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Cost benefit analysis and sustained yield forestry in India.

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COST BENEFIT ANALYSIS AND SUSTAINED YIELD FORESTRY IN INDIA

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by

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SUMMARY

The basis of scientific forest management in India has been the principle of maximum physical sustained yield of timber and other high-valued products in the interest of posterity. This leads to long rotations, slow turnover of the crop, and slow conversion of existing forest into more productive crops. The needs of the local population have generally been given a lower priority. The community is thus often not in sympathy with the forest departments. This makes the job of protecting and managing the forests as envisaged more difficult.

It would therefore be desirable to compare the relative merits of alternative management regimes: maximizing long-term flow of physical product as professed by foresters, maximizing economic efficiency as demanded by neo-classical economists, or maximizing net social value to the current generation, as suggested by modern welfare economists. One framework for such an analysis is afforded by social cost benefit analysis (SCBA).

The Little-Mirrlees methodology of SCBA has been used for a study of the teak-bearing forests of North Kanara in Karnataka State, India. Generally, applying economic criteria hastens the liquidation of existing crops, and shortens the optimal rotations of future plantations. Teak plantation as an investment activity is seen to be highly sensitive to the discount rate chosen. This is ultimately a subjective parameter. Hence there is no objective case against long rotations.

The social value of maintaining basic needs supplies may, under some conditions, compensate for the loss due to postponement of exploitation of the existing crop. This would support a slow pace of conversion. On the other hand, fuelwood plantations may be more valuable socially than commercial timber crops, thus favouring faster turnover of short rotation smallwood crops in place of timber crops on long rotations. There is thus no inherent social advantage to maximizing physical yield.

In conclusion, it is suggested that forestry can serve the interests of posterity better by being more responsive to social needs. On the other hand, economists might make a better contribution to forest management by clearly pointing out the subjective elements in their 'objective' prescriptions.

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PART TWO

INTRODUCTION

A number of possible conflicts face the decision-maker in the forestry sector. There is the need to balance long-term interests with short-term benefits. Factor resources and products have to be allocated between 'modern' industrial uses and 'traditional' subsistence activities. Costs or benefits may fall unevenly on different classes in society, and such effects need to be accounted for when considering production goals and means.

The forester's response has been to press the advantages of sustained yield forestry. However, many choices are not really arbitrated by this management model, but are made rather on the basis of existing value judgements or perceptions. Foresters themselves may sometimes not be aware of all the assumptions implicit in their decisions. Such considerations become relevant when the range of concerns is widened a little from the forester's exclusive preoccupation with physical sustained yield as the most desirable outcome.

Economists have countered the claims of sustained yield with the argument that only an economic framework can enable the decision maker to weigh all factors in a consistent fashion, so to lead to an optimal solution. Some have stressed the distributive effects of alternative management systems. Social activists and conservationists with a social awareness have stressed the links between environmental degradation and impoverishment of the masses, as dual effects of development.

A consequence of applying economic criteria may be, however, not some other 'responsible' land use, but a precipitate deforestation. The consequent ecological damage might be devastating to the community sometime in the far future. Economic criteria trivialize the present value of even very heavy costs (or benefits) that occur more than a few years in the future. They would, therefore, favour resource-exploitative management options, until the situation were bad enough for economic forces to act in the opposite direction. Economic criteria may therefore be superseded by other considerations, a suggestion that generates much discussion and disagreement in the economic literature.

There are thus many considerations involved in forestry beyond the physical sustained yield principle. Foresters would like to make a meaningful assessment of the place of economic criteria in the sphere of forestry management decisions. Too broad a view might result in generalizations of doubtful validity. What is needed is to apply the economic principle under a wide variety of conditions and assumptions, so that foresters become aware of the shortcomings <u>and</u> advantages in the economic principle. At the same time, decision makers will have a quantitative assessment of the trade-offs between conflicting objectives and values in the sphere of forest management and policy.

We therefore take up a study of a specific forestry context and forest management unit, relating it where desirable to the wider economic, cultural and historical perspective. The management area so chosen is the rich timber-bearing forests of the state of Karnataka in South India. The problem addressed is the economic and social considerations involved in the management of the teak-bearing forests in this zone.

Part I provides the background to the study. Chapter 1 introduces the geographical and socio-economic features of the sub-continent. Chapter 2 describes the place of forestry and forest products in the economy, and the history of forest management and policy. Chapter 3 presents the received neo-classical economics of forestry, and suggests the possible grounds for qualifying these conclusions. Chapters 4 and 5 take up the theoretical and methodological features of 'economic' and 'social' cost benefit analysis. These two expand the neo-classical framework to take account of, respectively, the economy-wide costs and benefits, and the distributive interests in society.

Part II is the case study which attempts to apply the theoretical constructs. Chapter 6 starts with a description of Karnataka State and the forests of the study area in order to put the subsequent discussion of the management record in perspective. In Chapter 7 we discuss the financial analysis of sustained yield management of teak plantations, and the question of the rate of conversion of old growth. Chapter 8 deals with the estimation of SCBA parameters. The SCBA methodology is applied to the sustained yield management of teak in Chapter 9, and results discussed and compared with those of the earlier FCBA. In Chapter 10, we address the trade-offs between basic needs and productive efficiency in the conversion of existing crops under the sustained yield principle and under economic criteria.

PART ONE

CHAPTER ONE

SOCIAL AND ECONOMIC BACKGROUND

By many standards, India is a continent rather than a country. In terms of population alone, it contains over 15% of humankind. This is more than the population of all Africa, or both the Americas put together, and only a little less than that of Europe with the USSR.

If a parallel is to be drawn, it would be with the Peoples' Republic of China, not least because both countries have had a long history of civilisation, and share the more recent experience of western colonialism. Early preoccupation with ideological contrasts seems to have given way to a better appreciation of the urgent need to improve living standards in both nations within a reasonable period.

1.1 Land and natural resources

1.1.1 Physiography and geology

Early pre-Cambrian and Archaean rocks are the main formation in the ancient southern peninsular region of the Deccan plateau. The Deccan lavas in the northern portion of the peninsula evolved from depositions of basalt, many thousands of metres thick, from immense lava eruptions in the late Cretaceous and Tertiary periods. Sedimentary and igneous rocks that are interspersed, especially along the northern boundary of the peninsular region, now constitute the rich mineral belts of central and eastern India. The geological origins of the ancient peninsular region thus explain its prominent physiographic features.

To the north of the central plateau are the intervening alluvial basins of the Indus, Ganges and Brahmaputra river systems, and the massive Himalayan ranges. As the southern Gondwana plate approached the mainland of Asia, the intervening marine trough gradually filled up with sediments. The southern land mass gradually subsided under the massive northern continent, pushing up the sedimentary layers in stages to form the relatively young, and geologically still active, Himalayas. This also explains the high propensity to erosion in the northern catchment of the Indo-Gangetic river system, while erosion from the more ancient formations in the peninsula was generally lower.

The features that shape the land affect cultural development as well. The natural barrier of the Himalayas emphasised the unity and identity of the land, the waters of the Arabian Sea and Indian Ocean forming the complementary southern boundary. The broad plain of the Indo-Gangetic river system set the stage for the major movements in the cultural history of India. Other prominent features are the elevated central uplands of the Deccan plateau; the steep escarpment of the Western Ghats, and the lesser hills of the Eastern Ghats, that form the rims of the central plateau; and the coastal plains, narrow in the west, broader to the east.

1.1.2 <u>The major river systems</u>

The river systems closely follow geological features. The Ganges is the major channel draining the runoff from the southern face of the Himalayan ranges. It traverses the northern boundary of the peninsular mass from west to east, to join the Brahmaputra in Bangladesh. The two mighty rivers reach the Bay of Bengal through a massive network of streams and channels that forms the spectacular Sunderban delta. These snow-fed, perennial rivers occupy a special place in Indian culture. The Indus, or Sindhu, river system, which has given the sub-continent its name, now lies substantially in Pakistan, except for its upper reaches which drain the western Himalayan catchment.

The Narmada and Tapti drain the northern peninsula westwards into the Arabian Sea, between the Vindhya and Satpura hill ranges. The major rivers systems of the peninsula, the Damodar, Godavari, Krishna, and Cauvery, follow the gentle eastward slope of the plateau. Though not perennial, these rain-fed rivers are the life-line of the south. Their continued health is intimately bound up with the land and forest management practices on the upstream catchments in the Western Ghats.

Some streams that drain westward down the escarpment of the Western Ghats, like the Kalinadi in Karnataka and the Bharatapuzha in Kerala, are especially valued for their hydroelectric potential. This may conflict with the protection of natural vegetation, either principally for preserving genetic and wildlife resources, or for the maintenance of the hydrological and ecological balance. The campaign to save the virgin rain forest of Silent Valley is a prominent example of this conflict.

1.1.3 Climate

Of all climatic factors, it is rainfall that is most crucial to the life of the people. It is rainfall, or the lack of it, that distinguishes the seasons, rather than temperature and sunlight, except in the temperate hill regions of the Himalayan tract.

January is the coldest month; the average daily temperatures are below freezing in the Himalayas, but on the coastal plains they are around $24^{o}C$ to $27^{o}C$. Inland, it is about $21^{o}C$ at humid Nagpur, at 310 m in the central peninsula; $21^{o}C$ at Bangalore, 921 m up on the sub-humid Deccan plateau; and $13^{0}C$ at Kodaikanal, 2,343 m up in the humid peninsular hills. The temperature builds up, until by May, the average daily temperature reaches 34^{o} to 35^{o} in the northern plains and lower parts of the peninsula, somewhat lower around the coastal plains and central plateau. The heating up of the air over the land mass brings the south-west monsoon to the waiting land, breaking successively from the south-west to the north from the beginning of June.

The south-west monsoon comes up immediately against the escarpment of the Western Ghats, resulting in heavy downpours amounting, at Cochin, to 724 mm in June, 592 mm in July, and 353 mm in August. On the eastern side of the Western Ghats, the rainshadow region of the Deccan plateau, and generally the eastern side of the peninsula, derive a higher proportion of their annual rainfall from the North-east monsoon.

In the north-east, the combination of the north-eastern hill ranges and the Himalayas acts as a trap, causing a very high precipitation; Cherapunji holds the world record for annual average rainfall, 11,437 mm. The normal precipitation is 1,280 mm in May, 2,695 mm in June, and 2,446 mm in July. This decreases as the monsoon winds move north-west up the Ganges basin along the line of the Himalayan ranges, until the June rainfall is only 74 mm at Delhi (July 180 mm). At Simla, due north of Delhi but at an elevation of 2,202 m, it is 175 mm in June, 424 mm in July, and 434 mm in August. By the time the monsoon reaches Rajasthan, most of the moisture has been given up, and the desert starts.

1.1.4 Soils

Soils are an end product of the interaction among climate and the materials present on the land. The rain-shadow region of the central plateau is characterised by red soils derived from gneisses and schists of igneous and metamorphic origin. Usually deficient in nutrients, especially calcium, potassium, and phosphorus compounds, their light texture makes them suitable for irrigation. The northern part of the peninsula carries mainly black soils, both those associated with the Deccan lavas, and those associated with red soils away from the lavas themselves. Though rich in potash and phosporus, and generally littered with calcareous nodules ('kankar'), black soils are clayey and liable to produce alkali patches under prolonged irrigation. Their capacity to hold moisture is, however, considerable.

Alluvium, being relatively recent, is probably the least affected by climate. To the agriculturist, the main concern is with its texture and water-holding capabilities. The presence of underlying clay pans may induce waterlogging, while intense leaching in humid regions may produce lateritic soils that are fine textured, but with poorer water holding capacity. Lateritic soils are found along the coastal strips, and, being difficult to cultivate, are often put under tree crops like cashew.

Climate, soils, and physiography together influence the type and growth of natural vegetation, the use of land and other resources, the agricultural practices of the people, and the economic life of the nation. It is to these aspects that we turn now.

1.2 Social background

1.2.1 Cultural history

The theme of the Indian experiment has been one of 'unity in diversity'. The unity is grounded in the cultural and philosophical ethos which reveres the sub-continent as a progenitor, a feeling which Indians from all parts of the sub-continent share. The diversity is the result of an intermingling of many racial and ethnic streams, a process that was old many centuries before the start of the Christian era.

The oldest ethnic elements include the aboriginal inhabitants of proto-Australoid and Negrito stock. The civilization of Harappa and Mohenjodaro, which had links with the Mediterranean and Mesopotamian civilizations, was widespread over north-western and western India in the second millennium BC. It had many urban centres, supported by agricultural surpluses and trade. The pastoral Indo-Aryans are believed to have migrated into the sub-continent during the second millennium BC from their original home in south-eastern Europe (as usually suggested). They are sometimes credited with the destruction of the Harappan civilization. Endless waves of invaders entered from Persia, Central Asia, and the north-west in general, bringing in diverse ethnic and racial elements.

The early invaders, like the Greeks, the Kushans, and others, were ultimately absorbed culturally. Muslim invaders conducted raids from the tenth century AD. Later invaders stayed to found dynasties, culminating in the establishment of the Mughal dynasty in the sixteenth century by the Central Asian Baber, a descendant of Genghis Khan and Timur, who was displaced from his homeland by internecine feuds. Later decadence, combined with the intractable problem of succession in the Turko-Mongol political system, paved the way for British rule by the end of the eighteenth century.

The British, unlike previous invaders, did not fuse racially or culturally with the native population. In the spirit of the times, however, they initiated the process of modernization. Ironically, it was this that forced the issue of freedom from foreign domination and the end of colonialism. However, the pace of modernization has been increased beyond recognition since independence, in an effort to improve the material welfare of the people.

1.2.2 <u>Demography</u>

In common with other 'less developed countries' (LDCs), the population of India is large, young, and growing fast. This gives it the characteristic pyramidal age profile, with a high proportion in the younger age-classes. In 1951, 43% were in the dependent age groups 0-14 (37%) and 65+ (6%). Between 1951 and 1971, the age composition pyramid had developed the 'pinched' profile characteristic of rapidly growing LDCs due to the progressive decline in death rates (Ehrlich, Ehrlich and Holdren, 1977, p.204).

Though material prosperity is low, the benefits of modern medicine and preventive health care have helped to achieve rapid gains in survival rates in every age class. A similar demographic transformation in industrialized countries took place over longer periods. The emphasis on materialistic values which accompanied the development of technology and the industrial society probably helped to bring down the birth rates as well. In the agrarian Third World, increasing prospects of material advancement may actually reinforce the traditional tendency to produce many children. Controlling the population thus comes high in the list of priorities of a development programme.

On the other hand, assurance of infant survival through better health and sanitation services might well work to change peoples' attitudes to reproduction in a few decades. Some signs have been seen of a decline in fertility rates in recent decades (Table 1.1). Increasing literacy and awareness of the earning power of women are factors that could counter to some extent the effect of larger age cohorts moving into the reproductive stage. Thus instead of necessarily accelerating population growth, improvement in the living conditions and economic prospects of the poor could, if seen to be sustained and equitable, actually reverse the trend.

Table 1.2 presents the most recent population estimates in the International Financial Statistics of the IMF, themselves based on UN figu- res. They show substantial divergence from Government of India estimates (RBI, Report on Currency and Finance, 1984-85) for post-1981 years. There seems to be a discontinuity in the latter after the 1981 census, which introduced a spurious sudden spurt in the growth rate.

For the historical past, decennial population figures based on the census enumerations from 1901 to 1981 are shown in Table 1.3, based on Government of India statistics (Government of India, 1982a). The growth was not monotonic as in the post-independence period. There was a sharp drop in the population between 1911 and 1921, as a result of famines and epidemics.

1.2.3 Population growth and projections

The mechanisms underlying population growth are complex, involving the composition by sex and age classes, and the age-class specific natality and mortality rates (UNO, 1985). Systematic differences may exist between urban and rural dwellers, and according to economic status.

It appears that the decennial rate of growth (Table 1.3) has increased gradually over the course of this century (with a negative value for the decade 1911-1921) to around 22 per thousand during 1961-1971 and 1971-1981. The conclusion that the growth of population will stabilize at this rate in the future may be premature, due to the momentum in population growth (Keyfitz and Flieger, 1971; Ehrlich et al., 1977). The youth of today will be moving into reproductively active ages in ever increasing proportions. Even if young people started reducing the number of children to two per couple, as exorted, any change in their patterns of child-bearing may take a generation or more to make a dent in the growth rate of the population.

Logistic growth functions, fitted to the annual population series for the period 1950 to 1985 and the decennial population figures from 1911 to 1981, suggest that the asymptotic limit of population would be around 25 to 35 thousand million, or almost a hundred times the 1950 population (Table 1.4). Long before such an eventuality, of course, the Malthusian doom would have taken over. The proportional growth rates they imply, however, are entirely reasonable, 13 to 16 per 1000 on the decennial data and 20 to 21 per 1000 on the annual series.

As much by necessity as on rational grounds, therefore, the United Nations demographers have assumed, as part of world population projections (UNO, 1985), that the annual rate of increase would fall from a peak of around 2.17% over 1980-1985, to 1.09% for 2000-2005, and 0.58% by 2020-2025 (medium variant).

Their projections are compared with some of those derived by our regression models in Table 1.4. The latter in general fall within the range of the UN variants up to around 2000 AD; beyond this, the UN projections remain lower, in accordance with their rather optimistic assumptions that annual growth rates would fall appreciably. It is apparent, however, that the birth rate would not really register a decrease until the cohorts from planned births started moving into reproductive ages. By that time there would be a massive burden of both young and old, and the resources of the sub-continent would be stretched thin to satisfy their needs and utilize their labour.

1.3 Economic life of the people

1.3.1 Occupational patterns

Of the estimated population of 665.3 million on 1-3-1981, the total 'economically active' was 244.6 million, or 36.8% (ILO, 1985). Some 153.0 millions or 62.6% of them were engaged in the primary sector (agriculture, hunting, forestry and fishing). The secondary sector, including manufacturing, commercial energy and water, and construction, provided for 29.7 millions, or 12.1% (31.0 millions or 12.6% if mining and quarrying are included). The tertiary sector (commerce, transport and communications, financial services, and community and social services) occupied 38.6 millions, or 15.8% of the economically active population. The occupational sector of 22.1 million people (9.0%) was 'not adequately defined'.

According to the 1971 census, 32.9% of the population were working. Of these, 72.0% were in the primary sector (69.6% in agriculture, and 2.4% in livestock, forestry, fishing, plantations, etc.); 11.1% in the secondary sector; and 16.7% in the tertiary. Though there seems to have been a marginal movement from the primary and tertiary to the secondary sector, the substantial unclassified portion is likely to be predominantly in the rural, self-employed, agricultural sector. This factor may qualify any conclusions on long-term trends.

1.3.2 Land use

The occupational patterns described above highlight the dependence of over 80% of the people on the primary sector. Land is the one resource that is valuable above all else to sustain the rural population and provide employment.

Statistics of land use show lack of uniformity of concepts and coverage, thereby limiting their utility in analysing long-term changes. There is, apparently, an underlying disagreement between different departments of the government regarding the legal and practical status of land in the country-side. The 'reporting area' was only 284.3 million hectares (ha) in 1950-51, against the total land area of about 329 million ha (Government of India, 1982a). Since 1965-66, however, it has been fairly steady around 305 million ha.

Rather surprisingly, agricultural land has not undergone much change as a percentage of 'reporting area' over the period 1950-51 to 1978-79, starting and ending at 59.7% (Table 1.5). The forest area was only 40.5 million ha or 14.2% in 1950-51, but was reported to be 61.5 million ha or 20.1% of reporting area in 1965-66, ending with 67.4 million ha or 22.1% in 1978-79. This seeming increase in extent and proportion is obviously due to the slowness with which the forest departments have been brought into the reporting system.

One cause for concern is the decline in 'land under miscellaneous tree crops' and in fallows, both in absolute and in percentage terms. The increase in agricultural net area sown, without a reported expansion of the total agricultural land base, may be partly explained by this shrinkage of non-crop land uses. Remaining private tree stands have been gradually exhausted over the years. Village pastures and fallow lands, that could provide sustenance to the cattle in times of need, have similarly been put under the plough. The result is the gradual denudation of the country-side, leaving both agriculture and livestock more vulnerable to the ever-present spectre of drought. The increase in permanent pastures over the initial years has been reversed in the later period, when reporting also seems to have been more consistent.

The controversy regarding loss of forest area to non-forest uses cannot, unfortunately, be settled by the above land-use statistics, as nothing is known about the nature of the unreported 24 million ha. Ministry of Agriculture figures (Government of India, 1980a) ascribe 75 million ha to forestry against the previous 67 million ha during the 1970's (Table 1.6). This accounts for 8 million ha of the area left out by the Planning Ministry's statistics, which reported land uses for only 304 to 305 million ha out of the country's 329 million ha. The remaining 16 million ha still to be accounted for seem to be allotted as follows: 0.8 million to non-agricultural land, 12 million to cultivated or net sown area, and 4.2 million ha to other cultivated land, including cultivable waste and fallows.

The picture that emerges from the above statistics is not one of a massive diversion of forests to cultivation. But we do not have information on land use on the unreported area during the early years of independence. Forest ministry figures (Government of India, 1980) speak of the loss of 4.1 million ha of forest over the period 1951-52 to 1975-76 (2.5 million ha to agriculture, 0.5 million ha to hydroelectric projects, the rest to roads, industry, etc.). The gain in food grains production is said to have come from intensifying practices on the existing land rather than extending it. However, practical experience suggests that there is a broad grey area of extensive encroachments on forest land over the decades.

1.4 Agriculture and food production

1.4.1 Principal cereal crops

Agricultural practices and crops depend on soil and climatic conditions, the subsistence needs of the farmer and on marketing systems and opportunities. Rice is the dominant cereal, grown under rainfed and irrigated conditions over some 25% of the cropped area. The distribution is broadly along the coastal plains of the peninsula, and all over eastern India. Wheat is the favoured staple cereal over some 12% of the cropped area, mainly in the north and west. Improvements in yield were first achieved with wheat, and this has encouraged its spread to other areas which have assured winter irrigation.

Various millets occupy about 20% of the cropped area. Jowar, or sorghum, is predominant on black soils in Maharashtra, northern Karnataka, and adjoining Andhra Pradesh. Bajra is concentrated in the semi-arid north-west, in Rajasthan and Gujerat, and scattered through the peninsula. Ragi, or finger millet, is the common man's staple locally, in the dry central southern plateau.

1.4.2 Non-cereal food crops

Pulses, important as a source of protein due to the predominantly vegetarian diets, occupy about 15% of the cropped area, mainly as a rain-fed crop. Groundnut, castor, and sesamum oil-seeds are the main crops under dry conditions, largely absent where the rainfall exceeds 1000 mm. Thus they are concentrated in the west and in Tamilnadu and Andhra Pradesh. Winter oilseed crops are more dispersed in their distribution; mustard is the staple cooking oil in the north and east, but both this crop and rape are widespread except on the western coast.

Another important source of oil is coconut, which grows both on the coasts and inland. The coconut palm provides a host of useful products apart from the valuable nut: materials for rural construction, handicrafts, chemicals, coir for furnishings and rope making, and so on. India is however generally deficient in edible oils, which it makes up by imports; exports are usually of non-edible oils and oilcake.

1.4.3 Other commercial crops

Fibre crops of importance include cotton, occupying 5% of the cropped area, jute, and mesta. Cotton favours sub-humid conditions, and is concentrated in Gujerat, Maharashtra, and northern Andhra Pradesh, on the Deccan lavas; northern Karnataka and adjoining Andhra Pradesh; and in west-central Tamilnadu. Jute grows in moister regions, in eastern and north-eastern states. The hardy mesta or kenaf, which produces a more brittle fibre suitable for sacking, grows in south-central to eastern India.

In areas with assured irrigation, sugar-cane is a favoured crop. Concentrations occur in the sub-Himalayan terai, the Indo-Gangetic plain from Punjab to Bihar, and the Krishna-Godavari belt in Maharashtra and Karnataka. The residual fibre, or bagasse, is an important source of raw material for the paper industry.

1.4.4 Plantation and tree crops

Fruit trees are widely grown, with mango, orange, apple, and banana, among others, grown in concentrated orchards. Coconut plantations are common on the coastal plains as well as on the plateau in southern Karnataka. Arecanut palm is another important crop grown in small farmsteads along the western coast and in the moist uplands in Kerala, Karnataka, and Assam. Cashew grows well on the sandy beach ridges in Tamilnadu and on the lateritic coastal plateaus along the western and eastern coasts.

The real plantation crops are tea, coffee, cardamom and rubber.

These were built up by the British when the East was still the source of raw materials, herbs and spices. India's plantations in the western Himalayas and in the high ranges of the south produce 34% of world tea production. Coffee, brought from western Asia as early as the seventeenth century, is largely confined to the southern states of Karnataka, Kerala and Tamilnadu. Cardamom is commonly cultivated in moist and shady watersheds in association with coffee, rubber, or in lightly opened forest. Rubber is an important plantation crop in Kerala, and to a lesser extent in the moist areas of Tamilnadu and Karnataka.

1.4.5 **Food, agriculture, and the green revolution**

The Indian farmer has traditionally been dependent on the vagaries of the monsoon for his survival, but there have been great improvements in irrigation and plant breeding, and public storage and distribution systems. These gains have made India essentially self-sufficient in food grains, so avoiding the harsher short-run consequences of failure of the monsoon.

The need to increase food production in pace with population was perceived even before independence, and more so the need to make the poor strong enough economically to procure food in times of scarcity. Irrigation was seen as one of the important means of reducing uncertainty in harvests. Plant breeding for better resistance to pathogens, and better growth characteristics, achieved much progress. Small-scale irrigation and well irrigation was also developed.

The other prong of the strategy was to build up sizeable reserves of food grains, and a massive system of public distribution that could bring them to the most needy sections of the urban and rural population at controlled prices. These reserves were also available for distribution in areas suffering from drought or scarcity, and in part payment of wages on 'scarcity relief' works (Food for Work programmes).

Agrarian reform is needed to give the cultivator ownership of the land, as the system of tenantship inhibits investment in wells, improved inputs, and other development. Effective implementation of land reforms requires a great deal of political commitment, and is easily thwarted by vested interests. However, some states, like Kerala and Bengal under communist, and Karnataka under non-communist parties, have achieved considerable progress in this direction.

The 'green revolution' starting from the mid-60s has depended on the co-ordinated provision of better varieties of crops, controlled irrigation and chemicals applied at the right times, and extension of credit and technical guidance to the farmer. India has stressed the goal of self-reliance in the production of food and of manufactured products, as such a massive economy cannot depend solely on imports. A co-ordinated effort was needed to develop all the co-operating sectors in agriculture and industry from a rudimentary base. To this end, the developmental effort was organized under a series of Five-Year Plans.

1.5 Industry

1.5.1 The urge to industrialization

Self reliance in manufactured products has been high on the list of national priorities. Modernization of agriculture, improving the terms of trade, and safeguarding India's dearly-won freedom all dictated the emphasis on industry. The democratic ideals and cultural ethos of Indian leaders, however, made them choose the path of persuasion and state regulation, rather than coercion and state dictatorship as in the communist countries.

1.5.2 Industries in the organized sector

The range of manufacturing industries built up after independence is impressive. India can manufacture most of the goods and machines needed for a modern nation; shortages, however, exist in some sectors. In the 34 years from 1950-51 to 1982-83, the production of coal has gone up over four-fold from 32.8 million metric tonnes (MT) to 143.5 million MT; that of electricity from 5,900 million kWh to 135,932 million kWh. Iron ore production has risen from 3.6 million MT to 38.0 million MT; finished steel from 1.5 million MT to 6.2 million MT.

Production of capital and basic goods required for the agricultural revolution has also increased. The production of tractors was 72.6 thousand in 1983, zero in 1950-51; that of fertilizers increased from 11,000 MT of N and 11,000 MT of P_2O_5, to 4,339,000 MT of fertilizer of both kinds combined. Other industries in which notable advances have been made include petroleum extraction and refining, machine tools, diesel and electric motors, nuclear power, and a host of intermediate and consumer goods industries.

1.5.3 Industries and employment

The achievements since independence are, by any standards, impressive. However, against the fact of India's massive population, such advances in the organized sector start appearing inadequate. The most pressing requirement is to find gainful employment for the masses of poorly educated, but hard-working and willing, labour force. Modern industry requires a large investment for every job it provides, and so the majority have to support themselves through occupations in the 'informal sector' around the towns and villages. These are bound to be linked to the needs of the predominantly agricultural population, and the peripheral services they require.

1.6 National income and growth

1.6.1 Measures of national economic activity

Economists try to express the increase in the economic activity of a nation through various aggregate measures. In a market economy, three main approaches are available, and will give the same result if all transactions are indeed enumerated fully and without double counting. These are the product, income and expenditure approaches (cf. Ackley, 1978).

The product approach measures the value of the economy's **aggregate current output** of goods and services, usually at market prices (including direct and indirect taxes). Double counting of intermediate goods is avoided by only counting the market value of 'final goods', including new capital goods and increases in inventories of intermediate or final goods. The value of imported goods is deducted, so that only the net exports are added to the national product.

The wear and tear on capital goods is evaluated by available means as the 'consumption of capital'. If the national product is expressed without deducting this wear and tear, the measure is called the Gross National Product; if the consumption of capital is deducted, it is the Net National Product. If, further, the value of taxes not based on income, like sales or property taxes, is deducted, we get the measure known as National Income, which is equivalent to the NNP at 'factor prices' (rather than at market, or final purchasers', prices).

The GNP ought also to be equal to the Gross National Expenditure, in a market economy. Unless there are large quantities of goods and services exchanged by barter, it is usually the GNE that is assessed with the help of various regular returns filed by economic enterprises.

The third approach is that of income. Productive resources are ultimately owned by individuals or the State, and the expenditure of business enterprises comes back to the owners of factor resources as earnings of income, rents, interest, and dividends. There are various equations expressing the finer relationships among these measures of economic activity (Ackley, 1978, gives an accessible account).

A useful distinction is that between national and domestic product. The GDP includes net factor payments to foreigners, for example those who have lent capital or expertise to the national economy. If this amount is deducted, the resulting GNP expresses more closely the economic activity of the nationals of the country.

1.6.2 **National income of India**

A significant proportion of the transactions is probably not conducted in the commercial markets, and is therefore simply not registered in the returns of the organized sector. In general, we would expect the GNP estimates to be an understatement of the actual value of the peoples' activities. International comparisons are, therefore, to be done with caution when comparing market with non-market economies.

The official estimates of national income statistics are frequently revised. This makes it difficult to examine trends in national economic activity. The IMF has worked out the figures for GDP at, successively, 1970, 1975, and 1980 prices, based on the constant-price series published by the Government of India. There are at least two such series, one based on 1960 prices for the period 1960 to 1970; and the other, based on 1970 prices, for the period 1970 onwards. The IMF statistics chain these two series by simply using the value of 1970 GDP at 1960 prices as the link between the two series (1960-1970, 1970-).

The resulting series of figures of GDP at current prices and at 1980 prices are shown in Table 1.7. The series at 1980 prices was converted into one at 1970 prices, by using the GDP at 1970 prices for 1960-61: this was put at Rs 276.28 billion, as given in the IFS Supplement, May 1977 (Table 1.7).

1.6.3 **Growth of gross income over time**

The GDP is a measure of aggregate economic activity in the nation. Of major interest is the growth of GDP, and whether it is keeping pace with the needs of the people. As these are proportional to the size of the population, the per capita GDP (or GNP) would be a good measure of average welfare. Leaving out values for 1950 to 1953 as extremely deviant, the following simple equations are derived by linear regression from the series of gross GDP at, respectively, current (purchasers') prices and '1970' prices:

$$\ln Y_{cur} = 4.0026 + 0.1041\ T_{50},$$
$$R^2=99.3\%,\ DW=0.34,\ t= 117.0 \quad 63.88$$

for the period 1954 to 1984 (GDP in Rs billion, current market prices, T_{50} = year-1950); and, for the more reliable data for 1960-1984,

$$\ln Y_{cur} = 3.8343 + 0.1108\ T_{50},$$
$$R^2= 99.6\%,\ DW= 0.82,\ t= 119.32 \quad 79.79,$$

and
$$\ln Y_{70} = 5.2433 + 0.0363\ T_{50},$$
$$R^2= 98.7\%,\ DW= 1.39,\ t= 261.02 \quad 41.83,$$

where the subscript 70 refers to the constant price series.

The Durbin-Watson statistic for the first equation is low, indicating that years of low or of high GDP tend to occur in succession. The periodic failures of the monsoon result in shortages of food and high inflation rates. These fluctuations are reflected in the money value of the GDP, and so the constant-price series is a better guide to the increase in real product. The DW statistic in the equation based on GDP at 1970 prices above is closer to the optimum of 2.00.

The rate of growth of GDP in real terms is seen to be about 3.6% per annum; intermittent periods of slower, even negative, growth, usually linked to bad monsoons, are interspersed with periods of faster growth, either during the recovery from bad years or due to a long run of good monsoons. The nominal GDP is seen to have been growing at about 11.1% indicating a nominal inflation of around 7.5% over the same period, 1960 to 1984.

