-0.75	-1.46	-0.083	0.66	-0.083	0.36
1982	0.05	3.005	0.644	1.027	0.92	1.33	-0.81	-1.4	-0.09	0.66	-0.09	0.26
1983	0.057	3.18	0.728	0.827	1.04	0.99	-0.92	-0.98	-0.101	0.58	-0.101	-0.13
1984	0.062	3.329	0.79	0.711	1.13	0.79	-1	-0.73	-0.11	0.53	-0.109	-0.38
1985	0.067	3.468	0.858	0.544	1.23	0.51	-1.08	-0.38	-0.119	0.45	-0.119	-0.71
1986	0.072	3.596	0.926	0.363	1.33	0.21	-1.167	-0.01	-0.129	0.37	-0.129	-1.05
1987	0.078	3.706	1.003	0.1	1.44	-0.21	-1.265	0.52	-0.14	0.25	-0.14	-1.51
1988	0.09	3.677	1.152	-0.778	1.65	-1.6	-1.45	2.2	-0.16	-0.17	-0.16	-2.88

'ear	Mech. Woodpulp		Chem. Woodpulp		Other Fibrepulp		Paper+Paperboard		Newsprint		Printing+Writing Paper	
	I	II	I	II	I	II	I	II	I	II	I	II
1962	0.06	0.123	0.008	0.09	0.008	0.033	-0.0002	0.006	-0.0004	0.009	-0.0001	0.0015
1963	0.12	0.252	0.017	0.19	0.017	0.067	-0.0005	0.013	-0.0009	0.02	-0.0002	0.0031
1964	0.19	0.393	0.028	0.29	0.027	0.103	-0.0008	0.02	-0.0015	0.031	-0.0004	0.0049
1965	0.25	0.514	0.036	0.38	0.034	0.136	-0.0011	0.026	-0.0019	0.04	-0.0005	0.0063
1966	0.31	0.646	0.045	0.48	0.043	0.171	-0.0014	0.033	-0.0024	0.051	-0.0006	0.0079
1967	0.4	0.803	0.058	0.58	0.056	0.208	-0.0018	0.042	-0.0031	0.065	-0.0007	0.0102
1968	0.48	0.947	0.07	0.67	0.067	0.244	-0.0021	0.05	-0.0038	0.078	-0.0009	0.0121
1969	0.59	1.108	0.085	0.76	0.082	0.28	-0.0026	0.061	-0.0046	0.094	-0.0011	0.0146
1970	0.69	1.266	0.101	0.85	0.097	0.314	-0.0031	0.071	-0.0054	0.11	-0.0013	0.0171
1971	0.77	1.411	0.113	0.94	0.108	0.349	-0.0034	0.08	-0.006	0.123	-0.0014	0.0191
1972	0.85	1.55	0.124	1.03	0.119	0.384	-0.0048	0.088	-0.0066	0.135	-0.0016	0.021
1973	0.97	1.711	0.141	1.1	0.136	0.416	-0.0053	0.099	-0.0076	0.153	-0.0018	0.0238
1974	1.07	1.86	0.156	1.18	0.15	0.448	-0.0057	0.109	-0.0084	0.168	-0.002	0.0261
1975	1.26	2.023	0.183	1.18	0.176	0.465	-0.0066	0.126	-0.0098	0.195	-0.0023	0.0302
1976	1.37	2.169	0.199	1.24	0.191	0.495	-0.006	0.136	-0.0106	0.211	-0.0025	0.0327
1977	1.57	2.305	0.228	1.19	0.219	0.498	-0.0069	0.153	-0.0122	0.237	-0.0029	0.0367
1978	1.76	2.42	0.256	1.12	0.245	0.496	-0.0078	0.17	-0.0137	0.263	-0.0033	0.0408
1979	1.77	2.59	0.257	1.33	0.247	0.538	-0.0078	0.174	-0.0138	0.268	-0.0033	0.0416
1980	2.01	2.69	0.292	1.19	0.28	0.538	-0.0089	0.193	-0.0156	0.299	-0.0037	0.0463
1981	2.23	2.76	0.325	1.02	0.312	0.51	-0.0099	0.212	-0.0174	0.328	-0.0042	0.0508
1982	2.41	2.86	0.35	0.95	0.336	0.504	-0.0106	0.227	-0.0188	0.357	-0.0045	0.0543
1983	2.72	2.81	0.396	0.54	0.38	0.41	-0.012	0.251	-0.0212	0.388	-0.0051	0.06
1984	2.95	2.81	0.429	0.28	0.412	0.355	-0.013	0.269	-0.023	0.416	-0.0055	0.0643
1985	3.21	2.77	0.466	-0.07	0.448	0.276	-0.014	0.288	-0.025	0.446	-0.006	0.0689
1986	3.46	2.7	0.503	-0.43	0.483	0.19	-0.015	0.307	-0.027	0.475	-0.0064	0.0734
1987	3.75	2.56	0.545	-0.95	0.523	0.065	-0.017	0.328	-0.029	0.508	-0.007	0.0783
1988	4.31	1.81	0.626	-2.53	0.601	-0.354	-0.019	0.361	-0.034	0.56	-0.008	0.0862

Year	Other Paper+ Paper Board I	II	Wraping+ Packing Paper+Board I	II	Paper+PaperBoard(NES) I	II
1962	-0.0003	-0.001	0.0005	-0.0104	0.042	0.091
1963	-0.0006	-0.004	0.001	-0.0232	0.088	0.189
1964	-0.0009	-0.01	0.0016	-0.0406	0.142	0.301
1965	-0.0012	-0.011	0.0021	-0.499	0.183	0.389
1966	-0.0015	-0.015	0.0026	-0.0638	0.231	0.491
1967	-0.0019	-0.028	0.0034	-0.09	0.299	0.627
1968	-0.0023	-0.037	0.0041	-0.1113	0.358	0.748
1969	-0.0028	-0.056	0.005	-0.1454	0.436	0.898
1970	-0.0033	-0.078	0.0059	-0.1816	0.515	1.051
1971	-0.0037	-0.089	0.0066	-0.2056	0.578	1.176
1972	-0.0041	-0.097	0.0072	-0.2247	0.634	1.29
1973	-0.0046	-0.127	0.0083	-0.2711	0.725	1.46
1974	-0.0051	-0.146	0.0091	-0.3035	0.798	1.6
1975	-0.006	-0.212	0.0107	-0.3927	0.938	1.838
1976	-0.0065	-0.237	0.0116	-0.4321	1.018	1.988
1977	-0.0074	-0.318	0.0133	-0.5349	1.166	2.231
1978	-0.0084	-0.399	0.0149	-0.6378	1.309	2.461
1979	-0.0084	-0.362	0.015	-0.6179	1.317	2.517
1980	-0.0096	-0.473	0.017	-0.7436	1.493	2.787
1981	-0.0107	-0.587	0.019	-0.8804	1.663	3.043
1982	-0.0115	-0.662	0.0204	-0.9748	1.792	3.247
1983	-0.013	-0.856	0.0231	-1.1957	2.026	3.561
1984	-0.0141	-0.988	0.0251	-1.3495	2.198	3.802
1985	-0.0153	-1.146	0.0272	-1.5296	2.387	4.054
1986	-0.0165	-1.308	0.0294	-1.7133	2.576	4.311
1987	-0.0179	-1.511	0.0318	-1.9384	2.791	4.563
1988	-0.0205	-2.023	0.0366	-2.4774	2.206	4.948

Table 3.9
Projected Consumption of Forest Products in India

Forest Product\Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Roundwood (A) I	271102	276952	282858	288814	294815	300851	306919	313013	319119	325227	331333	337422
'000m^3 II	271324	277352	283518	289798	296215	302777	309493	316380	323460	330744	338260	346037
Fuelwood+Charcoal I	224365	220250	214973	208564	201064	192552	183117	172878	161956	150506	138688	126670
'000m^3 II	271069	297096	333131	383728	456215	562727	724278	978906	1399423	2132658	3494917	6217756
Ind.Roundwood I	26790	26683	26443	26065	25549	24896	24110	23198	22167	21032	19805	18502
'000m^3 II	24179	22159	19727	16988	14083	11182	8454	6047	4063	2545	1473	780
Sawlogs+Veneerlogs I	21326	22260	23231	24241	25292	26384	27518	28696	29920	31189	32506	38272
'000m^3 II	21501	22364	23237	24115	24993	25866	28725	27564	28373	29142	29860	30516
Pulpwood+Particles I	1042	901	759	621	493	379	282	203	141	94	60	37
'000m^3 II	1451	1648	1967	2496	3408	5077	8385	15616	33443	84153	254771	953524
Other Ind.Roundwood I	4832	4937	5041	5145	5247	5349	5549	5547	5643	5737	5827	5914
'000m^3 II	4738	4762	4763	4735	4676	4582	4451	4281	4072	3825	3542	3227
Sawnwood+Sleepers (A) I	22156	24122	26273	28626	31204	34028	37127	40526	44261	48365	52880	57851
'000m^3 II	19597	19312	18500	17147	15295	13053	10588	8104	5807	3560	2357	1307
Woodbased Panel (A) I	539	598	666	746	840	952	1085	1244	1435	1668	1954	2305
'000m^3 II	489	500	502	494	474	441	397	344	284	223	165	114
Plywood I	477	542	620	714	830	972	1149	1370	1650	2007	2466	3065
'000m^3 II	411	413	404	382	348	303	250	194	141	94	58	32
Particle Board I	27	27	27	27	26	26	25	24	23	21	20	18
'000m^3 II	32	37	45	56	74	103	152	243	423	813	1743	4243
Fibre Board I	54	58	63	68	74	82	90	100	111	124	140	159
'000m^3 II	51	53	54	55	55	55	54	51	48	44	39	34
Woodpulp (A) I	1328	1454	1590	1737	1897	2070	2257	2459	2676	2910	3160	3429
'000mt. II	1171	1155	1105	1022	909	771	620	470	333	218	131	72
Mech. Woodpulp I	273	352	462	619	847	1183	1691	2476	3716	5726	9069	14788
'000mt. II	241	280	323	367	409	446	472	483	475	444	392	324
Chem. Woodpulp I	668	740	823	917	1025	1150	1294	1461	1656	1883	2151	2467
'000mt. II	569	552	518	467	402	327	250	178	117	70	38	18
Other Fibrepulp I	2298	2525	2780	3071	3401	3779	4211	4710	5286	5954	6733	7645
'000mt. II	2191	2314	2424	2513	2574	2600	2584	2520	2404	2237	2023	1770
Paper+Paperboard (A) I	2205	2307	2415	2527	2644	2766	2894	3027	3165	3310	3460	3617
'000mt. II	2466	2632	2814	3013	3231	3470	3732	4020	4336	4685	5068	5489
Newsprint I	498	526	556	587	620	655	691	729	770	812	856	903
'000mt. II	588	640	698	763	836	917	1010	1113	1230	1363	1512	1681
Printing+Writing I	984	1029	1077	1126	1178	1233	1289	1349	1410	1475	1543	1613
Paper '000mt. II	1011	1063	1118	1176	1238	1303	1372	1446	1523	1606	1694	1796
Other Paper+Paper I	718	748	779	811	844	879	914	952	990	1030	1071	1114
Board '000mt. II	881	951	1030	1118	1208	1330	1456	1600	1762	1945	2154	2391
Wrapng+Packing I	478	512	548	588	630	675	724	777	833	894	960	1031
Paper+Board '000mt. II	487	523	562	605	651	701	755	814	878	947	1023	1105
Paper+Paperboard I	359	414	485	576	576	694	850	1343	1735	2285	3073	4221
(NES) '000mt. II	341	376	414	455	498	542	585	624	656	677	683	671

Table 3.10
Future Percentage Imbalance in Market Equilibrium of Forest Products in India.

Forest Product\Year		1989.00	1990.00	1991.00	1992.00	1993.00	1994.00	1995.00	1996.00	1997.00	1998.00	1999.00	2000.00
Roundwood (A)	I	0.32	0.47	0.64	0.83	1.05	1.29	1.56	1.86	2.18	2.54	2.93	3.36
	II	-0.30	-0.32	-0.32	-0.33	-0.32	-0.31	-0.29	-0.25	-0.21	0.15	-0.09	0.00
Fulewood+Charcoal	I	0.30	0.40	0.52	0.65	0.79	0.95	1.13	1.33	1.54	1.77	2.02	2.30
	II	-0.16	-0.24	-0.34	-0.46	-0.61	-0.79	-1.00	-1.26	-1.56	-1.92	-2.34	-2.82
Ind. Roundwood	I	1.02	1.83	2.76	3.84	5.07	6.46	8.02	9.78	11.75	13.59	16.40	19.13
	II	-1.67	-1.05	-0.16	1.04	2.62	4.64	7.21	10.41	14.40	19.35	25.45	33.01
Sawlogs+Veneerlogs	I	-1.13	-0.93	-0.69	-0.39	-0.04	0.37	0.84	1.38	1.98	2.66	3.42	4.26
	II	-0.19	1.67	4.17	7.50	11.83	17.43	24.65	33.94	45.95	61.57	82.09	109.42
Pulpwood+Particles	I	161.07	236.65	346.03	508.00	753.95	1137.69	1754.14	2775.69	4525.63	7631.02	13349.60	24310.50
	II	-40.15	-53.98	-66.90	-77.97	-86.61	-92.66	-96.43	-98.49	-99.45	-99.83	-99.96	-99.95
Other IndRoundwood	I	0.12	0.16	0.21	0.25	0.31	0.37	0.43	0.50	0.58	0.67	0.76	0.86
	II	-1.77	-3.03	-4.60	-6.32	-8.82	-11.54	-14.70	-18.31	-22.37	-26.89	-31.82	-37.13
Sawnwood+Sleepers	I	-6.77	-7.45	-8.16	-8.90	-9.68	-10.48	-11.32	12.20	-13.11	-14.06	-15.05	-16.08
(A)	II	7.85	18.99	35.11	58.65	93.67	147.24	232.24	373.37	620.90	1084.04	2017.90	4072.24
WoodbasedPanel	I	-21.63	-27.17	-32.84	-38.56	-44.26	-49.88	-55.35	-60.62	-65.61	-70.30	-74.63	-78.59
(A)	II	6.61	8.10	10.98	15.04	20.64	28.26	38.57	52.51	71.52	97.75	134.57	187.46
Plywood	I	-17.67	-22.96	-28.43	-34.01	-39.62	-45.22	-50.72	-56.08	-61.22	-66.11	-70.69	-74.93
	II	16.73	28.86	46.65	72.95	112.62	174.27	273.96	443.31	748.76	1340.14	2583.39	5460.29
Particle Board	I	57.25	68.72	82.17	98.02	116.76	139.03	165.74	197.63	236.34	283.51	341.44	413.20
	II	2.62	-9.79	-23.70	-38.30	-52.63	-67.75	-76.88	-85.57	-91.76	-95.75	-98.05	-99.21
Fibre Board	I	-8.47	-11.88	-15.48	-19.25	-23.18	-27.23	-31.39	-35.63	-39.91	-44.21	-48.49	-52.72
	II	-0.79	-0.16	1.17	3.40	6.75	11.54	18.19	27.31	39.76	56.80	80.37	113.49
Woodpulp (A)	I	42.83	51.63	61.08	71.24	82.18	93.98	106.71	120.47	135.37	151.51	169.03	188.09
	II	-14.99	-12.81	-8.72	-2.01	8.47	24.52	49.25	88.13	151.41	259.42	455.07	836.49
Mech. Woodpulp	I	-59.46	-66.12	-72.21	-77.64	-82.38	-86.41	-89.75	-92.46	-94.58	-96.21	-97.42	-98.30
	II	1.88	11.88	25.63	44.76	71.90	111.37	170.59	262.79	412.89	670.38	1139.70	2057.71
Chem. Woodpulp	I	17.55	19.43	21.01	22.26	23.16	23.68	23.79	23.47	22.71	21.49	19.80	17.63
	II	-2.77	3.64	13.62	28.88	52.24	88.68	147.34	246.09	422.12	758.79	1459.00	3067.59
Other Fibrepulp	I	-8.93	-11.16	-13.55	-16.12	-18.84	-21.72	-24.73	-27.87	-31.19	-34.48	-37.91	-41.40
	II	6.01	9.98	15.25	22.19	31.31	43.33	59.28	80.67	109.72	150.12	207.34	290.74
Paper+Paper Board	I	-20.49	-21.79	-23.22	-24.77	-26.43	-28.21	-30.11	-32.11	-34.22	-36.43	-38.74	-48.12
(A)	II	-13.00	-12.69	-12.40	-12.14	-11.90	-11.68	-11.51	-11.36	-11.26	-11.20	-11.18	-11.21
Newsprint	I	-62.24	-61.98	-61.83	-61.79	-61.86	-62.04	-62.35	-62.79	-63.35	-64.04	-64.86	-65.81
	II	-20.71	-3.49	19.76	51.76	96.80	161.73	257.86	404.45	635.31	1012.16	1651.92	2786.50
Printing+Writing	I	-6.42	-7.03	-7.67	-8.35	-9.07	-9.83	-10.64	-11.49	-12.38	-13.32	-14.31	-15.35
Paper	II	-8.25	-8.94	-9.59	-10.19	-10.71	-11.15	-11.49	-11.69	-11.73	-11.59	-11.24	-10.62
Other Paper+Paper	I	-12.62	-15.94	-18.06	-21.06	-24.23	-27.56	-31.03	-34.62	-38.30	-42.05	-45.84	-49.65
Board	II	-7.12	-10.53	-14.64	-19.45	-24.95	-31.07	-37.70	-44.73	-51.96	-59.21	-66.25	-72.86
Wraping+Packing	I	-2.60	-2.89	-3.21	-3.56	-3.93	-4.32	-4.74	-5.19	-6.67	-6.18	-6.71	-7.28
Paper+Board	II	-4.03	-5.23	-6.67	-8.37	-10.37	-12.68	-15.32	-18.32	-21.67	-25.39	-29.46	-33.88
Paper+Paper Board	I	-35.41	-42.66	-49.81	-56.69	-63.20	-69.22	-74.69	-79.56	-83.79	-87.39	-90.40	-92.84
(NES)	II	11.48	17.12	24.29	33.45	45.24	60.61	80.88	108.07	145.26	197.30	272.10	383.06

Fig. 3.1 Consumption of Roundwood in India (1962-88)

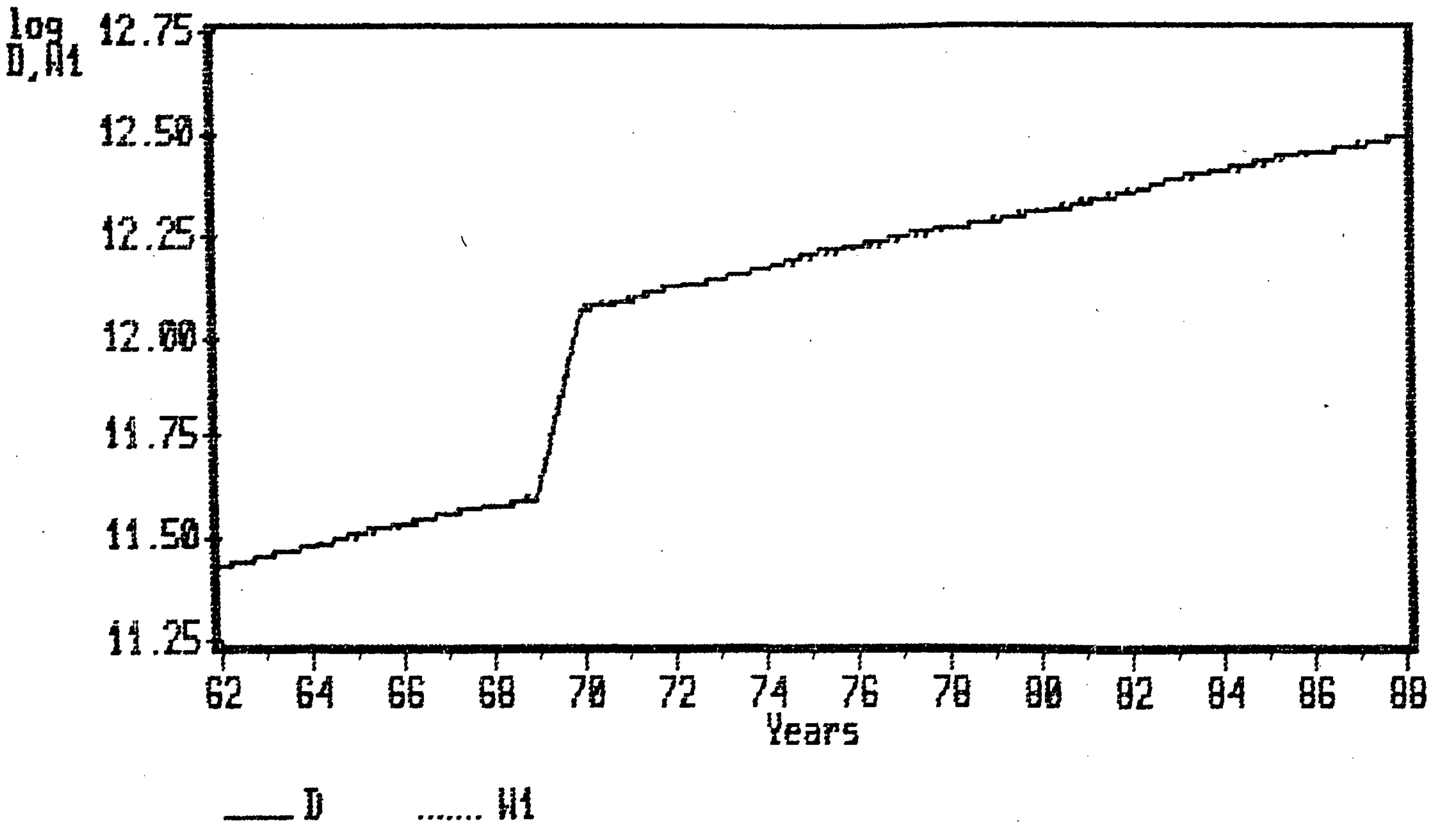


Fig. 3.2 Consumption of Roundwood in India (1962-88)

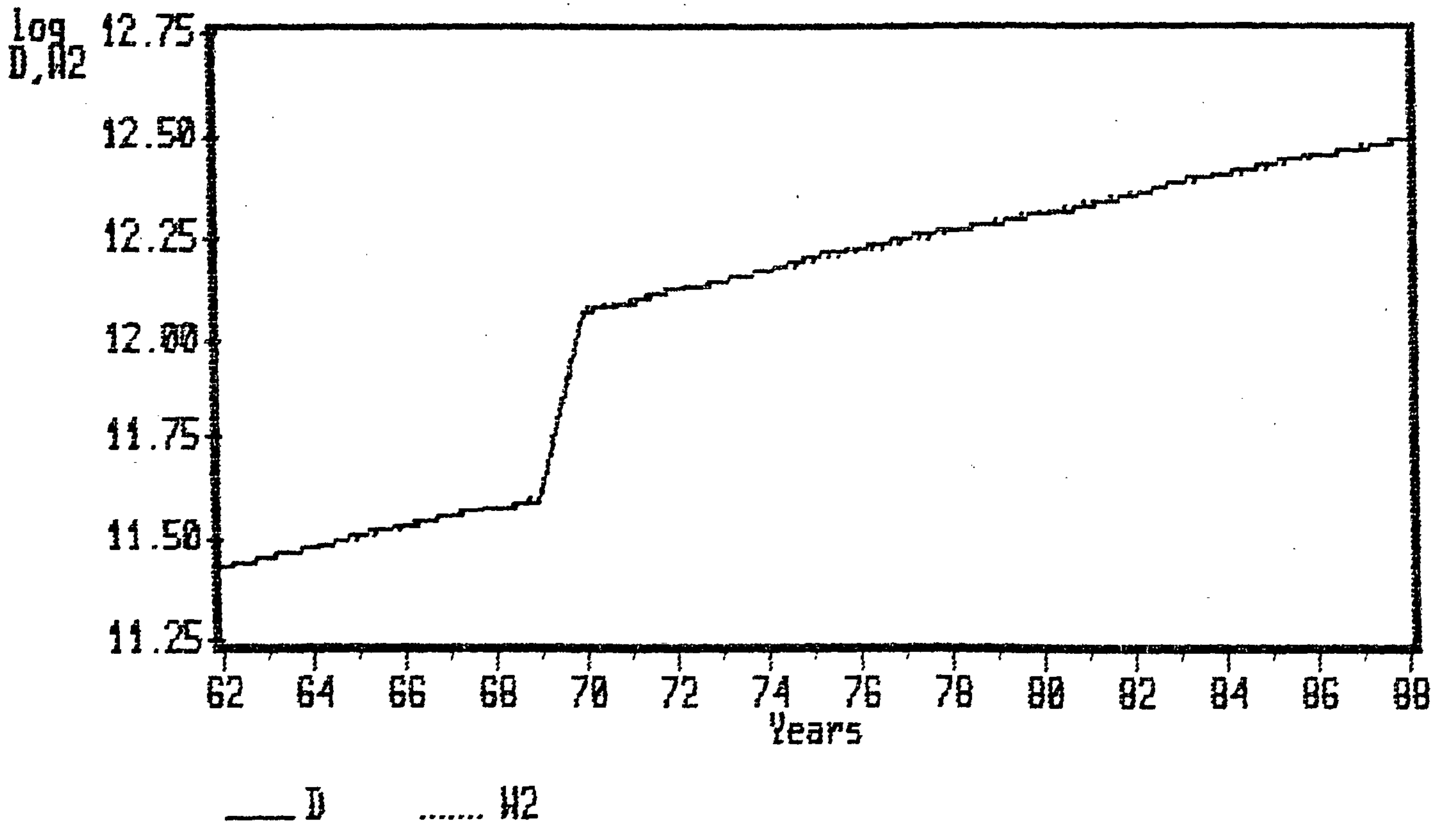


Fig. 3.3   Consumption of Sawnwood + Sleepers in India (1962-88)

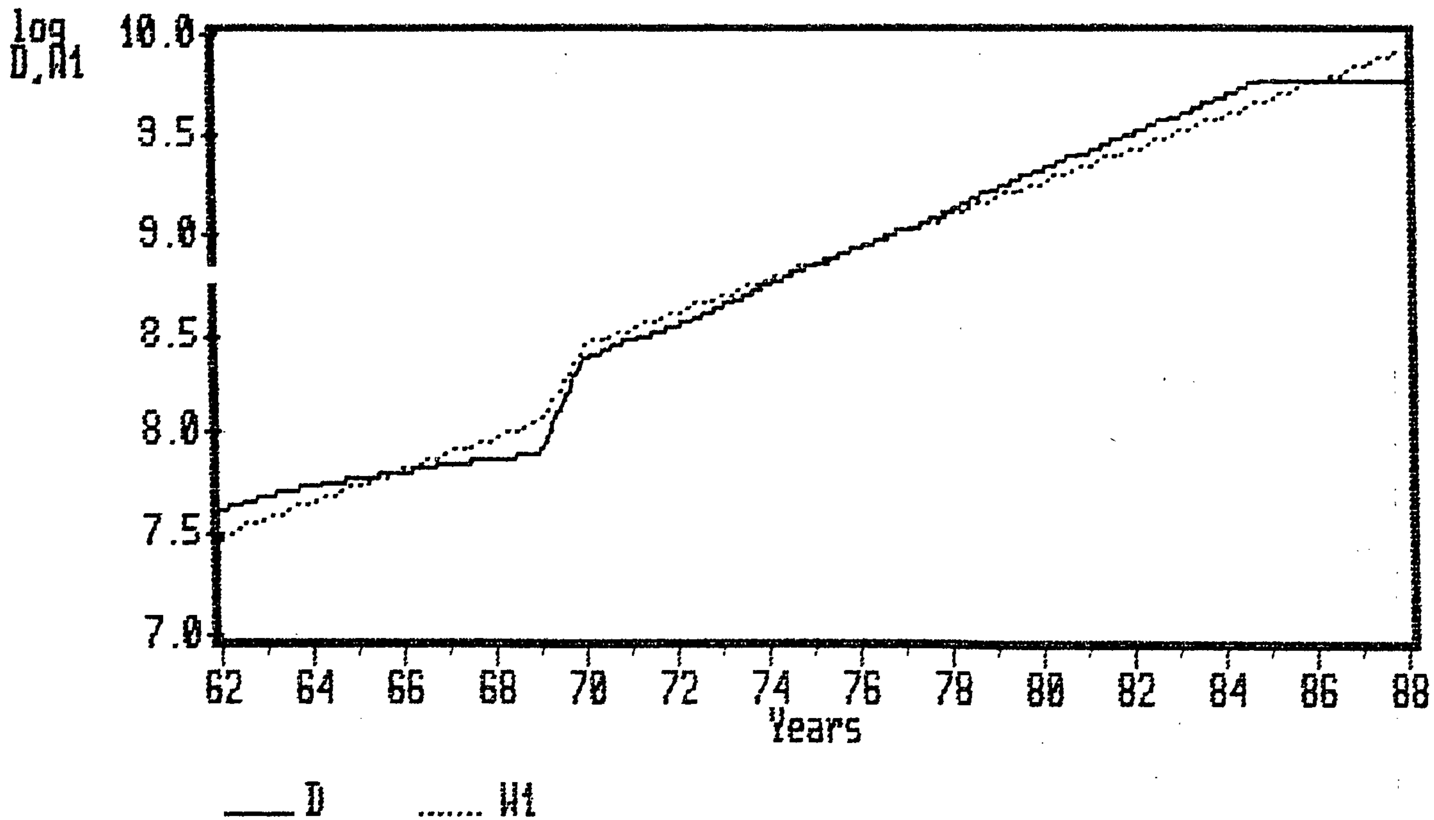


Fig. 3.4 Consumption of Sawnwood + Sleepers in India (1962-88)