1.6.4. Growth of per capita income

With population growing at 2.1 to 2.2% per annum, and real (constant-prices) GDP at 3.6%, it appears that the overall mean per capita GDP (ignoring the concentration of incomes at the higher income classes) should be growing at about 1.4 to 1.5%. The annual growth rate of real per capita GDP is seen to be a little less that 1.4% from the following regression equations:

$$\ln Y_{70} = 5.6116 + 0.01397\ T_{00},$$
$$R^2 = 92.1\%,\ DW = 1.57,\ t = \quad 92.86 \quad 16.71,$$

based on data for 1960 to 1984, where Y_{70} is GDP in Rs per cap., and T_{00} is years since 1900.

1.6.5 Sectoral composition of national income

The major part of the national product is produced in the primary sector, over 57% in 1950-51, falling gradually to 42.8% in 1973-74 (at constant, 1960, prices). Agriculture produced the overwhelming share of this, 54.1% in 1950-51, 39.6% in 1973-74; while forestry remained almost static at around 2.0%, and mining increased from 0.9% to 1.2% (Table 1.8). It appears that in both real and nominal terms, the secondary and tertiary sectors, which by and large consist of the modern, organized activities in manufacturing, trade, and services, are increasing the value of their output at a faster rate compared with the primary.

The problem of unemployment, however, cannot be solved by the organized sector alone. Much of the employment needs to be be in the small, cottage, or informal sectors. The government has to weigh the benefits of investment and incentives in the organized sector, which may mean making the rich richer, against the need to revitalize the informal sector which provides sustenance through self-employment for the majority of the population. The trade-offs become more significant when the development strategy is biased toward the organized sector. There is the danger that income distribution will become less equal as investment in the organized sector increases at a faster rate.

1.6.6 Distribution of income in India

Data on the distribution of income and wealth in India are difficult to obtain. The 25th Round (July 1970 to June 1971) of the Sample Survey Organization collected information on the distribution of consumer expenditure by per capita expenditure classes. The 26th Round (July 1971 to June 1972) gave information on the consumer expenditure of rural cultivator households.

Data on the distribution by expenditure classes of the urban and rural population, based on the 32nd Round (July 1977 to June 1978), are reproduced in Table 10.2. The percentage in higher expenditure classes is slightly higher in the case of the urban population than in the rural. Distribution of per capita incomes in Karnataka state during 1972-73 is given in Table 8.14.

A commonly used measure of inequality of income distribution is the Gini ratio. This is derived from the Lorenz curve of distribution, which is a plot of the cumulative percentage of income or consumption enjoyed against the cumulative percentage of the population, moving from the poorest to the richest classes. In an ideal case, the percentage of consumption would be equal to the percentage of population: the poorest 10% would enjoy at least 10% of the aggregate income, the poorest 20%, 20% of the income, and so on to the richest. Such a Lorenz curve would be a straight line at 45° through the origin. It would imply that all classes enjoyed the same income per head.

More usually, the Lorenz curve sags toward the population axis. The more pronounced this sag, the more unequal is the distribution. This is the basis of the Gini ratio, which is the ratio of the area between the diagonal and the curve to the area beneath the diagonal. If the distribution is ideally egalitarian, the diagonal is the Lorenz curve, and the Gini ratio is 0.0. As the distribution of aggregate consumption is biased more and more toward the rich, the Gini ratio becomes higher. Many underdeveloped countries have higher Gini ratios than developed countries. The Gini ratio for the distribution of consumption in India comes out to about 0.37 (Sec. 8.5.7).

1.7 Underdevelopment and growth with justice

1.7.1 The nature and causes of underdevelopment

Poverty, unemployment, and human misery characterize the condition of most underdeveloped countries. They usually have high rates of mortality and natality, resulting in fast growth rates and high dependency loads on the middle age classes. The literacy percentage tends to be low. The educational system tends to be geared to the needs of the middle classes, who see secondary education as a stepping-stone into the Universities and thence to better-paid white-collar jobs. Often there are not enough suitable jobs for them in the domestic economy, inducing a 'brain drain' to the west in the hopes of better job satisfaction and incomes. The poorer people tend to drop out at the primary level, but what little education they receive itself tends to be impractical and bookish, contributing little to their work environment or skills.

While a particular figure would be arbitrary, a level of income of US$ 1000 (1961) per head per year has been taken as the borderline for the underdeveloped world (Buongiorno, 1977). The low per capita incomes are usually associated with a much greater inequality in the distribution than in developed economies. This inequality is mirrored in a dualistic society. Disparities seem to be increasing in many countries, with the absolute number of poor growing, and the income distribution becoming more inequitable.

Many explanations and mechanisms have been advanced for the phenomenon of underdevelopment. One is that foreign economic dominance caused the draining away of local resources through legal and tax privileges, monopolies in banking and shipping, access to land and mineral rights on extremely favourable grounds, and repatriation of funds and levies, pensions, home education, and government debt (Maddison, 1970).

The industrial revolution that took place from the mid-eighteenth century in the west flooded the colonies with cheap mass-produced goods, that local industries were unable to compete with. With the help of tariff protection and cheap raw materials from the colonies, foreign commercial dominance "creamed off a monopolistic surplus" and impoverished the colonies by a steady outflow of funds (Maddison, 1970). Unlike the case of European economies like Sweden, foreign capital and trade were not exactly 'engines of growth'; in India, "trade had only a very marginal influence in raising income levels" (Maddison, 1970).

Since the main reason for the cheapness of primary products of the third world is the subsistence wages in the primary sector, increases in production and export of these products usually implies further impoverishment of the poor labourers in these sectors. This is a "process of circular and cumulative causation which tends to award its favours to those already well endowed and even to thwart the efforts of those who happen to live in regions that are lagging behind" (Myrdal, 1956).

1.7.2 <u>Strategies for development</u>

Economists and others have not been chary of suggesting strategies for development. **Balanced growth** strategies generally require that all sectors in the economy be activated simultaneously, by private or public investment in a number of complementary activities. The **unbalanced growth** doctrines stress the dynamic effects of a few 'leading' sectors or activities, letting the natural forces of market inequilibrium induce investment and growth in other sectors. There is much disagreement on the role of the rural-agricultural sector versus the urban-industrial; of the informal versus the organized; on investing for production of consumer goods versus building up the social capital and basic and heavy sectors; and on the role of export versus import substituting sectors.

Rostow's "stages of growth" (Rostow, 1956, 1960, 1963) model has much in common with the 'unbalanced' growth theories. The traditional, typically agricultural, society stagnates for a long period, saving little more than is needed to replace its capital and equipment. At some point, "usually from outside the society, but sometimes out of its own dynamics, comes the idea that economic progress is possible". The decisive transformation is sparked off in one or more "leading sectors", usually in modern manufacturing industries; and within two or three decades of this "take-off" (Rostow, 1956), economic growth is, subsequently, more or less automatic.

The universal applicability of such a simple design as Rostow's stages of growth has been questioned (Kuznets, 1971). Fishlow (1965) comments that the sectoral variant of Rostow's theory relies too much on backward linkages from the leading industry, but <u>forward</u> linkages could be as important. Thus commercial agriculture may well be the natural leading sector in "new" countries with large land resources, though less likely to be so in the European and South Asian context of sedentary agriculture (Fishlow, 1965). Gerschenkron (1962) noted that in 19th-century Europe, the more backward the economy, the more likely was its industrialization to start discontinuously as a sudden great spurt of growth of manufacturing output; the less likely was agriculture to play any active role by offering to industries an expanding market based on rising productivity of agricultural labour.

If Rostow tended to "understate the role of the market... in favour of derived demand nexuses" (Fishlow, 1965), the market mechanism is central to the unbalanced growth theory of Hirschman (1958). To achieve a break-through from an initial point of "underdevelopment equilibrium" to a subsequent point at which development will practically have been accomplished, "....our aim must be to keep alive rather than to eliminate the disequilibria of which profits and losses are symptoms in a competitive economy. If the economy is to be kept moving ahead, the task of development policy is to maintain tensions, disproportions and disequilibria." It is left to free market agents to respond to imbalances in supply and demand, at the cost of some "temporary shortages and disequilibria in the balance of payments or elsewhere."

For underdeveloped economies, linkage effects of traditional agriculture and of primary product export sectors are weak and narrow. Because of this, manufacturing is felt to be much superior in providing a direct stimulus to the setting up of new activities through linkage effects. "Enclave import industries" are particularly attractive according to Hirschman, as they "set up backward linkage effects of practically infinite range and depth". Some underdeveloped countries have recently achieved rapid growth by first producing or assembling final products, then progressing to production of intermediate, and finally of basic, industrial materials. According to Hirschman, it is a mistake to start with the latter, as this requires the prior existence of a great many user industries to justify replacing imports of intermediate and basic goods by domestic production at the scale demanded by minimum economic size of these industries (Hirschman, 1958).

In the doctrine of balanced growth (Nurske, 1953) the 'vicious circle' of poverty works on the supply side of the capital market from the low incomes, hence a shortage of savings, which means low investment, low productivity, and low incomes again. On the demand side, low incomes mean low demand for products, hence low inducement to invest, which in turn keeps productivity and incomes low. The key to breaking this ring is, in Nurske's model, to increase the productivity of workers by pumping in capital investment. This will raise consumer demand for a whole range of manufactured goods, so that the infusion of capital has to be synchronized in all these industries. Since many of them will have to be of a certain minimum scale to take advantage of modern technology, no one industry can take on the leading role in the absence of assured support from other industries supplying the inputs, and of assured demand for all of the product.

As world demand for primary export commodities is typically sluggish, economic growth in underdeveloped countries must concentrate at least initially on production for local requirements (Nurske, 1961). This is one justification for the newly independent underdeveloped countries turning to industrialization, and away from the traditional export sectors (Nurske, 1952). Trade would swamp the local industry, in particular their small scale and handicrafts, by letting in cheap imports, so that a certain measure of protection is justified (Myrdal, 1956). "'Balanced growth' is a good foundation for international trade, as well as a way of filling the vacuum at the periphery" (Nurske, 1953).

In the similar **big push** model of Rosenstein-Rodan (1943, 1961), "proceeding 'bit by bit' will not add up in its effects to the sum total of the single bits." A vigorous developmental effort of a certain minimum size and speed may be necessary to establish "an atmosphere of development", (akin to Rostow's "preconditions" for take-off into self-sustained growth), which "may well constitute the difference between necessary and sufficient conditions for success". He commends an outward-looking policy of international division of labour; for a labour-surplus backward country, this would indicate starting the less capital-demanding, light industry, with perhaps imported capital (Rosenstein-Rodan, 1943, in the context of post-War Europe).

Critics of the big-push, however, argue that external economies that can actually be realized are limited in underdeveloped economies. Too much emphasis on capital leads to investment in costly imported plant and equipment. More efficiency in the use of existing capital, perhaps by better maintenance, extra shifts, and a greater intensiveness in other factors, might be a better path to development.

Indeed, it may be demand growth in the agricultural sector that induces investment, rather than the other way round as in the 'big-push' and 'balanced growth' theories (Cairncross, 1962), so that imported capital need not always be necessary. It is unwise to neglect agriculture and primary production, which provide the major part of national income and pay for imports and investment in general. Thus "...the improvement of general and technical education, the amelioration of agriculture.., and progress along the family-limitation front..." may well, together or even singly, "outweigh a burst of State-engineered investment" (Ellis, 1958).

1.7.3 <u>The role of labour in development</u>

In the absence of sustained investment and advance in agricultural technique in the colonies, overpopulation led to fragmentation of land holdings, while the higher consumption further reduced the chance of much reinvestment occurring in the land (Nurske, 1957). Since the entire family is supported on the farm if no other occupations are available, there is 'disguised unemployment' (Sen, 1960). If an individual worker is withdrawn from the backward sector of traditional agriculture, the other members of the family can easily make up for the loss of his labour by working harder or longer. There is thus a need "to take away some labour from current production for work on capital construction", as suggested by Nurske.

Lewis (1954) saw the subsistence sector as an unlimited source of unskilled labour at low wages, for manufacturing industry. The best hope of increasing the rate of reinvestment lies in increasing the profits to industrial entrepreneurs, who have a high rate of saving and reinvestment; except that any improvement in agriculture that succeeded in keeping food costs low would help to keep industrial wages low as well. The farmers should be denied the full benefit of their increased productivity, e.g. by heavy land rents as in Japan, or heavy taxes and raising the price of manufactures, as in the USSR. Inflation is a means of forcing savings (Lewis, 1966).

Overpopulation in the traditional, backward agricultural sector, and the dynamic nature of the modern, technologically advanced, industrial sector, leads to a greater faith in industrialization as a means of absorbing the surplus labour (Fei and Ranis, 1964; Ranis and Fei, 1961, 1963).

However, Viner (1957) is, for one, sceptical about the possibility of zero marginal productivity of employed labour existing as a chronic phenomenon. On the other hand, seasonal unemployment is a feature of agriculture even in the most developed temperate zone agriculture. Adjustments in the mix of output products or in inputs between, for instance, labour and capital, could in most situations absorb more labour in agriculture. Seasonal unemployment can be taken up by industry, but prolonged or permanent absence of the workers from the farms would reduce output. The shortage of skilled manpower might also be an impediment to expansion of modern industry. The problem of generating adequate demand for the output of the modern sector, if wages are depressed, may also impose a restriction on the growth of the modern sector.

Thus industrialization alone may fall far short of achieving the desired reduction in unemployment. This realization has prompted a second look at alternative vehicles of development. Managerial rigidity in modern organized companies is liable to perpetrate a dualism in the labour market, by sticking to formal patterns of permanent employment of the adult male population. This suggests the need to develop the "small-scale indigenous economic units which are more likely to be able to take advantage of the abundant supply of casual labour" (Myint, 1971).

Serious attempts should be made, even in over-populated countries of South Asia, at absorbing labour in agriculture by introducing more efficient, labour-intensive methods, and by removing the dualism in government economic services and credit extension to industry and agriculture. In industry, labour employment per unit capital could be considerably increased by substituting the output of small-scale economic units, which employ "by far the largest proportion of labour and contribute a substantial proportion of the output of the manufacturing sector", for that of the larger-scale units (Myint, 1971).

1.7.4 The experience of planned development in India

Supply limitations are ubiquitous in South Asia, with limits on capital, natural resources, skilled labour, and so on. "Unbalance is inevitable" for countries embarking on development in such circumstances, without the "admonitions of theoreticians" who advocate unbalanced growth (Streeten, 1963). Some authors feel that balanced growth can be started with a small nucleus of 'mutually supporting' industries, while unbalanced growth would perhaps indicate a greater degree of selective emphasis within the small nucleus (Mathur, 1966); but in either case, there would be the need for a 'big push', probably under government patronage.

To the Indian planners, there seems to have been little conflict between these strategies, and little cause for hesitation in these choices. The emphasis on planned development on a wide front was carried over from the balanced growth doctrines, but certain leading basic and heavy industries, power, etc., were identified for special attention. This has been termed a "vertical" balance between the chosen subset with "horizontal" imbalance among sectors (Mathur, 1966). Licensing and other measures were needed to control expansion of consumer goods industries in initial stages. National industry merited protection from competing imports by high customs duties. Import-substitution was favoured as a route to self-reliance.

The aims of Indian planning can be summarized as improving the living standards of the people through increasing production. In the First Plan, 1951-1956, agriculture and irrigation received the most attention, taking 14.8% and 22.2% respectively of total outlay (Table 1.9). The national income ultimately rose by 18%, well above the targeted 12%., but no major thrust was planned in industrialization as the government had to grapple with the problems of partition and food shortages.

This had to wait for the Second Plan, 1956-1961, in which time heavy industry and power dominated the planners' thinking. Agriculture had a reduced share, 11.7%, while industry and minerals took 20.1%, transport and communications 27.0%, of total plan outlay. The share of irrigation dropped to 9.2%, but power increased to 9.7%. The national income rose by 20%, against a target of 25%. The Third Plan, 1961-1966, continued the trend in priorities, with industry and minerals taking 20.1%, transport and communications 24.6%, and power, 14.6% of total outlay. The emphasis on power was for both industry and for irrigation, as well as to meet the growing consumer demand.

In the Fourth Plan (1969-74), the share of agriculture was increased somewhat to 16.9%, while irrigation and flood control remained at 7.4%. Power was given a higher 17.8%, indicating the growing feeling that this was the bottleneck holding both industry and agriculture back. The share of industry and minerals was down to 18.5%, that of transport and communications to 18.4%. The performance of industry, however, remained mediocre. National income rose only by 15%, while industrial unrest, the Bangladesh war, and influx of refugees put further pressure on the economy. There was more emphasis on the need to uplift the condition of the backward groups and ensure them social justice, a concern that gained ground in the Fifth Plan (Johnson, 1979).

The sluggish response of the industrial sector after so many years of investment, however, raised doubts about the effectiveness of state planning of all investment, and state control of the 'commanding heights' in the economy, the basic or 'key' sectors (Bhagwati, 1973). The system of controls, licences, and protection acted more to allocate rent-earning, monopolistic privileges among the claimants, behind a facade of socialism. To get better redistribution, land reforms and rural works programmes were repeatedly urged in the plan documents.

Outlays were much as before in the Fifth Five-Year Plan (1974-1980). The green revolution, however, brought the 'modern' agriculture into closer integration with the industrial sector. The needs of the 30% to 40% of the population below the poverty line were emphasized, as was the urgency of land reforms and rural employment, credit and infrastructure development schemes. These concerns were strong in the Sixth Plan as well (1980-85). The highest shares of the outlay were however as before, for industry and minerals (20.9%), transport and communications (15.9%), and power (19.8%). Agriculture and allied services received 13.6%, irrigation and flood control 9.7%, of total outlay.

1.7.5 Poverty, unemployment, and rural development

Investment in the industrial sector has not expanded as rapidly as desired, nor has industrialization solved the problem of mass unemployment. Export-led growth has limitations in an economy with problems of meeting basic domestic demand. In any case international demand for primary products is inelastic. In contrast to industry-led growth supported by low rural wages, therefore, an alternative model, which calls for increasing productivity, incomes and living standards in the larger agricultural subsistence sectors (Myrdal, 1956), is becoming more attractive. Indeed, "the very idea of aggregate growth as a social objective has increasingly been called into question" (Chenery, 1975, p.xiii).

Despite the lack of linkages with the formal sector, the informal sector, composed of small personally run work-places and concerns, provides a very significant part of the increase in employment. The bias toward the modern sector in government protection, and the difficulty of getting credit, are some of the impediments to its expansion (Chenery, 1975). It is here, however, that the employment problem can be tackled, by choosing labour-intensive alternatives.

Income redistribution is not an issue separate from income generation on the national level. Reallocation of public investment is an effective instrument to achieve the desired change in asset concentration (Ahluwalia and Chenery, 1975). Redistribution of employment is preferable to direct income transfers (were this possible in a poor country), as it is a form of investment in the human resource. Labour-intensive avenues of self-employment in agriculture, village industry, rural services, and others will have to be encouraged, labour productivity increased, the terms of exchange made favourable to rural production, and the gap between real incomes in the rural and urban sectors reduced. In doing this, leakages to the rural affluent have to be minimized (Ahluwalia, 1975). Such measures are essential to avoid the "demoralizing effects" and political dangers of widespread unemployment, and to maintain the respect for work itself (Stewart and Streeten, 1972)

These concerns have been summarized as the objective of "redistribution with growth" (Chenery et al., 1975). Development measures should increase the income earning capacity of specifically identified occupational and income groups (Ahluwalia, 1975; Ahluwalia and Chenery, 1975, p.48).

To reformulate the statement of social objectives, a measure of social welfare that combines growth and distribution is needed in place of the GNP measure that leaves out the distributional aspect. Such an approach might entail some sacrifice of growth in GNP in the short run. But "judgements about economic progress cannot be separated from social and ethical postulates" (Chenery, 1980).

CHAPTER TWO

FOREST ECONOMY IN INDIA

2.1 The role of forests in society

The role of forests and forestry in India can be assessed from many points of view. Forests have traditionally been an important source of fairly basic consumption goods for the rural population. The forests also provide grazing grounds for some 13% of the livestock population of the country (NCA, 1976). As population increases, and political participation broadens, the process of development and modernization is quickened. Attention is increasingly focused on the linkages of forestry to the social and economic life of the nation. Suggestions of a dualism in the way forestry has developed are seen when these factors are examined (Eckholm, 1979; Shiva et al., 1982; Douglas, 1983).

The relationship of the rural population to forests and the forest departments is likely to be ambivalent. An agricultural and pastoral people is constantly engaged in pushing back the "hollow frontier" of the forests (Tucker and Richards, 1983, p.xvii, referring to the massive clearance of land by peasants employed on plantations). In India this process contains within it the seeds of a conflict between the expanding dominant communities and the retreating tribal populations.

The other, recent, role of forests is to feed modern industry with raw material. This role has been prominent after independence. It may cause a conflict between the rural-informal substrate and the urban-organized element. The threat to forests as an ecological resource is also seen, sometimes, as essentially a part of this conflict.

2.2 The consumption demand for forest products

2.2.1 Methodology of assessing consumption trends

Past patterns of consumption of broad groups of products are useful as a pointer to future demand. Such predictions are useful for 'perspective' planning in fields involving the use of natural resources, recruitment and training of manpower, and other spheres where advance preparation and planning are desirable, and precipitate action is difficult or harmful.

Among the pioneering studies of forest products were the series of Timber Trends and Prospects studies, e.g. the FAO/ECAFE study pertaining to the Asia-Pacific Region (FAO, 1961), further developed in the series of studies on demand for food and agricultural products (FAO, 1967, 1971). The latter used estimates of income elasticity from household budget surveys, inter-country comparisons, and time series of consumption and income (per capita). Forecasts were based mainly on the growth of national income and population. The influence of price was not included formally, as that would require a more 'behavioural' model of forest products in the economy than could be built up with vastly aggregated data.

Such a model was however developed by McKillop (1967) in his study of the forest products economy of North America. The problem remains, however, of projecting these diverse 'independent' variables, such as prices of complementary or competitive goods, wages, levels of activity in user industries, and so on. McKillop solved this by using simple exponential relationships with time, which detracts, to some extent, from the realism gained by incorporating the wide range of determining variables.

Madas (1974) made forecasts of world demand for forest products, using time trends as well as correlations with per capita GDP of cross-sectional data from many countries. He also recommended using the 'wood availability index' developed by Gregory (1966) to incorporate the supply element.

Buongiorno (1977) found, from international cross-sectional data, that current consumption itself was the most influential variable determining future consumption among 24 developed countries (per capita GDP of US$ 1000 or more at 1970 prices), while in the underdeveloped (106 countries with GDP less than US$ 1000), it is future income that plays the major role (with the exception of structural wood and total paper and board). Buongiorno and Grosenick (1977) attempted to relate the (proportional) rate of change in per capita consumption to that in per capita income, through equations of the form

$$dC/C = (a+bC)(dY/Y) ,$$

which implies that the elasticity of consumption C with respect to income Y is a linear function of the consumption level. Usually the elasticity diminishes as C increases, approaching zero as consumption approaches a saturation limit, $C_m= (-a/b)$.

Recent exercises in forecasting trends in consumption include the UNECE/FAO study on European timber trends (FAO, 1986b), which gives a comprehensive discussion of the methodology.

2.2.2 Studies on consumption of forest products in India

The problems and prospects of agriculture, animal husbandry, forestry, and allied sectors in India were thoroughly examined by the National Commission on Agriculture (NCA, 1976). The NCA found that previous projections of consumption of forest products made for the Indicative Plan for forestry in India (as part of the Indicative World Plan sponsored by the FAO) had been high. The NCA reassessed the projections, taking into account the growth of population and of per capita GDP, changes in consumption patterns and the impact of imports and exports, for each of a number of products and product groups. Regression equations of various forms were applied to consumption of paper and paper products, and the input coefficients of various types of raw material examined. The report of the

NCA is a major document for analysing the forest situation in India, and will be used as a basis of discussion.

Another set of projections was made from the time series of apparent consumption by Chandrakant et al. (1979) and Chandrakant (1980), following the method of Buongiorno and Grosenick (1977) to derive the demand for raw material from the income-based forecast of final product demand. Equations of the 'transcendental' form

$$\ln(C)= \ln(a) + b\ln(Y) + gY ,$$

were used to relate consumption C to National Income Y (at constant 1960-61 domestic prices). [On differentiation, the above equation yields an expression for income elasticity linearly related to income, as suggested by Buongiorno and Grosenick (1977)]. However, none of the coefficients g were found to be significant at any level of probability, so that "strictly speaking" the income elasticity is not sensitive to income level within the range of observations used.

A simplified estimate of aggregate demand to 2000, based on observed or assumed unit inputs in various uses, plus projection of end-use activity based on population growth and industrial activity, is afforded by Chetty (1983).

2.2.3 Consumption of forest products: the data base

The collation of data on consumption is beset by the usual problems of uneven coverage, confusion on classification, and, in a country as huge and populous as India, of ensuring the inclusion of even a reasonable proportion of transactions. The alternative would be to draw on sample surveys, but this method has not been systematically applied for forest products.

In practice, estimates of aggregate consumption are made by the government on the basis of recorded production as reported by the forest departments, and estimates of imports and exports that are less imprecise. Aggregate 'apparent' consumption is production plus imports less exports; it is an approximate estimate of annual consumption.

The Food and Agriculture Organization subjects data from India, as from other countries, to a critical appraisal for inclusion in its series of Yearbooks of Forest Products (Statistics) (e.g., FAO 1962, 1966, 1974, 1975, 1986a). From the FAO data, apparent consumption of industrial and non-industrial roundwood from 1954 to 1984 has been computed, and presented as Tables 2.1(i) and 2.1(ii) for aggregate and per capita consumption respectively.

2.3 Projections of demand for round wood

2.3.1 An overview of the demand for industrial wood

Included in industrial wood are sawlogs for house construction, furniture, and other 'domestic' uses; veneer and ply logs; and pulpwood. Pitprops and other miscellaneous categories are a residual category, which are quite important locally.

The growth in consumption of industrial wood categories can be assessed from Table 2.1. On the whole, the per capita consumption of industrial wood is low, not above about 30 cmt(r) ptc (cubic metres, round, per thousand capita) at the maximum level during the 1980s. In comparison, the world production of industrial roundwood was 324.8 cmt(r) ptc in 1980, and 310.6 cmt(r) ptc in 1985 (FAO YB of Forest Products, 1985). For Asia, it was 89.7 cmt(r) ptc in 1980, 87.0 in 1985, owing to the higher levels in timber-rich south-east Asia. With around 15% of the world population, India accounted for only 1.36% of the aggregate world production of industrial wood in 1980.

2.3.2 Demand for sawnwood and sawlogs

The major end-use categories of industrial wood, in 1953-55, were construction (40%) and packaging (20%) (FAO, 1961). Around 69% of the latter came from sawlogs, the rest from panel and paper products. The average sawnwood requirement of construction was estimated to be about 1.66 cmt(sawn) per dwelling built in urban areas, and only 0.17 cmt(sawn) in rural areas, where mud, bamboo, and other organic materials were substituted for scarce and costly timber.

The FAO/ECAFE study projected an increase in sawnwood requirements for housing construction in South Asia to 153% of the 1953-55 level by 1975. Non-residential construction was expected to grow in step with national income, at 2% per annum, to 225% of the base (1953-55) level, as was the input of sawn timber. Including packaging, furniture, transport, communications and mining, the consumption of sawnwood in South Asia was expected to rise, by 1975, to 209% of the 1953-55 level (FAO, 1961).

Apparent consumption of sawnwood, however, rose in India to as much as 479% of its base level, over the period 1955 to 1975. One reason for such a high rate of increase (8.15% per annum) might be simply that consumption of the base years was under-estimated.

Projections of sawlog consumption by Chandrakant et al (1979) appear too low, even by the already modest FAO figures for 1980 to 1984. The NCA (1976) forecast an increase in sawlog consumption from 13,145,000 cmt(r) in 1980 to 22,940,000 cmt(r) in 1985 on the 'low' variant, a rate of 2.82% per annum; or from 14,100,000 to 29,650,000 cmt(r) or 3.79% per annum on the 'high' (Table 2.2).

2.3.3 Demand for roundwood for sheet products

Plylogs and veneer logs constitute a minor category in comparison with saw- and sleeper-logs. With 'new' products, there is usually a period of rapid rise in consumption as they move into the uses in which they have the highest relative advantage. The increase tails off after a certain period, and there follows a stabler pattern of growth with income and population (Madas, 1974). This appears to be already happening in India. The level of consumption of sheet products was less than 4% of sawnwood (in round equivalent) in 1960, 1.6% by 1980. The importance of this product group lies in its support of a modern industry, and the prospect of reducing the consumption of roundwood in non-structural applications.

The demand for panel products was dominated by the tea-chest industry for plywood, and the match industry for veneer (FAO, 1961). Neither of these was expected to grow very fast from 1953-55 to 1975: to 167% (2.47% per annum) in the case of veneers, 200% (3.36% per annum) for plywood, and 192% (3.16% per annum) for total panel products (solid volume), for South Asia as a whole. The rise in consumption was higher in India, from 40,900 cmt(solid) in 1955 to 120,000 cmt(solid) in 1975, a rate of 5.53% per annum, thanks to the efforts to become independent of imports. In recent years, however, the growth has levelled off.

The NCA projected an increase in veneer demand from 520,000 cmt(r) in 1980 to 1,345,000 cmt(r) in 2000 on the 'low' variant (4.87% per annum), or 600,000 to 2,155,000 cmt(r) on the 'high' variant (6.60% per annum) (Table 2.2). The FAO consumption figures show that performance lagged behind expectations; even in 1980, production was only 184,000 cmt(solid), or 423,000 cmt(r), at 2.3 cmt(r) per cmt(solid) plywood as per the 1972 yearbook (FAO, 1974). Production puts a ceiling on consumption due to the virtual absence of imports, and the NCA probably had too high an expectation of increased production. Chandrakant et al (1979) predict a <u>decline</u> in aggregate consumption of sheet products on their income-based version, and their time-based projection is rather low, perhaps because they have not included the matchwood component. On the whole, however, consumption of ply and veneer logs is likely to increase at a slower rate than that of sawlogs.

2.3.4 Demand for paper products and pulpwood

Compared with sawlogs, the consumption of pulpwood, 1,200,000 to 1,300,000 cmt(r), is almost as small as veneer logs (Table 2.1). The main use of pulpwood is in the paper industry. Projection of pulpwood requirements is complicated by the variety of raw materials that can be substituted, like bamboo, grasses, and bagasse, not to mention the significant import of wood pulp. Raw material input also varies considerably depending on the process used (chemical, semi-chemical, mechanical) to convert wood into pulp.

Consumption of cultural papers is linked to level and growth of literacy and education, as well as of population and income. It is also affected by the cultural influences active in society. The aggregate consumption of paper and paperboards has been projected using a time-based logistic or s-shaped curve (Madas, 1974), by a 'log-normal' function again on time (FAO, 1961), and a 'log-inverse' curve between per capita consumption and per capita GDP (FAO, 1971, Vol II). The NCA (1976) used linear regression involving per capita consumption and income.

The FAO study (1961) estimated that, on a 2% growth rate of per capita income, the demand in South Asia for newsprint would rise, by 1975, to 448% of the 1953-1955 level. The observed rise in India was only to 203%, from 75,500 MT (metric tonnes) in 1955 to 153,000 MT in 1975. Between 1979 and 1984, however, domestic production expanded, and the annual rate of growth of consumption went up from 3.6% (1955 to 1975) to 15.2% (1975 to 1984).

For printing and writing paper (PWP), the FAO (1961) projected an increase, by 1975, to 407% of the 1953-1955 level (for South Asia). In India, consumption rose from 114,000 MT in 1954 to 507,000 MT in 1975, which more than fulfilled the expectations. Consumption of 'other paper and paperboard' (OPB) is comparable to PWP in magnitude of production and imports. The increase of aggregate consumption by 1975 was to 378% of the 1953-55 level, not as high as projected by the FAO (1961) study, 407%.

Over the period 1955-1984, production of all paper and paper products (PAP) increased almost 9-fold, imports only 2-fold, and apparent consumption 6-fold. Population has doubled so that per capita consumption has registered a three-fold increase in these 29 years.

Imports of pulpwood have been negligible, while imports of woodpulp run at about 10% of domestic production. The NCA (1976) assumed a woodpulp input of 1.05 MT pulp per MT of PAP (except for PWP in 2000, 0.960 MT pulp). According to the 1966 yearbook (FAO, 1966), chemical pulp requires pulpwood in the round of 4.8-4.9 cmt(r) per MT pulp; mechanical pulp, 2.5 cmt(r) per MT pulp; and semi-chemical, intermediate at 3.3 cmt(r) per MT pulp. Newsprint, which takes mostly mechanical pulp, would have a lower wood requirement, estimated at 2.8-3.0 cmt(r) per MT newsprint; PWP requires 3.5-3.65 cmt(r), other paper 3.25-3.65 cmt(r), and paperboard 1.60-1.80 cmt(r) per MT of product (FAO, 1961).