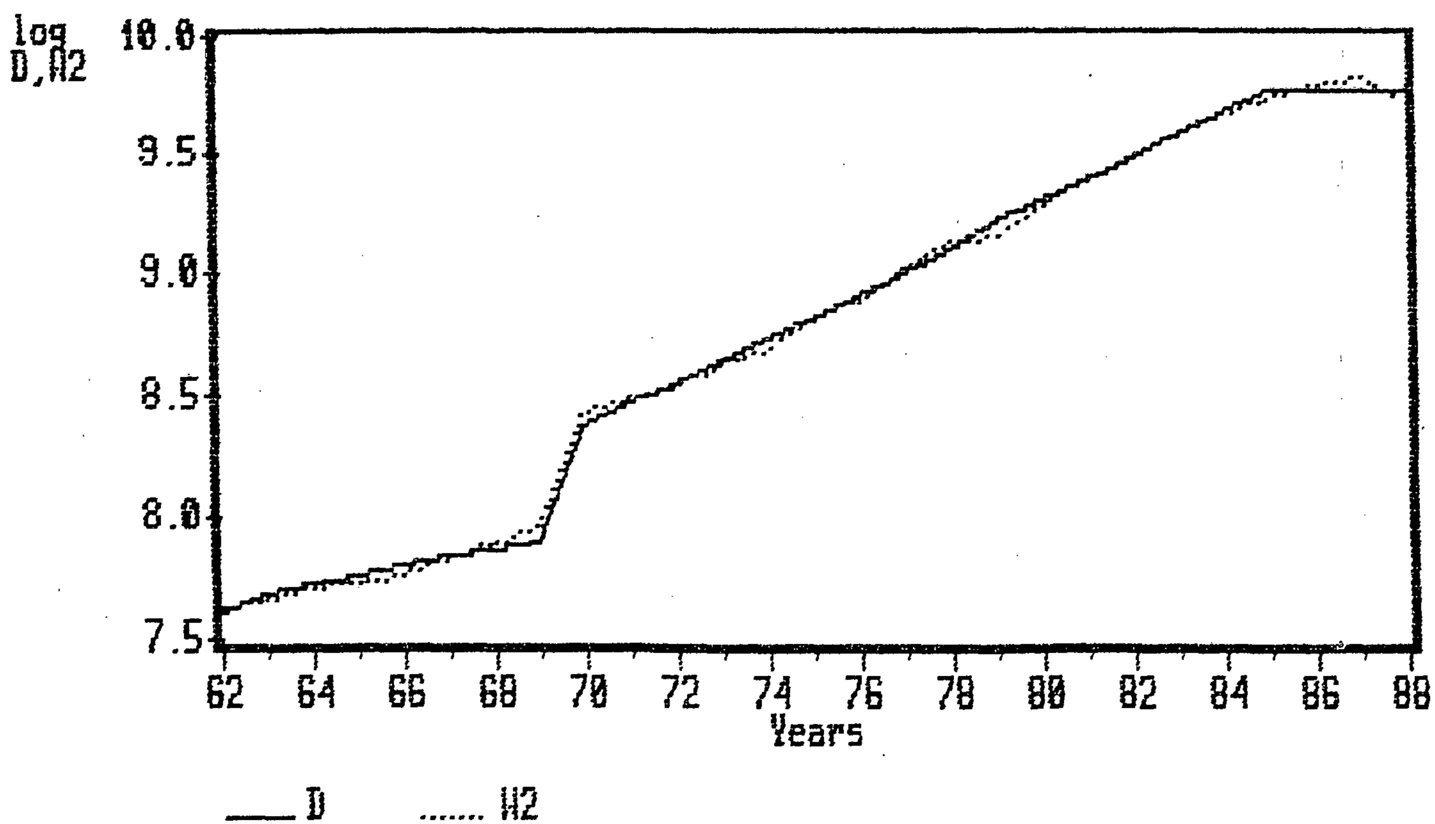


Fig. 3.5 Consumption of Woodbased Panels in India (1962-88)

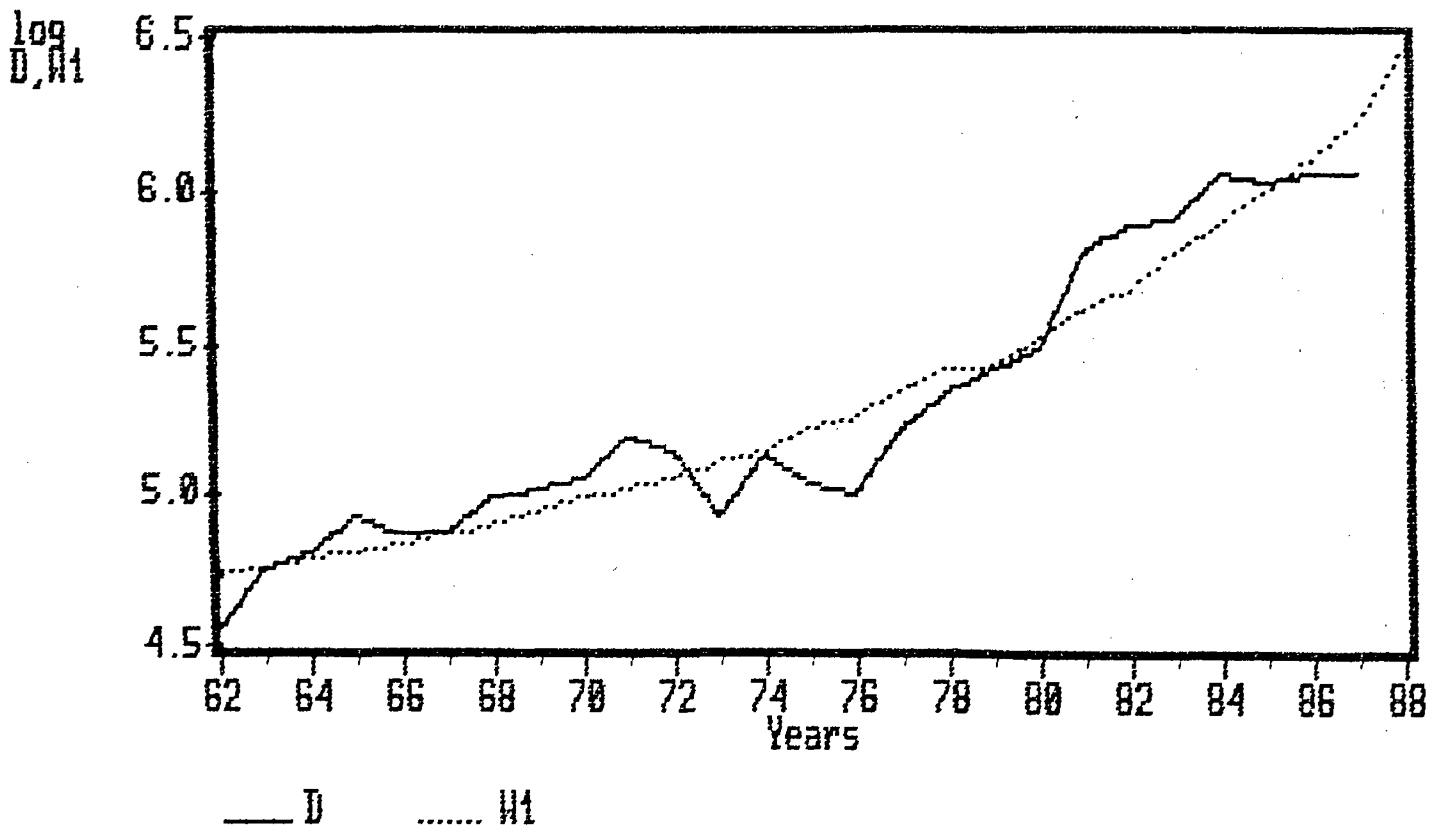


Fig. 3.6 Consumption of Woodbased Panels in India (1962-88)

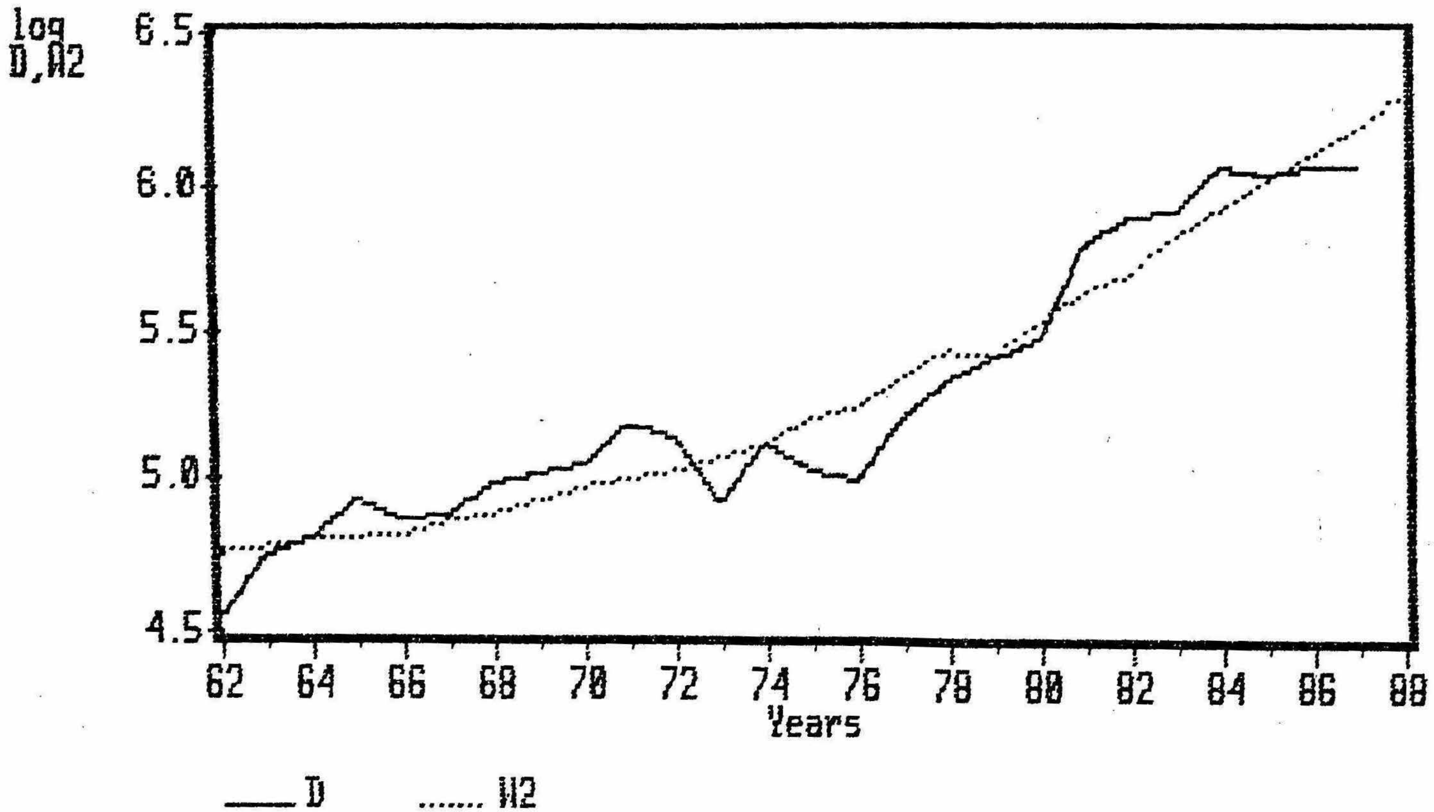


Fig. 3.7 Consumption of Woodpulp in India (1962-88)

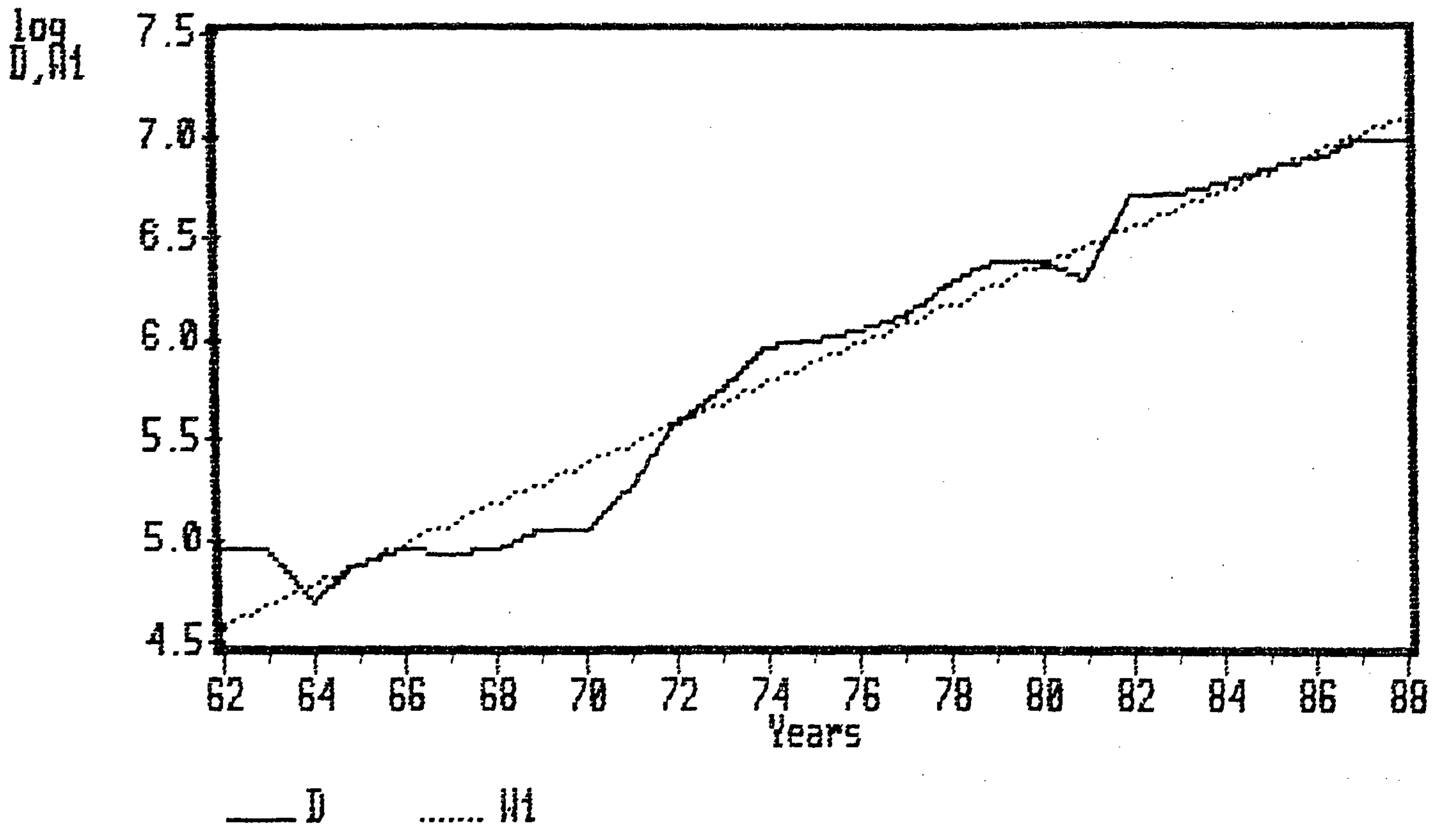


Fig. 3.8 Consumtion of Woodpulp in India (1962-88)

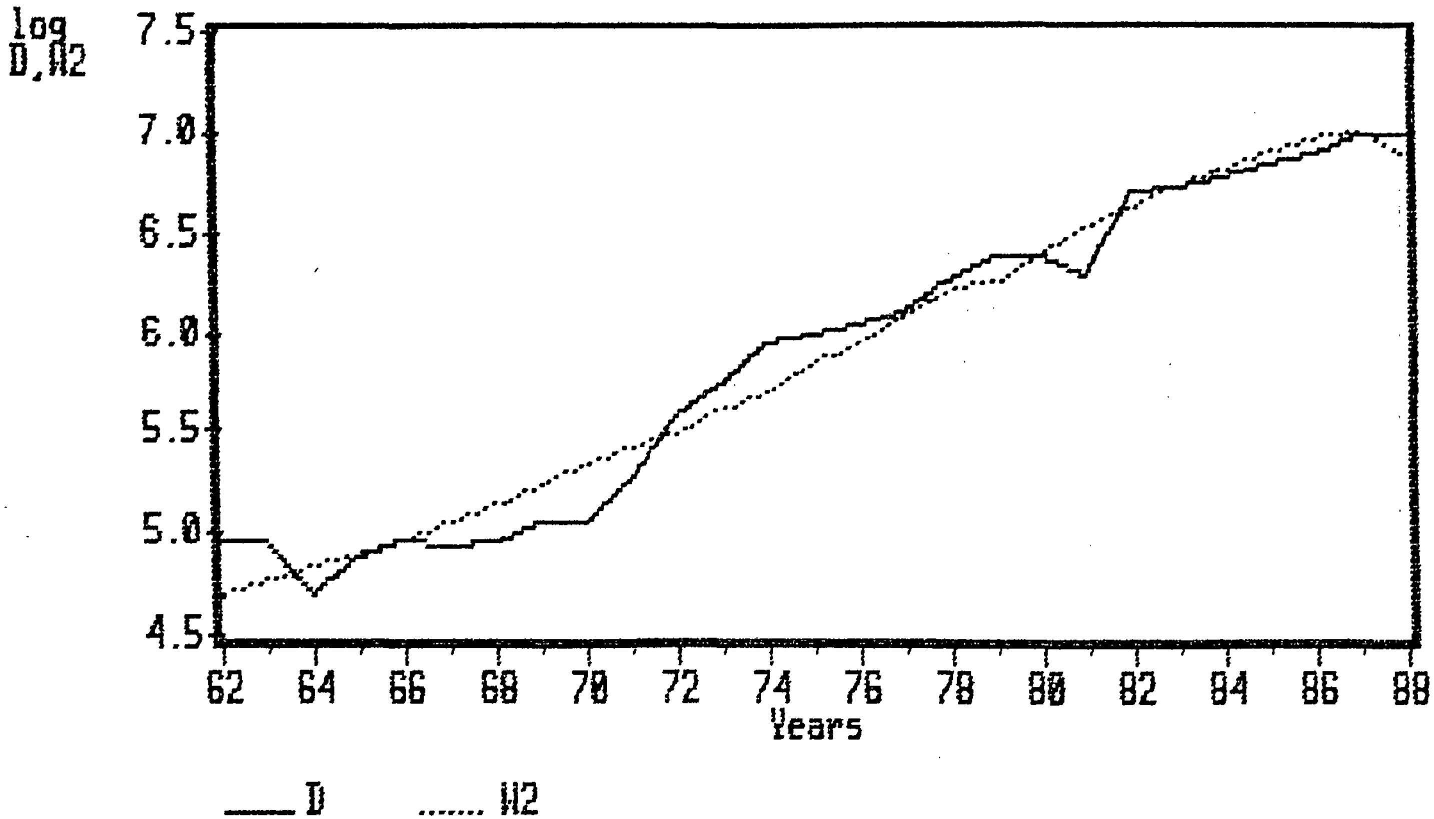


Fig. 3.9 Consumption of Paper + Paperboard in India (1962-88)

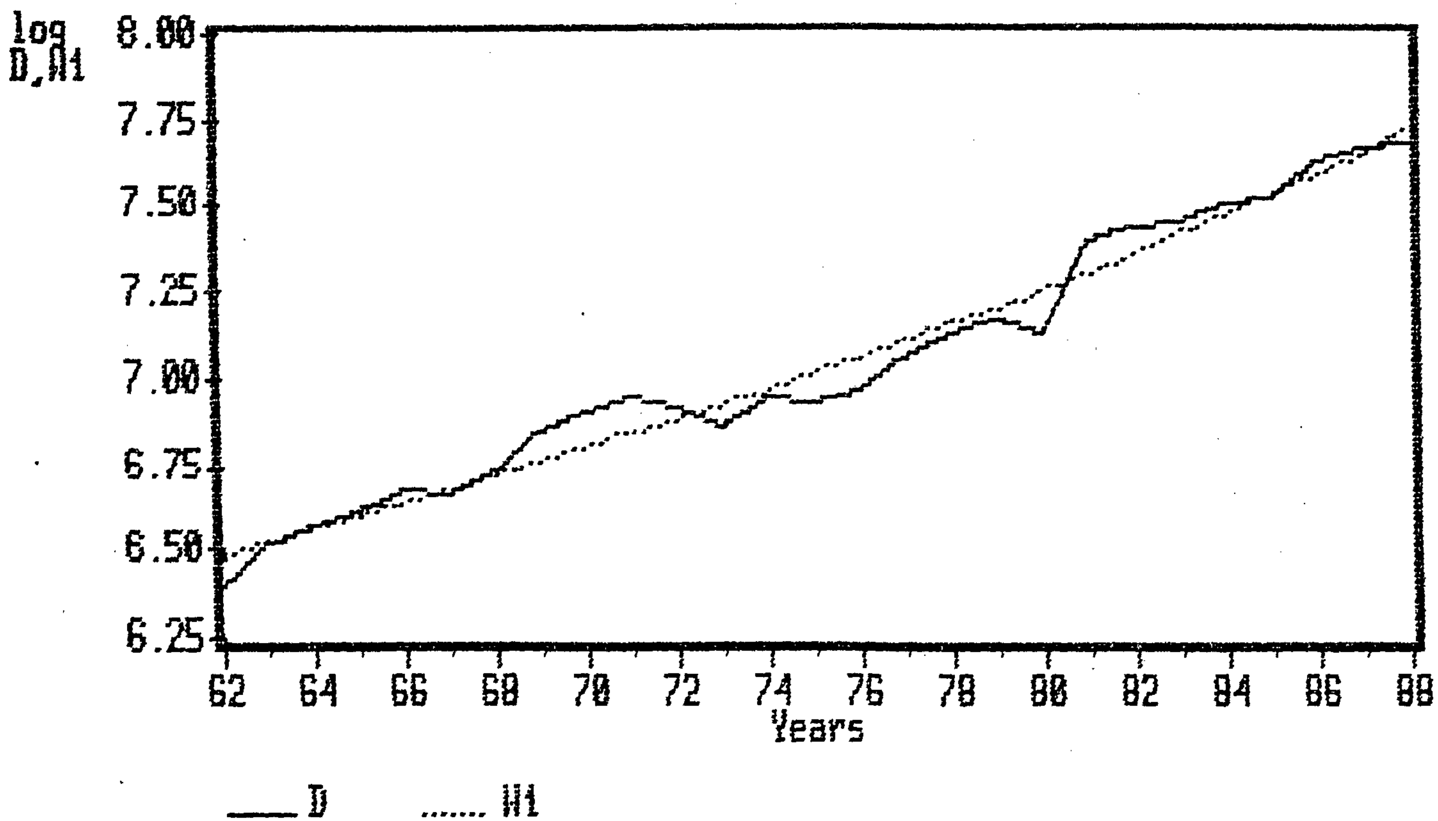
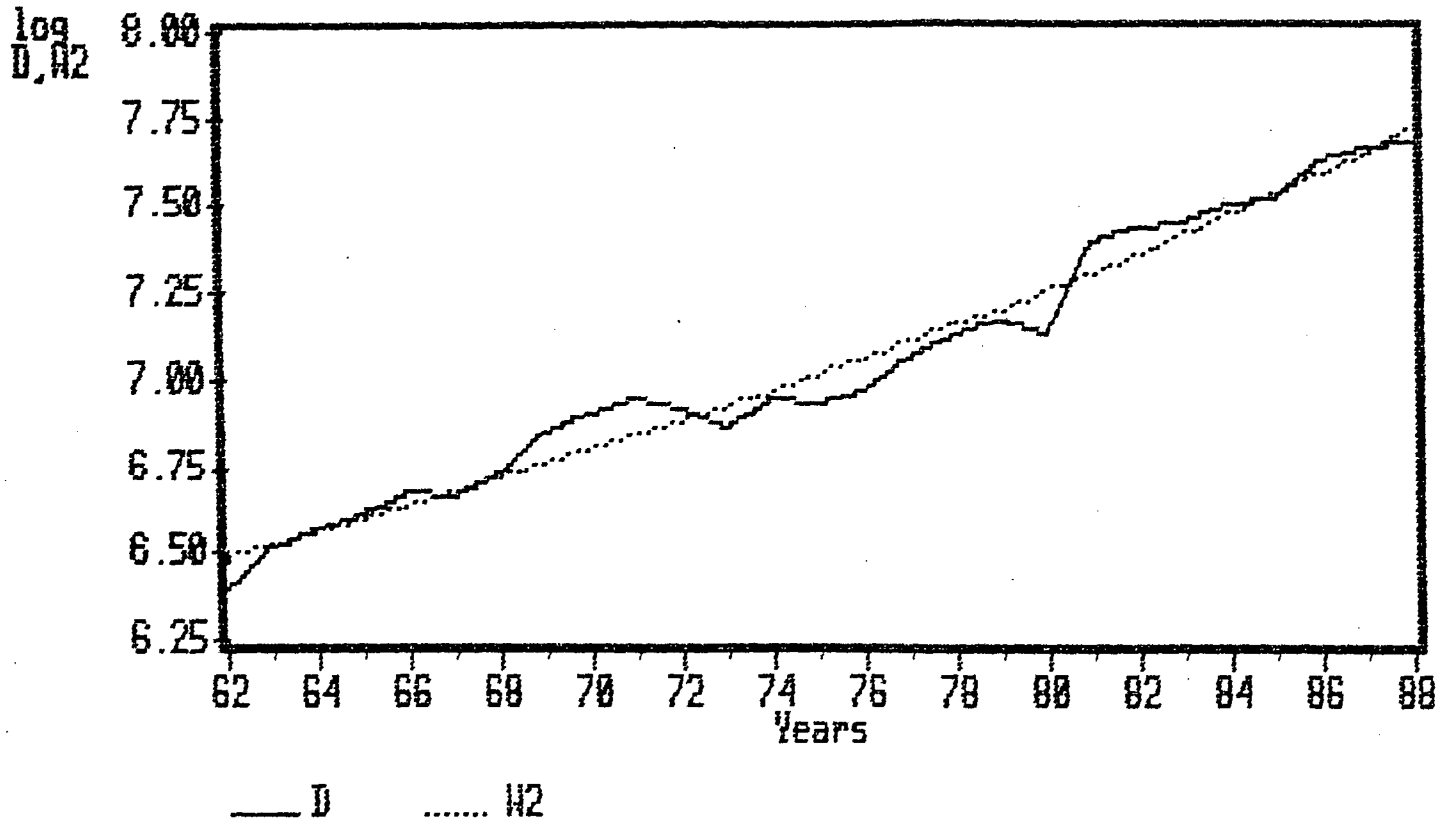


Fig. 3.10 Consumption of Paper + Paperboard in India (1962-88)



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CHAPTER IV

Forest Products Substitution and Valuation

1. Introduction: In chapter 3, we discussed that forest products consumption, which reflects that in 2000 A.D. the demand for major forest products will exceed from their supply at the present trend. This raises the basic question how can the demand be satisfied ? The problem can be solved either by increasing the supply of reducing the demand. In the short run supply cannot be increased, as the India's natural forests have a poor Growth rate, therefore, the yield on the capital (forests) is rather low as we have a standing 'growing stock' of 4196 million cubic metre giving an annual increment of 52 m. cum (A.R.Maslekar 1990). So, in the short run solution lies in reducing demand that is possible by subsitituting the wood products by non-wood products. But the long run solution lies, as the objective is sustainable development, in proper management of forest resources. In this chapter, the next section outlines the economic viability of substitution of forest products by metal and synethetic products, which is followed by role of economic factors i.e. valuation in forest management and closes with some concluding remarks.