In India, non-wood sources ('other fibre pulp', OFP) have traditionally provided around twice the pulp produced from wood. Wood input coefficients per MT of PAP will therefore be lower, historically, than in the northern temperate (boreal) zone which has relatively large resources of softwood pulpwood. Some of the OFP also goes into production of rayon-grade pulp (as does, of course, part of woodpulp as well).

In predicting the consumption of woodpulp, the NCA (1976) assumed that the woodpulp content would gradually increase as pulpwood plantations were built up, from around 24% of all pulp requirement in 1970 to 49.4% in 2000. They forecast an increase in annual consumption of pulpwood from 3,675,000 cmt(r) in 1980 to 9,680,000 cmt(r) in 2000 (low variant), or 4,175,000 to 17,695,000 cmt(r) (high variant) (Table 2.2).

Against this forecast, pulpwood consumption was running by 1984 at barely 1,200,000 cmt(r) (Table 2.1). The NCA projections on the 'low' variant may just be attained if conditions are very favourable, which would mean a 10.97% annual increase between 1980 and 2000 (taking actual 1980 consumption as the base; if the NCA prediction for 1980 is the base, the rate of increase implied would be 4.96%); while their 'high' variant appears unlikely to be reached.

2.3.5 Demand for other industrial wood

A substantial part of the industrial roundwood consumed cannot conveniently be put in either of the two groups, logs or pulpwood. These include wood used in the round, like poles, posts, and pitprops. In 1953/1955, housing construction took 30.7%, non-residential construction 7.1%, rural uses 42.6%, mining 9.5%, and communications 0.7% of wood used in the round (FAO, 1961). One of the major use categories of OIR in the rural sector was for agricultural purposes (wooden ploughs, carts, cattle sheds, fences). Unrecorded removal from forests, village commons, and farmlands must be considerable.

The FAO Yearbook for 1972 assumed a per capita production of 0.004 cmt(r) (FAO, 1974), revised to 0.0057 cmt(r) in 1984 on the basis of further information (FAO, 1986a), which may justify the fact that NCA (1976) projections seem high right from the start of their forecast period. The consumption of OIR was projected by the NCA to go up to 1.65 times the 1980 level by 2000, or 2.55% per year (low variant); and to 1.81 times or 3.0% per year (high variant).

2.3.6 Demand for total industrial roundwood

According to the 'low' variant, overall industrial roundwood demand would increase 1.89-fold over the 20-year period 1980-2000 (Table 2.2). On the 'high' variant, the ratio would be 2.40. Large sized timber, useful for sawing and peeling, forms the preponderant part of demand: both as per the NCA projections (56.7% in 1980, 54.5% to 51.5% in 2000), and even more so on observed consumption (73.6% in 1980) (Table 2.1). The predicted decline in the proportion of sawlogs plus veneer logs plus matchlogs is due to the predicted slower growth of the peeling and slicing industry and faster growth of pulpwood.

In general, these are modest growth rates compared with some other studies. The Indicative Plan for 1965-1985 (a part of the Indicative World Plan of the FAO) predicted, or recommended, an increase in industrial wood consumption from 14,000,000 cmt(r) in 1970, to 32,000,000 cmt(r) in 1980 and 50,000,000 cmt(r) in 1985 (NCA, 1976). According to the FAO statistics, consumption rose from 12,744,000 cmt(r) in 1970 to only 19,748,000 cmt(r) in 1980. The question remains whether the data underestimate consumption, and if so by what degree; or whether consumption is falling short of the expected or desired levels.

2.3.7 Consumption of non-industrial wood

The main constituents of this group are firewood and charcoal, the latter equivalent to 6 cmt(r) per metric tonne (MT) of charcoal (FAO, 1962). A sizeable quantity of these is actually used in various industries; the iron and steel industry in Karnataka was, indeed, founded on the local resources of wood and charcoal. Modernization, however, has reduced industrial demand in modern units, though there is an undiminished growth of demand from traditional industries like tiles, tobacco curing, etc. Firewood consumption is expected to vary inversely with the level of economic development (Madas, 1974), but today the problem is of meeting domestic consumption needs (Eckholm, 1975).

Even more than in the case of sawnwood and OIR, data on 'production', removals, and consumption of fuelwood are bound to be imprecise. The FAO in fact uses certain figures of per capita production, as in the case of OIR: for firewood, 0.188 cmt(r) (FAO, 1974), or, latterly, 0.2793 cmt(r) per capita (FAO, 1986a); for charcoal, 0.0023 cmt(r) per capita (FAO, 1986a). Availability influences the consumption, as does development level; substitutes are many. Madas (1974) estimated world average consumption of fuelwood as 0.36 cmt(r) per capita, 0.23 in Europe and North America, 0.89 in Latin America, 0.67 in Africa.

The Ford Foundation estimate of aggregate consumption in 1970, 103 million cmt(r) (NCA, 1976), works out to around 0.191 cmt(r) per capita. The Fuel Policy Committee of the Government of India (GoI) estimate for 1970-71 was 116.62 mtcr (million MT coal replacement) (Cecelski et al., 1979), which, at 0.95 MT coal per MT firewood, amounts to 123 million MT fuelwood. At 1.33 cmt(r) to a MT, this would work out to 163,756,000 cmt(r), or 0.304 cmt(r) per capita. Arnold (1978) estimated rural household fuelwood consumption in 1970 at 0.38 cmt(r) per capita; Henderson (1975) at 126 million MT in 1964, or around 0.381 cmt(r) per capita.

On this basis, it is obvious that the consumption trend (Table 2.1) would follow that of population growth. Projections would depend on assumptions about the role of substitutes, the influence of modernization on the quality of energy demanded, and on the availability of both fuelwood and its cheaper substitutes like kerosene oil and agricultural residues.

According to Henderson (1975), total energy consumption increased from 187 mtcr in 1953-54 to 380 mtcr in 1970-71; but the share of non-commercial fuels fell from 68% to 48%. Though 80% of the population was rural, the agricultural sector consumed only 4.6% of the commercial fuel in 1970-71 (3.5% in 1960-61). Animal and human energy are not included in the aggregate estimates quoted, so it is obvious, if any evidence were needed, that rural India is almost totally dependent on non-commercial energy. Revelle (1976) estimates that of the total energy consumption of the rural sector in 1971, human power contributed 9.5% and bullocks 14.1%; crop residues 9.4%, dung 16.3%, and fuelwood 40.3%. Commercial energy accounted for 10.5%, mainly for lighting and irrigation. Little commercial energy is used for cooking, and it is firewood, agricultural wastes, and dung that serve this need.

For the purpose of projection, a 'high' variant can assume the consumption to be 0.35 cmt(r) per capita, and the 'low' variant, 0.30 cmt(r) per capita. With no change in the composition of energy types, over the period 1980-2000, aggregate fuelwood consumption would be expected to grow around 1.4 times (Table 2.2). The NCA projection is lower, as shown in Table 2.2.

Fuelwood is seen to pose around 10 times the demand for industrial wood in 1980 (Table 2.1). Though it will grow at a lower rate, demand for fuelwood may still be 3.5 times the industrial wood demand in 2000, on a conservative estimate. This indicates the relative scale of magnitude of demand for the two groups.

2.4 Production and supply of forest products

The consumption of industrial and non-industrial forest products is low by international standards. The availability of forest resources naturally influences the level of consumption. However, the availability of imports and the possibility of substitution in production and consumption complicate the concept of 'scarcity'.

2.4.1 Production: the major constraints on consumption

Independent India started with a rudimentary base in infrastructure, social overhead capital, and manufacturing capacity. In the case of paper and paperboards, for instance, the domestic production in 1955 was 225,600 MT, while imports were 150,400 MT. Since then, production has steadily increased to 1,980,000 MT by 1984, while imports have fluctuated between 100,000 and 300,000 MT a year. Domestic shortage has been mainly of newsprint. In the case of plywood and veneer, domestic production was increased from 29,000 cmt(solid) in 1954 to 184,000 cmt(solid) in 1979.

Under the import-restricting path of development chosen by India, the main constraint on domestic consumption has been production, rather than income or economic level per se. India's self-sufficiency has been won at the cost of low consumption. In a way, this might be viewed as the Indian way of forcing sacrifices on people's consumption needs. Such sacrifices, however, have to be translated into worthwhile investments to derive the proper benefit from them.

2.4.2 **The problem of capacity utilization**

The foregoing examples highlight a recurring theme in the Indian economy: it is usually supply-side constraints that limit consumption, rather than deficiency in aggregate demand limiting production. It is, however, not installed industrial capacity alone that constrains production. Actual utilization is commonly much below the capacity.

In the case of newsprint, teething troubles of new plants explain the shortfall in utilization of capacity seen in the early 1980s. Shortages of power and raw materials are the main reasons for low capacity utilization; setting up of captive power units contributed substantially to the improvement in 1983-84 (RBI, 1984, Vol I). Critics of the policy to increase domestic production capacity point out that there do not seem to be any "competitive strengths" for India either in quality or in price in the production of newsprint (IIPO,1985).

In the plywood industry, gains in capacity were dramatic between 1970 and 1976, at 15% per annum (KFRI, 1977). But production increased only by 16% over the entire period, or at 2.5% per annum. Production fell from 86% of capacity in 1970 to 56% in 1976 (KFRI, 1977). The constraints on production are lack of a steady supply of plylogs, availability of adhesives, technology that would make specifications of input logs more flexible; policy regarding export of high grade plylogs; and availability of machines for production of better quality veneers in the "export-oriented" veneer industry (NCA, 1976). Inadequate supply of wood raw material was identified as the main reason for under-utilization of capacity by the study conducted by KFRI (1977) as well. The above diagnosis suggested the cure. Restrictions were placed on export of round logs, but the option of importing raw material to build up an export industry was apparently not taken up.

Thus modern wood-based industries, which were meant to economize on the use of wood in the Indian economy, suffer from lack of suitable raw material. Their growth tends to fall below projections based on observed trends of income and population. On the other hand, the low-technology traditional industries like sawing expand faster, as they are less specialized in their input requirements, and less dependent on modern technology. Under the conditions of an underdeveloped society, it is often an advantage, in terms of maintenance, replacement and manpower training, to use less sophisticated technology. Wastage of scarce raw material, and lack of export capabilities, may however be perpetuated by this process.

2.4.3 **Production and supply of non-industrial wood**

Rural requirements of fuelwood, small timber, bamboos, fencing and thatching materials, fodder and manure leaves, and other products have traditionally been collected from forest and common land. Apart from the cost of time and effort spent collecting and transporting the material, the rise in urban and peri-urban demand for some of these products poses an opportunity cost of returns that could have been got by selling the collected material.

In both rural and urban areas, firewood supplies the major part of energy consumed in households. Access to firewood thus determines the energy consumption of the household. Increasing commercialization of fuelwood reduces the amount available for free local collection, both from the organized sector (forest departments) and on farms. The landless are the hardest hit by this commercialization (e.g., the study by the Tamilnadu Agricultural University, 1982). This is one reason why the production of fuelwood can hardly be discussed on the lines adopted for industrial wood products. The concepts of market demand and supply are even less applicable in the context of basic needs than in the controlled market economy for industrial products (Shiva et al., 1982).

2.5 The forest resource base and supply of roundwood

2.5.1 The forest resources of India

Of the 328 million ha of land area, official estimates put the forest area at 75 million ha (Table 23.i). Land use statistics have been discussed already in Chapter 1, and the probable reduction in the actual area under closed forest cover ascribed to expansion of agriculture, encroachments, and other uses. It is probable that only about 40% of the legally declared forest is actually under forest cover (Government of India, 1985). This would probably correspond broadly to the reserved forests proper, the rest having been either degraded or occupied by other uses, especially among the minor, village or unclassed forests.

The forest types follow broadly the patterns of climate and topography. The wettest zones, in north-east India and along the western slopes of the Western Ghats, bear rain-forest formations (classified as tropical wet evergreen forest, cf. Champion and Seth, 1968). These, and the semi-evergreen forest immediately below them, are the main source of plywood and matchwood timber. The Andaman Islands are an additional evergreen forest formation opened up to exploitation.

The less humid areas of the sub-continent bear moist and dry deciduous formations. Teak (*Tectona grandis*) forms the major species in the south, sal (*Shorea robusta*) in the north. In the semi-arid areas, they peter out to various associations of miscellaneous tree species and scrub vegetation. Though the population of the country is large, it is unevenly distributed. Thus there are still many sizeable extents of forest in the central plateau, along the Western Ghats and its eastward prominences, in the Himalayan belt and the north-east. By the historical process of immigration, conquest, and settlement, these forest belts are now home to the dispersed tribal populations of India.

2.5.2 **Production in the Indian forest**

Not all the forest area is in 'productive' use. The village or minor forests were designed to be a buffer between the forest proper and the village population. Inaccessibility and the dictates of soil and water conservation have taken more area out of productive forestry.

In 1950-51, for instance, only 39.3 million ha (57.0%) of the 68.9 million ha forest were "in use", a further 8.2 million ha (11.9%) were "potentially exploitable", and the remaining 21.4 million ha (31.1%) were assessed to be non-exploitable, having no prospect of being worked because of physical conditions or other reasons (Government of India, 1952). In 1975-76, of the total 74.7 million ha, 46 million (61.5%) were "exploitable" (in use), 16.2 million (21.7%) "potentially exploitable", and 12.6 million (16.9%) others (Government of India, 1980). As population, communications, and consumption needs expand, hitherto remote, uneconomical forest resources become workable properties. A gradual reclassification of the use category is evidence of this process (FAO, 1984).

Production remains low due to various factors. Estimates for 1950-51 (Table 2.3.ii) put the standing crop volume on the 39.3 million ha of "exploitable" forest ("forest in use") at an average of 58.5 cmt(r) per ha (underbark volume). State forests averaged 118.97 cmt(r) per ha in coniferous, and 69.98 cmt(r) in broadleaved, forest. Communal forests averaged only 22.42 cmt(r) per ha in coniferous, and 2.73 cmt(r) per ha in broadleaved, forest. Private forests were intermediate, at 20.01 cmt(r) per ha of broadleaved (Government of India, 1952).

Gross annual increment was highest in the state forest, 1.53 cmt(r) per ha per year in coniferous, 1.09 cmt(r) in broadleaved. Private broadleaved forest had 1.31 cmt(r) per ha per year; communal forest, only 0.54 cmt(r) in coniferous, 0.11 cmt(r) in broadleaved. The net annual increment, the difference of gross increment and harvest plus natural mortality, was positive in state forests, 0.24 cmt(r) and 0.58 cmt(r) per ha, respectively; and negative (almost zero) in private.

The growing stock was apparently being built up in state forest, and drawn down in private. But estimates for 1976-77 (Government of India, 1980) show the total growing stock on state forest averaged about 1964.4 million cmt(r), about 86% of the 1950-51 level; or 26.28 cmt(r) per ha for a total area of 74.8 million ha, down to 38% of the 1950-51 estimate. The "annual availability" was about 0.40 cmt(r) per ha, around the same as the annual harvest rate from state forests in the 1950-51 estimates.

In the absence of a series of detailed estimates, however, it is not really possible to infer anything unequivocal about the fate of the forests. Growing stock may have accumulated for some period, and then heavier harvesting might have brought it down again. The 1950 estimates of gross increment might have been too optimistic. The area of state forest in the 1976-77 estimates may have included private forests transferred to the forest departments after abolition of the 'inamdari' or 'zamindari' system of land ownership. In isolation, decrease of standing crop need not necessarily be a sign of over-exploitation. It could well be a symptom of better management, as stagnating, old, or inferior crops are replaced by healthier, better stocked young crops.

2.5.3 <u>The "gap" between supply and demand</u>

The general consensus is that productivity per ha, or per ha per year, in Indian forests is low because there is rarely full stocking, while grazing, lopping, burning of the undergrowth, and irregular removal reduce the annual increment. The difference between 'recorded' production and estimated consumption of forest products constitutes a supply-demand 'gap'.

For example, in 1961, state production of industrial roundwood was 5,430,000 cmt(r) (Sharma, 1980, p.56), against the FAO estimate of consumption of 6,498,000 cmt(r). The 'deficit' was thus around 16.4% of apparent consumption. The deficit in government production of industrial wood was around 4.8% in 1969, 28.4% in 1970, 37% in 1971, 39.7% in 1973, etc. (Sharma, 1980, and FAO Yearbooks).

This gap is of a much higher order in the case of fuelwood than of industrial wood. The "recorded" production of fuelwood from government forest was between 10,750,000 cmt(r) in 1961 to 15,210,000 cmt(r) in 1973 (Sharma, 1980), compared with consumption of 83,201,000 to 173,195,000 cmt(r) (FAO Yearbooks). The highest estimated recorded production was 20,311,000 cmt(r) in 1976-77 (Government of India, 1980), when consumption was around 185,397,000 cmt(r).

The "gap" of 100-150 million cmt(r) has to be met from somewhere; if by illicit felling from the state forests, the standing volume of 1964.4 million cmt(r) of 1976-77 would be finished off in less than 20 years, the net increment being less than 1% per annum under normal circumstances. The suggestion is strong that the low productivity problem originates in this dualism. The unceasing search of an impoverished population for firewood, to the extent of digging out the roots and stumps, presents the prospect of converting vast areas of productive land into arid wind-blown wasteland.

2.5.4 Supply-demand gap and economic scarcity

In economic parlance, there can be no such gap in the long term, as the market moves to equate supply with demand, or vice versa. The only recognized symptom of scarcity in the economic sense would be a rise in the market price of a commodity, relative to other commodities (Barnett and Morse, 1963). For the USA, these authors found that natural resources in general did not show this symptom of increasing scarcity, thus belying the alarms raised by environmentalists: except for the group of forest products. This would indicate that forest products are in some measure not substitutable by other products, though synthetic materials and metals have gone a long way in replacing wood in many uses.

In developing countries, metals, which require sophisticated machinery and technology, are in short supply, and it is expected that wood resources will be under even more pressure. The index numbers of wholesale prices for the period 1970-71 to 1984-85 show clearly that the group 'logs, timber and bamboo' had an extremely high rate of price rise, the index reaching 1018.2 in 1984-85 contrasted with the general price index of 345.4, or with the 'primary food' group index of 297.4 (Table 2.4). Of substitute structural materials, cement went up to 501.3, while 'iron, steel and ferroalloys' went up to 517.3. Thus it is clear that wood is becoming exceptionally scarce in the economic sense.

This is however true mainly of timber, poles, bamboos, firewood, canes, etc. in the uncontrolled markets. Products manufactured in modern forest-based industries have registered less dramatic inflation rates (Table 2.4). Paper, plywood, and board had levels comparable to that of food articles. In Kerala, (real) prices of round timber were relatively stable up to 1976-77, after which the supply from government forests fell at the same time that there was a boom in construction with earnings from the Arabian gulf. However, the price of government supplies of plylogs has lagged behind the inflation rate in general wholesale prices, and even behind the already lower rate of increase of plywood prices. Private timber supplies have, in contrast, kept pace with wholesale prices. Extraction costs are also closely linked to general price changes (Krishnankutty et al., 1985).

Thus the government price control is a prominent reason for the moderate price increase in the organized sector. Such control is not exercised on the timber and firewood trade. At the most, governments try to provide a supply of firewood at 'reasonable' rates to the poor in the towns and large villages through retail shops. The demand in urban centres is often too high to be met from the surrounding forests; transport over long distances may become inevitable. In rural areas, few people have the money or the inclination to buy firewood they are used to collecting from the land.

The bias toward the requirements of industries is apparent in the production and supply decisions both from natural forest and from plantations. This is a consequence of the developmental policy adopted by the government, which stresses self-reliance and import substitution, taking advantage of available natural resources. The peculiar nature of forestry often generates counter-pressures that confuse the signals to the market. Periods of heavy clear-felling for industrial plantations or agriculture bring liberal supplies of timber and firewood to the market, so that the supply squeeze that follows is all the more acutely felt.

2.6 The conflicting roles of forestry

Development and welfare may therefore be mutually conflicting objectives in the forestry situation in India. Such a conflict has already been perceived by some observers in the propagation of eucalypts under social forestry schemes (Shiva et al., 1982; Shiva and Bandyopadhyay, 1983). Populist movements for tree protection seem to have their roots in a genuine concern among quite ordinary people that commercial forestry is incompatible with the survival of their economy and environment.

There are intense pressures on the forests as a source of basic needs goods for the people, on the one hand, and of industrial raw material, on the other. Both these are, fundamentally, economic forces that originate in the needs of the people.

The question is whether the different pressures and demands can be ordered as 'national' priorities, or whether they are more in the nature of partisan interests of different income or other sections of society. Forest management and policy cannot ignore these questions. They call for an examination of both the productive and the distributive aspects of forestry under the light of economic requirements and conditions.

2.6.1 Early forest administration in India

Traditionally, the forests were a royal preserve, and exploitation prohibited except on royal license. Export of teak, sandalwood, and ivory from the forests of the Western Ghats was an ancient trade. The British started getting direct control of Indian territories from around 1799, and the traditional system of forest administration was carried on, through concessions given to various timber syndicates to exploit the timber (Garland, 1935). For the British, "simply the latest of the predatory conquerors of India", the fundamental concern was the creation of "an efficient and pliant" administrative structure and, particularly, the mobilization of the financial resources to pay for British rule (Charlesworth, 1982). The pacification of the country also encouraged a naturally diligent peasantry to expand cultivation into the jungle, especially in the latter half of the 19th century. One effect of commercialization was the depletion of traditional food stores, and another, the depletion of forests (Tucker, 1983; Richards and McAlpin, 1983, p.85; Akbarsha, 1985).

As the initial 'laissez-faire' soon led to signs of depletion of timber sources and decrease of annual revenue collections, administrative control was gradually tightened. The first conservator of forests held office under the Madras government from 1806 to 1823 (Sharma, 1980). The Company monopoly on timber trade was lifted in 1823 (Garland, 1935). By 1843, a heavy surcharge was imposed on all small-sized timber exported, to check the exploitation of immature trees (Garland, 1935). But this was rescinded in 1848 along with all duties on internal trade. On the Western Ghats, felling of teak trees below 21" girth was prohibited. The famous teak plantations of Nilambur were started by Chathu Menon under the guidance of the collector of Malabar, Conolly, in 1842.

Regular forest conservancy is considered to have started with the appointment of the first regular conservator of forests in Madras Presidency in 1846, and in Bombay in 1847. The Governor-General, Dalhousie, promulgated an outline for forest conservancy in 1855, and in 1856 Dr Brandis, who later laid the foundation of forest administration and management in India, was appointed the superintendent of forests in Burma.

Evidence presented before a committee of the British Association for the Advancement of Science, Edinburgh, in 1850, had indicated that areas that had received regular supervision, like Malabar, Burma and Sind, had improved considerably in comparison with others, like the base of the Himalayas (Cleghorn, 1861). The committee felt that the mass-scale destruction of the forests was continuing over a large portion of the Indian Empire "because of the wasteful habits of the people and the convenience of the British rulers". With the withdrawal of the charter to the East India Company and the tranfer of the Empire to the Crown, the administration of the forests began to be put on a stronger footing. Forest legislation and reservation were taken up. Forest departments were engaged in the hard task of surveying, demarcating, and consolidating forest reserves all over the sub-continent.

2.6.2 <u>The forest policy of 1894</u>

The concern about the state of India's forests found expression in the remarkable Report on the Improvement of Indian Agriculture, by Voelcker (1893). Though forest conservancy had started only a few decades back, Voelcker already sensed a divergence between the interests of the forest departments and people's needs. This was not solely the fault of the department, which had protected large stretches of forest from haphazard clearance by the villagers. But since the success of the department was judged by the revenue surplus it generated, and this in turn depended on timber outturn, its interests were in a sense "opposed to agriculture, and its intent was rather to <u>exclude</u> agriculture than to admit it to participation in the benefits" (Voelcker, 1893).

The guiding principle of Dr Voelcker's recommendations was the conviction that "one great object should be to directly <u>serve</u> the agricultural interests". Timber was to be the main objective in the more remote and dense timber forests, but local needs were more important near agricultural tracts. Much stress was laid on the need to develop fuel and fodder reserves for the local people.

The forest policy proclaimed in 1894 was ostensibly influenced by the report of Dr Voelcker, perhaps because of falling agricultural productivity and land revenue. Since "the sole object in administering the state forests is public benefit", forests on hill slopes should be maintained as protection forests, reserves of valuable timbers should be managed on commercial lines, and inferior forests yielding mainly fodder and small wood should be managed mainly in the interests of the local population, but so controlled that "the people are protected against their own improvidence" (National Forest Policy, 1894, quoted in NCA, 1976).

The concession to agriculture was that wherever an effective demand existed for cultivable land that could only be supplied from forest area, the land should ordinarily be relinquished without hesitation. However, honeycombing of the forest would not be allowed, the proposed cultivation should be permanent, and the minimum forest needed to meet present and future needs would always be preserved.

In practice, however, investment in forestry could be funded only by increased revenues. Timber outturn and net revenue became the yardstick for measuring efficiency. The relationship between forestry and agriculture did not seem to improve. Going even further than the Voelcker report, the Royal Commission on Agriculture in India (HMSO, 1928) declared that "...the most promising method of establishing village forests is to hand over to village management certain more or less wooded areas now under the control of the Forest Department. Management by the people for the people of the forests close to their villages possesses so many desirable features that every effort should be made to ensure its success....".

One of the unwritten articles of the 'charter' given to the forest department appears to have been that annual revenue should not fall. During the 75 years from 1864-65 to 1946-47, the average annual current revenue surplus in the forest department of British India rarely fell below 30% of gross revenue. It was above 40% during the period 1889-90 to 1918-19 (Government of India, 1941), and with some marginal exceptions, through the war years to 1946-47, when it was almost 60% (Stebbings, 1962). In the environment in which foresters worked, it was difficult to obtain any generous allocations of finance for long-term investment.

The forest department was apparently in the curious situation of having to propel its development by enlisting the more immediate imperial interest of commercial gain, but to defend its rear from competing land uses by appealing to the interests of environmental conservation and the interests of posterity. Political awakening and independence served to deepen these contradictions.

2.6.3 National forest policy declaration, 1952

The revised forest policy of 1952 was based on the "paramount needs of the country", in brief to improve the physical environment and material conditions of the people. The underlying principle would be "national well-being". Two considerations would have to be "combated": one, that "neighbouring areas are entitled to a prior claim over a forest and its produce"; the other, that "agricultural requirement has a preferential claim over forest lands". The first circumstance is a mere accident, and cannot be allowed to deprive the nation at large of the benefits of the resource. The second consideration has led, in the past, to expansion of agriculture into areas unsuitable for it, resulting in "general deterioration of physical conditions to the detriment of national interests, and must therefore be given up" (Government of India, 1952).

Each type of land ought to be allotted to that form of use under which it would produce the most and deteriorate the least. In 'protection' forests, environmental conservation was the primary concern. In 'national' forests, the basic aim would be to attain national self-sufficiency in the vital supplies of wood for industry and defence. 'Village' forests are primarily for the needs of the local villagers, whose requirements should be made available at "non-competitive rates" provided they are utilized by the villagers themselves and not traded in.

Past experience had proved the dangers of village ownership of forest; but their help could be enlisted in the creation and protection of village forests, and in the distribution of forest produce assigned to meet the needs of the local population, "but not at the cost of economy and efficiency". While the "profit motive" should be relegated to the background in such forests, "there is no justification for allowing them to become a burden on the general tax-payer; ...the expenses for development and maintenance of such forests must come from their own income" (Government of India, 1952, p.24).

In the following decades, during the 1960s and the 1970s, the 'national' forestry sector was gradually made the major recipient of investment funds. The revenue surplus was if anything higher, over 50% of gross revenue till 1963-64. It subsequently fell to a little over 45% for the period 1969-70 to 1971-72 (cf. NCA, 1976, Table 41-3). The role of forestry in the industrial-urban developmental strategy also found a cogent and persuasive expression in the tract by Westoby (1962), who stressed that forest resources could support industrial development if the timber or other products were processed within the underdeveloped countries instead of being exported as raw material.

If the contribution to national income from the forestry sector itself was only 1%, its share of public sector outlay in the Five-Year Plans was even less, only around 0.5% till the Annual Plan for 1979-80 (Government of India, 1985). Of the total outlay on afforestation, only 12.8% was for 'social forestry' in the First Plan (1951-56); 29% in the Second (1956-61); 25.7% in the Third (1961-66); 18.6% in the Interim Plans (1966-69); and 15.9% in the Fourth Plan (1969-74). This was in consonance with the NCA (1976) recommendation of a major change in forest policy "from the present conservation oriented forestry to a more dynamic programme of production forestry", heavily slanted toward monoculture of fast-growing species.

Thus the rural and 'national' streams in the forestry sector were measured by different yardsticks: the former had to justify itself financially, while the latter was justified on loftier grounds. The result of the investment in 'national' forestry was the increasing alienation of the people from the forest departments.

2.6.4 **Financial returns, social values and sustained yield**

There has thus been more than one strand in the skein of forest policy and management. Running through all these, however, is the thread of the forester's traditional concern with the long term. This concern was expressed in the principle of sustained yield.

Even the 'progressive' 1952 policy falls back upon this central principle. The sustained yield principle demanded that existing forest be protected, and annual removal restricted to annual increment. The combination of sustained yield and the national importance of large sized timber supported the management policy of long rotations and slow conversion. Such a policy, however, did not elicit much sympathy from the people at large, despite the 1952 policy's exhortation that "...once the local population learns to look upon the forest as a means of livelihood, a great step forward will have been taken" (Government of India, 1952).

Indeed, the forest department seems to be fated to lose if it follows sustained yield principles, and fated not to win if it follows 'commercial' short rotations. Both these are basically geared to the needs of industry. The resources of land, capital funds, and manpower in the forest sector have been put at the disposal of the industry. To the people, it appears that the forest, which was previously at their service, has now been taken away. There is thus popular resentment at the forest department. This bodes no good to the success of plantations and other activities under the new and bold policy.

2.6.5 Forestry and the social interest

When policy-makers started thinking of direct measures to tackle rural poverty, they realized the seriousness of the rural energy problem. Forestry was seen to be a good sector for productive rural employment. It was with this improvement in the social climate for forestry that the share of the forest sector was increased to 0.7% of total outlay in the Sixth Plan (1980-85). The share of social forestry, in total expenditure on afforestation, went up to 49% in the Fifth Plan (1974-79), and 77.8% in the Sixth (1980-85). The proposal for the Seventh Plan (1980-85) was to put 83.5% of an afforestation outlay increased almost 13-fold into social forestry alone. Since these were only the proposals of the study group (Government of India, 1985), they are indicative of the change in public perceptions rather than of the final priorities accorded in the plan.

The growing disenchantment with the 'received' doctrine of industry-led growth was given expression in the forestry context by, interestingly, Westoby himself (1978). Striking a discordant note in the self-congratulatory mood at the Eighth World Forestry Congress, Westoby now felt that forestry could help in socio-economic development only if the goods and services it produced corresponded to the "real" or "basic" needs of food, clothing, shelter and elementary health and education services; and if the expanded output were so distributed that the most urgent of those needs are satisfied first, and in an equitable manner.

Between social needs and economic gains, there would seem to be a gulf that cannot be bridged by forestry alone. It is here that a framework is needed to weigh the relative costs and benefits of adopting alternative courses of action. Not only is production of goods and services important to society; it also is a matter of concern how the benefits of increased incomes and increased consumption will be distributed. Forestry cannot ignore the distributive consequences of policy and management decisions on the ground that all forestry is good. It is such aspects and considerations that may be better dealt with in a wider economic framework that takes into account both private and social values.

CHAPTER THREE

ECONOMIC ANALYSIS OF SUSTAINED YIELD FORESTRY

Forestry in India was modelled on the lines of European forestry of the nineteenth century. Silviculture and management, as represented in the working plans, are geared to sustaining the maximum physical productivity of the forests. Foresters traditionally elevate this (maximum) sustained yield principle to almost a 'received' doctrine. Actions purporting to flow from this principle are usually considered to be justified in themselves, without reference to the immediate social and economic conditions (Roberts, 1974). The underlying attitude of the forester is that the people should be protected from their own short-sightedness. However, free market economists have usually been sceptical of the sustained yield principle.

3.1 The theory and practice of sustained yield forestry

3.1.1 The principle of sustained yield forestry

Sustained yield management gives priority to establishment of the successor crop. In theory, harvesting is but an incidental outcome of regenerating the crop. It is the establishment of the new crop that is the real objective. According to Schlich, one of the founding fathers of Indian forestry (1911, Vol III, p.168):

> "Generally speaking, a sustained yield is secured, if all areas which have been cleared are restocked within a reasonable time and the young woods which spring up are properly tended, so that the soil continues to produce crops of wood."