2. Substitution of Forest products

" No policy, however well-meaning, can either be correctly conceptualized, nor implemented in the absence of reliable data regarding forest resources, level and pattern of utilization and the socio-economic dynamics determining this utilization in the face of non availability of substitute products" (IIPO, 1988).

Substitution of wood is some times confused with its optmimum utilisation. Replacement of wooden boxes by corrugated board boxes to pack and the use of card board in match box manufacture is sometimes recommended as a measure in the direction of wood. Substitution, while the same appropriately fall under optimum utilisation of wood substitution, while the same appropriatelly fall under proper utilisation of wood.. The substitution of wood should include its replacement by materials other than wood and and wood products. For commercial purpose a considerable quantity of wood can be substituted by metal and synethetic products. Scaffaldings and props used in construction, pitpros in mining, door and window frames, railway sleepers, truck bodies and interiors for railway coaches, construction of packing cases and furnitures readily come to mind. Steel is the obvious substitute in areas of structural uses, white synthetics present the alternate for packing materials. Door and Window frames made out of extraded aluminium are in use.

Before going to further discussion on the viability of substitution. It is essential to know some different issues. Firstly, where the concerned consumers have fairly elastic budget and can go in fancy things like aluminium doors and window frames where price cannot be a issue. Here purchase decision is being based on completely different set of priorities. Second, the consumers, which make the larger share in the market, have restricted budget and are price conscious. Further it is necessary to make distiction between final products and intermediate products. In the case of final use products, a consumer contemplating the purchase of an item proposes to live with the product. But for intermediate case, for instance, a building canstractor views the purchase of the materials purely in the light of its utility; he would have little regard for elegace or any other peculierly individualistic idiosycracy.

Of being a developing economy, most of the wood is going into the economy as an intermediate good, pitprops, construction, railway sleepers etc. So, here decision to go for one or other substitute is purely determined by costs, provided the substitution of wood by metal or some other products is technologically feasible. Costs are of two kinds. The relative market prices and the expected longevity. To see the economic viability of substitution we are using two techniques. One is elasticity approach which uses only relative prices, the other the approach which taken into consideration both relative price and longevity and and rate of interest (IIPO, 1988)

2.1 <u>Data:</u> Data of industrial roundwood is taken from FAO year book of forest products, where as data on prices of timber and its substitutes is calculated. The price indices for all these products were obtained from the India database-the Economy and the absolute prices of one of the years of 1960s is available in statistical Abstract of India 1989 and its previous issues. so, on the basis of these two sources, the time-series (1962-88) of prices is calculated (Table 4.1).

2.2 **First Approach** Two commodities are substitutes if both can satisfy the same need of the consumer. A more rigorous definition of substituability is provided by the cross substitution term of "Slutsky's Equation". Accordingly if the cross elasticity is possitive, commodities are substitutes.

To observe the cross elasticity we have used the regression lines these are:

(1) $\text{Log } D = 6.827 + 1.674 \log PL\ 12$ $\quad \bar{R}^2 = 0.578$
$\qquad (4.641) \quad (4.248)$

(2) $\text{Log } D = 4.546 + 2.841 \log PL\ 13$ $\quad \bar{R}^2 = 0.203$
$\qquad (0.05) \quad (6.11)$

(3) $\text{Log } D = -4.784 + 8.836 \log PL\ 14$ $\quad \bar{R}^2 = 0.795$
$\qquad (-6.509) \quad (2.357)$

(4) $\text{Log } D = 9.505 - 0.039 \log PL\ 14$ $\quad \bar{R}^2 = 0.884$
$\qquad (10.277) \quad (-0.937)$

where D = Demand for industrial roundwood

PL12 = Ratio of Prices of Aluminium to timber

PL13 = Ratio of Price of Tin to Timber

PL14 = Ratio of prices of Rubber to timber.

PL15 = Ratio of Prices of pig-iron to timber

Figures in parentheses are t- stat.

The cross elasticities reflect the degree of responsiveness of change in demand to proportional change in the substitutes price Except the case of pig-iron the cross elasticities are positive and elastic, which implies that if the proportional price of wood to its substitutes increases, the substitution will take place sharply. In the case of pig-iron the sign of cross elasticity is negative, but the relationship is statistically insignificant. Here, we think that this may be due to discrepancy in the price data of pig-iron.

2.3 Second Approach: This approach takes into consideration relative prices vs longevity of products and the avilability of funds. We generally see that wood products substitutes has greater longevity than timber yet timber finds common acceptance, despite the fact that its price has risen very sharply in the recent past. The question we pose here is for instance, why would the building contractor prefer a bamboo scaffolding which would last for two years, and not a steel tubular scaffolding which would last for 15 years, even when the later costs less than 7.5 times that of bamboo scaffolding. The answer lies in high interest rates the consequent reluctance to incur larger cash outlays. Indian Institute of Public Opinion used an approach, according to that approach the relative prices at which substitution of the cheaper product timber can become possible by the more expensive substitutes can be worked under different assumptions. The condition for the relative prices at which it becomes possible for the substitute product to pose a reasonable alternative to timber wood then by given by:

$$\frac{PS}{PB} = \frac{1}{(1+r)AT} \cdot \frac{(1+r)T(1-A)-1}{(1+r)T-1}$$

where: PS = Price of substitute per unit of the some designated use.

PB = Price of Timber per unit of same designated use.

T = Longerity of the timber product

T+AT = longerity of the substitute product.

r = rate of interest.

Fixing some vlues for T,A and r, some relative price substitution thresholds have been worked out by IIPO. and are given at table 4.3. The threshold price ratios in the table have been expressed in terms of the price of timber as a per centage of the substitutes price. If the price of timber were to be above this relative price, substitutions would become a possiblity. Table 4.2 presents the price ratios of timber via-a-vis its substitutes in percentage terms. The comparison of the table4.2 and4.3 reflects at what point of T,A and r the substitution become attractive. The substitution of wood by cement and pig-iron is very attractive and is taking place in most of construction activities. But, there may be discrepency in the prices of cement and pig.iron (table 4.1). The substitution remains attractive if these products prices be doubled or tripled. In the case of aluminium and rubber substitution become attractive at certain conditions, for example, aluminium as substitution became attractive at rate of interest 18 % and the longevity of wood product one year and its substitute (aluminium) product is 4 years or longervity 2 years and 8 years for wood and aluminium products respectively. But substitution by tin products remained unattractive because the timber prices were very low in comparison to tin prices. This also reflects that substitution becomes attractive when the prices of wood products will increase relative to its substitute products.

Immediate shifting away from timber is possible by a combination of fiat, can be adjusted to hasten the process of substitution in areas which falls into the ambit of government. In many other areas, innovative application engineering, the use of coated and cladsteels, can seek to create the technological basis for substitution of timber in industry. We would like to lay emphasis on the need to do so, since in many of applications hardwoods are used and further the possibility of exercising such a shift is conceptually less difficult than in case of fuel wood. Where technologically feasible and sufficient alternatives are not currently available (IIPO, 1988).

Above mentioned technique presents fairly obvious price ratios to underscore the extent of dilution of considerations of longevity by interest rates alone. Further to the above are factors which are important, just less easy to quantify, namely, absolute restrictions on fund availability and work practices.

The substitution of wood by steel and aluminium etc. should not a desirable long term policy because of the fact that wood is a renewable resource while steel and aluminium are non-renewable. The energy requiremnt to produce one tonne of aluminium, rolled steel and timber is reported to be about 67,000 kwh., 12,000 kwh., and 2,500 kwh., respectively (R.V. Singh 1990). Further the problem of over burden landscape damage and environmental degradation are quite serious in the production of steel and aluminium, while the production of timber help in ecological restoration and conservation (R.V. Singh, 1990). The employment generation in production of wood substitutes leads to many other environmental problems. The employment generation in wood products production is more than in production of its substitutes. Timber production provides employment to the people at their doorsteps in rural areas without making them move to big cities. While the production of wood substitutes will result in migration of rural labour to industrial centres creating immeasurable problems as are being already exprienced in many urban centres of the country. The wood produced can be locally processed and utilised. The wood can be finished and shaped according to simple technology available with the rural people, while the use of substitutes will necessitate new technology to be introduced in rural areas.

2.4 **Fuel Wood**: From the poorest of poor to multimillionaire all need something daily to keep his health warm. The fire wood/fuelwood plays a major role. In rural India and even in small towns majority of people use wood as cooking material. Fuelwood consumption decreases in total energy consumption as income increases. Fuel wood is a major energy source for the poor people. Moreover the share of purchased fire wood increases as income increases in both rural and urban areas (Govt. of India, 1991). In rural areas fuelwood is collected free of cost, where as in urban areas it is purchased. Who is benefitted by this supply and who suffers ? The answer is simple that by this type of suply those transportors are benefited who supply and sell fuelwood in urban areas, by illegal removal of wood from forests which is the major couse of deforestation. The sufferers are the landless village labourers, mostly from tribal and backward classes who survive on head load business.

The substitution in the case of fuel is needed one to one i.e. providing for equivalent heat value in the form of some other fuel. In chapter 3, we observed that fuelwood of being an inferior commodity is substituted by fosil fuels as income increases. But in India, majority of the population is leaving below poverty line and the non-availability of fosil fuels domestically puts the question mark on the possbility of substitution. In 1988 fuel wood share in total roundwood's demand was about 90% and on the basis of current production trends fuelwood demand will exceed from its supply and the fulfilment of this demand further will lead to deforestation. So, now it becomes essential to discuss about the fuel wood substitutes which are in our limits.

Substitutes of fire wood can be gas, kensene, coal etc. but one day they will be exhansted. Biogas can be another source, but for how many and at what cost is the big question ? Efforts on this line are really commandable. But it is not being to solve the problem of all. It is argued that cowdung cake can be used in place of fuelwood. But this will be a collosal loss to the nation. This will have even adverse impact on agricultural yields, as cowdung can be used as a manure. Study (K.K. Chsvan, 1990) revealed that the animals like Cows/buffalows consume dry matter as fooder and produces double the quatumn of fresh cowdung. But when it is converted into cowdung cakes, weight only 1/4 the value as burning material.

People, after thresing their crops such as bajra, jawar etc. left huge heaps of husk as waste on the sides of roads. This is neither used as foddder nor as fire wood. But these heaps are usually set on fire. This material burns, that means it has energy. Now the question arises how to use it ? Why not use this waste material as mixture in cow dung. Such materials if collected can it be converted in-to powder form and mixed with cow-dung ? Yes, it is possible with the help of threshing machineries now locally available everywhere. So that biomass, which is dry can be collected and converted into powder forms. According to K.K. Chavan (1990) cowdung considering as binding material was used in different quantum and cakes were prepared.

- From 5 kg. pure cowdung, cakes were made, it gave 1.25 kg. of dry cowdung cake.
- Various proportions of cow-dung, water and Biomass powder were tried to make the cakes. Nearly 40 types of combinations were tried and it revealved that 5 kg. cowdung mixed with 20 litres water, 2 kg. of sticky earth and 5 kg.

of powdered biomass gave cowdung cakes to the tune of 8.25 kg. This was burnt in usual chulla and it has worked with most prominent success. Atleast, a part substitute to cow-dung was found with help of Biomass, presently of no use.

so the permanent solutions may be in these things

- the things that burns but is not wood.
- the things that burns but is not available in present day chulla.
- the things that burns, but have no other use at present,

what it is ? It is non-wood Biomass.

- Non wood Biomass includes:
- Dried leaves of all types of trees.
- unpalatable grasses growing all along.
- Agricultural by product like stumps of jawar bajra crops and their husk.
- waste fodder from cow sheds.
- Sugar cane leaves left after harvest of sugar cane crop.
- Any other vegetative matter which burns, but is not a wood.

3. **Valuation and Management:**

It is observed that long term solution of the problem lies in proper management of forest resources. In this section we would like to venture the role of pricing of forest products and national income accounting of forest resources in the management of forest resources respectively.

It is argued that many forests are destroyed as a result of policies that make timber artifically abundant and discourage conservation, low concession fees that encourage acquition and holding of concessions beyond company needs, and low forest fees that allows firms to survive even with inefficient logging practices. Concession policies in most west and central African and other tropical countries accomodate the demand of commercial firms for concessions. (IIPO, 1992). In India also, the wood and wood products prices remained low due to wrong subsidising policy of government. Govt. subsidised the wood industries which kept wood products prices low and by these subsidies benefits of forestory have gone to a few pockets of haves. Industry did not bother about long term sustainability of supply because they had made so much profits which justifies its closure, so the long term considerations are irrelevant for them. Secondly industry did not used wood efficiently because they had fear in mind that if they had used wood efficiently, the state might have assigned it to other uses, so the sustainable use would not be in their interests (Madhav, Gadgil, 1990).