A second objective was that areas of forest should, as far as possible, be worked in self-contained units that could continuously produce a steady stream of products and services in perpetuity. This is expressed as the **even-flow** condition. It is not, evidently, a necessary condition of sustained yield. Even flow is considered desirable, however, over large blocks of forest, for reasons of social stability, ecological health and administrative convenience (Schlich, 1911, Vol. III, p.168).

3.1.2 Qualifications to the sustained yield - even flow principle

The proponents of the (maximum) sustained yield - even flow regime were not completely unmindful of possible disadvantages. In an irregular forest, some crops would have to be cut before, and others after, the age which was most desirable from the point of view of maximizing mean annual increment. It could also interfere with the complete utilization of "special demands" for forest products, or with the delaying of felling when the demand was slack (Schlich, 1911). The equalization of annual yields could therefore be restricted to final fellings in the first instance, ignoring fluctuations of intermediate yields, provided this does not impose "sacrifices out of proportion to the general advantages of the method" (Schlich, 1911).

3.1.3 Sustained yield forestry in practice

The sustained yield principle does not by itself dictate the detailed silvicultural characteristics of the forest. Market influences do come into play when the manager decides which species of tree will be cut, or grown, and what types of product aimed at. To the extent that the sustained yield forester aims at producing the most 'valuable' timber, of the most 'valuable' sizes, he is being guided by consumer preferences.

The goal of conversion is to attain a 'normal' forest with 'normal' stocking and 'normal' increment. The term 'normal', however, is loosely defined. In practice it probably meant the 'ideal' levels of age and spatial structure, and hence of growing stock, which would result in the maximum annual increment. As knowledge of the forest and its needs and responses improved, the ideal could be modified (Holt, 1968). In the meantime, the forest ought not to be so heavily felled as to reduce the growing stock to very low levels, which would result in a dip in annual flow of products. On the other hand, too little felling would perpetuate an accumulation of overmature wood, reducing the annual growth of the forest.

Various silvicultural systems were developed to cope with varying conditions and species requirements. For species which regenerated under shade, it was essential to maintain a dense canopy. The selection system suited these forests. Species that required good overhead light were managed under various shelterwood or clear-felling systems.

A crucial way in which social and economic considerations did influence sustained yield forestry was through the funding of forest departments. The orderly progress of fellings which were, in theory, aimed at regenerating a normal successor forest, had often to give ground to the dictates of the annual budget provision. The government seldom provided funds for building up the stock; it was more generous, however, if the case for increased expenditure could be supported by prospects of increased revenue surplus. This is probably a general characteristic of forestry in the public sector, even in advanced economies (cf. Clawson, 1985, p. 167).

Indeed, the performance of a forest officer was usually judged by the increase in revenue achieved; decreases were not to be countenanced, not the least because it would attract punitive cuts in budget allocations from the government. During times of slackened demand, as between the world wars, investment suffered (though growing stock may have been built up automatically as felling decreased). During times of heightened demand or special needs like the war effort, fellings were brisker than warranted by sustained yield principles.

3.1.4 Sustained yield and the allowable cut effect

The sustained yield principle requires that the quantity of wood or other product removed annually from a forest should be limited to the amount it produces annually. For a forest as a whole, it can be assumed that the annual increment is proportional to the area, the number of acres under tree crop. The only way of increasing the annual cut, then, would be to increase the actively growing volume, through more intensive management (Downs, 1974).

If, however, we accept the approximation that the annual increment remains more or less constant throughout the life of the crop, it follows that adding new acres to the forest by planting up bare land has the effect of proportionately increasing the annual increment, or annual production, of the estate as a whole. Then this additional annual increment can be taken out from the mature crop, without violating the sustained yield principle.

This is the phenomenon discussed by American writers as the 'allowable cut effect' or ACE (Schweitzer et al., 1972; Lundgren, 1973; Teeguarden, 1973; Bell et al., 1975). Our interest at this point in the ACE is that it suggests a way of justifying expenditure on extending the land base of forestry (Bell et al., 1975; Clutter, Fortson, et al., 1983).

If the forest is full of old and stagnating trees and crops, the annual increment is bound to be low, and the interests of future yields may actually be harmed by insisting on the "truly pernicious notion of 'no-dropoff' in the timber harvest rate" (Hirshleifer, 1974). By a higher rate of planting new areas, the forester can justify the faster conversion of the unproductive stands to young, vigorously growing crops. The ACE thus affords a way out for the conscientious forester who believes in sustained yield but would like a more dynamic approach to planning for the future.

Government planners are seldom happy about investing in long-term ventures in forestry. The forester, while protecting the unsung interests of posterity, can show that a hectare of plantation will yield <u>immediate</u>

returns through increased fellings in the mature forest. This is supposed to convince the financial watch-dogs of the government that investment in forestry is a highly paying proposition, hence to break down the prejudice against managing forests on long rotations and for big timber.

However, economists point out that the decision to fell and the decision to plant are essentially independent of each other. The extra revenues obtained by accelerating the conversion of existing forest could as well have been realized without the excuse of new plantations (cf. Price, 1976, p.100); the real productivity of the new investment is thereby overestimated (Teeguarden, 1973). Plantations, like any other investment in intensified management, should stand or fall on their own merits (Hirshleifer, 1974), not on the operation of what is, after all, a contrived constraint in the form of legislation prohibiting harvesting unless supported by preplanting.

3.2 The economic view of sustained yield management

3.2.1 The neo-classical economic view

The particular view that challenges the accepted tenets of forestry can be broadly characterized as that of the neo-classical economics (Stiglitz, 1979). This view rejects physical product as the best measure of value. On the contrary, the best guide to relative value, expressed most consistently and truthfully, is in this view the amount of other goods that the individual is willing to sacrifice in exchange for a unit of the product in question. It is, further, in the best interests of society to allow the inclinations of individuals, freely expressed in the market through voluntary transactions, to dictate how the resources of the society will be used, produced, and rewarded.

Rational consumers are supposed to exercise choice consistently in such a way as to maximize their overall utility, the satisfaction they get from consumption. Choices are conditioned by consumption possibilities, incomes, relative prices, and the mutual trade-offs involved in allocational decisions. The ultimate result of the free play of market forces, in the neo-classical model, is that resources are allocated to their optimal uses.

The optimality conditions are expressed conveniently in the marginal form (Lerner, 1946). For consumers, the given income is allotted to different commodities in such a way that the marginal utility per rupee of consumption is the same whichever commodity is considered. For producers, the marginal revenue per rupee of costs is the same, whichever factor they try to vary. Analogous optima are assumed to obtain in the supply of factor services to different employers, and to the production of different commodities by producers.

If income distributions change, a series of readjustments may occur, finally yielding another position of equilibrium in which no agent can increase his or her own level of satisfaction without a reduction in some other person's. Such states of optimality are called Pareto-optimal or Pareto-efficient states. The link between individual welfare and social welfare, however, is essentially a stalemate: it is not possible to change to a state in which at least one person has a higher level of satisfaction, without any decrease in the level of satisfaction of one or more of the remaining members of the society.

The aggregate level of satisfaction can be called the level of 'welfare' in society, but this is a rather loose term. Neo-classical welfare economists usually abjure the convenience of adding up individual utility levels to arrive at some measure of aggregate utility, as they hold that utility is a subjective, introspective feeling. Each person has his own scale and his own units, incommensurable with those of others (cf. Green, 1976; Just et al., 1982).

For the poor, such an attitude may appear unjust, unless perhaps differences in income were low enough, and access to income-augmenting opportunities fair enough, to give them more than a vain hope of one day joining the rich. This is a hint why the normative conclusions of neo-classical economics do not find much favour in the dualistic economies of underdeveloped countries, which tend to lean toward authoritarian or paternalistic models.

The economic view-point involves an alternative view of social obligations and opportunities, which treats past expenditures as essentially 'sunk' costs, and pays more attention to the opportunities that lie in the future. In a sense, if traditional foresters (and, perhaps, traditional societies in general) look at the future as the repository of punitive consequences on a profligate present, the alternative view of the future sees mainly the great potential for a more varied and more productive use of resources. To lock up land, capital, and other resources in forest crops that will yield returns a century or more in the future, while there are so many other, more productive, uses, even within the forestry sector itself (Teeguarden, 1985), is seen as a disservice to future generations (Haley, 1968; Pearse, 1970; Klemperer, 1976).

3.2.2 The economic critique of sustained yield forestry

The neo-classical economics of the market serves as underpinning to much of the application of forestry economics. Since distributive considerations are effectively ruled out, we are left with the principle of the collective good through the private optimum. The economics of forestry reduces to the optimal behaviour of a producer, the behaviour of the firm in economic parlance.

This has been thoroughly explored by a number of scholars. Among the definitive statements are the detailed review of Gaffney (1960), Bentley and Teeguarden (1965), Pearse (1967), from the classical view-point; the expository article by Samuelson (1974); the detailed work of Hyde (1980), which restates the problem in the language of optimization theory. Hirshleifer (1970; 1974) explores the sustained yield problem from the capital theory view-point. Herfindahl and Kneese (1974) and Johansson and Löfgren (1985) examine the problem in the broader context of natural resource management.

The economist's objection to physical sustained yield maximization is that it pays little attention to the costs incurred to support this particular management regime (Thompson, 1966; Smith, 1969; Waggener, 1969; Roberts, 1974). The only concession it gives to economic considerations is that the highest-valued product is favoured as far as possible. But the price paid to produce this high-valued product is not considered (Thompson, 1966; Chandras and Grayson, 1968).

Where the costs find expression is in the regeneration and tending expenditures. As long as the net revenue is positive, neither the forester nor the government is unduly concerned about these costs. One result could be that expenditures are then incurred mainly on the basis of how easily they can be justified by immediate revenues, for example by fellings; and not by the increase in annual product they will be likely to yield in future. This is an invitation to liquidating capital stock slowly, ploughing the returns into unproductive investments.

On the other hand, the maximum MAI principle requires us to postpone the returns from unproductive older crops to the far future. This is a prime target of the economic critique of forestry (Price, 1976; Hirshleifer, 1974; Hyde, 1980; Clawson, 1985).

The time element enters the picture from the outset, as time is an indispensable input in growing tree crops, much more than in manufacturing processes. The possibility of substituting fertilizers, irrigation or other growth-promoting inputs is present, but to produce the large timber that sustained yield forestry favours, it is probably inevitable that a period of a few decades elapses. Like time, land is an indispensable input. In this respect, land and time can be compared to the material inputs that are the physical substrate of manufacturing processes.

Sustained yield forestry errs in not considering these two major elements (Ledyard and Moses, 1974). Thus the decisions of the sustained yield firm get out of step with relative valuations in the rest of the economy. Sustained yield forestry is consequently so liberal in its use of these inputs, that such a firm would not survive long in a competitive economy.

The primary decisions in plantation forestry are the planting and felling decisions. To simplify the problem, economists usually consider a 'point-input, point-output' case, i.e. one in which planting is done at the start of year 1, and felling brings returns at the end of year T, the rotation period. The decision is reduced to the production problem of a firm. Looking at the acre of plantation as a marginal activity, then, the firm will undertake it only if the marginal revenue is at least equal to the marginal costs, but not if it is lower.

3.2.3 The cost of time

The returns to investment will be received only at the end of the rotation. The firm always has the option of investing the same money in some other venture or in a deposit at some rate of interest. This poses a an opportunity cost in economic terms. It is not enough, therefore, that the firm just recover the plantation costs at the end of year T; it has also to get the accumulated interest on its capital investment (Teeguarden, 1985).

As is well known, compound interest accumulates slowly at first, but soon, like Malthusian explosions, grows to enormous proportions. Forestry, or any long-term venture, is thus is at a natural disadvantage in comparison with ventures that may not be so productive in gross terms, but which return the investment at an earlier date. Foresters naturally resist the application of the principle of interest as a false 'bogey' created by economists, which should not influence production decisions, especially those on the use of 'god-given' natural resources. In the financial and business domain, however, interest is an unavoidable and real cost.

3.2.4 <u>The cost of land</u>

Next to the cost of capital, economists have stressed the cost or hire price of land. Once again, the concept is one of opportunity cost (Worrell, 1953; Haley, 1966). A piece of land acquires value in society because it is useful; either as an input in a productive process, or even as a personal possession (Waggener, 1985).

The market for land, however, is less competitive and perfect than that for capital (investible funds). This is because capital funds are mobile, and do not vary significantly in quality in a modern economy. Land, however, is a fixed and immobile asset. The very factors that make it the favoured means of accumulation also make transactions in land much more personalized, occasional occurrences. Locality factors and individual quirks play a great part in such transactions.

It is therefore difficult to assign a price to land, to the particular hectares being considered for forestry. In theory, the opportunity cost would depend on the best alternative use. This would, in the absence of a sufficiently broad-based market for land, depend on the personal qualities and fancies of the potential owner, much more so than in the case of investible funds.

For any land-based venture, however, there is one method to assess the opportunity cost that is always present: that is, to assess the relative merits of all the conceivable alternatives in the chosen activity (Haley, 1966a, 1966b; Ledyard and Moses, 1974; Bare and Waggener, 1980; Waggener, 1985). In forestry, this is usually expressed as the rotation decision, although a more sophisticated data base might enable comparison of different cultural treatments, species compositions, spacing, etc.

3.2.5 NPV, land rent, and the Faustmann formula

Given the difficulty in ascribing a value to the land acquired in year 1, or alternatively to the annual hire charges of the land used from year 1, the expedient suggested is that of treating it as a residual factor, and maximizing the net returns per acre of land.

Samuelson (1974) presents two approaches to the problem. The first is to maximize the annual rental that can be charged to the land, while still breaking even. This highest feasible rental will reduce the net present value (NPV) of its operations to the minimum value of zero, assuming that the land hire charges are counted as a part of annual costs. The condition is expressed mathematically as follows:

$$\max_T \; R, \qquad \text{subject to}$$

$$0 = \max_T \{PQ(T)e^{-rT} - wL - R\int_0^T e^{-rt}dt\} ,$$

$$= PQ(T_F)e^{-rT} - wL - R_F[1-ePT^{-rT}]/r ,$$

where T_F is the 'Faustmann' rotation. It is that rotation which maximizes the annual rental R of the acre of land.

The gross returns at rotation-end are the volume or quantity, Q(T), multiplied by the stumpage price, P; discounted to time 0 at (continuous) rate of interest r. From this is subtracted the rental (R per year accruing continuously from t=0 to t=T, integrated to simplify the algebra) and establishment costs (wage rate w multiplied by labour units L, assumed to be incurred all at time 0). The property of this maximal R is that it would absorb the entire surplus of the enterprise, i.e. reduce to 0 the net receipts to all the other factors put together.

The other approach is to maximize, not the annual rental R, but the capital value of the land. This is equal to the NPV of the infinite series of forest crops that can presumably be grown on it, as shown by Faustmann (1849), all of the same rotation and silvicultural characteristics. Thus this is the maximum value of an acre of land under <u>sustained</u> yield forestry. The objective and conditions are expressed as follows:

$$\max_T \, [PQ(T)e^{-rT} - wL][1 + e^{-rT} + e^{-2rT} + \ldots]$$

$$= [PQ(T_F)e^{-rT} - wL]/[1-e^{-rT}] =$$

$$= \max_T \, (R/r) = R_F/r \, .$$

The capital value of the land is expressed in the first line as the sum of an infinite series of rotation-end returns, each discounted successively by 1, 2, ... rotation periods T; and net of establishment costs wL, successively discounted 0, 1, ... rotation periods. The rotation that maximizes this capital value is the Faustmann rotation T_F.

Faustmann (1849) used this approach not so much to find the optimum rotation, as to evaluate forestry land for taxation purposes. Samuelson (1974) shows that the two approaches however yield the same optimal rotation. For a given interest rate r, the rotation that maximizes annual land rent R also maximizes the capital value R/r. This is the same as the maximum capital value derived by Faustmann's formula, and the optimal rotation period is also the same, T_F.

3.2.6 The problem of the correct economic criterion

The Faustmann equation in either of its forms is seen as the 'correct' formulation of the problem of optimizing economic returns to land in the forestry enterprise. There are, however, a number of other economic criteria which yield differing optimal rotations. Since the problem of the proper economic criterion is one which crops up repeatedly, the main points of the discussion are summarized here.

The internal rate of return (IRR) is a commonly used criterion to choose between alternative uses of investible funds. It seems intuitively obvious that the rational individual will prefer to invest his savings in the account yielding a higher interest rate. It has also been adopted by many authorities (Boulding, 1955). It is surprising, then, to see informed opinion emphatically opposed to applying it in forestry and land use in general. The explanation lies in the treatment of capital expenses, implied or actual.

Bentley and Teeguarden (1965) suggest that the return to the fixed factor should be maximized: if land is fixed, it should be maximum land rent; if capital, it should be IRR. If land is a captive resource, however, the natural tendency is to ignore its cost altogether, as pointed out above. The rate of return, the IRR, then tends to be calculated on the cash outlay alone. This explains why the IRR in many cases comes out to be much higher than the market interest (discount) rate.

If capital is the fixed factor, the residual profit or rent accrues to capital. As the owner maximizes return to capital, the interest rate has only a limited bearing, in determining whether the project will be undertaken or not (Goundrey, 1960). The crop is always cut at the age when its rate of growth in value is the highest. The rotation of maximum IRR tends to be shorter than the Faustmann or single-rotation NDR rotation.

One result of adopting the maximum IRR criterion is that the optimal rotation is unaffected by changes in the interest rate. This is considered an anomalous result, which should seriously question its validity (Samuelson, 1974).

Another consequence is that the IRR criterion implies an infinitely expandable land base (Fortson, 1972). In the Faustmann model, the cost of land absorbs any surplus ('pure') profit, so that the original acre is all that is required to continue reinvestment in perpetuity. In the Boulding model, however, the surplus has to be reinvested at the same IRR, that is in an additional bit of land, and so on. The ultimate goal would be an infinite land base, implying an infinite wealth (net present worth) of the firm. So fortunate an entity should be able to trade in its endowments of income streams for an infinite stream of present consumption (Hirshleifer, 1970).

That such a case never happens is because there are physical limits to how much reinvestment can take place (Price, 1976). In practice, the firm would rapidly start pushing up the market price of land, and along with it of labour, investible funds, and other resources. Its IRR would start falling, and the market interest rate rising, until the two became equal. Pure profits would disappear, and the firm would be back in the position of just making ends meet, the zero NPV case (Hirshleifer, 1970).

Even before that, however, a firm which worked on the short rotation of the IRR would have so low a NPV that it would simply not be able to afford to hire land, in competition with NPV-maximizing firms. Unless it was working with captive land resources, it would be forced into liquidation. Samuelson (1974) describes this as follows:

> "Anyone who misguidedly adopts this foolish ... rotation period will find that he either goes broke or is permanently sacrificing return on original capital that could be his."

If, however, the competitive price of land were included as a capital cost (to be recovered at the end of the rotation), or if the annual rental were included as a recurring cost (calculated at the same percentage of capital value as the discount rate), the maximum IRR obtainable would be the same as the discount rate. In terms of capital theory, all types of capital stock would be so adjusted in magnitude as to equate their marginal rates of return (Hirshleifer, 1974). The Boulding rotation would then be the same as the "correct Faustmann-Gaffney-Hirshleifer formulation" (Samuelson, 1974).

Another variant of the NPV criterion is the net present value of one rotation, sometimes termed the net discounted revenue (NDR) (Johnston, Grayson and Bradley, 1967). This yields optimal rotations that are longer than the Faustmann solution, but still shorter than the sustained yield rotation. The defect is again in not accounting fully for the cost of land. If the Faustmann capital net value of land is included as a cost, the optimal rotation is reduced in order to avoid paying extended rent.

3.3 The effect of economic criteria on sustained yield management

3.3.1 Rotation periods and economic criteria

The sustained yield method ignores establishment costs and the cost of time. These two omissions work, however, in opposing directions. The higher the cost of establishment, the more advantageous does it become to postpone future expenditures; the way to do this is to defer the felling of the first crop. It pays to retain the present crop a little longer, till its value growth rate falls a little lower, to be made up by the postponement of the outlay on the next, and subsequent, rotations.

Ignoring the interest rate, on the other hand, reduces the cost of waiting. By adding the element of discounting, the rotation is shortened considerably. In marginalist terms, the crop is retained as long as the (relative) rate of increase in its value is higher than the interest rate plus the annualized equivalent rental for the site. If the interest rate is lower, the crop can be 'run down' longer, allowing the rate of value appreciation to fall lower. The compensating effect is that the annual rent then rises, so rotation cannot be increased all the way to the sustained yield optimum.

The effect of land rent is generally more pronounced at low interest rates, as the value of future crops still has an appreciable value. At high interest rates, there is much less difference between the NPV of the infinite series and the NDR of the first rotation. The value appreciation of the first crop itself can be taken as a fair approximation of the rate of return, to be compared with the discount rate. The effect of future crops is also more pronounced, the shorter is the rotation.

Gaffney (1964) gives examples of a number of American species to demonstrate the above phenomena. When the effect of future rotations is ignored, there is a considerable increase in the optimal rotation period when the interest rate is reduced from 5% to 2%. Adding the element of rent due to future rotations weakens this lengthening effect.

3.3.2 Optimal rotations and price variations

One of the arguments for sustained yield is that it safeguards the interests of future generations. Divested of philosophical overtones, this concern can be thought of as reduction of scarcity in the future. Rising prices are a sign of future scarcity. It is, therefore, interesting to see the effect on economic rotations of a rise in price.

A once-for-all increase in the relative price of the product increases the land rent, while it does not increase the rate of value appreciation of the crop as long as the price increase is neutral to the age of the crop. The period over which the crop can be maintained therefore becomes shorter, as the rate of growth in crop value is now compared with a reference rate that is higher. In the long run, therefore, the response of economically-motivated forestry firms would be to decrease rotations, and presumably the mean annual increment, when the relative price rises once and for all. Thus even this does not lend support to the above argument for longer rotations and deferred fellings.

A rise in output price is broadly equivalent to a fall in the relative cost of exploitation. The gradual improvement in communications has usually the effect of reducing costs of transport, while the spread of population often increases labour supply and brings consumption centres closer to the forest. Ultimately the pressures, both for forest products and for land, may become so strong that the forest is clear-felled and planted with fast-growing tree species, or with agricultural crops.

Variations on the theme include the possibility that the price per unit of output might rise with the age of the crop. This is expressed as the 'quality' appreciation in forestry. A crop, or a species, exhibiting this pattern of value growth can be kept longer on the ground, as its value growth falls a little less slowly. If the NPV becomes higher as a consequence, of course, this lengthening effect is moderated. The forester's urge to grow high quality large logs may be explained, if not entirely justified, by this consideration.

A continuous inflation in the relative price of forest products might encourage the firm to retain its crops longer. The precise magnitude of this effect is difficult to calculate, as the optimal rotation ages of successive rotations are different. Hyde (1980) simplifies the problem by neglecting the changes in rent, on the grounds that "the changes are small in terms of periods as long as timber rotations". In the case of a rate of inflation that is higher than the discount rate, the value growth rate may not fall below the discount rate until actual physical deterioration sets in. The stand may be kept much longer than under the static price assumption, approaching the sustained yield values.

3.3.3 <u>Supply behaviour on a hectare under economic criteria</u>

The supply behaviour of the economic firm depends on the marginal costs and returns. A once and for all price rise resulting in shorter rotations, at presumably lower mean annual increment (MAI) per hectare, would imply smaller annual outputs as long as the land base were constant. It yields an unusual backward bending supply curve associated with a fixed resource base. This may occasion criticism of blindly following the economic principle. Sustained yield foresters stress the long-term nature of forestry, and the contraction of annual supplies under a higher price seems to confirm their fears that economic criteria are short-sighted.

There are other factors at work, however, which might render this conclusion premature. A continuous rise in price is one example, as mentioned above, which might reduce current harvests, deferring them to the future. An expectation of future rise in output prices might act similarly to defer current harvesting.

The supply response to a price change depends partly on the expectations people form of future price movements (Roberts, 1974). The long time periods required for forest crops to mature confound the already confused response. In the short term, as rotations contract in response to a once-for-all price rise, existing crops may become suddenly over-mature, leading to a temporary surge in annual removals. Once the disinvestment is complete, there will be a long-term contraction in annual supplies in response to the rise in price. In the case of a continuous rise in price, the short term effect is to reduce harvests, and the long-term effect is indeterminate.

Such effects are equally unpalatable to the economist, as they would be counter-stabilizing. A price rise brings prospects of increased profits, and the neo-classical prediction would tend to be of an increase in supplies. To explain this anomaly in the economics of forestry, the assumption of a constant land base and constant silvicultural effort are abandoned, and all inputs considered variable.

3.3.4 Supply behaviour with variable inputs

If the silvicultural inputs are amenable to variation, "...a price increase induces expanded silvicultural effort, which reflects in expanded harvests for rotations of any length..." (Hyde, 1980). Hence "sustainable annual harvests ... are larger after the price increase. This effect counters the rotation reducing effect of a price increase. ...It is unclear which effect predominates, therefore the slope of the single acre supply curve remains in question."

The effect of a price increase might be favourable to an increase in future supply levels due to variation in another input, land. The increased rents possible under forest crops will attract some marginal acres out of alternative land uses into forestry (Price and Dale, 1982; Waggener, 1985). "Sustainable annual harvests increase by the share of harvests originating from the newly productive land" (Hyde, 1980). Some acres might have been marginal or extra-marginal for intensive forestry, "due to either low biological productivity or expensive access", hence not given much care. Such lands would become profitable for more intensive forestry. "As harvests from both of these land classes are added, long-run annual harvests expand" (Hyde, 1980).

3.4 <u>Consumption, conservation and distribution</u>

3.4.1 <u>Possible basis for reconsidering the economic model</u>

Though the basic economic model had been worked out by Faustmann as early as 1849, forestry has generally been more comfortable with physical yield criteria (Price, 1976, p.99; Waggener, 1969; Clawson, 1985, p.173). Indeed, the concepts of sustained yield forestry themselves developed at about the same time. Their origin has been traced to the 18th century (Waggener, 1969), or more usually to the conditions in mid-19th century Germany (Hyde, 1980), when the economy was stable, closed to external influences, and undeveloped in transport and market structures. "Small, self-sufficient political and economic units were the rule" (Hyde, 1980). A bulky commodity like wood, especially fuelwood, needed to be found fairly close to the consumption centre. Collective action was necessary to prevent exhaustion of the common timber resource (Leslie, 1967). This favoured the "Dauerwald", the permanent forest, which found favour in other environments, including that of colonial India.

From these considerations to those of economic forestry, there seems to be a deep gulf. It is these concerns, however, that have been enlisted in the critique of the economic model. They are discussed below under three heads: externalities; inter-temporal distribution among the generations; and intra-temporal distribution among contemporaries.

3.4.2 <u>Ecological externalities and sustained yield</u>

The economic model is basically about market transactions. Usually, however, there are a number of products or services that flow from a given activity, which are not the object of market transactions. They do, however, cause changes in the welfare of individuals outside the economic firm. Such effects are termed externalities. The complaint against the market mechanism is that it does not take account of these effects (cf. Roberts, 1974).

Some effects are better termed market imperfections, or market failures, than external effects. The neo-classical model assumes perfect knowledge, perfect mobility, perfect competition, and consistent behaviour among all economic agents. Such a situation never obtains in the real world. In practice, therefore, there is often a consensus that society should exercise due caution in undertaking courses of action that might conceivably cause gross changes in welfare levels (Roberts, 1974).

Positive externalities have often been advanced as a prominent part of the benefits of sustained yield forestry, in contrast to economic forestry. Samuelson (1974), for one, is sympathetic to the claim of externalities on collective social, or public, intervention:

> "...there is no ironclad presumption that profit seeking laissez-faire will lead to the social optimum. ...Indeed, if the externalities involved could be shown to be sufficiently important, I am naive enough to believe that all economists would be found on the side of the angels, sitting thigh next to thigh with the foresters." (Samuelson, 1974).

The problem, then, reduces to one of describing the technological functions that produce these external effects.

The ecological role of forests is one of these positive externalities. Maintenance of pure drinking water sources, control of soil erosion and prevention of landslips, amelioration of harsh climatic conditions, have all been seen as more important than maximization of NPV. Perhaps the most serious criticism of the economic criterion is induced by its neglect of these valuable contributions of sustained resource use.

However, even if externalities were included, the economic criterion need not favour sustained yield management. Price (1976) cautions that a similar level of positive externalities may equally well be associated with other options; a <u>special</u> case for long-rotation forestry is not automatically merited. In some respects, the <u>negative</u> externalities of unbridled private enterprise may be a more convincing argument for public intervention, e.g. the probability of extinction of a renewable resource (Johansson and Löfgren, 1985).

It is further not always true that ecological benefits are restricted to older or larger sized crops alone. Young crops may well provide as much protection as old against soil erosion etc., while generally presenting a more hospitable environment to wildlife (the 'edge' effect, need for openings for behavioural reasons and for forage and fodder). Secondly, if ecological benefits were to be quantified and put on the returns side of the balance-sheet, it would probably increase the opportunity cost of postponing future crops, again to the advantage of shorter rotations (Johansson and Löfgren, 1985). Against this, if ecological effects do not decrease with crop age, there would be no rotation-contracting effect (Price, 1987).

The problem of marginal adjustments in resource use are not likely to be affected overmuch by the ecological argument. If it is the rate of conversion of old growth forest that is the bone of contention, even a doubling of the annual cut would still not devastate the forest. If sustained yield forestry can countenance a certain rate of conversion, there does not seem to be a major objection to duplicating this on an equal number of additional acres each year (cf. Downs, 1974).

Indeed, this very aspect has been used to beat sustained yield with its own stick. Forestry itself, the argument goes, is often inimical to maintaining the ecological balance. By restricting forestry to sites on which it can be pursued economically, additional acres will be released for wilderness, wildlife, recreation, and conservation in general. The economic principle, according to this view, would then be actually helpful in identifying such acres, and in other cases in putting an economic value on conservational use to help decision makers weigh the sacrifice of timber revenues (Hyde, 1980).

3.4.3 Inter-temporal equity and sustained yield

The effect of applying economic criteria would depend on the type of response elicited by economic forces. It is easy to argue from the position that economic forces will act to optimize welfare, to throw the onus of disproving this on the opponents of economic criteria (e.g. Stiglitz, 1979). The externalities argument shows, however, that even economists recognize that real markets will not account for all costs and benefits. The sustained yield forester can find support in the popular concern about exploitative resource use by private enterprise. Though forestry itself might often be the butt of criticism, there is a general feeling that purely economic criteria miss an essential part of the problem.

This is, fundamentally, a concern of present citizens about the future of the nation, and by extension of the world community. The consistent application of economic criteria might lead to a high rate of liquidation of existing stock of, among others, environmental resources. In forestry, it is not so much a choice between long rotations and medium or short rotations. It is, in fact, between forestry and 'cut-and-run' timber mining.

A responsible use of environmental resources requires them to be worked under a continuously productive system. A "wise forest policy for the long pull" requires "adequate research and careful monitoring of the results of every program", especially if undertaken on any large scale (Clawson and Sedjo, 1982). In case it is not possible to work them under fairly intensive management systems due to lack of demand or information, then they should be placed under 'custodial' ownership for the whole of society. This is the alternative proposed by economists like Hyde (1980) when assessing the trade-off between forestry and (wilderness) recreation.

Economic criteria, however, would force a choice, not between two such long-term systems, but between the short and the long term. In practice, there will always be the "hollow frontier" beyond which forests are pushed back, as marginal acres carrying remnant timber are yet uneconomical for silvicultural inputs, but eminently suited to timber mining. Inter-temporal externalities will be inevitably pulled into the cost benefit calculus.

The motivating force behind forestry has been to sustain the supply of a variety of desired goods and services (Kimmins, 1974). The short-run increase in harvests under economic criteria is in effect a way of hastening the liquidation of accumulated capital. The immediate benefit is appreciable (Olson, 1977), but the 'user' costs of reduced supplies (Nautiyal, 1966) are shifted on to future generations.

In economic terms, this sort of concern does not have much meaning. To the present decision-maker, future losses loom small, "...because the losses occur at such distant future dates that the effect of discounting is decisive" (Olson, 1977). Market forces act to clear the market demand, and there cannot be more than a temporary, short-term 'gap' between supply and demand (Haley, 1968). If increase in supply is difficult to arrange at short notice, as the forester points out, then price will rise, forcing consumers to economize on wood or shift to other materials.

Similarly, technical progress has belied the prophets of the Malthusian doom in the past, a ground for optimism about the future (Barnett and Morse, 1963). For the economic point of view, if the people want wood, or conservation, they must be prepared to pay for it, or go without. They cannot expect society to subsidize their luxuries. Government intervention has in any case been the cause of inefficiency in the allocation of resources than anything else (Stiglitz, 1979).