But now question arises at whose cost these haves are benefited ? Such grossly inefficient resource use has to be at some body's cost and in our country it is at the cost of (a) capital stock of renewable resources and (b) masses of people outside the iron triangle[1] . Of being, the forests source of financial as well as environmental benefits - these

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1. Iran triangle word is used by political scientists in West, it includes politicians beaucreates and industrialists.

subsidies lowers the private cost to social cost, and when the social costs are higher than their private costs, resource based goods may be presumed to be under priced in the market. Quite obviously, the less rourd about or less distant, is the production of the final good from its resource base, the greater is this underpricing, in percentage terms. But another way the lower is the value added to the resource, the larger is the extent of under pricing of the final product. (Dasgupta, 1990). So, the extent of these forest product by subsidising them gave birth to resource drainage to developed countries from developing countries, as the developing countries are making export of wood.

Moreover, it is argued that the developmental benefits of forestry have not been realized because of the consistent inability of public institutions to control forest destruction and to raise the stumpage value of forestry to producers. (Repetto, 1988). Stumpage values are lowered by policies that raise risks and reduce long term returns. Public subsidies to competing agricultural land uses, combined with lack of vigilance in enforcing laws against deforestation ensource that forestry remained a low return activity (Guess, 1991).

These problems consistently come together due to low market value of forest resource to producers. Stumpage prices are the product of market forces and producers expectations about the investment climate, which also affects their decision to sell timber (meaning positive reservation prices) or burn it and convert the land to pastures or crops (meaning negative reservation prices) Producers stumpage prices are profoundly influenced by competing public subsidies to agriculture and non-market based public prices charged for timber concession. Stumpage prices are then a forecast of what standing timber will be worth when cut and processed (Davis , 1966). As in the United States in the early 1900s when the existence of unregulated high quality virgin timber acted as a disincentive to regrowth or conservation, it is argued here that timber growing cannot be practicable until it also becomes profitable (Davis, 1966). Hence the core forestry problem may be the low market value of forestry and forest production.

To make any thing profitable, markets are necessary, according to preceeding discussion. But emphasis is placed on the fact that markets for these goods either don't exist, or when they do exist are prone to malfunctioning (Dasgupta). But here by markets we mean not price guided instituions, but mean institutions which make available to affected parties the opportunities to negotiate courses of actions and by malfunctioning markets we mean circumstances where these opportunities are some what one-sided - maldistribution of cost and benefits.

Setting proper prices for forest products can contribute to long-term management of forest. Forest pricing and concession policies for managing the forests by charging higher fees for cutting timber can contribute to the financial sustainability of forests, generating revenue to finance the management and protection of these areas. A key issue in forest management is setting appropriate fees for the timber cut by logging industries. The forest industry of courne, would prefer low forest fees, the government should seek forest fees which reflect the value of the resources. Setting minimum fees for forest concenssions is appropriate to ensure 'that the benefits to the country of cutting timber cover all the costs involved. These fees should include expanses such as the cost of protecting and administering forests, the cost of selling forest products and possible environmental costs, for example increased soil erosion. Forestry development face difficulties in regulating and supervising concessions distributed throughout the country. And the inability to provide essential support services is a problem of over centralised, administrative structures, which control producers and growers profitability at the expanse of both the rural and urban poor. Govt. Policies are not the only determinant of stumpage prices, Nor are producers prices the only determinant of improved utilisation of forest resources for development. But they are powerful influences. Thus resolution of these related problems largely on development of decentralised community based administrative structures which reward profit seeking behaviour with sustained long term forestry production. This means that public institution must be able to control deforestration, as well as stimulate profitable production for the long-term. Moreover, the concessionaires should be on the spot because they generally have greater resources than the govt. forestry departments, will be better able to protect and improve the forests in their area and carry out regeneration where necessary provided a good system of incentves and disincentive is in place.

Finally, as the decentralised community based people participatory system is considered best for forest management, the following points should also be taken into account in order to encourage participation in forest management.

(1) For participatory forest management to be at all workable, not only the community itself, but also and especially the technical staff responsible for management should have certain degree of education and training.

(2) The achievement of effective participation requires an accessible information system so that all groups involved have an adequate knowledge of matters on which they are expected to have an option or make a decision.

(3) In proposing the need to institutionalize participation, we assume that it has been decided to decentralize state management to a large extent. (Bustamante , 1991).

Valuation is an integral part of the theoretical statement of sustainable development. The case can be bostered by three strong practicle arguments, namely, that valuation improves the selection of projects, gives a truer measure of economic performance and is essential for resolving disputes and awarding compensation for environmental damage.

Conventional national income accounting do not take into considering natural resources, which results in that most of the countries are making progress at the cost of their natural resources or they are overestimating their growth rates. But for making development sustainable it is essential to evaluate what happens to natural endowment, what changes have occured in it over time, what changes are for foresceable. To take these issues in national income accounting, as already mentioned, will help in proper allocation of funds.

But to think that national income cannot take into consideration the inter generational and inter-temporal well being is wrong. As the theory of inter temporal planning tells us that this is none other than the current value Hamiltonian of the corresponding optimisation problem. The current value Hamiltonions is the sum of the flow of current utility and the shadow value of all the net investment currently being undertaken as the current value Hamiltonion also contain terms showing the social cost of breaking any social constraint that happens to characterize the optimisation model. If our objective is intergenerational bell being, then along the optimal programme, the Hamiltonian remains constant through time. The constancy of current value Hamiltonian implies the sustainablility of well beings index (Dasgupta, 1990).

Perhaps no country is taking into account the change in natural resources stock in national income acounting. Change in natural resouce stock is the same change is total capital stock as the change is manufacturing capital occur. When we take into account environmental resources they do not merely affect the well being as service flow, but also as a stock stock for example forests are not only beneficial because they provide timber, but also beneficial (as a stock) as they prevent soil erosion, help maintaining a varied genetic pool and contribute substaintially to the recyling of Co_2 and social benefits, all these compounds the problem of estimation.

Suppose the social good, the aggregate well being in any economy at time t is not only function of current flow of consumption, (C_t) but also function of stock of assests, S(t), that for our purpose we can assume that it is environmental resource. So the social good will be W(c(t), S(t)). The current value Hamiltonian H(t) at time t is

$$H(t) = W(C(t), S(t)) + P(t)\, d\, S(t)/dt.$$

where P(t) is the shadow price of environmental resource in our example. If we use the environmental stock as our numeraire , it will follow from the Hamiltonaion that real national income Y(t) is

$$Y(t) = C(t) + (WS/WC)\, S(t) + d\, S(t)/dt$$

Where WS and WC are the marginal effects of the capital stock and consumption flow or current well being. The third terms of right hand side in equation is the change in environmental stock which is what Agarwal and Narain (1989) call <u>net nature product</u>. It is the second term we are alluding to now. WS will be positive if the stock is directly beneficial and will be negative if the stock is damaging and the second term will be negative. In this way, we can say that neglecting environmental factors in national income accounting leads to its over estimation and reduces the funds availability for forest management.

4. Conclusion

The wood is in short supply and the substitution of wood needs to be taken into depth in order to relieve the existing pressure on forest for timber demand, even though the long term solution for meeting timber demand lies in increasing the productivity of forests. The introduction of bidding for concessions would allow. Govt. to capture more of the economic value of timber, and the resulting higher timber price reduce the demand pressure on the forests and will be on in continue for forestry management. The best way for forestry management is people participatory community based system and the proper measurement of national income will also help in mantaining ecological balance.

Table 4.1

Prices of Timber and Timber Substitutes

Year	logs & Timber per Cubic meter	Aluminium sheets per Tonne	Cement Swastika per Tonne	Tin block Penang per Per tonne	Rubber per Tonne	Pig Iron per Tonne.
1962	598.10	3830.00	124.36	33972.70	4043.27	266.26
1963	596.20	2690.00	129.76	31945.50	4288.28	275.01
1964	605.80	3860.00	130.12	32975.00	4453.68	306.43
1965	633.90	4320.00	145.78	32871.90	4864.13	339.39
1966	682.30	4480.00	160.53	46458.30	5854.40	382.13
1967	741.30	4560.00	160.35	38333.30	5746.29	404.79
1968	843.90	4410.00	162.51	40833.30	5917.82	436.72
1969	969.70	4620.00	172.59	54875.00	6132.24	467.11
1970	967.80	4920.00	179.97	64940.80	6126.11	515.00
1971	1023.90	4950.00	189.69	57992.20	6230.25	515.00
1972	1102.30	5270.00	197.07	63966.70	6352.78	515.00
1973	1288.10	5320.00	202.65	89358.60	6450.79	637.57
1974	1625.90	6450.00	266.00	137155.00	8576.55	834.82
1975	1592.00	10500.00	307.21	141051.50	9611.87	903.31
1976	1503.00	11220.00	312.25	136700.00	9630.25	935.24
1977	2132.10	11270.00	317.83	201706.20	9611.87	935.75
1978	2939.20	11940.00	353.28	228007.30	11143.40	967.17
1979	3705.70	12790.00	412.13	265478.10	13165.01	1086.65
1980	3939.90	15390.00	418.61	289571.20	15241.76	1158.75
1981	5379.00	17740.00	482.02	294376.80	17404.28	1609.89
1982	7164.00	17850.00	654.91	302559.30	18752.02	1936.92
1983	7847.90	18040.00	757.86	364642.80	18752.02	2259.82
1984	9152.50	20170.00	832.91	397113.20	19395.27	2670.79
1985	7995.00	21530.00	886.53	405360.70	20540.85	3059.10
1986	8403.40	22070.00	845.32	249113.00	22090.75	3050.10
1987	9256.00	26450.00	856.84	270803.30	24418.68	3194.55
1988	11050.00	29890.00	867.28	325613.30	25411.11	3718.30

Table 4.2

Price Ratios of Timber Vis-a-Vis Its Substitutes [%]

Year	Logs & Timber Aluminium	Logs & Timber Cement	Logs & Timber Tin	Logs & Timber Rubber	Logs & Timb Pig Iron
1962	15.62	480.94	1.76	14.79	224.63
1963	22.16	459.46	1.87	13.90	216.79
1964	15.69	465.57	1.84	13.60	197.70
1965	14.67	434.83	1.93	13.03	186.78
1966	15.23	425.03	1.47	12.07	178.75
1967	16.26	462.30	1.93	12.90	183.13
1968	31.00	519.29	2.07	14.26	193.24
1969	20.99	561.25	1.77	15.81	207.60
1970	19.67	537.76	1.49	15.80	187.92
1971	20.68	539.78	1.77	16.43	198.82
1972	20.92	559.34	1.72	17.35	214.04
1973	24.21	635.63	1.44	19.97	202.03
1974	25.21	611.24	1.19	18.96	194.76
1975	15.16	518.21	1.13	16.56	176.24
1976	13.40	481.35	1.10	15.61	160.71
1977	18.92	670.83	1.06	22.18	227.85
1978	24.62	831.97	1.29	26.38	303.90
1979	28.97	899.16	1.40	28.15	341.02
1980	25.67	941.19	1.36	25.85	340.01
1981	30.32	1109.03	1.83	30.91	334.12
1982	40.14	1093.98	2.37	38.27	369.90
1983	43.50	1035.53	2.15	41.85	347.28
1984	45.38	1098.85	2.30	47.19	342.69
1985	37.14	901.83	1.97	38.92	261.35
1986	38.08	994.10	3.73	38.04	261.35
1987	34.99	1080.25	3.42	37.91	289.74
1988	38.31	1320.22	3.52	45.06	307.94

Table 4.3

Threshold Price Ratios of Timber Vis-a-Vis its Substitutes.

	r = 18 % p.a.					r = 24 % p.a.				
A	1	3	5	1Ø	15	1	3	5	1Ø	15
T										
1.	54.1%	31.5%	24.2%	18.2%	16.4%	55.4%	33.5%	26.7%	21.4%	21.4%
2.	58.2%	38.4%	32.7%	28.9%	28.3%	6Ø.8%	42.8%	37.8%	35.3%	35.Ø%
3.	62.2%	45.4%	41.2%	39.3%	39.2%	65.6%	51.4%	48.6%	47.6%	47.6%
4.	66.Ø%	52.1%	49.4%	48.5%	48.4%	7Ø.3%	59.6%	58.Ø%	57.7%	57.7%
5.	69.6%	58.4%	56.7%	56.3%	56.3%	74.6%	66.8%	66.Ø%	65.9%	65.9%

Source: Indian Institute of Public Opinion (1988)

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CHAPTER V

Steady State Forest Stock and Agricultural Productivity

1. Introduction

In the preceding Chapter an attempt was made to recognise the substitutes of forest products, which are metal and synthetic products, on the basis of price. The problem is than that iron and aluminium etc are exhaustable resources and the over use of these resource cannot go with sustainable development. The marriage between natural resources and development can be made sustainable with the development of forest resources. Chapter 4 also investigates, at what extent pricing and national income accounting towards forest resources helps in management and development of forestry. Now question arises, what should be the level of steady state forest stock, so that agricultural productivity can be maintained, as forests prevent soil erosion, provide nutrient content etc, which is declining over time. Simeon K. Ehui and Thomas W. Hertel (1989) used an optimal control model to estimate the optimal steady state forest stock for the Cote d' Ivoire this model helps in optimal allocation of land between forest and agricultural use keeping in mind the problem.

In this chapter an attempt is made to apply the model for India. The theoretical framework of the model as was used and developed by Ehui and Hertel is outlined in the next section, which include the specification of a quadratic agricultural yield function and in which optimal steady state forest stock is expressed a function of prices, the social discount rate and a variety of agronomic parameters. This is followed by numerical estimates of optimal steady state stock for India. The chapter closes with some concluding qualifications and comments.

2. The Model

The social objective is to maximise the utility derived from aggregate profit function, which depends on both forested and deforested (agricultural) lands subject to changes in forest stock over time.

Formally, the central problem, over an infinite horizon, is stated as follows:

$$(1) \quad \max_{X(t),\,D(t)} W = \int_0^\infty e^{-\delta t}\{u[\pi\ (D,X,F)]\}\ dt$$

Subject to

$$(2) \quad \pi(.) = P_f\ (+)\ F(t) + [L - F(t)] * [\ P_A(t) * Z\{D_t,\ F(t) - F(\emptyset),\ X(t)\} - P_x(t) * X(t)],$$

$$(3) \quad F(t) = -\ D(t) = \emptyset \text{ if } F(t) = \emptyset,$$

$$(4) \quad F(t),\ D(t),\ X(t) \geqslant \emptyset,$$

$$(5) \quad F(o) = Fo,\ L = L.$$

where: W = A measure of present value of society's welfare.

δ = Social Rate of Discount

F(t) = Forest Stock at time t.

L = Total available land

[L - F(t)] = Total land area devoted to agricultural use at time t.

In this function it is assumed that utility function, u(.) is a twice differentiable instantaneous function depending upon aggregate profit. Further, as the total utility depends as both forested and deforested land, the agricultural yield function is assumed concave shaped which depends on purchased inputs, X(t), the current rate of afforestation/deforestation, D(t), and the commulative amount of afforested lands, [F(t) - F(Ø)].

It is anticipated that average agricultural yield is an increasing function of purchased inputs, we also assume that yield increases with increase in commulative afforestation. This is because of productivity benefits from decreased erosion, increasing of nutrients etc. The effect of current period afforestation is assumed negative which is due to movements of cropping into more marginal land.

The variables $P_A(t)$ and $P_F(t)$ denote per kilogram returns to agriculture and per hectare returns to forestry at time t. PX(t) is the per kilogram of purchased inputs. These returns and costs are assumed exogenously determined.

The current value Hamiltonian associated with the central problem, assuming an interior solution, described by (1) - (5) is given by equation 6 (time subscripts have been omitted in order to simplify notation).

(6) $H(D,F,X,\Psi) = U[\pi(D,F,X] - \Psi D,$

Ψ is the current value costate variable associated with the equation (3). Assuming an interior solution the maximum principle requires that (7) - (10) hold

(7) $0 = U_X = U_\pi * (L - F) * (PAZX - PX),$

(8) $\Psi = U_D = U_\pi * [PAZ_D (L - F)]$

(9) $\delta\Psi = UF = U_\pi * [P_F + P_A Z_F (L-F) - P_A Z + P_X X].$

and

(10) $\lim_{t \to \infty} e^{-\delta t} U(t) F(t) = 0.$

Equation (7) indicates that, the purchased inputs are applied to the point where their marginal utilities are zero. Equation (8) indicates that, the rate of deforestation/aforetation should be chosen so that the marginal utility of deforestation/aforestation is equal to the opportunity cost of the forest stock which reflects the future benefit loss for-gone by a decision to deforest/aforest today.

In equation (9) the right hand side shows the marginal productivity of forest stock. It contains two parts. The first part, represents the direct marginal contribution of forestry ($U_\pi PF$) and the latter represents the indirect marginal contribution of forest stock through its efect on agricultural productivity, which has further two components. The first is enhanced agricultural yields ($U_\pi P_A Z_F(L-F)$]. Due to increased forest cover. The second is the net cost of not having an additional unit of land in agriculture [$U_\pi(-P_A Z + P_X X$]. And the left hand side is the marginal cost of forest capital at any point in time, which includes an interest charge ($\delta\Psi$) and a capital gains term ($-\dot{\Psi}$). In this way equation (9) implies the equality between marginal cost and marginal utility of forest capital. Equation (10) is the transuerpality condition.

The time rate of change in the rate of deforestation/afforestation along the optimal path is obtained by totally differentiating equation (8) with respect to time and combining this result with (9) and (7).

$$(11) \quad \dot{D} = - \frac{UXX}{(U_{XX}\ U_{DD} - U_{DX}^2)} [-\delta U_D + \{U_F - D(U_{DF} - \alpha U_{XF})\}]$$

where $\alpha = U_{DX}/U_{XX}$

The sign of $\dot{D}$ along the optimal path, from (11) and the second order concavity of U in X and D, $(U_{XX}U_{DD} - U_{DX} > 0)$. is determined by the following equation.

$$(12) \quad \dot{D} \gtreqless 0 \text{ as } \delta^{\prime} [U_F - D(U_{DF} - \alpha U_{XF})] \gtreqless U_D.$$

A large/lower value of U_D implies a large/lower agricultural yield response from current period deforestation/afforestation. This in turn implies a higher/lower marginal utility due to increased/decreased profit. This is a one time effect only, and may be due to deforestation/afforestation motive.

Along the optimal path, the net marginal utility of forests is the difference between the marginal contribution of forest area to utility and indirect interactions between the forest stock, the productivity of purchased inputs and the rate of deforestation/afforestation. Thus, conditions (12) reflects that the rate of deforestation/afforestation falls/increases overtime if the conservation motive is weaker/stronger than the preference for current deforestation/afforestation.

In steady state the rate of change in forest stock is necessarily zero. Setting F = Ø in equation (3) and using equations (7) - (9) a steady state forest stock (F^*) is uniquely defined by

(13) $\frac{1}{\delta}[U_F(D^*, F^*, X^*)] = U_D(D^*, F^*, X^*)$

(14) $Z_X(D^*, F^*, X^*) = P_X/P_A$

(15) $D^* = Ø$

Equation (13) indicates that in steady state, the marginal utility of further deforestation/afforestation (U_D) must equal the present value of the foregone marginal future benefits/loses, as the left hand side is present value of marginal utility of sustainable economic rents and the right hand side is the marginal utility of current deforestation/afforesttion.

The steady state forest stock F^* is obtained by the solution of equations (13) - (15).

2.1 Specification of the Yield Function and Steady State Implications:

A parameteric form for the aggregate yield function is required in order to solve for the steady state forest stock as the social utility function is function of both agricultural yield and forestry returns. To recall that the form of utility function is assumed twice differentiable and because of second order derivatives of the yield function are critical to the analysis, a second order approximation of the underlying function is required. Therefore, we assume a quadratic functional form as follows:

$$\mathbf{Z}(t) = \beta_o + \beta_1[X(t)] + \beta_2[D(t)] + \beta_3[F(t) - F(o)] + \beta_4[TR] + 1/2\ \beta_{11}[X(t)]^2 + 1/2\ \beta_{22}[D(t)]^2 + 1/2\ \beta_{33}[F(t) - F(o)]^2 + \beta_{23}[D(t) * \{F(t) - F(o)\}] + \beta_{12}[X(t) * D(t)] + \beta_{13}[X(t) * (F(t) - F(r))].$$

Based on the assumptions about the yield function, the following signs are expected for the parameters in (16). β_o, β_1, β_3, $\beta_{22} \geq Ø$, β_2, β_{11}, $\beta_{33} \leq Ø$. An additional variable, TR, is included which is an index of current technology, of which coefficient β_4 is expected to be positive.

2.2 <u>Steady - State Comparative Statics</u>:

Analytically optimal steady state forest stock can be derived by taking positive discount rate and using equations (13), (14), (15) and (16). The expression for a steady state forest stocks

$$(17) \quad F^* = Fo + \frac{\Delta}{\mu} + \frac{(\mu - \beta_3)A}{\mu}$$

where

$$(18) \quad \Delta = [(\beta_o + \beta_1 X^* + 1/2\ \beta_{11}\ X^{*2} + \beta_4\ TR^*) - \bar{P}_X X^*] - \bar{P}_F$$

and

$$(19) \quad \mu = \delta(\beta_2 + \beta_{12}\ X^*) + 2\ \beta_3$$

here $X^* = \beta_{11}^{-1}\ (\bar{P}_X - \beta_1)$

TR^* = level of technology in steady state

A = (L-Fo) = Total arble land not under forest cover at time t = Ø

$\bar{P}_X$ = PX/PA and $\overline{PF}$ = PF/PA

In equation (17) indicates the difference between modified steady state agricultural returns (i.e. returns evaluated at F = Fo) and per hectare returns to forest land (PF). μ represents is the sized "yield Kick" relative to forest stock.

Consider first the situation where A = Ø, whether or not deforestation will be optimal ($F_o > F^*$) depends on the sign of second term on the right hand side of (17). The $F^* <$ Fo as long as $\Delta > Ø$ i.e. as long as the modified per hectare return to agriculture exceeds the per hectare return to forestry. Next consider the case of A > Ø, which simply raises the value of F^* because the stock effect (β_3) applies to all arable land and more agriculture land will benefit from forest cover in steady state and F^* is expected to increase accordingly.

The partial derivatives of F^* with respect $\bar{P}_x$ and $\bar{P}_f$ are positive.

(20) $$\frac{\partial F^*}{\partial \bar{P}_X} = - \frac{X^*}{\mu} > Ø \text{ and}$$

(21) $$\frac{\partial F^*}{\partial \bar{P}_F} = \frac{1}{\mu} > Ø$$

This implies that an increase in relative profitability of forestry brought about an increase in agricultural costs or by an increase in forestry returns leads to an increase in F^*.

(22) $$\frac{\partial F^*}{\partial \delta} = \frac{(\beta_3 A - \Delta\ )}{\mu^2} (\beta_2 + \beta_{12} X^*) < Ø$$

For $\beta_3 A - \Delta < Ø$

This states that a higher social discount rate lowers F^* as long as modified agricultural returns exceeds per hectare returns a forestry by less than the value of the stock effect on arable land available at t = Ø. Finally the effect of expected level of technology on steady state forest stock is expected negative, i.e.

$$(23) \qquad \frac{\partial F^*}{\partial TR^*} = \frac{\beta_4}{\mu} < \emptyset.$$

3.Application to India:

3.1 Data: The yield function specified in equation is estimated in order to determine the agronomic coefficients which link deforestation to agricultural productivity. Data on relevant variable are provided in Table5·1. Details on variable construction follow:

Time-series data on crop yield and prices were otained from the various issues of economic surveys of Indian Economy. Fertiliser quantity (in Kilograms per hectare of land) is taken as a proxy for all purchased inputs and time series data of this variable is obtained from the fertiliser statistics, published by fertilisers Association of India, and data on fertiliser prices Index is provided by India's Database-The Economy.

Forest stocks are measured as an annual time-series of remaining forest cover (in millions of hectares), sources consulted include Indian Agricultural Statistics (various issues). The rates of afforestation are taken as a difference between forest stock levels in consecutive years.

The commulative afforested land at the beginning of year t may be computed either as the difference between the forest stock level in year t and the initial year forest stock. The data on annual forestry return are obtained from the India's Forests - an annual publication of Ministry of Forest and Environment, Govt. of India. The per hectare returns are calculated by dividing total forestry returns by total forest stock.

3.2 <u>Empirical Results:</u>

For estimation purpose important interaction terms are chosen based on agronomic evidence. Moreover, because of data limitations, no attempt is made to measure the interaction effects between forest stock and the variables X(t) and D(t). The interaction term between X(t) and D(t) is included because current period deforestation is analogous to fertilization. Therefore, the estimated quadratic yield function gives the following results (t statistics in parentheses)

$$(24)\quad Z(t) = \underset{(13.91)}{85.874} - \underset{(+\,0.28)}{0.463}\,[X(t)] - \underset{(-2.06)}{8.676}[D(t)] - \underset{(-0.26)}{0.38}[F(t) - F(o)]$$

$$+ \underset{(1.47)}{2.649}\, TR^{*} + \underset{(0.31)}{0.032}(1/2)\,[X(t)]^{2} + \underset{(2.15)}{1.251}(1/2)\,[D(t)]^{2}$$

$$+ \underset{(1.32)}{0.366}\,[\, X(t)^{*}\, D(t)].$$

$R^2 = 0.909$ F Stat. 33.76 DW = 2.79

In equation (24) except intercept and deforestation/afforestation rate non of the perameters are different from zero at 5 % or 10 % level of significance.

When we drop the variable TR^* and take into account first order autoregression to solve the problsm of serial correlation then estimates are:

$$Z(t) = \underset{(14.47)}{81.729} + \underset{(1.56)}{1.357\,[X(t)]} - \underset{(-2.27)}{8.262\,[D(t)]} + \underset{(0.53)}{0.703\,[F(t)-F(o))]}$$

$$+ \underset{(0.14)}{0.004[X(t)]^2/2} + \underset{(2.27)}{1.155[D(t)]^2/2} + \underset{(1.41)}{0.341[D(t)^*\, X(t)]}$$

$$- \underset{(0.85)}{0.218\, AR(1)}$$

$R^2 = 0.901$ DW = 2.066 F Stat. 30.985

Now the sign of x(t), D(t) and [F(t) - F(o)] become as expected, but still they are not different from zero except D(t) at 5 % or 10 % level of significance. This is all due to the problem of multicolinearity which makes the results biased, inconsistent and imprecise. The correlation matrix of independence variables shows that there is high degree of colinearity between dependant variables.

Correlation Matrix.

$$\begin{bmatrix} r_{X^2} & r_{XD} & r_{XF} & r_{XX'} & r_{D'X} & r_{XF'} \\ r_{DX} & r_{D^2} & r_{DF} & r_{DX'} & r_{DD'} & r_{DF'} \\ r_{FX} & r_{FD} & r_{F^2} & r_{FX'} & r_{FD'} & r_{FF'} \\ r_{X'X} & r_{X'D} & r_{X'F} & r_{X'^2} & r_{X'D'} & r_{X'F} \\ r_{D'X} & r_{D'D} & r_{D'F} & r_{D'X'} & r_{D'^2} & r_{F'D'} \\ r_{F'X} & r_{F'D} & r_{F'F} & r_{F'X'} & r_{F'D'} & r_{F'^2} \end{bmatrix}$$

where X = X(t), D = D(t), F = [F(t) - F(D)]

$X' = 1/2[X(t)]^2$, $D' = 1/2\,(D(t)]^2$, $F' = 1/2[F(t) - F\,(t)]^2$

1.00	-0.35	0.79	0.96	-0.29	0.87
- 0.35	1.00	-0.23	-0.28	0.94	-0.29
0.79	-0.23	1.00	0.64	-0.24	0.96
0.96	-0.28	0.64	1.00	-0.204	0.74
- 0.29	0.94	-0.24	-0.204	1.00	-0.29
0.87	-0.29	0.96	0.74	-0.29	1.00

To see the effect of individual variables on the dependendt variables following regression lines were estimated.

$$Z(t) = \underset{(19.66)}{79.324} + \underset{(4.79)}{2.07}\,[X(t)]^2 - \underset{(-1.004)}{0.019}(1/2)[X(t)]^2$$

$R^2 = 0.899$ $F = 102.93$ $DW = 2.159$

$$Z(t) = \underset{(24.767)}{118.35} - \underset{(-1.77)}{9.311}[D(t)]^2 + \underset{(1.145)}{1.085}(1/2)[X(t)]^2$$

$R^2 = 0.136$ $DW = 0.632$ $F = 2.81$

$$Z(t) = \underset{(8.1)}{90.204} - \underset{(-1.9)}{5.392}\,[\,F(t) - F(o)]^2 + \underset{(4.11)}{1.496}(1/2)[F(t) - F(w)]^2$$

$R^2 = 0.748$ $DW = 1.27$ F Stat. $= 35.21$

All there estimated regression lines reflect that the relationship between the explanatory variables and dependent variable is as expected, but the results are becoming inconsistent and imprecise due to econometric problems.