Against this fiat, sensible people realize that market relations are not always as free, fully informed, and perfect as in the neo-classical model. If costs are pushed on to the future, just because market agents discount future values, society may, by consensus, set up legal and institutional systems to compensate for private short-sightedness. The legislation regarding land ownership and use is sometimes obstructive, but the underlying philosophy is that land, and other productive and protective powers of the environment, are to be held in custodial care, private property rights notwithstanding. Economic motivation need not lead to this result, making social regulation desirable (Clark, 1973; Roberts, 1974; Webster and Gordon, 1975; Price, 1976; Johansson and Löfgren, 1985).

If it is desirable to give extra-market weightage to long-term undertakings, this would justify using discount rates for forestry closer to the long-run rates of return to private capital, that are lower than the short-term rates (Row et al. 1981). Foster (1979) suggests multiple discount rates, the low rates for long-term undertakings, to take into account the durability of different investments. Presumably this will be to the advantage of sustained yield forestry.

The "true source of forest wealth resides in the forest ecosystem" (Thirgood and Haddock, 1968), and this requires that economic analysis "be tempered by reason". Extending this argument, life itself depends on a unique combination of material and environmental inputs. Substitution in the neo-classical model is restricted to a certain class of problems, to do with optimal allocation of resources. Even in this restricted sphere, the technological substitution of wood has its limitations (Price, 1976). But economics does not address the "ultimate ends" and the "ultimate means" with which to satisfy them (Daly,1979; Georgescu-Roegen, 1979). The solutions of neo-classical economics, therefore, cannot be taken to extremes that will undermine the continued existence of life.

Conservation economists have accordingly recognized that every society needs to maintain a certain "safe minimum level" of conservation (Ciriacy-Wantrup, 1968), which entails postponement of current consumption in favour of future. Until management methods are developed which will enable some forests, that are not regenerable under current knowledge, to be worked as renewable resources, these lands should be <u>reserved</u> "until appropriate methods and technologies are physically available and economically realisable (Kimmins, 1974). It is here that government intervention may be a means of assuring a certain flexibility in future decisions (Rothenberg, 1967). Nash (1973, p.617) goes so far as to say that in the case of large-scale projects the future consequences of which are practically irreversible, "the standard economic approach to public decision taking is simply unworkable."

3.4.4 Inter-personal equity, community stability, and sustained yield

A prominent externality claimed on behalf of sustained yield - even flow forestry is the maintenance of community stability. Economists advance similar counter-arguments as in the ecological context (Haley, 1966; Waggener, 1969; Downs,1974; Josephson, 1976): community stability may be maintained as well by a more economical use of resources; inevitably, progress in technology will alter the demand for certain professions and products, so some workers and communities will inevitably face retrenchment; retraining and relocation would be a better way to help such backwoods communities, and increase national product at the same time.

Against stability of individual communities, economists would put the great benefits to consumers at large of faster conversion of old growth forests (Waggener, 1969). The high prices maintained by restricted cuts under the sustained yield regime enable private owners of timber crops to make high profits. Accelerated conversion would bring down prices, leading to gains in consumer surplus, cheaper material for housing and industry, more investment and jobs, and so on (Downs, 1974).

In fact, keeping the annual supply of timber fixed to the allowable cut, when market demand is changing, causes timber values to fluctuate more widely, resulting in less stability (Pearse, 1967; Smith, 1969). A price stabilization policy may, on the contrary, achieve a net increase in welfare through gains in consumer surplus dominating any losses in producer surplus (Adams, Haynes and Darr, 1977). All this argues against the rigid sustained yield model of conversion and exploitation.

If there were no big reserves of 'god-given' forest, of course, the above considerations would not be very relevant. Now the question would only be of increasing investment in plantation crops. Public forestry might carry on with long rotations, but would neither attract much investment, nor add many forest products to the economy. Private stocks of timber would be managed on commercial lines, however, and probably fill the gap in the market in any case.

For a dualistic society with large sections of the population living under minimum subsistence levels of consumption, additional considerations of distribution come up. Indeed, negative externalities in general are likely to fall most heavily on the poor, for they exercise little economic power, and hence cannot force the market to recognize the costs incident on them. Positive externalities, however, are easily denied to them, or a price extracted. The better-off also exercise enough economic power to force some compensation out of the system for any costs they may have to bear.

Unfortunately for the long-term view, the costs of custodial preservation of ecological resources may fall heavily on the poor, as sacrifices in consumption are avoided by the affluent. Sustained yield forestry may also have this effect, if large capital resources are locked up in growing stock. The maximization of the stream of physical products, however, might conceivably be of benefit to the poor, provided the products include a sufficiently large proportion of basic needs goods and services that the poor would not be able to obtain from other sources.

If, on the other hand, the production systems of sustained yield, or any other, forestry, are heavily geared to luxury products, the poor are hit from two directions. Firstly, the forest resource no longer contributes to local subsistence consumption. On top of this, wage employment is reduced, as the products leave the local economy for processing and fabrication in the modern sector (Richards and McAlpin, 1983, p.93, illustrate this with the fate of the Bhil tribals in the Deccan). Sustained yield forestry, therefore, could conceivably play as damaging a role in the subsistence sector as commercial forestry. Commercial forestry, however, may well be the worse, as it also values the costs and benefits of economically weaker sections in proportion to their willingness to pay. This is bound to be negligible, reflecting their low ability to pay.

The weakness in forest policy and management practices followed under the revenue earning colonial administration, and the development oriented period in independent India, has been to ignore the existence of such distributive effects. Beyond statements of intent, both sustained yield forestry and economic forestry ultimately satisfy the demands of the modern organized sector. The eighty percent of the population in rural India are admitted on sufferance, but are not welcome in the forest. The forester waits for the day the local people will realize that they are partners in forestry (National Forest Policy, 1952), but in the meantime the people know that they have to grab what part of the spoils they can, as proprietary rights of local communities are gradually withdrawn in the greater 'national' interest (the familiar problem of the commons, Hardin, 1968, 1979; Clark, 1973; Stiglitz, 1979).

There is therefore a need to incorporate explicitly the distributive aspect in the economic analysis of forestry: the question of who pays, and who gains, must be considered (Clawson and Sedjo, 1982). This may not be entirely to the advantage of sustained yield forestry as such, but it will throw light on how the latter could be modified to maximize social welfare in the presence of externalities and market imperfections.

Both inter-temporal and intra-temporal distribution of consumption have to be incorporated into such an analysis. When the whole of society itself is the economic entity, the social discount rate need not necessarily be the same as that of the individual (Price and Nair, 1985). The relative valuation of benefits and costs falling on the poor and the rich needs to be reassessed; if the present distribution of income is not acceptable, the needs of the poor might well be accorded more importance than their economic power dictates.

As the framework of such an analysis, the economic model is retained as it can still be stretched to consider many different types of costs and benefits. The difference would be the acceptance of the principle that ability to pay will not necessarily be a measure of <u>social</u> value. It is not necessary that all sustained yield practices will stand exonerated, or condemned. These aspects are taken up in the following chapters.

CHAPTER FOUR

ECONOMIC COST BENEFIT ANALYSIS

The main consideration in moving from the neo-classical model of the market, to economic cost benefit analysis, is that market prices may not reflect the real resource cost of undertaking any particular activity. The reasons are to do partly with imperfections in the market, and partly with externalities.

4.1 Market imperfections in economic cost benefit analysis

Social welfare is optimized in the neo-classical framework if there are no impediments to the working of the free market system. Imperfections and distortions in the market change equilibrium prices, which no longer signal the true resource costs in the economy. Thus imperfections widen the gap between the social and private optimum. It makes it less likely that private decisions will achieve a social optimum.

4.1.1 The source of market imperfections

Imperfections due to fiscal and monetary policies or other administrative decisions of the government are common. Direct and indirect taxes, excise and customs duties, price and quantity controls, and other instruments are used by governments, to stimulate or channel investment or production into certain industries or sectors; to control inflation; conserve foreign exchange; and so on. Though they may be seen at the moment as specific responses to specific phenomena, they may reflect a consensus among the leadership regarding an underlying philosophy, or model, of growth and development.

Market imperfections in the narrower sense are those due to monopolistic conditions in factor or product markets of some commodities. Such effects may be common in underdeveloped economies, especially in the modern manufacturing industries and agro-industries sectors. A few business houses are able to exercise some control on the market price of inputs or outputs, often due to the policy of protection in the colonial era. It is perhaps less common in the agricultural crops, as production is essentially through uncounted numbers of essentially independent small peasants and land-owners.

4.1.2 The response to imperfections in economic cost benefit analysis

Different approaches have been made in modern cost benefit analysis to the question of optimal decisions under market distortions. Little and Mirrlees (1974) contend that since domestic prices are in general so distorted, domestic consumption patterns are not a good basis for resource allocation decisions. The true opportunity costs of changing the consumption or production of given goods and services are given by the set of world market prices facing the country. Thus, the net value of alternative activities is best measured in terms of border values.

The Little-Mirrlees (LM) approach to the problem of distortions is to draw up a complete set of 'accounting prices' to parallel the domestic market prices. These are analogous to 'shadow prices', each of which reflects the effect on the value of the 'objective function' of varying a given constraint by a marginal unit. As put by Squire and van der Tak (1975), the shadow price is the value of the contribution to the country's basic socio-economic objectives made by any marginal change in the availability of commodities or factors of production. These shadow prices should be used in framing sector strategies and identifying promising project possibilities and designing their major features.

4.1.3 Efficiency prices, trade, and market imperfections

Thus one way of circumventing market imperfections would be to evaluate all uses for resources at border , i.e. international, prices. These are termed 'efficiency' prices, as they reflect the true resource costs, as opposed to the distorted domestic market prices.

World prices, however, are themselves not determined in free markets. The question arises how national planners should react to imperfections and barriers in trade. Little and Mirrlees (1974) feel that all that should matter to the national economy, is where its best advantage lies. This is measured by the marginal cost of import or marginal revenue from export; whether these prices have been determined in competitive markets is not so important.

By separating the production and consumption decisions, a country can attain a higher level of welfare by allocating productive resources according to world prices, then resorting to trade to bring relative consumption into consonance with domestic preferences. The 'efficiency pricing' argument "has its rationale in the neo-classical doctrine of comparative advantage" (Irvin, 1978); this is to nations what the 'Fisher separation' principle (Fisher, 1930) implies for individuals in choosing between consumption and investment.

Some authors see this as less than binding. According to Irvin (1978, p.68), "it does not follow that to use the methodology is to espouse free trade". The reasons are, firstly, the "well known provisos covering infant industries and other externalities"; and secondly, that "a country will plan its production pattern in a manner most efficient in the light of planned trade policies, it being feasible to weigh up the gains and losses resulting from alternative trade patterns (including pure autarky) accordingly" (Irvin, 1978, p.68).

It appears that use of efficiency prices was urged in the LM approach as a moral pressure to move the economy in the direction of less protection, more openness to world currents. The aim would be to gradually make the use of existing resources more efficient. For example, if imports would be cheaper, the government ought not to insist obstinately on domestic production. If the government were highly powerful, it could compel the private sector to apply the same efficiency prices, even though existing market prices were distorted (recalling the 'command' economy of Lerner, 1946).

However, such possibilities are remote in practice. So some scholars have come to the conclusion that shadow prices will depend on the fundamental objectives, socio-economic goals, and economic environment, which will be determined by physical constraints on resources and by various constraints that limit governments' control over economic development. Hence distortions may exist, and persist; shadow prices will not be the equilibrium prices that would prevail in a distortion-free economy, but a "second-best" set (Squire and van der Tak, 1975, p.26) that will move the economy toward only a 'second best' sub-optimum (Layard, 1972).

4.2 Externalities in economic cost benefit analysis

4.2.1 The nature of externalities

'Goods' or 'bads' for which there are no markets turn out to be externalities (McKean, 1968). For the individual economic agent, external effects, being incident on others, cause no change in private utility. Financial criteria usually do not take them into account, as they are not subject to the normal market exchange mechanism.

For society as a whole, however, such effects are no longer 'external'. They have to be included in the cost benefit calculus if social welfare is to be optimized. Even in the neo-classical system in which money is the only yardstick, a competitive economy will no longer attain a Pareto optimum when externalities exist (Just et al., 1982).

The reasons why the market fails to put a price on external effects may be many (Musgrave, 1959, 1969). The external effects or the commodities which represent them may not be appropriable. It may be impossible to exclude non-buyers from enjoying certain external benefits, or to compensate all sufferers of external costs, for technological or administrative reasons (the 'exclusion' principle). This is usually the case when there are numerous potential beneficiaries or sufferers (Arrow, 1970).

4.2.2 The response to externalities in economic cost benefit analysis

In the case of production decisions, the social optimum is attained when the marginal social cost (of expanding the level of activity in a given sector or industry) is equal to the output price. If there are external costs, like pollution, then the marginal social cost is higher than the marginal private cost; the above principle will then limit production to a lower level than under the working of the purely private marginal condition. This entails the internalization of external costs and benefits, to achieve the joint optimization of more than one economic agent (Just et al., 1982).

To bring about such a readjustment of private decisions, some form of state intervention is required. This may be a 'Pigovian' tax (Pigou, 1952; Just et al., 1982); an administrative quota on production; a legal requirement that the firm should set right the social damage it causes (e.g., pollution abatement); or a modification of the legal-institutional structure so as to give the polluter the right to pollute (the 'permissive' solution) or the pollutee the right to be free from pollution (the 'prohibitive'). This grant of entitlements may enable Pareto optimality to be attained if the agents are allowed to enter into market transactions (Coase, 1960).

When more than one externality exists, however, a measure intended to set right one might distort the other further. This may drive the economy further from the point of social optimality than if the distortions were allowed to (partially) offset each other (Just et al., 1982). This is an illustration of the problem of the second best (Lipsey and Lancaster, 1956-57).

Externalities which affect the production possibilities of others, or the satisfactions that consumers can get from given resources (Prest and Turvey, 1965), are termed 'technological' effects. For example, erosion caused by clearing uphill vegetation may ruin farmland in the valley. The other type of externalities are 'pecuniary' spillovers, that affect the prices of products and factors facing the producer or consumer.

Economists recommend different treatment under cost benefit analysis for the two categories of externalities. There seems to be a broad consensus that technological externalities can be considered with justification, but purely pecuniary effects should not be compensated for due to the element of double counting (Prest and Turvey, 1965). The latter are in the nature of transfer payments, and do not represent a change in the 'real' social product or welfare. In this view,

> "... we have to eliminate the purely transfer or distributional items from a cost-benefit evaluation: we are concerned with the value of the increment of output arising from a given investment and not with the increment in value of existing assets. In still other words, we measure costs and benefits on the assumption of a given set of prices, and the incidental and consequential price changes of goods and factors should be ignored" (Prest and Turvey, 1965).

This fiat appears to stem from the principle that changes in aggregate welfare flowing from an initial change in one market, can be captured in just the one market, if competitive adjustments take place in all other markets affected (Just et al., 1982). The final welfare change in the primary market is supposed to already take into account welfare changes in the related markets. This disposal of the problem may be objected to if distributive effects were themselves an object of social concern.

The Little-Mirrlees (LM) view appears to be that externalities are generally over-emphasized just to make a case for otherwise socially uneconomic projects. Giving a positive bias toward some sectors or projects on the plea of externalities "seems hard to justify"; firms could as well enter into mutual contracts to capture the benefits of forward and backward linkages. The LM methodology, it is claimed, does take into account immediate externalities. Some, like project-specific environmental effects, can be accommodated in individual cases; but no general factors which account for divergences between social and market prices have, it is claimed, been neglected in the LM method (Scott, MacArthur and Newbery, 1976).

4.2.3 Cost benefit analysis and the problem of the second-best

The last consideration is, however, a question of fact. Once again, we meet the repeated question of economic analysis in the presence of imperfections: is an optimizing decision to be taken as if the rest of the economy were free of such effects, or whether those imperfections should be taken as a fact, a part of the data?

Little and Mirrlees (1974) appear to be saying that projects should be analysed essentially on the basis that other decisions will be taken on efficiency grounds. Sen (1972), while broadly agreeing with the efficiency objective, qualifies this approach on the grounds that it may perpetuate projects which will in fact have a heavy cost. For instance, governments cannot be expected to overcome the existing pressures for maintaining protection to domestic industry, agriculture, etc., even if the economist points out their inefficiency.

Some authors, however, feel that it may be worthwhile to make estimates of people's willingness to pay (wtp) to alleviate some negative externality (e.g., noise pollution) (McKean, 1968, in Chase, 1968), provided the cost of collecting the additional information was likely to be justified by the additional social benefits possible. However, the wtp criterion is difficult to judge in the case of externalities, not the least because they will be coloured by people's perceptions of the probability of it being tested in practice. This is summed up as the problem of the "free rider" (Sinden and Worrell, 1979, p.410).

4.2.4 Externalities and the compensation principle

In the framework of neo-classical welfare economics, there is no preference of one distribution of incomes over another. The optima sought by such a framework are, in other words, Pareto-optimal states. The existing income distribution is accepted as given, and the social choices follow as an aggregation of private choices under this given distribution.

Under such assumptions, welfare economists suggest the 'compensation principle' in one form or other (Kaldor, 1939; Hicks, 1943). For optimizing social welfare, a proposed course of action should be potentially capable of paying this compensation in principle; an actual transfer is not compulsory (Just et al., 1982).

A potential conflict in this situation is that depending on whether the 'before' or 'after' set of private utility levels is considered the original, the losers might be in a position to reimburse the potential gainers, or the gainers might be able to compensate the losers. This is the 'reversal paradox' of welfare economics (Scitovsky, 1941). Unless the reversal test is passed in addition to the potential compensation test, one cannot really say that one state is even potentially preferable to another (Just et al., 1982).

4.3 The methodology of economic cost benefit analysis

The actual methodology of SCBA, exemplified by the system of Little and Mirrlees (1974), and some parallel ones like that of UNIDO (1972), derives much from further exposition and practical application by many workers, among them Squire and van der Tak (1975), Bruce (1976), Little and Scott (1976), Scott, MacArthur and Newbery (1976), and Lal (1980). The methodology is referred to as the LM-ST in the following. We consider the economic analysis, deferring distributional considerations to the next chapter.

The underlying principle is that any proposed use for the nation's resources should be assessed at the real opportunity costs involved. Prevailing market prices are not always, or even usually, a good guide to these. The relative performance of each of several alternative projects or policies is evaluated by using the economic values of various parameters, rather than the observed market values. This will ensure consistency among different analysts and analyses, so that the best use can be made of the economy's resources, moving it closer toward the chosen objective.

4.3.1 The concept of the numeraire

Of the global parameters to be specified, one of the basic ones is the unit of account, or numeraire, in which to measure economic value. The LM-ST numeraire is identified as the unit of "uncommitted social income, measured in terms of convertible foreign exchange" (Little and Mirrlees, 1974, p.145; Squire and van der Tak, 1975, p.135). Lal (1980) modifies this to "savings expressed in foreign exchange", thereby differentiating between savings and income, but treating private and 'social' (government, or public) sectors at par.

This is an especially convenient unit of account in economies in which a number of commodities are traded in international markets, as the border prices (or, to be precise, the marginal cost or return per unit) of the representative commodities represent the 'true' cost to the economy of a marginal increase in imports or the return from a marginal increase in export. Other systems, however, utilize alternative measures of value. The UNIDO methodology, for instance, uses aggregate consumption in the domestic economy rather than free foreign exchange as numeraire.

One of the ambiguities in this treatment is whether foreign exchange is the objective to be maximized, or merely a convenient unit of measure that can bring various effects onto a common scale of values. For a small population satisfying most of its requirements through trade, this might not be a serious distinction. It is difficult, however, to apply this concept directly to the Indian economy. Here, the domestic demand is huge, and met primarily from domestic production. Trade forms but a small part of the maintenance consumption. True, the dynamic effects of trade may make it more valuable than the mere exchange value of the commodities; but as discussed above, even this is a hotly debated issue.

It is preferable, on the whole, to interpret the LM-ST numeraire as a unit of account rather than an objective to be maximized. That is, the net value of product is measured at efficiency prices, in terms of the numeraire, which can be called 'border' rupees, <u>or</u> the equivalent foreign currency. This need not be taken as implying that it is only dollars or pounds that have efficiency value. The net gains of economic activity could as well be measured in rupees, and the value could be generated, not by international, but by domestic demand and supply forces acting within the domestic economy. It is only the measure of value that links this domestic activity to its foreign exchange value.

Under this formulation, it becomes necessary to know the value at efficiency prices of each priced commodity within the domestic economy. In general, we need some overall measure to relate value in domestic rupees to value in foreign exchange (border Rs or equivalent dollars at the official exchange rate). This is provided by the concept of conversion factors.

4.3.2 <u>Expressing market values in terms of the numeraire</u>

A dollar of foreign currency may be able to purchase Rs 15 of domestic currency, at the 'official exchange rate' (OER). Because of tariffs, taxes, etc., however, $ 1 worth of goods at the 'border', i.e. the 'cif' (cost, insurance and freight) value of imports, for instance, or the 'fob' (free on board) value of exports, come to cost, say, Rs 20 in the domestic market. As a measure of value, therefore, Rs 20 in the domestic economy, where goods are valued at domestic prices, have a purchasing power of only Rs 15 worth (at the OER) of foreign exchange at the border.

This is the source of the divergence between 'domestic' and 'border' rupees, and of that between the UNIDO and LM-ST numeraires.

As a starting point to eliminate the effect of taxes and subsidies on traded goods, it is suggested that a **standard conversion factor**, or SCF, be calculated for all traded goods. This would be the ratio of their aggregate value at 'border' prices (cif for imports, fob for exports), to their domestic price. Extending the concept, we could calculate SCFs separately for imports and for exports; and for different groups like consumer goods, consumer durables, producer goods, intermediates or capital goods, etc.

The SCF of all traded commodities is denoted a. It serves as a very broad estimate of the value of domestic rupees relative to border rupees, and hence leads to an estimate of the real, or 'shadow' exchange rate, SER. The taxes and tariffs accrue to the government, and it is assumed that they are not a real cost to the economy, though they are costs to the private consumer. In equation form,

$$a = [M + X]/[(M+T_m) + (X-T_x)] ,$$

where M and X are value of imports and exports respectively at border prices. In the denominator, the market value in domestic Rs is derived by adding the tariffs and taxes on imports, and subtracting the net taxes on exports. The SCF, a, is also the ratio of OER and SER. For instance, if imports cost twice as much in domestic rupees as they ought to on the official exchange rate, this means that domestic rupees are only half as valuable in relation to dollars as the OER would have us believe. Since SER and OER refer to the cost of foreign exchange, the real cost (in domestic market rupees) of dollars, or the SER, is twice the official cost, the OER;

$$SER = OER / a \text{ ; or,}$$
$$a = OER / SER .$$

It may be remarked, here, that the literature of CBA appears to take for granted that 'real' cost can only be expressed in terms of border

Rs. However, for reasons discussed above, the real cost could as well be expressed in domestic market rupees, provided it is always made clear which unit of account is being used in a particular instance.

4.3.3 **Efficiency pricing: Traded Commodities (TCs)**

Fully traded commodities (TCs) are those commodities that will be actually imported or exported at the margin as a result of the project under analysis (or generally, in response to the policy measure in question). Commodities which are produced and consumed within the domestic economy are called non-traded commodities (NTCs), or partially traded commodities (PTCs) if they are partially traded, and partially consumed or produced in the domestic economy.

The efficiency pricing of TCs is fairly straightforward. The principal source of divergence between domestic and efficiency prices is the distortions introduced by controls, taxes etc. Instead of computing the 'real' value by correcting for the effect of all such imperfections in the case of each observed market price, the LM methodology adopts the expedient of calculating the accounting ratios ('ARs') of the border prices to the average domestic market prices.

It is assumed, on the basis of past experience, that these 'accounting ratios' are fairly stable. They can be applied to the bulk of the commodities figuring in the transactions of the project, except for the few items that are so important in terms of value that they merit a fresh estimation of their economic value (at efficiency prices).

Two clarifications are in order. Firstly, it is not just the border price of the particular commodity, but the marginal cost of import that is the real cost. If the supply conditions are not perfectly elastic, the additional demand posed by the project may push up the traded price, not just on the marginal unit, but on all the units being imported. On analogy, the value of a commodity produced for export would be the marginal revenue, which would have to account for any fall in aggregate returns due to a fall in world price.

The second point is that one has to <u>predict</u> the response in the economy to the setting up of the project (or, generally, to a certain policy measure). The basic question, according to Little and Mirrlees (1974, Ch. 12), is how much foreign exchange could be saved (or earned) by producing this good. It may increase exports; replace imports; reduce imports of other goods if expenditure is diverted to this home-made good; and so on. There is, in other words, no <u>self-evident</u> formula to tell us the marginal cost or benefit of such-and-such a good.

In practice, it will usually be reasonable to assume that the demand or production of an individual project will not affect the border prices to any significant extent. If the border elasticities of demand and supply are known, however, such effects can be taken into account using, the full formula given by Squire and van der Tak (1975, p.144).

4.3.4 Efficiency pricing: Non-traded Commodities (NTCs)

Non-traded commodities (NTCs) are those that are not imported or exported at the margin (Lal, 1980). Market price will be set by domestic demand and supply. An increase in domestic demand will normally be met by increase in domestic supply.

For any NTC that is required as an input in the project, the recommended procedure is to make an analysis of all the inputs required to produce the marginal unit of the commodity, and value these at their accounting prices. Since some of the factor inputs may themselves be NTCs, this may require further rounds of such decomposition, until, theoretically, we should end up with only two categories, Traded and Non-traded. In the forestry context, for instance, the most important 'primary' non-traded factor inputs expected to remain after these successive rounds of decomposition are the services of land and labour.

One difficulty with this procedure is that of specifying the optimal input combinations for each factor used in producing the marginal unit of the NTC. The analyst also has to make specific assumptions on how the surrounding economy will respond to the demand and supply effects introduced by the project.

A related difficulty is that an increase in project demand for a NTC may, instead of eliciting an increase in domestic production, draw off the factor units from other sectors or uses. The opportunity cost of the resource now depends on the net benefit derived from the marginal unit in the alternative use. Once again, the familiar problem of the second best will have to be met: whether the opportunity cost of an inefficiently utilized resource is its actual marginal product, or the hypothetical optimal marginal product.

Similar considerations operate on the supply side. A project output of a NTC may increase domestic consumption, leading to a net benefit which could be measured by willingness to pay or change in consumer surplus (Little and Mirrlees, 1974, Ch. 10). On the other hand, it may lead mainly to the diversion of consumption from some other commodity, which may be as well a TC. In this case we come to the grey area between the TCs and the NTCs, termed variously Partially Traded or Potentially Traded commodities (PTCs).

In practice, such detailed analysis may be made only for a few major NTCs, and one or more SCFs used for the rest (Little and Mirrlees, 1974). Alternatively, economy-wide accounting ratios calculated on the basis of input-output tables could be used for a few dozen commodity groups (Lal, 1980), thereby answering the question of what production function we care to assume.

4.3.5 Efficiency pricing: Partially Traded Commodities (PTCs)

Many goods will not be distinctly classifiable under either the TCs or the NTCs. Changes in domestic demand or supply may be met partly by changes in domestic production, partly by shifts in domestic consumption, partly by changes in imports or exports. Such goods are termed Partially Traded Commodities (Lal, 1980). Irvin (1978) uses the term Potentially Traded Goods (PTG) to mean those which do not enter into trade at the margin because of present policies, in contrast to Non-Tradables, which by their very nature cannot enter trade.

In the case of a PTC, some prediction will have to be made whether the marginal unit figuring in the project will affect trade or domestic production/consumption, directly or indirectly; or if both, to what proportion. The traded part is treated as a TC, the domestic part as a NTC, and the two effects aggregated to estimate the overall marginal cost or benefit. For changes in domestic consumption, it is the cost at social prices of providing the other goods and services to which consumers will switch their expenditure. The average basket of commodities consumed can be used to derive standard conversion factors (SCFs) for valuing consumption changes (Lal, 1980).

For the Potentially Traded Good, Irvin (1978) suggests that their valuation "depends on the view taken about the likelihood of present restrictive policies continuing to hold in future". If the restrictions are expected to be removed, the PTG will be treated like fully traded goods. If not, it will be treated like the non-traded goods, i.e. decomposed into its marginal domestic cost elements, the traded and non-traded components of which can be multiplied by their respective ARs (Irvin, 1978).

This brings us to the valuation of the final non-traded (and, intrinsically, non-tradable) resources left after all the rounds of decomposition. Most important for cost benefit analysis are the primary factors of production, which cannot be transported across national boundaries for various reasons.

4.4. Efficiency pricing of residual non-tradables

4.4.1 Efficiency pricing of primary factors

The question remains of how to value the primary factors like the services of land and labour. The procedure recommended is to estimate the forgone marginal product of the particular land and particular labour used in the project, which may require a comparison of something akin to 'with-and-without project' scenarios. Thus these will be project-specific values, given the fragmented nature of the domestic market for such relatively immobile commodities.

A certain circularity is involved here, since some of the commodities involved in the marginal product of the primary factor may themselves be NTCs. This may require the analyst to start the procedure with arbitrary estimates of certain ARs, based on experience with other economies or on the most likely value around which the ARs are expected to cluster. A process of iteration may be required to remove any significant bias imposed by the choice of such initial values.

Specific assumptions may also have to be made to link the project with transactions in the wider economy, ultimately tracing them through to international trade transactions. Sometimes the assumption is made that there will be no appreciable change in the composition of the total product derived from the factor in question. Then the marginal product will be similar in composition to the average product.

For example, it may be assumed that the marginal product of agricultural land (or agricultural labour) is made up of various commodities in the same ratio as the average annual product of the state or country, per hectare of agricultural land (or per agricultural worker). The value of the marginal product is assumed to be well represented by the social value, at accounting prices, of the average agricultural product per hectare of land (or labourer). A summary SCF can be worked out for the composite commodity, and it will be this SCF that will be used to value agricultural land (or labour) inputs in other projects.

The inclusion of a wide variety of items is expected to minimize any bias introduced by using summary SCFs for groups of commodities. In the absence of detailed information on the marginal shifts and adjustments in consumption and production, it is left to the analyst to make plausible predictions of the market effects and the social costs and benefits involved. In a social cost benefit analysis, he would also have to make predictions on the sections of the population on which they will be incident.

4.4.2 Efficiency pricing of land

Little and Mirrlees (1974) suggest that where there is a market in land, the opportunity cost (in domestic rupees) would be well measured by the amount that other producers would have been willing to pay for it. The market price would reflect purchasers' assessment of net returns (Irvin, 1978), but market price would not always be a good measure of net social benefits. To convert this into efficiency values, it would have to be multiplied by a conversion factor related to the inputs and outputs of the alternative producers. Normally, however, a SCF would be adequate. Where no very good market in land exists, the present value of alternative uses may have to be found, using economic accounting prices (APs) of inputs and outputs, to estimate the marginal social benefit (MSB) directly.

Land, water and other 'natural' resources are often devoted to producing non-traded, frequently non-marketed, goods and services of major importance to the local economy. Environmental and other external costs or benefits imposed by alternative uses of such primary resources are especially difficult to quantify and evaluate. In some cases, a unit value can be imputed on the basis of the least-cost alternative goods or methods of providing the same or equivalent services, or some generally agreed minimum 'safe' level of such services (Sinden and Worrell, 1979). If there were some basis to predict the adjustments in other sectors that would be induced by a specified change in the use of the domestic resource, it might be possible to connect these domestic phenomena to the border transactions and hence derive the accounting ratios.

4.4.3 Efficiency pricing of labour

Once again, to estimate the accounting price of the labour input, we start with the opportunity cost of employing labour in the project. This is the output that the workers are responsible for in their previous occupation. The value of this output, forgone by society when they are employed on the project, is to be assessed in efficiency, or accounting, values, rather than at market values.

Strictly speaking, the accounting wage rate so calculated is specific to the project, or at least to the locality and the broad type of activity or category of the labourer involved. In practice, however, assumptions on inter- and intra-sectoral adjustments may enable us to calculate a few general conversion factors that can be applied without much error in a wide variety of situations.

A simplified formula to calculate the accounting, or 'efficiency', wage rate for a given type of labour is:

$$EWR = m.AR_m,$$

the net marginal product forgone by withdrawing a worker from current occupation, m, multiplied by the accounting ratio applicable, AR_m, to convert it from market values to border (efficiency) values.

Estimation of the marginal product m is crucial in the formulation (Irvin, 1978). Again, the uneasy compromise between the 'ideal' maximum m, and the 'predictive' second best comes up. In a competitive economy, the wage will generally come to equal the marginal value product of the factor in question. Market wages would then be a good measure of marginal product, at least at the set of domestic prices. There would be no (involuntary) unemployment of any factor, be it land or labour, because price would adjust downward if there were an excess supply of the factor, as in the surplus labour theories (Chapter 1).

Various alternative guides to m may be the modern sector wage, the informal sector wage, the average agricultural wage, or the casual agricultural wage (Irvin, 1978). Observers, however, point out that wages in agriculture are not low enough to absorb the whole rural work force. The modern sector wage is generally higher than the agricultural wage. This is likely to be true of project wages as well. Thus, neither of these wage levels necessarily reflects the true marginal product of the rural labour force, which may be near zero.

One explanation for the excess supply of labour rests on the expectation of higher wages in the urban and modern sector. It is likely, however, that there is unemployment, not of men, but of time. The withdrawal of one person from the rural work force would result in reduction of output unless others worked harder. The marginal product per person would then be positive, not zero. The unemployment might be seasonal or occasional, depending on the cycle of agricultural operations or the success of the monsoons, and could be called under-employment.

If there were much underemployment in the particular sector or in the economy as a whole, the forgone net marginal product may not amount to as much as a full marginal product of a worker-day. According to Irvin, the current "orthodoxy" is to take the wages of casual agricultural labour, weighted by some estimate of the degree of unemployment. Bruce (1976) suggests

$$m = (1/n)\sum_i (D_i/S_i)W_i \quad ,$$

where i refers to to the month, from 1 to n; D is the demand for casual employment, S the supply of casual labour, and W the wage rate for casual labour. A crude estimate would be to take the average value added per person in agriculture (w_a), and halve it to allow for underemployment. It is also possible that a chain of reactions follows on the induction of one worker in the project, so that the respective terms need not refer only to the class or sector from which the worker is immediately drawn, but may be a weighted sum of similar adjustments through many interrelated classes or sectors.

Some more terms could be added to the expression. Transport costs and overheads involved in meeting increased consumption are cited by Little and Mirrlees (1974); these would have to be added on the cost side (revalued at their accounting prices). Second-order effects like the multiplier effect of added demand may increase the benefits. The disutility of effort has not been considered so far. If the market wage rate were thought to compensate this element, then it may not be such an overestimate of m after all. The accounting wage rate may then be higher than the theory of surplus labour demands. This may be quite significant in forestry, which calls for working in places far away from the villages, often for weeks at a time.

In our case study, we have used a modification of the above approach to the question of estimating the shadow wage rate. We first look at the available evidence on the supply and demand conditions in the market for casual labour, to make a judgement on the surplus labour point. We take the market wage rate as an estimate of the marginal product of a man-day, that is, of labour time rather than labour population.

To estimate the surplus of labour time in the rural sector, we look at the proportion of time unemployed, i.e. the number of days per week that rural workers were available and searching for work, from the unemployment statistics. It does not appear that workers are being paid to be idle even in government forest departments; still, due to rigidities in the rural labour market, a project may use the labour of partially employed workers as well as of fully unemployed workers. The proportions of project workers recruited from the respective employment classes are assumed to be the same as the proportions of time spent unemployed.

This is different from the assumption usually made that urban projects recruit workers from each employment category in proportion to the numbers in each category (rural unemployed also being one of them) (Scott, MacArthur and Newbery, 1976). On that basis, the fully employed rural workers would be expected to contribute the greatest number to urban recruitment. In our model, this is moderated by the fact that the fully employed spend the least time looking for employment, while the contribution of the underemployed is greater because they spend more of their time searching (or available) for work. Our model would appear to be especially justified for a rural project, in which costs of dislocation are lower, but prospects of a great increase in income weaker.

The overall cost of employing a worker, in terms of forgone rural product, may therefore not be as low as zero, but it will not also be as high as the marginal product of a fully employed worker. The forgone product is calculated as the weighted mean of the average outputs of different unemployment classes, the weights being the proportion of time spent working.

4.4.4 Efficiency pricing of capital

The principle of opportunity cost is extended to the cost of capital invested in the project. It is the rate of discount used in the economic evaluation. This can be termed the economic accounting rate of interest, EARI, when the unit of account is the numeraire (Irvin, 1978).

Capital invested means present consumption forgone. For the individual choosing between saving and spending, the problem can be seen as essentially one of consumer behaviour. Assuming that the interest he can earn, r, is essentially outside his control, and given his endowments of present and future income streams, he will put by a rupee of present income, if the utility of Rs (1+r) worth of consumption in the future is more than the utility of Re 1 worth in the present. The ratio (1+r) represents the marginal rate of substitution of the individual between present and future consumption, and in a perfect economy, would equal the market rate of exchange.

This, however, is only one side of the picture. If savings are to yield future returns, there must be some way of transforming them into larger future income streams. Thus, the interest rate is influenced not only by the preference functions of individuals, but also by the opportunities perceived by them of transforming present into future incomes (Fisher, 1930).

One measure of this is the marginal product of capital, q, here the rate of return to investment. In the context of ECBA, we usually refer to the marginal product of the free investible funds in the hands of government. In efficiency terms, costs and benefits are to be measured in terms of the chosen numeraire, which has been specified as free foreign exchange. This means, in essence, that we talk in terms of accounting prices, expressed in border rupees, hence the term economic accounting rate of interest (EARI).

The EARI is supposed to serve two purposes. One is to discount future returns, as described above. The second is to ration out the investment resources of the economy among competing uses. In the perfect economy, the marginal returns to a rupee of present income must be the same across all its myriad uses, including consumption and investment. The purpose of the interest rate, and of ECBA, is to ensure this, by subjecting all potential uses to the same process of analysis using the same parameters.

If the interest rate is pitched too low, more projects may pass the NPV criterion than can be financed with the available funds. The question arises whether subjective discount rates are lower than the objective marginal rates of transformation available in the economy. This suggests a difference between what is usually called the social time preference rate (STPR) and the social opportunity cost of capital (SOC), which here means the same as q defined earlier.

4.4.5 Estimating the marginal product of capital, q

To estimate q, individual items of costs and returns must be converted to accounting values before calculating the rate of return. As an approximation, the domestic marginal product of an investment of Re 1 of numeraire can be simply turned into border values by multiplying by the "accounting ratio transforming domestic into foreign exchange equivalent value" (Irvin, 1978):

$$EARI = q.AR_q ,$$

or, if we assume the latter is equal to the SCF for all traded commodities,

$$EARI = q.a .$$

Though this is the usual formula prescribed, the factor a may be superfluous in cases where both the original investment, and the costs and returns, are expressed in efficiency or border values.

One difficulty in actually estimating the return to capital is that the concept of capital is itself ambiguous. If it refers to the machinery and plant (the 'fixed' capital), these productive resources derive their capital value not just from the cost of producing them, but rather from the expected values of their future returns. To evaluate the present value of the latter, we need to know the discount rate, which is what we are setting out to estimate in the first place.

A second problem relates to the concept of depreciation and replacement of worn-out capital. In the national accounts, for instance, data on consumption of capital may be based on the conventions in corporate accounts and the dictates of taxation laws, rather than on an estimate of the actual physical deterioration of plant and equipment and its physical replacement. A related difficulty is that the new capital equipment may be inextricably linked to the introduction of new technology; then it becomes difficult to separate out the marginal product to technological improvements from that to capital of the existing type.

We may regard capital as roughly representing all the material productive assets inherited by the present society. The concept of a 'marginal product of capital' then implies that the existing allocation of capital is in some way optimal, if it is to be measuring an opportunity cost. However, past investments may have been made in assets that are not so productive as current investment avenues, by today's standards. The observed annual rates of return (to existing capital) may then be a poor guide to the actual opportunity cost.

Free market enthusiasts would expect the 'invisible hand' to speedily weed out the sub-optimal and weak investment projects, and thus reward the truly efficient and productive, but it is rarely the case that the organized sector of the economy is completely bereft of support from the government. If the organized sector is substantially dependent on such public support, the 'real' opportunity cost of capital might be fairly low.

With all these reservations in mind, a rough estimate of q can be made by using the national accounts statistics. We take up the approach referred to by Irvin (1978); a similar approach is also suggested by Squire and van der Tak (1975). One looks at the "projected output capital ratio for the next planning period subtracting the wage bill from output" (Irvin, 1978). We develop the simple approach below.

Suppose the existing capital stock in the base year were K_0. This, in co-operation with given levels of other factor resources, yields an annual net product Y_0. We assume that there is a relationship

$$Y_0 = R_0 K_0$$

where R_0 is a certain average net output/net capital ratio.

Out of the annual net product, a fraction s is saved and invested in fresh fixed capital assets, which now become

$$K_1 = K_0 + sY_0 \ ;$$

if the co-operating factors are assumed to remain at the same level, the annual net product from this new level of capital assets

$$\begin{aligned} Y_1 &= Y_0 + q\ sY_0 \\ &= Y_0(1+qs). \end{aligned}$$

Analogously,

$$Y_t = Y_{t-1}(1+qs).$$

The entity (1+qs) is estimated from the regression of NDP (in constant rupees) on itself, lagged one year. The propensity to save, s, is estimated as the ratio of net fixed capital formation to NDP each year.

It is not expected that the year-to-year changes in national product are related to the net fixed investment of the previous year in exactly this manner. Indeed, the concept of a marginal product of capital is an abstraction. It ignores the myriad interactions that are possible between different factors, including some not under human control at all. It also abstracts from the questions of organizing the production process, the length of the gestation period, the shortages and bottlenecks that are caused by failures in administration or the market system, and so on. But we expect reasonably that, in the long run, as net fixed capital accumulates, annual product will rise to higher levels. It is this broad relationship that we seek to elicit from the national accounts data; it is a historical, rather than a normative, assessment of the marginal product of capital. In this sense, what we have is a 'second-best' q, which may well be less than the maximum value that could have been obtained if investment had been allocated optimally.

It remains to allow for the fact that the increase in NDP cannot be ascribed solely to an increase in capital, but is also partly due to changes in other co-operating factors and resources. Assuming that the input of land does not change extensively, the major variable component is expected to be labour. It is likely that the contribution of increased labour input will be measured by the increase in real emoluments. Thus, if the increase in real labour emoluments over the base year were netted out, we would be be left with a better estimate of the increase in product due to increase in capital alone. The procedure is not entirely satisfactory mathematically, but as an approximation, it has been endorsed by Irvin (1978) as suggested by UNIDO (1972).

Other suggested methods to arrive at q include the estimation of aggregate production functions (e.g., of the Cobb-Douglas form) in the economy. The problem with capital is that it is difficult to arrive at a valuation of it without presupposing an interest rate. Trivedi (1988) gets around this problem by choosing that value of capital which gives the best least-squares estimation of the production function. Average output-capital ratios have also been suggested (Irvin, 1978). Finally, the market rate of interest on loanable funds would appear to be a good estimate of the returns to the marginal investment opportunity in the private sector.

The familiar problems of externalities and market imperfections will act to make the market rates of interest non-optimal. The probable effect is to overstate the marginal returns to capital, as the private sector generally avoids external costs but captures or denies external benefits. As before, this is likely to be detrimental to the interests of the poor.

4.4.6 The distributional interest and economic cost benefit analysis

This brings us to the most important externality, that of distributional effects. Cost benefit analysis that is restricted to the efficiency criterion is now termed 'economic' (ECBA), as against 'social' cost benefit analysis (SCBA) which includes this consideration (Irvin, 1978, p.78).

Beyond private willingness to pay, there may be a broader concept of social value, which takes into account the distribution as well as production aspects of alternative policies. Modern cost benefit analysis recognizes the limitations of the efficiency criterion. Increasing the income-earning capacity of the poor is in itself a socially valuable use of incomes. There has thus been a move away from the 'objective' approach of neo-classical economics, to acknowledging the system of weighting the consumption (increments) of different groups on a relative scale of social value. This is the subject of social cost benefit analysis, SCBA, taken up in the next chapter.

CHAPTER FIVE

SOCIAL COST BENEFIT ANALYSIS

In economic cost benefit analysis, social welfare is measured by the aggregate of individual welfare measures. The difference in social cost benefit analysis is that we no longer remain neutral to the distributional consequences of government policy and government action. This introduces the need for some system of weighting income or consumption increases of different groups in the economy.

5.1 Distributional values in SCBA

5.1.1 The case for inter-personal welfare comparisons

Recognizing the distributional interest is a departure from the traditional neo-classical framework. Neo-classical welfare economists usually deny the possibility of comparing or adding the utility experienced by different individuals on a common scale of social utility, but public administrators and governments are constantly called on to make such inter-personal judgements regarding the distribution of incremental costs and benefits among different groups or sections in society. The Hicks-Kaldor condition of potential compensation would rarely be acceptable in a society where different groups have some say about their own future.

No reasonable rule exists for combining rankings of various states of society by individuals into a societal ranking (Arrow, 1951). Thus, to make ethical judgements theoretically, one is forced to compare the utilities of different people (Just et al., 1982, p.40 et seq.).

Especially in backward economies, mass poverty makes it unlikely that the market system will be able to mediate a transaction in externalities. External costs are systematically pushed on to those who are least able resist them, least able to establish their own entitlement to be free of them. This fact makes it important to consider intervention without waiting for the market to step in. Depending on the 'hidden hand' of private interest will not solve the problem of externalities in the arena of distribution.

There is no little disagreement on what would be the proper response to such externalities. The traditional reply would be that government can at the most exercise its general fiscal powers to make transfer payments to the poor, through social security schemes and so forth, but without tampering with the set of relative market prices. The authoritarian solution (to borrow the phraseology of Marglin, 1963a, in the inter-temporal context) would be for society, or the government, to impose certain norms on all decisions.

That the power of most governments, not just in the developing countries, is limited in either direction cannot be denied. Transfer payments are politically and administratively difficult to accomplish. Private decisions also tend to be made in a less organized or centralized and consistent fashion. What is left is for government to compensate for the limitations of the market system by itself undertaking projects, if not instituting policies, that are consciously biased toward the poor. Some of these may be in producing goods for mass consumption; others may be labour intensive in technique, but producing for the affluent or for foreign markets.

5.1.2 <u>The basis of inter-personal welfare comparisons</u>

The basis for attaching social weights to distributional effects is usually referred to the principles of consumer behaviour. This makes the departure from orthodox neo-classical marginalism less abrupt.

The average individual is assumed to derive a diminishing marginal utility from successive increases in the rate of consumption of a given commodity. The condition required for an aggregation of utilities derived from individual commodities, is that there are no 'consumption externalities'; that is, "the individual's utility is assumed to derive solely from his own consumption" (Squire and van der Tak, 1975, p.133). One might perhaps add that the individual's utility also shows additive independence, i.e., the utility derived from one commodity does not depend on the level of consumption of any other commodity.

The next step is to postulate that all members of society have the same 'well-behaved' total utility function, characterized by this diminishing marginal utility. The justification is that we have no basis for assuming any <u>systematic</u> deviation from the average utility function. Then society as a whole measures utility increases in a common unit, and this gives the basis for measuring aggregate utility or welfare as the sum of individual utility levels (Squire and van der Tak, 1975, p.133).

From this it follows that the transfer of a rupee of consumption from the rich individual to the poor will result in an overall increase in social welfare. The rich person attaches a lower value to the rupee in comparison with the poor, so his loss is less than the gain to the poor man. If social welfare is the sum of individual welfares, then society as a whole is better off. This suggests that redistribution of income, at the margin, can lead society to a higher level of welfare. As put by Little and Mirrlees (1974):

> "It is widely accepted that u [the social value weights to be attached to consumption increases] should be smaller, the more consumption a man has in total: that an extra rupee is better given to a poor man than to a rich man... We take it that most governments, administrators, and advisers would wish to make u depend on the man's total consumption (including what he gives to his dependents) and would wish to have it smaller for men with greater consumption, who are in other respects similar."

The foregoing suggests that society should apply certain weights to income increases of different classes on a consistent scale, based on private elasticities of marginal utility with respect to income. However, this is usually not possible, as governments are rarely so powerful. This brings us again to the second best situation: indeed, it is not necessary that the government be able to, or desire to, apply a set of consumption weights uniformly and consistently to all its fiscal and monetary programmes. In reality there may be a continuous process of political bargaining and lobbying, influencing the extent of any bias toward particular income or other classes.

An alternative 'revealed preference' approach suggested by Weisbrod (1968) is to deduce the distribution weights <u>implicit</u> in past decisions of the government. We identify distinct groups or classes of citizens (say, those in given income or social classes, or in given regions), and ascribe an unknown weight d_i to a rupee's increase in per capita consumption in each ith class. Then the total increase in social welfare from a project that results in net income increases y_i, would be $\sum(d_i y_i)$.

The method now consists of identifying projects that were chosen for implementation in preference to a more efficient alternative. The distribution pattern of benefits and costs is assumed to be known for each alternative. A minimal requirement would be that the less efficient alternative selected was at least as valuable socially as the more efficient alternative that was however rejected. This results in a set of <u>simultaneous</u> (in)equations in the unknown weights d_i. By collecting such information from a wide variety of past decisions, Weisbrod hopes to solve the equations for the set of consistent weights.

The problem is, of course, that government decisions may be quite <u>inconsistent</u> over a period of time. Thus the search for the objective set of social weights may well be futile. Indeed, according to Bruce (1976, p.28) "...ideally, a system of income distribution should be based on the weighted average of individual utility functions, but this is impractical. Consequently, any utility function used is bound to be arbitrary... In any case, what is important is that the derived income distribution weights should be reasonable, not what the precise shape of the utility function is... the iso-elastic one...seems to be as good as any."

5.1.3 The iso-elastic social marginal utility function

One widely used form of the utility function is the iso-elastic function that relates the marginal social utility of consumption, U_c, to the level of consumption c, through the elasticity of marginal utility of consumption, n:

$$U_c = Ac^n ,$$

A being a constant. By integration, the implied level of utility at a consumption level c, ignoring the constant of integration,

$$U(c) = Ac^{1+n} / (1+n) , \qquad n \neq -1, \text{ and}$$
$$U(c) = A\ln(c) , \qquad n = -1.$$

The parameter n is seen to be an elasticity by differentiating the marginal utility function (defining marginal utility in such a way that A=1):

$$d(U_c)/dc = nc^{n-1} = nU_c/c \text{ ; i.e.,}$$
$$d(U_c)/U_c = ndc/c \text{ ; or}$$
$$n = [d(U_c)/U_c]/[dc/c].$$

Thus n is the proportional change in marginal utility divided by the proportional change in consumption: in other words, the <u>elasticity of marginal utility of consumption</u>.

The relative weight, d, of an individual's incremental rupee of consumption would be proportional to the social marginal utility of consumption applicable to his level of consumption. To standardize the weights, one assigns a value 1 to the social weight for some reference level, say the average level of consumption in the society. Then all weights are expressed relative to the social marginal utility of consumption at the average consumption level, $\bar{c}$.

$$d_i = (c_i)^n / (\bar{c})^n$$

A value of n = -1 shows a fairly strong egalitarian bias, implying as it does that the social marginal utility of a rupee's worth of consumption falls in proportion as the consumption level rises. A value of n more negative than -1 will imply an even stronger egalitarian bias; while a value of n = 0 indicates that society is neutral as regards distribution of the costs and benefits. This is the assumption implicit in the usual economic analyses which simply aggregate them without reference to the consumption level of the persons on whom they fall.

Assuming a single value of n also implies an assumption that n is constant over the full range of incomes. In reality, governments might be indifferent between two relatively affluent income levels in the distribution of benefits or costs. The distributional bias may be operative only when comparing the effects on potential beneficiaries at or close to the poverty line, with those well above it.

5.1.4 Operational estimation of n

The concept of elasticity of marginal utility, n, has been used by some economists to arrive at an 'objective' estimate of distributive weighting. If private marginal utility were equal to social marginal utility of income, the value of n could be estimated by observing how the consumption of a particular commodity varied with its price and with the real income (Fellner, 1967).

Suppose we were able to derive a function relating the price of a commodity (say, Food, the capital letter serving to indicate that this is a composite rather than a single identifiable commodity) to the real income levels at which a given constant quantity of it were consumed. The elasticity of such a function would tell us by what percentage the price should change, in response to a 1% change in real income, in order that the consumption of that commodity remained constant.

The marginal utility afforded by the (last) unit of the commodity is, presumably, constant under all such combinations of price and income, on the usual assumption of the additive independence of utility from different commodities. Thus, suppose there needs to be a change of x% in price to neutralise a change of 1% in real income, thereby keeping the consumption of Food constant. This implies that the marginal utility of income has changed by -x% (negative since the marginal utility per rupee is inversely proportional to the price). The elasticity of marginal utility of income is thus -x.

Fellner (1967) represents this quantity x as the reciprocal of the elasticity e_4 of the function relating the real income at which a given constant quantity of Food is consumed, to the relative price of Food, the composite commodity;

$$n = -x = -1/e_4 \ .$$

We now need a method of estimating e_4. Fellner suggests using the pure price elasticity, $\tilde{e}_1$, and income elasticity, e_2, of Food consumption. For suppose the price of Food were to change by 1%; at a given real income, this would have led to a change in consumption of $\tilde{e}_1$%. To counter this change in consumption, the real income needs to be changed; since a change in Food consumption of e_2% is brought about by a change in income of 1%, a change in consumption of $-\tilde{e}_1$% requires a change of $-\tilde{e}_1/e_2$% in income. The last expression is nothing but the elasticity e_4 that we used before. Then the elasticity of marginal utility of income,

$$n = -1/e_4 = e_2/\tilde{e}_1 \ .$$

The pure price effect $\tilde{e}_1$ is estimated from the uncompensated price elasticity e_1 on the basis that if the expenditure on Food formed a fraction f of real income, then a 1% rise in price of Food alone would imply a change of -f% in real income; this would, by itself, be responsible for a change in consumption of Food of $-fe_2$%. This is the income effect part of the overall uncompensated price elasticity; the pure price elasticity is given by the uncompensated price elasticity less the income effect,

$$\tilde{e}_1 = e_1 - (-fe_2)$$

For a consumer under normal circumstances of non-satiation and independence in consumption, the pure price elasticity is negative, and the income elasticity is positive, unless it is an inferior good. An increase in price leads to a reduction in consumption, firstly because of the pure price effect, and secondly because of the shrinkage of total real income due to the inflation. The latter effect would lead, however, to an increase in consumption if the good were an inferior one. The composite effect, measured by the uncompensated price elasticity, might be positive if the income effect were sufficiently strong in opposition to the pure price effect.

The point remains that private n might vary widely over the wide range of incomes and endowments prevalent in a dualistic society. Indeed, the aggregate of individual decisions could come up against the aggregation problem. If income increases were concentrated in upper income classes, the national averages might not reflect the response of the 'average' individual. The rich wield more economic power in the market, so private n and 'social' n could be different.

5.1.5 The subjective nature of objective weighting methods

Ultimately, the choice of n is a political decision. Hence,

> "...there is an understandable reluctance on the part of project analysts ... to introduce value judgements into what is called positive economics, but cost benefit analysis is applied welfare economics, and in point of fact, one cannot get away from making value judgements" (Bruce,1976).

In a similar vein, Little and Mirrlees (1974) comment that even if methods of measuring 'utility' as suggested by economists could be accepted, as roughly measuring something objective, "which is very doubtful",

> "there is still the problem that utility thus measured cannot necessarily be equated with the social value to be put on different levels of consumption... We regretfully do not think that the social planner can get much comfort from this source."

While it may be desirable to have a "systematic, consistent, and thorough-going attention" to income distribution (Little and Mirrlees, 1974, p.239), in practice such an orientation may be reserved for a subset of public projects, in the 'social' or 'basic needs' sphere, and the remaining projects appraised on efficiency terms without distributional considerations. In the analysis of the former, a set of income weights may be useful, if limited to a few broadly recognized categories like those below the poverty line, or the average small or marginal farmer, the landless rural labourer, the urban unemployed, and a few others.

It appears, therefore, that we cannot derive the social weighting factors on a purely empirical basis. Some sort of value judgement needs to be made, by the policy-makers, or, by default, the analyst, reflecting his or her perception of the popular will. Little and Mirrlees (1974) suggest that "most people would put n in the range 1 to 3" (referring to the absolute value of n). The usual alternative is to present the results of the analysis based on a range of values (Squire and van der Tak, 1975, suggest -0.5 to -1.5), enabling the decision-makers to relate different levels of distributional bias to the respective project performance. We examine these issues further in the case study in Part II.

5.2 The discount rate in social cost benefit analysis

One of the less tractable, and certainly more controversial, issues in SCBA is the issue of the suitable discount rate (Harou, 1985). The importance of the discount rate has been suggested already in the chapters on forestry economics and economic cost benefit analysis (ECBA). The issue is placed in the social context here.

5.2.1 The multiple role of the discount rate

Two major roles of the social discount rate are to determine the optimal overall rate of saving from current income, and to allocate investible funds between competing uses in the optimal fashion. These interests are, broadly speaking, that of inter-temporal allocation of consumption, and of intra-temporal allocation of productive resources.

The issue gains importance because use of the market discount rate in discounting is likely to be unfair to the future in general (Price, 1973). This has been illustrated by the ubiquitous case of environmental externalities. Indeed, one of the contexts in which neo-classical economists expressed their doubt about the optimality of private decisions, was that of intertemporal distribution: the natural "defective telescopic faculty" (Pigou, 1952) of the individual would systematically undervalue the future, leading to a less than adequate provision by the present society for future generations. The discount rate is thus clearly a crucial parameter in public resource use decisions, and is particularly critical in land use decisions (Price, 1973).

The decision of what to invest in for future returns is expressed as the productive decision, the problem of the social opportunity cost of capital (SOC). The choice between consumption in the present and consumption in the future is one of social time preference (STP). The basis of the social discount rate (SDR) is provided by the interaction of these two concepts (Feldstein, 1964a; Fisher, 1930, p.149).

5.2.2 <u>The social time preference rate, STP</u>

One approach to the STP is that it is the "normative 'interest rate' that represents government policy with respect to the desirability of consumption at different times" (Feldstein, 1964a; 1964b). This is the rate at which future <u>consumption</u> streams are discounted. It is this rate that will be used to judge the present value of future returns from a rupee of investment in the public sector (and, by extension, anywhere in the economy).

Different patterns of discounting could be envisaged. A low STP implies a high present value of future consumption flows. A low STP rate for the near future and a higher rate for more distant years "would reflect a greater concern with the welfare of generations in being than with that of those yet unborn". Imposing a time-horizon, after which benefits and costs would not count at all, "is equivalent to using an infinite STP rate... for all consumption after the horizon date..." (Feldstein, 1964a, p.122). Ciriacy-Wantrup (1968) has even suggested a <u>reverse</u> discounting whereby future consumption streams are given a higher positive weight, the <u>farther</u> in time they are expected.

A starting point for the STP is afforded by the time preference rate of the individual. Caused by "human impatience", it depends on the "time shape of the expected income streams" that the individual perceives as his given endowment (Fisher, 1930). Natural discount functions probably value immediate and proximate consumption too highly (Strotz, 1953); but only a constant discount rate can lead to consistent decisions that will not be repudiated and revised repeatedly as the future becomes the present.

Individuals differ in their attitudes to uncertainty and to future needs. Fisher's clubbing of "primitive races" with "children, and other uninstructed groups in society" as lacking in foresight was unfortunate, probably the result of failing to appreciate the complex nature of resource-use decisions in a traditional culture (the "<u>habit patterns</u> which safeguarded a 'minimum standard of conservation'", Ciriacy-Wantrup, 1968). Fisher indicated that inter-temporal decisions do not come naturally to human beings (perhaps especially among non-primitive races?), but that "foresight has to do with thinking; self-control, with willing..." (Fisher, 1930).

The connecting thread is the principle of diminishing marginal utility of consumption, which implies the possibility of comparing marginal utility across time intervals. An individual who expects his income levels to be much lower or less assured at some time in the future than at present, may well have a low rate of time preference, as the result of the higher marginal utility of a rupee of income at the lower future income levels.

For an individual, "uncertainty has a tendency to keep impatience down", but uncertainty as to expectancy of life may have the opposite effect (Fisher, 1930). A part of current consumption, however, may be more of an investment in reduced uncertainty in the future; medical and educational expenses are a case in point.

5.2.3 Operational estimation of the STP

The question arises how we are to arrive at the STP. A basis for determining one such rate, the consumption rate of interest, CRI (i) to discount future consumption flows, is afforded by the elasticity of marginal utility of consumption, n.

The approach is illustrated by Kula (1984). He applies a 'two-period' model to the average individual, whose marginal rate of substitution of consumption between the 'present' and the 'future' is assumed to be the same as society's. Let us assume that his assured income endowment in the two time periods is, respectively, c_0 and c_1. The utility attached to a unit of consumption on margin will be, by the former formulation of the marginal utility function, c_0^n and c_1^n.

Even if we disregard 'pure' time preference as irrationally short-sighted, there still remains a rational ground for the individual to discount a unit of consumption incident in the future: that is, the uncertainty about his surviving to enjoy it (Georgescu-Roegen, 1979; Bruce, 1976, p.37). Kula provides for this by multiplying the marginal utility of consumption in t_1 by the probability of survival of the average individual (simply 1 minus the overall death rate), symbolized by p here. The marginal rate of substitution of c_0 for c_1 is the quantity of consumption in t_1 that he is prepared to give up for a unit of consumption in t_0:

$$MRS_{c0,c1} = mu_0/mu_1 = (c_0/c_1)^n(1/p)$$

Conversely, to be persuaded to give up one unit of consumption in the present, the individual has to be promised a recompense of at least this much in the future. This is the link to the concept of interest as a compensation for the use of loanable funds, except that here we refer to consumption streams. Denoting the consumption rate of interest, CRI, as i, the above compensation for the sacrifice of a rupee of present consumption, assuming the time period is one year, is Rs (1+i).

If the social rate of interest is considered to be identical to that of the average individual, we get the expression for the <u>social time preference rate</u> (Kula,1984),

$$STPR = CRI,\ i = (c_0/c_1)^n(1/p) - 1.$$

The ratio of consumption endowments is equated to the cumulative growth rate of consumption,

$$c_1/c_0 = (1+g)$$

where g is the annual growth rate of consumption per capita. Thus,

$$\begin{aligned}(1+i) &= (1/p)(1+g)^{-n}\text{ , or, approximately,}\\ &= (1/p)(1-ng)\end{aligned}$$

It may be argued, however, that for society as a whole, discounting for mortality is not rational. If all individuals behaved as if society were subject to the personal probability of mortality, this may well force that very eventuality. We may prefer to believe, therefore, that the society is, for practical purposes, deathless. If the probability of death during period t to t+1 is ignored, p=1, and i reduces to the usual formulation

$$i = -ng$$

(the negative sign because we have defined n to be negative for diminishing marginal utility). Adding the pure time preference rho, the usual expression as given in Squire and van der Tak (1975, p. 140) is obtained (with a negative sign on n):

$$i = -ng + rho.$$

5.2.4 The social opportunity cost of capital, SOC

The classical theory of the interest rate is one of "...investment opportunity and human impatience, as well as exchange" (Fisher, 1930). From the individual rates of time preference, the market arrives at the social rate of time preference through the exchange of different time shapes of income streams. However, exchange of consumption streams is only one side of the picture. It is in the possibility of transforming given income stream endowments into others with a different time profile, that the opportunity cost comes in.

The social discount rate should thus be influenced not only by preference functions, but also by the opportunities for transforming present into future incomes (Samuelson, 1967). One measure of this is the marginal product of capital, q, the rate of return to the investment of a unit of free investible funds in the hands of the government.

If there were plenty of investment opportunities, the demand for investible funds, and the market interest rates, would be high. The individual may have a low rate of time preference, indicating his poor endowments of future consumption, but that does not mean that he should forgo the high returns possible at the market rate of interest. Applying the Fisher 'separation' principle, the individual should act to maximize his present discounted value, taking the interest rate as given; and then trade with others until he reaches the optimum allocation of consumption streams over time (Samuelson, 1947, 1967).

For society as a whole, however, the interest rate cannot be taken as given. It is the productive opportunities that decide what rate of transformation of present into future consumption is possible. This rate of transformation is the social opportunity cost of capital, SOC. The STP in turn determines how valuable the future consumption is relative to the present consumption forgone. Potential uses for savings are therefore to be measured against this net social benefit per rupee at the margin of current social investment in the economy (Feldstein, 1964a).

5.2.5 The choice of the social discount rate, SDR

The question remains whether one can validly identify the private time preference rate, as exemplified by the 'average' individual's preferences, with what society should adopt to decide inter-temporal valuations of consumption. For instance, society is, technically speaking, deathless, and hence the logic in discounting future values for the probability of premature death would appear to be questionable (Georgescu-Roegen, 1979; Price, 1984, p.831).

The neo-classical argument is that different individuals will have different income endowments and different degrees of impatience. Their market interactions should enable the optimum allocation to be reached in the economy, with the market interest rate representing the marginal rate of substitution of all individuals between present and future consumption.

Arguments of this nature led economists like Baumol (1968, 1970) to oppose the need for each generation to "engage in overall efforts to support its posterity beyond the level that is indicated by the free market" (Baumol, 1970, p.284). Marglin (1963a) likewise asserts that "...if, after being made aware of future needs, present individuals remain indifferent to the claims of future individuals, then, ...a democratic view of the state does not countenance governmental intervention on behalf of future generations".