There is no reason to believe a prior that F^* will lie between F_o , the corrent forest stock and zero. This is an empirical question which depends on the fitted yield function, prices, the social discount rate and the expected level of technology. Based on the estimated yield functions given by equation (24), the socially optimal steady state forest stock F^* may now be computed. But derivation of F^*

with the imprecise estimated results of yield function will no doubt make the F^* imprecise.

Assuming $A = 0$, then deriving the value of F^* with these results.

$$X^* = 0.032^{-1}(0.85 + 0.463) = 40.94 \text{ kg./ha.}$$

$$\mu = 12\% [-8.636 + 0.366 X^*] + 2\beta_3 = 72.46$$

$$14\% [-8.636 + 0.366X^*] + 2\beta_3 = 88.10$$

$$\Delta = [(85.874 + 0.463 X^* + 0.32(1/2)(X^{*2}) + 2.64 TR^*) - 0.85 X^*] - 0.464 = 159.96$$

at 12 % rate of social discount

$$F^* = F_o + \frac{\Delta}{\mu} + \frac{(\mu - \beta_3)A}{\mu}$$

$$= 67.16 + \frac{159.96}{72.46} = 69.37$$

at 14 % rate of social discount

$$67.16 + \frac{159.96}{88.10} = 68.96$$

These results reflects that as the rate of social discount increase the steady state forest stock decrease. But at any rate of social discount with these results further deforestation is impossible.

4. Conclusion:

In developing countries like India, increasing population is becoming a burden on land and to meet the food demand of this increasing population shifting cultivation is taking place. However, continued deforestation has a deleterious effect on crop yield. This model has used a two sector dynamic model to determine the impacts of the social rate of discount relative agricultural and forestry returns and expected technology on the optimal steady stock forest stock. This model may be helpful in planning process in the proper allocations of land between forests and agriculture. So, this requires that these results be improved by taking some alternative technique of estimation which have solution of multicollinearity.

Table 5.1

Data used in the Regression Analysis

Yeass	Index Number of Agricultural yield Z(t) [Base 1968-69=100] (1)	Forest Stock F(t) (million ha.) (2)	Average Fertisers (X(t) in Kg./ha.) (3)
1961-62	89.7	54.19	2.17
1962-63	89.0	60.54	2.88
1963-64	91.9	60.39	3.46
1964-65	90.8	60.35	4.86
1965-66	88.9	61.58	5.05
1966-67	89.1	63.48	7.00
1967-68	94.0	63.94	9.40
1968-69	100.0	64.70	11.05
1969-70	103.4	63.89	12.21
1970-71	106.8	63.83	13.61
1971-72	107.2	63.60	16.14
1972-73	106.8	65.43	17.06
1973-74	106.4	65.73	16.71
1974-75	111.5	65.87	15.67
1975-76	113.5	66.70	16.93
1976-77	115,6	67.16	20.39
1977-78	119.5	67.14	24.88
1978-79	122.2	67.46	29.28
1979-80	107.6	67.48	30.97
1980-81	122.7	67.42	31.82
1981-82	125.6	67.42	34.27
1982-83	123.4	67.35	36.15
1983-84	141.0	67.33	43.55
1984-85	142.9	67.16	46.39
Mean	108.73	64.47	18.83
S.D.	15.81	3.30	13.05

Source: 1. Economic Survey Various Issues

2. Indian Agricultural Statistics Vol. I, various issues

3. Fertilisers Statistics (1985-86)

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CHAPTER VI

CONCLUDING REMARKS

1**Introduction** This chapter proivides the summary and some concluding qualifications and comments.

The present study has three fold objectives. The one is to see the trends and prospects of forest produce production and consumption. The other is to explore the economic viability of wood products substitutes and role of economic valuation of forest products in forest management. The third one is to make an attempt in the direction of optimal allocation of land resources between forest and agriculture. Summary and conclusions of the study are outlined in the next section and closes with the suggestions which include how the estimates be improved and research priorities of forestry.

2. Summary and Conclusions:

Deforestation has created the problems of environmental degradation on the one hand and put the question mark on the survival of common man on the other hand, which produced the need of sustainable development. The progressive conservation and neoclassical economics has failed at the front of sustainable development. The progressive conservation tries to alleviate waste through Gospel of efficiency and the neo-classical economics like the classical assumes that the economic circular flow analogy links natural resources with production and consumption of goods and is rarely portrayed as influencing or being influenced by the natural environment.

The integration of environment and economy is the main concern of mankind. This is possible only through sustainable development. The Brundtland commission invoked the concept of sustainable development to describe a means by which economic and social progress could be achieved without compromising the integrity of the environment. The commission also pointed out that only growth can eliminate poverty and create the capacity to solve envirnomental problems. But growth connot be based on over exploitation of the resources of developing countries. The Rio conference held recently highlighted the philosophy of Earth for a suntainable development in order to materialise a happy marriage between natural resource and human resource exploitation.

Forests are a great source of benefits both from financial and biological point of view, economic benefits are derived in the form of forest produce of minor and major forest products. Minor forest products such as fruits, gum etc. are taken as the subsidary output of forests and these products are basis of life for the tribal people. Major forest products such as timber and fuelwood are considereded as major forest products. In India, fuelwood cover about 90% of total wood consumption which is assumed a sign of under development. At the existing forest capital india's forests can yield 52 million cum. of wood annually which falls short of demand and has given birth to the problem of deforestation. In India deforestation is taking place at a gradual rate. Deforestation not only effect the economic benefits but also causes major environmental problems such as reverse effect on agricultural productivity, human health etc.

It was assumed that the major cause of deforestation is the growing demand of major forest products. Therefore, for the sustainable management of forests, it becomes essential to make an attempt to estimate supply of and demand for forest products. In the present study supply was estimated on the basis of log lineor and log polynomial function of time. As the forest products are taken as the normal commodities from theory's point view, so in the estimation of the consumption of major forest products national income was taken as the sole explanatory variable associated with time element. In the estimation of consumption functions proper attention was paid to the econometric problems of estimation. As the omission of variables make estimates inconsistent and biased, so here log linear, transcendental and varying parameters models of linear and quadratic form were taken for the purpose of calculation of income elasticities of consumption. The model which gives the least RMSE was taken - varying parameter model of quadratic forms. Attempt was also made to calculate income elasticities for year to year on the basis of varying parameter models. These elasticities helps in the proper allocation of resources for forest products' development. Based upon the estimated values of these elasticities products have been classified under four major groups. Group I consists four products for which income elasticities increases with increase in income and time. Group II has six product for which income elasticity decrease and negative with an increase in income and time. Gourp III consists of ten products for which income elasticity increases upto a point and after that start to decline with an increase in income and time, for the remaining one product (i.e. particle boards) is observed first decreases but after a point it started to increase. This kind of grouping based upon the direction and magnitude of income elasticity has obvious implications for planned resource allocation programme in the core of forestry development. Given the income elasticities of India's roundwood and paper + paper products more attention needs to be placed on the development of forest raw materials, required for the production of these products.

The results obtained on compounds growth rate of consumption of forest products suggest that pulpwood + particle, sawn wood + sleepers and fibre board have experienced a growth rate over 10 percent. Twelve products have shown a growth rate ranging between 5 to 10 percent. In the case of supply wood pulp recorded the highest growth rate of 16. 18 percent per annum. Three products i.e. pulp wood + particle, Sawn wood + sleepers and chemical wood pulp have shown a growth rate between 10 to 15 percent. Nine products have experienced a growth rate ranging between 5 to 10 percent and the growth rate of rest of the products lies between 3.63 to 4.83 percent.

The high values of adjusted R^2 and near zero value of root of mean square error show the prediction and explanatory power of models. Demand and supply projections give an idea of probable quantities that will be demanded and supplied in the future i.e. 2000 A.D. The difference in their projected values has clear implications on the policy matter in production of different forest products in order of priority.

Attempt was also made to observe the economic viability of substitution of wood products by non-wood products. For this purpose two approaches were used, one is only price conscious i.e. elasticity approach and the other one is the approach used by the Indian Institute of Public Opinion's study which takes into consideration both price and nonprice elements. Non-price elements includes the rate of interest on capital expenditure because the forest products' subsitutes are generally expensive than forest products and longeuity of wood products and their substitutes. Both the approach almost reached the same conclusion that when the wood products prices rise relatively more than the price rise of their substitutes the substitution would be come attractive. The cross elasticities are highly elastic with respect to proportional prices of aluminium, rubber and tin. In the second approach the substitution became attractive only after a certain point on the basis of certain conditions. The substitution did not became attractive with respect to tin, as the tin prices are very high to wood and wood products prices.

The fuel wood can be substituted only when one to one substitution is made available. Fuelwood is going to be substituted by fossil fuels and purchased fuels of being an inferior commodity (as observed because income elasticity is negative) Fossil fuels such as kerosene, coal LPG etc would one day exhaust and India has not so much domestically produced quantities of these commodities and the use of cowdung cake is making the wastage of valuable manure which affects the agricultural productivity. The permanent solution may be found by the use of wastage of crop residues and stumpages which have no other uses.

Failure to increase forest profitability ensures that the ratios of timber harvest and waste to growth will increase. The profitability of forests remained low due to wrong pricing policy. The govt. has kept the prices of wood products low by giving concessions or subsidies to forest product industry and agriculture. The first type of subsidies led to inefficient use of forest products where as the later type of concessions led to shifting cultivation in nutshell these kinds of subsidies led to depletion of forest resources. The benefits, moreover of these policies have gone to influenced politicians bearucrates and industrialists, and suffered the poor people who live close to forests. This problem is due to market failure on the environmental front. The solution is found in creading markets where all the affecting and affected parties can negotiate. The solution of the problem may be in asymetrical pricing which include indirect interdependence and externalities of both the parties, that the producers (poor people) should be given incentives in the forms of concessions and the people who produce this type of problem should be taxed, Moreover the solution of the problem cannot be found in centrallised or free market system. So, it was thought that decentralised community based people participatory forestry management system may have some solution.

National income accounts shows the country's well being. The conventional method of national income accounts donot take into account the environmental factors into account. The national investment and planning mostly depends on the performance of national income. So most of the countries of the world are progressing on the cost of environmental factors which are depleting i.e. are over estimated and putting question mark on the well being of comming generations. If the Net Nature Product posstive or negative is taken into consideration it will help in maintaining the ecological balance and if these factors were taken into considerations, they will help in proper distribution of national resources. It is wrong to think that environmental factor cannot be taken into account. The control theory helps in this direction with the help of the principle of current value Hamiltonian.

It is observed that the long term solution of the problem can be found in afforestation. But the planners is developing countries face a dilemma. They must clear the forest now to feed an increasing population. However, continued deforestation has a deleterious effect on crop yields. Ehui and Hertel used a two sector dynamics model to determine the impacts of the social rate fo discount, relative agricultural and forestry returns and expected technology on the optimal steady state forest stock in the Cote d' Ivore While the Ehui and Hertel model considers the external benefits which the forest stock confers upon agricultue. It does not include all other possitive externatities such as preservation of genetic diversity and climatic benefits. Adding these considerations, which may well dominate commercial value of the forest, would raise the optimal steady state forest stock (F*). When this model, as it is , is applied on Indian data, due to the problems of multicullinearity results have become inconsistent and imprecise - which made the F* imprecise. But this imprecise value of F* is greater than current stock of forest stock even at 14% rate of social discount with arble land equal to zero. So, further research is needed to address how fast the India ought to move towards F* in those cases where it is less than the current forest stock.

3. Suggestions:

3.1 Improving Estimates:

Error of measurement in time series data and the fact that available statistical techniques can yield only consistent estimates, are major potential source of inaccuracy in estimates of coefficients and future phenomena. The presence of structural change is another potential source of inaccuracy and can be a distinct handicap in long range forecasting. The individual investigation can in general do little about the first two sources of error, but he has at his disposal a means with the third one. Experience indicates that if structural change is taking place in the relationships estimated in this study it is occuring slowly and in a systematic manner. This offers hope that it can be detected if it does exists by dropping early years from the sample period as data for later years become available. The detection of statistically significant change would of course require that data for a number of additional years be available. A procedure of reestimating relationships also holds considerable promise for imporving forecasts as it may be repeated a number of times and as effort made to 'map' improvement in the magnitudes of coefficients and prepare estimates of these magnitudes for the latter years of the projection period or beyond. Another source of error in predicting was errors in forecasts of exogenous variables. This is also a defect that can be estimated as data for additional years become available and permit recent trends to be taken into account. It is anticipated that an updating procedure employing both revisions of coefficients and revisions of forecasts of exogeneous variables will result in considerably better estimates of future consumption level (Mc Kilop 1967).

3.2 Research Priorities in Forestry:

Forests can be managed as on sustainable basis by applying data based, ecologically preceptive and socially just policies, which is possible by multidisciplinary approach. Much of the area is still unexplored by economists in forestry. So, the select biblography will help in further exploration of the area by using economic tools.

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