As usual, however, the real world is beset by imperfections and externalities that defy this neat conclusion. Imperfections are ubiquitous in capital markets; access to credit is impeded by institutional imperfections, by divergence of lending and borrowing rates, and by the interference of risk and uncertainty. These "give rise to the simultaneous existence of multiple interest rates" (Fisher, 1930). Imperfect information or predictability regarding future income streams precludes the possibility of all agents optimizing their investment-consumption decisions.

One of the most serious objections is that it is not one's own time profile of consumption that is decided by the STPR, but that of present versus future generations (Nash, 1973). Even were there a perfect market for capital, and a unique interest rate, this would equate private demand and supply schedules (in respect of investible funds), but would not be a guide to equating social productivity with a "politically determined saving supply schedule" (Feldstein, 1964b; Eckstein, 1958).

Indeed, future generations are not even a party to the intertemporal transaction (Georgescu-Roegen, 1979), so that market mechanisms can have but limited validity even in the neo-classical framework (Nash, 1973).

Even efficiency protagonists concede that externalities would not be allowed for by private agents, so that "corresponding adjustments naturally have to be made in the discount figure" (Baumol, 1970). Thus, conceivably, "an efficient result ground out by competitive market forces may not constitute a social optimum" (Herfindahl and Kneese, 1974, p.10).

An increase in discount rates will result in planning agents trying to "change the time distribution of net revenues in the direction of the present", thus bringing about a "depletion ex post considering a population of resource users as a whole" (Ciriacy-Wantrup, 1968). There is the possibility, therefore, that society as a whole may be prepared to discount long distance future returns at lower rates than apply to the private investment analysis (Leslie, 1967).

To environmental economists, externalities are the very heart of the problem, rather than merely a fringe consideration (Butlin, 1981). Forests, for instance, are usually considered to be renewable resources, capable of automatic "regenerative renewal" (McInerney, 1981); but there are in practice few instances where such renewal actually takes place without active intervention (Webster and Gordon, 1975). These are renewable or flow resources, among which the reversibility of a decrease is characterized by a "critical zone" (Ciriacy-Wantrup, 1968). This is one of the few cases where a departure from the market value of the discount rate is considered justifiable by economists in the mainstream of the neo-classical tradition (Barnett and Morse, 1963; Baumol, 1968, p.801; Samuelson, 1974).

One response of economists is to include the "user cost" (Scott, 1953), the cost imposed on future consumers by reduced availability of the resource or commodity by a higher rate of current consumption. This approach, however, preserves the egocentric valuation of alternative time streams of returns. Nautiyal (1966) suggests that user cost, as well as marginal user cost, increases as the current rate of exploitation increases. A high rate of discount would, however, render even heavy future losses of this nature quite insignificant to the present planner.

In general, it is accepted that a low discount rate implies a higher weight to future consumption. A paradoxical effect is possible here, however, at least in the case of environmental resources. A low discount rate may encourage resource-depleting industries and activities as much as resource-building ventures. This would happen especially if externalities like user cost were ignored (as they probably will be) by the market system. "The possibility of immoderate losses -- contingencies which threaten the continuity of a social group -- are even more important for government decisions than for private ones" (Ciriacy-Wantrup, 1968, p.252); the response is to maintain a "safe minimum standard of conservation". This is a 'supra-market' consideration justifying government, or public, interference with efficiency solutions.

If each individual could be certain that his sacrifice of current consumption would be matched by similar contributions from all others in his station, there might well be a social compact for a greater degree of distributive justice than under private market conditions alone (Marglin, 1963a). This principle could be extended to the inter-temporal case. [The problem would then be of ensuring that everybody adhered to the compact, failing which we would end up with the inter-temporal version of the 'tragedy of the commons', cf. Hardin, 1968; Hardin and Baden, 1979].

Feldstein's view is that "the search for a 'perfect' formula... is futile. An STP function must reflect public policy and social ethics, as well as judgement about future economic conditions.... [It] cannot be derived on the basis of existing market rates, but must be administratively determined as a matter of public policy" (Feldstein, 1964b). Similarly, Heal (1981) concludes that the "choice of a discount rate would then be a 'political and moral' question, up to society, as a whole or through its representatives, to decide".

This still, however, leaves the transformation possibilities as a plausibly objective fact. In the context of SCBA, the SOC would be in terms of social value, which includes the distributive aspect of transformation opportunities. Given a normative decision on the relative value of future generations' consumption, it is still possible that different 'investment' options will yield different streams of future incomes. The interests of future generations may well not be served by opting for investments of low productivity just because of a low STPR.

The more productive that marginal social uses of resources are at present, the higher will be the SOC. On the other hand, the lower the STPR, the higher will be the present value of the marginal social use of resources. Any proposed project or policy measure will have to measure up to these higher standards of social usefulness, so that a strong inter-temporal and inter-personal distributive objective does not necessarily imply a low opportunity cost of investment funds in SCBA.

5.2.6 The social accounting rate of interest, SARI

One of the complications of SCBA is the multiplicity of discount rate concepts. The discount rate adopted for public income is defined as the rate at which the social value of public income falls over time. This is the social accounting rate of interest, SARI. It is assumed that all values of benefits and costs are calculated at their respective accounting prices (except the price of capital which is given by the SARI).

There are two components to the fall in value of the numeraire over time. The first is that the social value of the numeraire, v, may be falling with time: the premium of public income over (contemporaneous) private consumption would be decreasing over time. The second is that the value of consumption (with respect to consumption today) itself is falling with time, because of the rise of average income and the principle of diminishing marginal utility (Baumol, 1970, p.285). This rate of fall is represented by the CRI. Thus, the overall rate of fall of public income with respect to the value of private consumption today, the SARI, would be

$$SARI = (1/v)dv/dt + CRI.$$

This is the concept of discount rate used in the LM methodology.

5.3 <u>Operational estimation of the SARI</u>

5.3.1 <u>The social value of public income, v and the SARI</u>

The social value of public income is assessed in terms of the marginal utility of consumption at the reference level (usually the average level of income) in society. The main uses of public income will be, generally speaking, either investment for future incomes, or distribution for current consumption. If it were invested, there would be a stream of annual income (or its equivalent in case of a short-lived activity). The annual income would be the residual from the annual (or annualized) social returns, after meeting all the social costs.

The net income accruing every year would itself be divided between (private) consumption and further investment. Further, the probable <u>distributional</u> consequences of these future income and investment flows would affect the social value of the initial investment. The trade-off between future growth and distributional effects is expressed in the LM methodology by estimating a parameter v. This is the <u>present value in terms of present consumption at the reference level</u>, of all the future consumption streams expected to flow from the rupee of initial public investment; in brief, the social value of public investment.

A simplified formula to calculate v is described by Bruce (1976) on the assumption that s, the propensity to save and reinvest out of the incremental income, remains constant over time. To take care of distributional issues, it is assumed that <u>all consumption accrues at the average level of consumption</u> in society, so that distributional weights do not need to be calculated to value the increases in consumption relative to the value of consumption at the average level.

Now let us suppose that Re 1 of net investment (valued at border prices) in year one, gives rise to a perpetual stream of annual net incomes q, at border prices. Here q is the marginal product of capital. A fraction s of annual income is saved and reinvested at the same marginal product. Then the present value of the future income streams, and hence the social value of the rupee of public investment, relative to a rupee of consumption (in domestic prices) at the average level of consumption, is given by

$$v = (1-s)q/[(i-sq)a]$$

where the standard conversion factor a appears in the denominator in order that the consumption stream is expressed in terms of domestic rupees (cf. Bruce, 1976, p.24).

The consumption rate of interest i is used as a discount rate to discount future consumption streams. The social value of each year's consumption stream is in relation to that year's average income level, rather than the level obtaining in the base year. Thus, under the assumption of unitary distributive weight, all the incremental consumption is distributed as if it were at the particular average level of the year in question.

A value of v of above 1.0 implies that there is a premium on public investment, here amounting to a premium on public income. Sometimes the assumption is made that this premium will disappear within a specific period, say 50 years, in which case the Accounting Rate of Interest,

$$SARI = i + (1/v)dv/dt,$$

the rate at which the value of consumption at the average level itself is falling over time, plus the rate at which the value of public income relative to consumption at the average level is falling over time. This is the rate of discount to be finally used in evaluating alternative uses of public funds.

The LM-ST methodology thus seeks to resolve the discount rate problem by using a separate rate of discount for consumption, and deriving the accounting rate of interest from this value.

5.3.2 The social value of public income, v, and the critical level of consumption, c*

An alternative route to the value of v is suggested by the fact that governments sometimes make pronouncements on what they feel is the 'minimum' consumption level, c*, they would like their citizens to enjoy. It is then argued that the government considers a rupee of private consumption at this 'critical' consumption level as valuable, socially, as the equivalent amount of public income.

The income distribution weight attached to private consumption at the critical level is a guide to its value relative to the social value of a rupee of consumption at the average level. The income distribution weights are assumed to be in the ratio of the marginal utility of consumption

$$d_i = (c_i/\bar{c})^n$$

Since a rupee of public income is as valuable socially as a rupee of consumption at c*, the value of d* must be the same as that of v; except that the rupee of public income at border prices is equivalent to 1/a rupees at domestic prices, whose social value is then

$$v^* = d^*(1/a) = (c^*/\bar{c})^n \ .$$

This is a source of another estimate of the social value of public income, that can be used as a countercheck to the value calculated from estimates of q, s, and i above. It will be useful in cases where these parameters are uncertain. Indeed, if some critical level of consumption could be identified, it would be a rough and ready method of assessing the urgency of any welfare measure that is competing for funds with other, less egalitarian (socialistic) projects or policy decisions. It could also be used to derive imputed values of parameters like the STPR i, which, as we have discussed above, are ultimately subjective, rather than objective, values.

5.3.3 The social value of public income versus public investment

One consequence of the foregoing derivation of v* from the critical income level would be the interrelation between the values of v* and i. They are no longer the independent parameters we started with. This may be a less than satisfactory state of affairs.

A consideration that occurs here is the distinction between a rupee of public income and a rupee of public investment. Different suggestions have been made as to the treatment to be accorded to these two numeraires. The usual practice is probably represented by the view of Squire and van der Tak (1975). The recommended numeraire is the unit of uncommitted public income, and consequently the social value of public income would depend on the uses to which it is put.

The usual approach is that in the absence of information to the contrary, it could be assumed that all the v_j values (the social value of public expenditure in each activity j) would be equal, and the value of any one particular type of government expenditure, for instance public investment, only need be assessed. Thus, strictly speaking, the values of v calculated so far have been the social value of government investment, and if this is to be taken as the relative value of the numeraire, the assumption is implied that all other uses of government income are also equally valuable.

It does not seem likely, however, that such an assumption can be justified by appealing to the absence of any information to the contrary. Indeed, there has been, if anything, frequent criticism by qualified observers of government spending (Rao, 1983; Bhagwati and Desai, 1970; examples for most countries are not difficult to come by). We have, moreover, not used any parameters specifically for the public sector; but, rather, assumed that the public sector follows the economy-wide behaviour. It would seem logical, therefore, to assume that the rupee of public income that we started with is divided in the same way between real net investment and consumption expenditure as the incremental income supposed to be flowing from public investment.

The portion saved and invested out of a rupee (border value) of government income is then s, the social value of which is Rs $(1-s)/a$ (at domestic values at the average income level $\bar{c}$); that of the portion $(1-s)$ (at border values) allocated to consumption expenditure, is Rs sv (domestic values at $\bar{c}$). The overall social value of Re 1 (border) of government income is then

$$x = [(1-s)/a] + sv \text{ Rs (domestic) per Re (border).}$$

The value of v could be calculated as before by using the a priori values of the CRI, i, for different values of n and q. A hybrid set of assumptions could be that the fraction s of public income is saved and invested, but that the entire incremental income stream goes to consumption.

A further variant could be that the government investment is as valuable as consumption at the critical income level, c^*, but that government consumption expenditure is only as valuable as consumption at the average level, $\bar{c}$. In this case, the investment portion, s, is valued in social terms at sv^*, v^* being the previously calculated value of public investment; the government consumption expenditure, $(1-s)$, is valued, as before, at $(1-s)/a$; and the overall value of a rupee of public income,

$$x^* = [(1-s)/a] + sv^* .$$

It might also be remarked here that when we talk of public income being as valuable as consumption at some income level like $\bar{c}$ or c^*, we are not necessarily assuming that these returns from public investment are actually accruing to those at the stated levels of consumption. We instead think of this as a device to impute a certain relative value to public income in terms of incremental consumption at what might be considered the socially 'deserving' levels of income in society.

It is necessary, however, to enquire into the effects on v, etc., if the pattern of distribution of project benefits (and costs) is not as uniformly at the average level (or at the critical level) of consumption in society. This is the topic of the next section.

5.3.4 Distribution of returns and the value of public income, v

The social value of public income, v, was first calculated on the assumption that all incremental consumption can be treated as though accruing at the average level -- the social weight being 1.0. Whether this is a valid assumption to make is debatable. Other manners of distribution could be suggested, and each will affect the value of v, and hence the relative valuation of public and private income.

One variant that has already been considered is that the streams of incremental consumption will all accrue to those at the poverty line, as it would if the government were very strongly committed to improving their lot. The social value of public income would then be d* times the previous values (where d* represents the social weight attached to consumption at the critical level c* relative to consumption at the reference, average level $\bar{c}$). It would also be equal to d*/a, so that, equating the two,

$$v = d^*/a = (1-s)qd^*/[(i-sq)a].$$

The distribution of project benefits could also be such as to leave the existing distribution unchanged. This may never be realized in practice, but it is a useful assumption in cases where the distributional effects "may be difficult to trace, too small to bother about, or so general that all income classes may be affected" (Squire and van der Tak, 198, p.137). In the absence of specific information on the way the increase in consumption due to the project are distributed across consumption classes, the analyst "might assume that the increase in consumption is distributed in the same way as current aggregate consumption".

In such a case, the aggregate distribution weight,

$$D = \hat{s}^N(\hat{s}-1)^{1-N}/(N+\hat{s}-1) \quad ,$$

where $\hat{s}$ is the parameter of the Pareto distribution curve, and N is the negative of the elasticity of marginal utility of consumption, n. The value of the Pareto distribution parameter is approximately

$$\hat{s} = (1+GINI)/2.GINI ,$$

where GINI stands for the Gini coefficient of the cumulative Lorenz distribution curve of proportion of consumption against proportion of the population (Bruce, 1976).

The higher share of incremental consumption flowing to the better-off would tend to depress the social value of public investment. Against this, now there is the share of those below the average level, indeed even those below the critical consumption level c*, which will have the opposite effect, though to a lower degree because a less than proportionate share of total income goes to these classes.

While the sharing out of incremental consumption according to the prevalent distribution is an attractive alternative assumption, it does require a fairly strong effort on the part of the government to ensure that the lowest consumption classes get their share from the general investment in the public sector. Of course this could well be achieved in individual projects specially designed to benefit the poorest. But we feel that this assumption would pose unfairly high standards in social cost benefit analysis for projects in general if used in conjunction with a fairly high egalitarian bias. The benefit of special projects whose benefits flow differentially to the deprived will come out clearly only if the distribution of returns from the general investment is not assumed to be more egalitarian than the existing balance of power and influence in society dictates.

5.4 Accounting prices under SCBA

In the previous chapter, the methodology of deriving accounting prices of products and factors was discussed under efficiency criteria. Now under SCBA, the general methodology is extended to incorporate the distributional interest as well.

5.4.1 Social cost of labour and the accounting wage rate, SWR

In a country like India, where the one overwhelming fact is that of a huge and fast growing population, human labour is bound to be one of the most important inputs, and labour employment an important objective. The social cost benefit analysis methodology takes these two facets of the labour element into account by seeking to value both the social costs and the social benefits of employing the extra worker.

The following expression shows this extension of the simple formula for the shadow wage rate already discussed under efficiency pricing (Sec.4.4.3):

$$SWR = mb_c + dc.b_c - dc.d/v .$$

The first term refers, as before, to the value of net marginal product forgone, revalued at border prices by multiplying by the SCF b_c (assuming that the SCF for the rural product is the same as that for rural consumption). The second term refers to the cost of providing for the extra consumption, dc, of the worker. The final term expresses the social value gained from increasing consumption. Here d is the relative social weight attached to a rupee's increase in consumption at the per capita consumption level of the category of workers in question. This is multiplied by 1/v, the equivalent in border rupees of a rupee of consumption at the average level, to express the social benefit in terms of the numeraire.

Instead of expressing the SWR in so many border rupees, an accounting ratio can be estimated of SWR to market wage rate, and this AR, b_L, used subsequently for that category of worker:

b_L = SWR/w, where w is the market wage rate.

Application of these general principles requires assumptions specific to the project or class of workers and locality in question. In particular, we have to predict which categories of workers will be employed in the project, and what their respective wage increments will be. If the entire wage increase will go to increase consumption, we still have to make some assumption on how the additional consumption will be shared between the worker and his dependents, in order to assess the per capita consumption levels before and after the change, and thereby the social value of additional consumption.

To calculate the consumption distribution weight, either of two formulae can be used (Squire & van der Tak, 1975; Bruce, 1976). If the increase in consumption were marginal, then the distribution weight attached to a rupee of consumption accruing to a person at consumption level c is given by

$$d_1 = (c/\bar{c})^n \ .$$

If the change in consumption were appreciable, say from c_1 to c_2, then the social weight,

$$d_2 = [U(c_2) - U(c_1)] \ / \ [(\bar{c})^n(c_2-c_1)].$$

Since the utility level $U(c) = c^{1+n} / (1+n)$ for $n \neq -1$, and
$U(c) = \log_e(c)$ for $n = -1$,

we can write

$$d_2 = [c_2{}^{1+n} - c_1{}^{1+n}] \ / \ [(1+n)(\bar{c})^n(c_2-c_1)], \text{ for } n \neq -1,$$

and

$$d_2 = [\log_e(c_2) - \log_e(c_1)] \ / \ [(\bar{c})^n(c_2-c_1)], \text{ for } n=1.$$

The formula for a 'marginal' change in consumption would give the higher d value; that for a nonmarginal change would give a somewhat lower value, as it would take into account the improvement in the consumption levels from the initial to the final position.

5.4.2 Accounting ratios for other prices

Not much change is needed in the procedure to arrive at accounting prices of other factors and commodities in the economy. For land, for example, the forgone product will be the main basis of estimating the opportunity cost or rental. If the payment for the land is higher in the project, the extra hire charges might conceivably lead to consumption changes among the recipients. These would have a certain cost, as well as a social value, to be assessed, as above, by predicting the consumption levels of those on whom such changes will be incident.

For commodities, we have again to predict the effect of project production or consumption on the rest of the economy. Not only that, we also have to identify the consumption classes of those on whom these effects are incident. For instance, increasing the production of a particular commodity might mean the increase in producer or consumer surplus in different income classes. Increased project demand might reduce consumption elsewhere in the economy; if this meant reduced consumer surplus for poorer sections, it might increase the social cost of the commodity.

Some of these effects may be incorporated in the unit price. In other cases, it may be more convenient, in practice, to evaluate specific distributional effects as part of the benefit or cost streams for the individual project. In this manner, any <u>special</u> distributional benefits of a particular project will be better highlighted.

5.4.3 The relevance of SCBA in public policy decisions

The foregoing discussion would have made one point clear, if nothing else: that not much is self-evident in social cost benefit analysis. There are, further, few objective parameters in the whole gamut of variables and value judgements required for any practical application of these principles.

The observer, therefore, inevitably questions the relevance of the methodology, and whether indeed it has any at all. One of the weaknesses of SCBA is, perhaps, that proponents have claimed too much for it. If it is expected that any methodology of SCBA, however consistently applied, will remove all the inequities and inefficiencies of the developing world, and bring them up to the level of the developed in material terms, then we are bound to be disappointed. The sober reality is, perhaps, that the gap can never be bridged, and the world is locked into a dualistic pattern of development until this historical era has passed over and become a curiosity for the diversion of itinerant scholars.

In the meanwhile, however, SCBA has a 'heuristic' value (Irvin, 1978). Our aim here is more modest than setting the nation on the proper path of development. We expect that a study of the forest management patterns being followed at present might fulfil this heuristic purpose of showing us where and how the conflicting interests are being served or neglected, and whether the conflicting claims for and against 'the forestry as she is practised in India' can be resolved in the framework provided by SCBA.

The following study of sustained yield forestry is restricted to certain major options facing foresters in a small part of the Indian sub-continent. It is therefore limited in coverage, and any generalizations made during the course of the discussion, should be assumed to be of limited applicability. With these provisos, we proceed to the case study of sustained yield management in the framework of economic and social cost benefit analysis.

PART TWO

CHAPTER SIX

SUSTAINED YIELD MANAGEMENT OF TEAK IN THE KANARA FORESTS

6.1 The backdrop of physical and natural resources

6.1.1 Karnataka state: a geographical outline

Karnataka (previously Mysore) state lies between latitudes $11^{o}12'$N and $18^{o}12'$N, and longitudes $73^{o}48'$E and $78^{o}18'$E in the peninsular region of South India. The state has a geographical area of 190,500 sq km, divisible broadly into three geographical regions as follows (Rama Prasad and Malhotra, 1984; Saldanha, 1984):

(1) The Coastal region

This is the strip of land between the Arabian Sea on the west and the parallel ranges of the Western Ghats. The coastal strip stretches for some 320 km in Karnataka, from Karwar in the north to Mangalore in the south. It continues into the neighbouring states of Maharashtra and Kerala respectively at the two ends, its width ranging from 5 km in the north to over 65 km in the south.

The coastal terrain is broken up by rivers, creeks, isolated peaks, and detached ranges of hills. The high escarpment of the Western Ghats causes the winds of the south-west monsoon to rise and shed their load of moisture, resulting in a heavy rainfall of 2,500 mm a year. The climate is therefore hot and humid. The soil is alluvial in the coastal plain and lateritic on the hill slopes. The average altitude is 75 m, rising to 150 m in places.

(2) The Malnad

Meaning the hilly region, this is the belt occupied by the main escarpment of the Western Ghats and associated systems. It stretches some 640 km from south of Bombay (the capital of Maharashtra state) to the southern tip of the peninsula, with an average width of 50 to 65 km. The unbroken, though uneven, rampart has an average altitude of 900 m, with deep valleys plunging to less than 200 m and peaks rising to over 1,500 m. The highest peak in Karnataka, Mullaingiri, rises to 1,923 m. To the east of the ridge, the Ghats descend gradually to the central Deccan Plateau by a series of rolling hills, leading to a different topography and vegetation.

The annual precipitation increases from 2,500 mm in the Coastal belt to the ridge of the Ghats (up to 7,000 mm at Kudremukh, 7,460 mm at Agumbe), but decreases rapidly on the leeward side in the east. It is only 2,210 mm at Saklespur just 10 km east of the ridge, and 875 mm at Hassan, another 32 km to the east. The soils are lateritic.

(3) The Maidan, or interior plateau

This is the plateau region on the lee of the Western Ghats. The Northern Maidan, at an average elevation of 610 m, has a rolling topography. It is underlain by sedimentary rocks, with black 'cotton' soils and brown clayey loams in the valleys, coarse gravely ('murram') soils on the ridges. This area is almost entirely in the semi-arid region of the peninsula. The Southern Maidan is a rolling plateau made up of archaean rocks. Its soils are predominantly red sandy loams, with black, and mixed black and red, soils also occurring in the north-western portion. The rainfall is about 700 mm.

6.1.2 **Natural vegetation**

Natural vegetation closely follows topography and precipitation. The humidity increases from the west coast to the crest of the Western Ghats. This is echoed by the succession in the natural vegetation, in which forest figures prominently. The drier interior plateau does not support such luxuriant natural forest (Saldanha, 1984).

Littoral vegetation on the west coast includes mangroves in the estuaries, and terrestrial communities on sand dunes. Immediately to the east of the coastline, the natural vegetation is of the secondary moist deciduous type, sometimes considered a "degraded stage of an evergreen climax" (Saldanha, 1984). Clearing for agriculture has considerably fragmented these forests. The Hopea-Syzygium-Holigarna series is found on the rounded hills and along the flanks of the lateritic sheet-rock.

The secondary moist deciduous forest in the foothills of the Ghats is better preserved. The canopy consists of species like Anthocephalus chinensis, Lophopetalum wightianum, and Vitex altissima. Xylia xylocarpa is abundant where laterization has taken place.

With increasing humidity, the natural vegetation graduates from the moist deciduous formation in the west, through semi-evergreen, to evergreen forests on the crest of the Ghats. The composition varies with soil, slope, altitude, and latitude. The canopy in the tropical wet evergreen forest is dense and stratified into layers, and woody lianas are common. On the highest reaches, above 1,500 m, the vegetation consists of grassy meadows with wooded patches (called 'sholas') of medium sized evergreen trees in the hollows. The sholas also occur on the higher hills on the plateau and the eastern off-shoots of the Ghats.

The leeward side of the Ghats carries the upland moist deciduous formation with the highest proportion of teak (Tectona grandis). The moist deciduous belt running from Belgaum to Coorg contains some of the most valuable hardwoods, prominent being the Tectona-Lagerstroemia-Terminalia series. Bamboos are an important part of the forest crop here.

The rainshadow region to the east naturally supports less well-formed vegetation. The western belt of the central plateau is characterized by dry deciduous forest with relatively tall trees compared with the eastern portion, where the vegetation is of a more pronouncedly xerophytic character. Irrigation has transformed the dry interior plateau, while an extensive area has been put under plantations of pulpwood (mainly *Eucalyptus* hybrid) and fuelwood (*Casuarina equisetifolia*, *Cassia siamea*, *Acacia auriculiformis*, etc.).

6.1.3 **Land use statistics**

The major part, 74.0%, of the land area was classified as cultivable in 1981-82 (Rama Prasad and Malhotra, 1984). The net area sown was 54.6% of total area, or 73.7% of cultivable area. Forests occupied 15.9%, other non-agricultural uses 5.7%, and barren and uncultivable land only 4.5% (Table 6.1).

Fallows accounted for 1,562,100 ha (8.2% of total, and 11.1% of cultivable area); cultivable waste for 495,100 ha (2.6% and 3.5% respectively); permanent pastures and grazing land for 1,313,700 ha (6.9% and 9.3% respectively), and other crops and groves not included in net area sown, for 328,800 ha (1.7% and 2.3% respectively of total land area and cultivable area).

Irrigation has changed the face of the land in the past few decades. The largest sown area is now in the drier parts of the state, in the districts of Belgaum, Bellary, Bijapur, Dharwar, Gulbarga and Raichur.

6.1.4 Agricultural crops

The major cereal crop of the uplands is paddy, grown on terraced fields. Among cash crops, coffee, cardamom, and arecanut are prevalent in the malnad, cashew on the lateritic lower slopes of the Western Ghats and coastal hills, and coconut in the coastal plains. In the drier plateau, jowar is the main food crop in the northern part, ragi in the southern. Cotton is an important cash crop in the dry regions, along with groundnut; coconut is important in the inland areas as much as on the coast.

Jowar (sorghum) is the major individual crop, occupying 18.8% of total cropped area in 1981-82 (Rama Prasad and Malhotra, 1984). It was followed by rice (10.4%), ragi (finger millet) (10.2%), and cotton (9.3%) . Group-wise, food crops occupied 72.6% of total cropped area, and non-food crops, 27.4%. The major sub-groups were cereals and small millets (52.9% of total cropped area) and pulses (13.9%) among the food crops; and edible oil-seeds (13.0%) and cotton fibres (9.3%) among the non-food crops.

6.2 Forest management practices in Karnataka

6.2.1 Forest resources

The total area under the control of the forest department in Karnataka is estimated variously at 3,634,200 ha (Government of Karnataka, 1980); 3,786,600 ha (Annual Report of the Forest Department, 1980-81 et seq., which ascribes the increase over previous years' figures to transfer of 'C and D' class lands from the Revenue Department under the unclassed forest category); or 3,864,600 ha (Chetty, 1985a). Remote sensing data indicated that only 2,621,700 ha were actually under closed forest, and 326,300 ha under open/degraded forest, in 1972-75; and 2,094,300 ha under closed, and 471,200 ha under open forest in 1980-81 (Saldanha, 1984).

The 'official' statistics (Government of Karnataka, 1980) give the following breakdown by legal status and forest types (Table 6.2). The reserved forests have generally survived in greater integrity than the protected and unclassed, which have been substantially cleared and occupied by cultivation. Further, moist forest types have suffered less extensive damage than the dry, whatever the legal status.

Approximately 2,800,000 ha of forest have been 'organised', with written working plans to direct and control operations.

6.2.2 **Framework of forest management**

The organised forests are being managed under the following major silvicultural systems (Chetty, 1985a):

1. Selection-cum-Improvement (SCI)	957 893	ha
2. Coppice-with-Reserve (CWR)	301 624	"
3. Conversion to Teak plantation (TEAK)	148 519	"
4. Non-teak plantation e.g. eucalypts (NTEAK)	201 022	"
5. Rehabilitation of degraded forest (RDF)	306 213	"

	1915 272	"
6. Protection forests (PROT)	628 788	"

	2544 060	"

In addition, there are some other important management objectives or crops, which get special attention both in silvicultural treatment and in harvesting operations. Where they form the major natural (or induced) crop or management objective, they may be put under territorially distinct working circles. Often, however, they occur as a subsidiary or secondary crop in association with some other major crop, or as a secondary objective. The special treatment or management regime required for them is organised in territorially 'overlapping' working circles, which thus share the forest area with other working circles. The main territorial working circle usually has precedence in any potential conflict of interests, at least in theory.

Chief among these secondary crops are bamboos and their allies, especially the species Dendrocalamus strictus (medar, solid, or small bamboo) and Bambusa arundinacea (dowga, hollow, or big bamboo). They occupy 15,452 ha under 'concentrated' working, and as much as 379,227 ha overlapping with other management systems in the deciduous and semi-evergreen forests. Sandalwood (Santalum album) occupies 165,985 ha under concentrated, and 139,441 ha under overlapping, working, mainly in the drier regions. Some other forest crops with commercial importance include khair (Acacia catechu) on 25,992 ha, coastal casuarina plantations on 1,541 ha (and extensive plantations both pure and mixed with other species in inland fuelwood plantations).

Some crops more usually associated with private enterprise have also been taken up on a minor scale by the forest department to enhance the commercial wing. Cashew (Anacardium occidentale) has been raised on 38,506 ha in the coastal slopes, while the more moist areas have been chosen for cardamom on 14,800 ha, rubber on 5,527 ha, and cocoa on 1,595 ha.

Not all the area under the department is given over to commercial or utilitarian forestry. Wildlife protection is the sole concern on 29,643 ha of sanctuary and national park, and is pursued as an adjunct to other objectives on another 882,510 ha. Collection of 'minor forest produce' and grazing of livestock are allowed, suffered, or occur in spite of efforts to discourage them, almost everywhere. They are considered 'overlapping' management systems, usually by default rather than purposive design.

6.2.3 **The environment for forestry**

The forest department has traditionally been considered a revenue-generating department, perhaps because there was always the feeling that the forest capital entrusted to it was in itself like a huge investment. Forestry was thus to be self-supporting as well as profitable.

As far as possible, therefore, the department has tried to subsume investment costs in its 'revenue' activities. Expenses on infrastructure, personnel, even plantation (in the guise of regeneration operations) are linked to the harvesting function. The department has always generated a revenue surplus, as data from 1965-66 to 1981-82 show (Annual Administrative Reports).

Timber sales have been the main revenue source. Interestingly, investment in new plantations has tended to favour fuelwood and pulpwood plantations. This reflects the dependence on natural regeneration in most of the timber bearing forests.

6.2.4 **Silvicultural basis of forest management**

The silvicultural system operating over much of the deciduous, semi-evergreen and evergreen forests is the selection or selection-cum-improvement (SCI) system. The essential feature of this system is that the crop is never cleared completely. The process of harvesting the mature trees and establishing regeneration is continuous and simultaneous on each unit of area. The crop thus consists of an intimate admixture of all age classes on each hectare.

The annual yield is calculated by approximations of the annual increment like the von Mantel formula. Annual removals are regulated by area with a volume limit superposed. Removal is restricted to trees above a certain girth limit. This ranges from 6-7 ft (1.83-2.13 m) for teak; 5-6 ft (1.52-1.83 m) for most other hardwoods like matti (*Terminalia tomentosa*), honne (Pterocarpus marsupium), nandi (Lagerstroemia lanceolata), kindal (Terminalia myriocarpa), heddi (Adina cordifolia), and others; and down to 4.5 ft (1.37 m) for other, inferior, species.

Most trees do not reach such sizes in less than a hundred years, and the effective 'rotation' is usually longer. The felling is done on a cycle of 30 to 45 years. A maximum limit is placed on the number of stems that can be removed in each hectare, from among the silviculturally available stems, in order to prevent the concentration of fellings in pockets of forest that are easily accessible or have a particularly good mature crop. This is doubly important because the desirable species (especially in the evergreen forest) do not establish regeneration if the canopy is opened up too much.

These prescriptions have not been always followed in practice, especially where extraction by the plywood or other industries have been involved (Chetty, 1985a). The resulting "depletion" in the growing stock has necessitated the reduction of the density of removals by half. The permitted removals are at present only around 2 trees per hectare (once in 30 to 45 years) in the coastal evergreen and semi-evergreen forests, and a little higher in the inland evergreen to semi-evergreen and moist deciduous forests of the Western Ghats. With increasing concern that regeneration is not being successfully established naturally, it is prescribed that planting of desired species under the canopy shade be carried out.

Some species, however, respond well to artificial regeneration under open canopy. Indeed, in many areas, the absence of natural regeneration or the high level of biotic disturbance practically precludes any choice. Most plantation activity is naturally concentrated in the less benign interior plateau, or the bare coastal dunes and denuded hills. However, teak is one species that has been raised by clear-felling and planting in the better forests of the Western Ghats.

Teak is a highly prized species due to the special qualities of its timber. Initially, variations of the uniform system were tried, taking the help of natural regeneration. Efforts were however made quite early in the history of colonial forestry to develop methods of raising it 'artificially'. With the standardisation of the stump-planting technique, teak was increasingly raised by artificial planting after clear-felling the existing crop and giving the area a good burn using the logging debris and remnant, unmarketable material. This procedure promised a more successful regeneration effort, as concentrating the logging and planting work made proper timing and supervision less difficult.

It also introduced a new element in the forest situation, as now a conscious investment was being made in the future, whereas hitherto one could argue that only the capital was being maintained. When a new asset, the growing plantation, could be built up in the clear-felled area, it could evidently also be extended to areas not containing a productive crop; and the concept could also be extended to other species. A number of choices would now have to be made; and foresters were not provided with any model, other than that of sustained physical yield in perpetuity, to make such choices.

6.2.5 History of management in the Yellapur-Mundgod forests

The study area chosen, the Yellapur-Mundgod division, contains representative teak bearing forest of the Western Ghats. The western half bears better quality crops, comparable to all-India site quality III, while the eastern half is of AISQ IV (FRI, 1959a for the stand and yield tables). The allocation to working circles in the successive plans is summarized in Table 6.3. The detailed record of management is relegated to Appendix 1. Only the highlights are touched upon here.

The first century of British control of these tracts was essentially a period of commercial exploitation of a captive resource. It was only by the end of the 19th century that forest reservation started to be taken seriously. The first working plans (Copleston, 1905; Aitchison, 1907) made a start of scientific management by fixing minimum exploitable girth limits (7'/2.13m, 6'6"/1.98m, etc.), and generally prescribing selection and improvement fellings. A 'coppice-with-standards' system was also prescribed under Miller's plan (1917) for the Kirwatti teak pole forest, on a rotation of 80 years.

Experience of these plans soon showed that teak was suppressed by shade and competition from other species. Teak regeneration was poor, further damaged by the animals of the Gowli buffalo-herders. Edie (1922) therefore introduced a 'conversion to uniform' system on periods ranging from 120 years for the better crops, to 60 years for the poorest. Much of the area had, however, to be gone over by 'improvement fellings' to clean the crop and release promising young stems.

The pace of conversion proved too ambitious, however, for the prevailing market demand, transport facilities, and staff provided. Artificial regeneration was not entirely a success. Garland (1935) reduced the annual clear-felling and planting area, but introduced the system of successive fellings in the regeneration periodic block of the uniform system. The regeneration period was pegged at 15 years, against a rotation of 120 years in the best, to 90 years in the poorest, crops. Selection and improvement fellings were prescribed for remaining areas.

Now the prescribed planting area turned out to be inadequate, and the reliance on natural regeneration in the uniform system, misplaced (Wesley, 1964). After a period of adjustment following the transfer of power, the post-independence era was one of industrial forestry. Wesley's plan (1964) grouped all the failed regeneration blocks of previous plans under a system of concentrated regeneration by clear-felling and planting teak, over a period of 30 to 40 years. The equivalent conversion period for the entire forest would be around 100 years for the good quality crops, and not fixed for the poorer crops. The major portion of the forest was, however, put under selection-cum-improvement fellings.

6.3 The major themes in Indian forestry

We have portrayed above (and in detail in Appendix 1) the sequence of decisions and responses selected by or forced on the forester over close on a hundred years of 'planned' management. The pattern is repeated, with minor modifications to conform to the particular geography and chronology of the locality, all over the Indian subcontinent. We can, therefore, use the Yellapur case as an illustration of the major themes in Indian forestry.

6.3.1 The human presence

The first major theme is the more or less inescapable presence of human 'interference', even in a relatively underpopulated area like North Kanara. Grazing, always associated with fire, is the single most serious interference that forests, and foresters, have had to contend with.

The division of interests between those who depend on livestock, and those who, like many of the forest tribes, have a greater identification with the forest and the economic opportunities provided by it as a forest, is perhaps inherent in the cultural history and pre-history of the subcontinent. The activities of the Gowli cannot be castigated merely as an 'interference' with the legitimate interests of forestry. They are a part of the land-use patterns developing on the subcontinent. Wishing away the problem by ignoring it may suit the forester's quest for an Eden of innocence, but will not halt the process of attrition in which the ultimate loss is of the productive resources of the nation.

6.3.2 The ecological limitations

The other major theme is the general failure to achieve the sustained yield silviculture aimed at. The natural regenerative capacity of the forest has failed to achieve the hoped-for conversion into a forest with the desired species and age class composition.

Beyond the damage ascribable to human, or biotic, interference, it is the ecological nature of the forest itself which often defeats the efforts of the forester. The species which come up on clearing the overwood are often not the favoured ones. Instead of teak or sal (Shorea robusta) in the respective zones, what we get are secondary hardwoods, bamboos, or inferior species of little interest to the forester. Sometimes, fire itself may be an ally in halting the ecological progression to a more moist climax, as in the case of teak in the peninsula, and sal in the sub-Himalayan 'terai'. This complicates the management decisions.

6.3.3 **The silvicultural response**

To the forester, such problems call for a silvicultural response. In the case of teak, this is well stated in the Proceedings of the All India Teak Study Tour and Symposium, Dec 1957-Jan 1958 (FRI,1959b, pp.1-3):

> "... In view of the immense importance of teak in the national economy ... and by reason of its high price and great value, even a slight improvement in the quantity or quality of production will have a significant effect. It is, therefore, necessary to devise measures to produce the maximum quantity of teak timber of all sizes, of the highest quality which the sites are capable of producing, from all existing and potential teak areas of the country, in the shortest possible time consistent with sound management practices...
>
> "...12. Areas suitable for growing large sized timber should be utilised for that purpose despite the financial advantages, if any, of working on shorter rotations";
>
> "...14. Teak is the most valuable forest crop being raised in India and teak plantations yield the highest revenue per acre of all forest crops. There is, however, a tendency to restrict expenditure on the establishment and proper maintenance of teak plantations. It is emphasized that all necessary expenditure to attain these objectives should be incurred unstintedly."

In reality, the silvicultural problem can rarely be dealt with in isolation from the socio-economic conditions in the surrounding countryside. Nor can the forester ignore administrative, political, financial, and commercial considerations. This is apparent in the history of the 'sustained yield' management of our forests.

In a sense, the British colonial administrators appear to have been more aware of this than their post-Independence successors; or at least paid lip-service to these considerations in a more convincing manner. It may also be the greatly increased pace of development after independence that has caused the more visible inroads into what is now recognised as a scarce resource, despite the efforts of the forester to protect it.

6.3.4 The broader context of sustained yield forestry in India

The sustained yield model is not in itself a sufficient guide to choosing between management options. There is now a shortage of all types of raw material, including some which were of no value a few decades back, posing higher opportunity costs.

The concern at the "gradual degradation" of the forest stock has caused a move to restrict the harvest in the hope of building up the growing stock (Chetty, 1985a). This is meant to be in the longer interests of industry. A different aim is involved in popular movements like 'chipko' (Bandyopadhyay and Shiva, 1987; the word indicates the tactic of villagers protecting trees from commercial logging by 'embracing' them). This campaign introduces the problem of unequal sharing of costs and benefits in society, and between present and future generations.

That forestry in India has to struggle against great odds is apparent. What is not equally obvious is that forest management objectives and methods are chosen on grounds consistent with either ecological or social conditions. Possibly, some of the options chosen by foresters are so divergent from the common man's perceptions of relative values and trade-offs, that a conflict of interests is almost inevitable. The traditional forester persists with his idealistic, but dogmatic, blend of conservation and commercialism, which makes him more often the target of criticism than the preceptor. Forestry usually has to fight a rearguard action to defend its actions.

In the past, the forest department was insulated by the sheer remoteness of the forests. Today, however, such considerations cannot be ignored. Unless the department makes an effort to come to terms with the new political and socio-economic situation, it may itself be ignored in the decisions being taken on utilization of forest resources.

We now proceed to the cost-benefit analysis of forest management choices in the study area. We first analyse the economic aspects of the conversion to teak of the natural forest. In subsequent chapters, we introduce the question of the costs and benefits of sustained yield management in the framework of a social cost-benefit analysis. We explore the possibility that economic analysis could pin-point the trade-offs mentioned above, and better illuminate the possible points of conflict and their resolution in this case study of sustained yield management.

CHAPTER SEVEN

FINANCIAL ANALYSIS OF SUSTAINED YIELD MANAGEMENT OF TEAK

The financial aspects of raising teak plantation as an investment activity in itself are first taken up. That is, we disregard the links with the returns possible from removing the standing crop.

7.1 Teak plantation as an investment

7.1.1 Teak monoculture on the single hectare

Divested of its links with the broader economy, a hectare of land could presumably yield periodic harvests in perpetuity, if the necessary inputs were provided. Theoretically speaking, felling and planting are mutually independent decisions. We assume that the firm can hire or purchase land either in a vacant state or by changing the use under the previous owner. The activity of raising a teak plantation could then be analysed as a self-contained option. Conversely, if there is a standing tree crop on a piece of land, the decision to clear it or not can, and according to the economist should, be taken independently of its subsequent use under forestry or other activity.

However, in practical situations this independence is probably difficult to maintain. The forest enterprise has to work with limited land and other resources. There may be varied claims on it, and it may also have to accommodate any interdependencies and externalities involved. Such considerations would modify the results of financial cost benefit analysis.

The question of the optimal rotation is of interest in the analysis of the single hectare of teak plantation, and we shall subsequently explore how decisions pertaining to this single hectare are linked to the broader context in the real world.

As in all such exercises, we will have to make a choice of assumptions from among a wide range of possibilities, whether it be with regard to inputs applied, outputs obtained, or their interrelations. We need to make these choices with limited information. We will thus be pre-empting the process of analysis to a certain extent, by limiting it to the chosen range of alternatives. This may not too objectionable if our assumptions conformed broadly to the plausible range.

7.1.2 The silvicultural requirements of teak

Regeneration of teak is not exactly generous in the conditions obtaining in our forests. This is obvious from the experience of past management and the comments of the working plan officers. Even artificial regeneration is not guaranteed of success unless a certain level of inputs is maintained through the life of the crop.

Especially important is protection from weeds like Lantana and Eupatorium, which not only overtop the teak saplings but also constitute a deadly source of inflammable material during the dry season. The next most important input is perhaps the regular thinning and cleaning of the crop. Neglect of these operations means that the trees quickly stagnate; woody epiphytes like Ficus spp., and parasites like Loranthus, often take such strong hold as to render the greater portion of the crop defective and useless. Under present conditions, growth of Lantana and Eupatorium is so virulent that considerable attention has to be given to the hygiene of the crop.

The detailed account of plantation technique and sequence of operations is relegated, as in the previous chapter, to Appendix 2. Here, it suffices to state that teak is a heavy light-demander, and is intolerant of shade. Planting of one-year old teak stumps is done on previously clear-felled and burned sites, with the onset of the pre-monsoon showers in May. Regular weeding and cleaning in the early years, and fairly heavy thinning in the later, is required.

7.1.3 Cost and benefit flows

The product assortments obtained from periodic thinnings and final fellings are assumed to follow the all-India yield and stand table projections (Table 7.1, 7.2, 7.3). The basis of converting the standard timber and smallwood volume of the yield tables into commercial outturn is detailed in Appendix 2.

Unit values of teak timber and firewood (Table 7.7) of average quality (Table 7.5) are based on depot auction rates (Table 7.6). Price-size data of individual trees (Table 7.9) are applied to the stand tables for different ages (Table 7.10, 7.11, 7.12) to arrive at the crop price-age relations used to value the standing crop at different ages (Table 7.14, 7.15, 7.16). A FORTRAN program (Appendix 3) was used to derive the crop unit values, based on the expected commercial outturn (rather than on the standard stem timber outturn portrayed in the yield tables).

Unit costs of forestry operations (Table 7.17 to 7.20) are based on rates sanctioned during 1985-1986 in Yellapur Division, and generally in Karnataka Forest Department (KFD). They are based on daily wages of Rs 9.75 for heavy, and Rs 7.80 for light, manual labour. Details are contained in Appendix 2.

The computations involved in Net Present Value (NPV) and Soil Expectation Value (Se) estimation were carried out using a FORTRAN program (Appendix 4), that allows variation in discount rate, rotation, export and transport costs, scale factors, tax or other price change rates, and inflation rates. All present values refer to the end of the planting year, when the age of the (first) crop would be, technically, zero. If it were required to refer it to the start of the planting year, these values need to be discounted by an additional year.

7.2 Economics of teak plantation under constant prices

We now discuss the financial analysis of a hectare of teak plantation. We assume, as discussed earlier, that the plantation activity does not result in any change in prices, either on the supply or the demand side. The criterion used to judge the financial performance of various alternatives is the net present value, or net discounted revenue, accruing to the hectare of bare land.

By implication, this method takes as unknown the cost of the land, its annual hire charges, or the opportunity cost of alternative benefits forgone. In essence, what is estimated is the residual rent to the land and the entrepreneur. We apply the NPV criterion successively to the case of a single rotation (the NPV which will be referred to specifically as Net Discounted Revenue, NDR, in conformity with some text-books), as well as to the theoretically more acceptable case of an infinite number of rotations, the soil expectation value Se.

7.2.1 Optimal rotations under sustained yield

At the outset, it is observed that the traditional sustained yield criterion, translated as the rotation of maximum mean annual increment, would take the crop beyond the limit of the yield table entries, 80 years. This is true of all site qualities (Tables 7.1-7.3).

Indeed, we cannot compare timber, smallwood or other products on physical grounds alone. It would therefore be difficult, even for the sustained yield forester, to argue for the rigorous imposition of the physical yield maximisation principle. Even at this stage, the influence of financial, or economic, considerations on the decision of the physical sustenance model is evident. We have to choose which product is to be maximised, and few foresters have any difficulty in deciding that it will be the timber, and not the smallwood or firewood.

The yield tables themselves do not show a culmination of the net revenue curve. The rotation would thus have to be beyond 80 years, perhaps closer to the values followed in working plans. Nor is this conclusion altered if the lead (distance by road from coupe to depot) is increased from 10 km to, say, 80 km (which on all counts can be considered an upper limit for the forest areas of the Western Ghats in the state). These observations are based on the results of financial analysis with zero interest rate, Tables 7.21 and 7.22 for SQIII and SQIV, respectively.

7.2.2 Optimal rotations under positive discount rates: SQIII

A positive discount rate is required to account for the cost of capital, whether from internal savings or from external borrowing. As the discount rate is raised, the NPV of the crop falls (Tables 7.21.i), and so does the rotation of maximum NPV.

We consider the example of the SQIII hectare with no taxes added to the depot auction prices. From the figures, it is apparent that NPV falls but gradually as the rotation period is extended. This is ascribable to the frequency and value of intermediate returns. For the single rotation NDR, the optimal rotation is still more than 80 years at 2%, and a not too short 75 years at 3% discount rate. At 5%, it has fallen to 55 years, at 6% to 35 years, and by 10%, to 20 years. At 13%, the NDR of an 80-year rotation on SQIII has just begun to become negative.

Though it seems to indicate that the 80-years crop has a fairly high internal rate of return (IRR) of 13%, the NDR is only a residual, which does not take into account the possible payment for the services of the land, or of forgone alternative uses which might produce a net profit.

One should therefore be cautious in drawing conclusions from piece-meal economic analysis. Isolated project alternatives could easily be taken up and shown to be highly profitable, for the simple reason that unidentified costs have been ignored. Cost benefit analysis would then be reduced to the status of "rubber-stamping" selected project proposals (Price and Nair, 1984). The market, however, is expected to be able to identify and evaluate costs (and benefits) on a much wider scale than possible for the single entrepreneur.

In our context, the market is supposed to recognize the possibility of achieving a higher NPV by investing in, say, a 35-year rotation, than in a 80-year rotation. The cost of the hectare is decided by the rental it can earn. Thus the price of the hectare will be higher than the 80-years entrepreneur could afford to pay in the long run. Either he has to accede to the market pressures, and shorten his rotation, or he will be squeezed out by his competitors (or the loan sharks).

Even the 35-year rotation would not, however, pay for the services of the land, at higher interest rates. For instance, the optimal rotation at 12.5% is as low as 15 years. Indeed, the difference between an affordable rotation and one that merely showed a positive NPV, would be even more accentuated, if the time horizon were the same: five crops of 15 years rotation could have been gone through to one of the 80-year rotation in the same period. Assuming that there is no foreseeable limit to the number of rotations possible on the single hectare, the proper measure of net value would be the present value of an infinite series of rotations, or the **soil expectation value, Se.**

In comparison with the NDR of a single rotation, there is a general contraction of the optimal rotation at a given discount rate. Now the rotation of maximum Se ranges from >80 years for 1%, through 75 years at 2%-4%, and a much lower 30 years at 5% and so on. The maximum discount rate that can be sustained is around 18%, with however an extremely short rotation of 10 years. Beyond this discount rate, even the 10-years rotation shows a negative Se.

The Se criterion dictates shorter optimal rotations than the NDR, for a given interest rate. This is because postponement of the harvest now implies delaying not only the first, but also each subsequent final crop to a greater and greater extent; this is an added cost. The higher the net returns expected from the final crop, the greater is this cost. The firm needs to curtail such losses by bringing forward the harvesting.

The rotation-contracting effect of lengthening the time horizon is not very apparent at low interest rates, for intermediate yields make the NPV fall very gradually with increasing rotation. At around 5%, however, the cost of delaying future returns is high enough to force a substantial reduction in optimal rotation.

The overall conclusion is that rotations of 'respectable' (to a sustained yield forester!) lengths of 75 years or more are justified only if the discount rate is 4% or lower. Intermediate rotations are indicated up to 5%, and only short rotations beyond that, up to a discount rate of 18% or so, when even the shortest conceivable rotations fail to give a positive net rendering. One would then have to look at other possible uses of the land; these may be other forestry options (perhaps characterised by a lower intensity of management, lower initial costs, dependence on natural growth, etc.), or they could be non-forestry ones.

The above conclusions are broadly valid even for distant crops, the lead from which we have assumed to be of the order of 80 km. The higher extraction or transport costs (also perhaps wage costs in the more remote coupes) imply lower returns, and would be expected to mitigate to some extent the burden involved in postponing felling. The value of teak is so high, however, that transport costs form only a small part of landed value of timber, and this effect is weak.

Comparing the optimal rotations of the nearby hectare (lead 10 km) and the distant (80 km), there is no noticeable difference at lower interest rates. The maximum interest rate that allows of fairly long rotations of not less than 75 years is 4% for either lead. At 5%, the Se is maximized at 30 years in both cases; at 6%, 20 years. A slight gap is seen only at 10%, when the Se is maximized at 15 years on the nearer hectare, 20 years on the distant. This difference however does not appear in the single-rotation NDR criterion.

It must be remarked that the differences in NPV of alternative rotations become quite small as the discount rate rises. One reason is the broad plateau in NPV values due to the frequent intermediate yields. Given the inevitable uncertainties in the values of the different parameters and variables, and the many approximations we have made, the concept of the optimal rotation may well be of academic interest rather than of practical significance. The differences, however, may be important in a species which did not have such a high unit value relative to extraction or planting expenses, or one which had little intermediate yield to mitigate the cost of waiting.

The case of teak is however useful to illustrate the broad trends. The increase of extraction costs was seen to induce the lengthening of the optimal rotation. This effect lends some support to sustained yield rotations. The support is gained at the cost of net revenue, for the Se becomes completely negative at a lower discount rate, around 15%, for the distant hectare, compared with 18% for the near. Thus the overall financial viability of planting the distant hectare may be called into question if capital is scarce, pointing to the dependence of economically afforestable area to assumptions regarding price and price trends (Price and Dale, 1982).

7.2.3 Optimal rotations under positive discount rates: SQIV

Broadly parallel results are obtained in the case of SQIV hectares, although the overall performance is much poorer (Tables 7.22.i). We may take the near hectare, under the soil expectation value criterion, as an example. The optimum rotation now stays above 80 years up to 4% discount rate. It falls to a precarious 20 years at 5%, and at 7% the Se is negative at any rotation. For a distant hectare (lead 80 km), the Se-maximising rotation stays above 80 years up to 4%; at 5%, the Se is negative for any rotation, though the loss-minimising rotation is again 20 years.

Once again, the fall in NPV can be seen to be very gradual. Indeed, there is a tendency for a secondary peak in NPV to develop at a longer rotation, indicative of the later occurrence of the quality increment in the SQIV crop. The fact that the yield tables stop at 80 years prevents a clearer demonstration of this effect. It causes some dramatic changes in optimal rotations, however, as the potential costs of postponement and gains from increased revenue are so finely balanced. One instance is afforded by the 4% discount rate case.

There is a tendency for SQIV rotations to be a little longer than SQIII rotations, for a given discount rate. For instance, at 4%, the Se-optimal rotations are 60 years for a (near) SQIII hectare (75 years for single-rotation NDR), and >80 years for the SQIV hectare. In one sense, the opportunity cost of postponing future returns becomes less significant, the lower the forgone value. However, the increase in value is sustained at a higher level for the better quality, encouraging the retention of the crop that much longer, so that at, say, 5%, the optimal rotation on a SQIII hectare is longer, 30 years, compared with 20 for SQIV.

Incidentally, there is not much difference in the optimal rotations for near and distant hectares in the case of SQIV plantations, except for cases where the secondary peak at a long rotation suddenly gives way to the primary peak at a very short rotation: e.g., at 4%, Se-optimal rotations are 80 years for the distant hectare, against just 20 years on the near.

7.3 Economics of teak plantation under variable conditions

We now consider the effect of changes in the value of various parameters or external factors. There is the possibility that the values may differ from those assumed by us, and that the values themselves may change in the course of time. We now test the sensitivity of the results to these possible changes, and so assess their implications.

7.3.1 Optimal rotations and the effect of taxes

Changes in extraction costs and interest rates have been broadly considered above, and the next most interesting factor is probably the output prices. These have been based on the open auction rates, and hence are unlikely to be far off the mark. However, the price to the government includes taxes, which have not been included so far.

The level of taxes in 1985-86 was approximately 12%, consisting of 8% sales tax going into the general revenue pool, and 4% 'forest development tax' going into a fund earmarked for forest development. Adding this to all the unit prices increases the net present value by more than 12%, the increase being especially marked at low interest rates (Tables 7.21.ii and 7.22.ii).

The optimum rotations are not altered within the limits of our data, though there is an occasional evidence of a tendency to shorter rotations. The interesting effect, however, is in the maximum discount rates that can be sustained by a given rotation (the IRR). Not surprisingly, these are higher than before. For instance, on a SQIII hectare, the 80-year rotation favoured by the forester now shows (for the 10 km lead) a positive Se up to a discount rate of 15%, against 13% before taxes. For the far SQIII hectare, the respective IRRs of the 80-year rotation are 12% with taxes, 10% without (Table 7.21.ii).

Similar results are obtained in the case of a SQIV hectare: with 12% taxes added on to all output prices, the 80-year rotation remains viable up to 5%, against 4% before taxes. At 6%, on the near hectare, the Se is positive up to rotations of 50 years, against 30 years without taxes (Table 7.22.ii).

Such considerations might be relevant when a summary analysis of a limited range of options is done. Otherwise, under the rigorous conditions of Faustmann's formula, there is no essential change in the non-optimality of long rotations at higher rates of discount.

7.3.2 Optimal rotations under one-time increase in output price

Indeed, a once-for-all rise in the price of all outputs has a tendency to make the optimal rotation shrink, if anything, as the opportunity cost of postponing incomes looms larger. The 'neutral' application of the rise to all ages and all commodities does not introduce any differential advantage to retaining the crop to an older age, as would be the case if, for instance, the tax rates were higher for larger timber or lower for smallwood.

Thus, if all output prices were multiplied by a factor of 1.5 instead of 1.12, the optimal rotation shrinks from 15 to 10 years at 10% discount on a near SQIII hectare, although the maximum IRR now goes up to 25% for the shortest rotation (against 18%), and 20% for the 80-year rotation (against 13%) (Table 7.21.iii). For the near SQIV hectare, similarly, the maximum sustainable IRR goes up to 10% (against 6% previously) for the short rotation, and to 7% for the 80-year rotation (against 5%) (Table 7.22.iii).

It must be remarked that these are, of course, not exact limiting interest rates. They are obviously fractional, and the round figures given above represent approximations. The Se is not precisely zero at these quoted rates, but of the order of a few hundreds or thousands of rupees. Again, the optimal rotations are not to be taken dogmatically, as there is often but a slender margin of difference in Se between different rotations.

As pointed out before, the fall in NPV with increasing rotation is often quite slow, apart from the tendency for a second peak noticeable in SQIV.

On the whole, a once-for-all increase in the returns only tends to strengthen the case for shortening the rotation. This would be the case for any effect which had a similar 'neutral' ameliorative effect. An improvement in the returns bolsters the case for teak plantation as an economic investment, if the comparison is with other alternative uses for the resources. This improvement in the climate for forestry is however not obtained without a price. The sustained yield forester now faces a dilemma between the economically most paying short-sighted time-profile within the teak option, and the professionally more satisfying but financially less competitive long rotation of maximum physical sustained yield.

7.3.3 Optimal rotations and uneven price increases

Not all effects, however, need be so 'neutral' as an *ad valorem* tax. Our assumptions on relative prices might themselves be unrealistically weighted in favour of those outputs that are relatively abundant at earlier crop ages.

One case in point is that of smallwood. The rate used for all smallwood, Rs 472.91 per cmt(solid), is based on the weighted average rate, Rs 250.64 per cmt(stacked), of teak 'firewood' at sales in December 1984 at Mundgod (average Rs 82.70 per cmt(stacked)) and Kirwatti (Rs 259.10 per cmt(stacked)). This may be an over-estimate of the rates that would be offered on average for the firewood produced at younger ages like 10 to 30 years. Teak is not much favoured as a fuel, and high rates for firewood extracted from high forest coupes are usually because of large-diameter sawable billets included in the stacks.

The above considerations may explain the fairly wide variation in auction sale rates: in 1984, for instance, they included, apart from the two disparate rates quoted above, rates of Rs 180.44 per cmt(stacked) in

Alnavar (May 1984), Rs 288.88 in Chipgi depot (December), Rs 309.26 for 'billets' in Mundgod (December), Rs 512.82 for firewood in Mundgod (May), and Rs 224.67 for 'billets' in the same sale.

Thus the rate for teak firewood is difficult to predict, and it might be safer to use the rates obtained for ordinary, non-teak, firewood. These were Rs 205.40 per cmt(stacked) (9/85, Kirwatti), Rs 126.86 (12/85, Mundgod), Rs 82.70 (12/84, Kirwatti), and Rs 135.25 (5/84, Mundgod) for 'firewood', and Rs 166.25 per cmt(stacked) (12/84, Mundgod) for 'billets'. On average, then, a ruling price for 'smallwood' might be considered to be half that assumed so far, which works out to Rs 236.46 per cmt(solid).

The following examples illustrate the results when the financial analysis is done with other parameters unchanged, apart from the halving of smallwood price. For a SQIII hectare (Table 7.21.iv) at 10 km lead, the proposition becomes uneconomic at any rotation, at a discount rate of 10%, against 18% previously; the long 80-year rotation is still viable, though far from <u>optimal</u>, up to 7% only, against 12% previously. On the other hand, the <u>optimum</u> rotation remains somewhat higher for a given discount rate: 75 years at 4% (against 60 years), 50 years at 5% (against 30 years), 40 years at 6% (against 20 years), and 30 years from 7% to 9% (against 20 to 15 years).

For the distant SQIII hectare at a lead of 80 km, the maximum IRR attainable is 7% (optimal rotation 35 years) against 15% (15 years); the long 80-year rotation has a positive Se till 6%, against 10%. On the other hand, the optimum rotations are higher; at 4% 75 years (against 60), at 5% 55 (against 30), at 6% 50 (against 30). At the ceiling of 7.5%, it is 30 years (against 20).

The pattern is repeated for SQIV (Table 7.22.iv), except that here the maximum discount rate sustainable is much lower, 4% for the near hectare, 3% for the far. On the near hectare, the optimal rotation remains above 80 years throughout the viable range of interest rates. This is slender basis for differentiation, however, for the optimal rotation is 80 years or over for the previous smallwood price as well, only falling to 20 years at 4% and then only for the near hectare.

On the whole, the results are affected substantially by the smallwood price chosen (though the response of the optimal rotation period or Se may not be technically termed elastic). The dilemma for sustained yield forestry is seen repeatedly. On the one hand, the better the returns expected, the stronger is the pressure to realize them earlier. The poorer they are expected to be, the longer they can be postponed. On the other hand, the competitive vigour of the undertaking then becomes weaker. Obviously, the economy will not be charitable to forestry if it tries to claim priority on the strength of its economic performance, but sacrifices this to the sustained yield principle in practice.

7.3.4 Optimal rotations under continuous inflation in relative price

A factor which increases the returns, the later in the crop life they occur, will counteract the forces acting to make the sustained physical yield management uneconomic. One such factor could be a continuous inflation in output prices relative to input prices. This is helpful in raising the value of the optimal rotations.

We illustrate this effect by using a 2% rate of inflation (strictly, the expectation that output prices will continuously inflate at 2% per annum), with all other unit values remaining constant over time (Table 7.23). Now the optimal rotation on the near SQIII hectare (Table 7.23.i) stays at 75 years up to a discount rate of 5%, against only 3% without inflation. However, it still falls to 20 years by 7.5%, to 15 by 10%, and remains at 10 years or under all the way to 22% (against a maximum IRR of 18% previously). The 80-year rotation retains a positive Se all the way to 15% (against 12%).

For the SQIV hectare, the optimal rotation remains at 80 years till 5% (against 3% previously) falling thereafter to 20 years, becoming all negative at just above 10% (above 6% without inflation). The 80-year rotation now retains a positive Se up to a discount rate of 7%, against 5% previously.

With higher inflation rates, long rotations retain not just a positive Se, but are optimal as well for higher discount rates (Table 7.23.ii). For the SQIII hectare (10 to 80 km lead), a discount rate of 10% brings the optimal rotation down to 20 years even with a 5% inflation rate. At a higher 7.5% inflation, the optimal rotation is 75 years up to 11% discount rate, while with a 10% inflation, it is 75 years even at 13% discount.

7.3.5 Optimal rotations and annual administrative charges

Another question that could be raised is whether the level of annual administrative charges we have assumed is realistic, and what the effect would be of varying them. The criticism has been made of applying the Faustmann formula to the 'marginal' hectare, that it underestimates the costs of setting up and running an investment project, thereby inflating the NPV or Se (Grainger, 1968). If so, the annual charges ought to be higher than merely the costs of supervision. The Se would be lower, and probably the result would be favourable to longer rotations.

If these costs are assumed to be constant throughout the life of the enterprise (if they are _net_ investments, for instance) there should be no effect on the _marginal_ costs, and hence no shift in optimal rotations; the production decision is not affected by a change in the level of fixed costs. However, the lower the discount rate, the greater will be the change in absolute terms in the NPV. It may therefore have a serious implication for the financial viability of the borderline cases where the Se is not very high.

The estimate of Rs 50 per year for the annual administrative charges was arrived at as given in Table 7.17(i), by adding to the pay and allowances of the recommended territorial staff, Rs 26.89/ha, the distributed divisional expenditure on administration, Rs 22.41/ha. Of other expenditure items, silvicultural expenditures are already incorporated in our plantation cash flow. What is left is the annual maintenance of depots, buildings, roads, and water supply installations, about Rs 2,068,700, and capital expenses on new buildings, roads, and water supply installations, about Rs 1,290,000. When distributed over the 148,886 ha of Yellapur division, this would mean an addition of Rs 13.90/ha toward annual running expenses, or of Rs 22.56/ha if capital investments were also included as an inevitable accompaniment.

Adding a round Rs 25 per annum to the previous cash flow, with other parameters remaining as before, the Se on the SQIII hectare falls moderately, as expected (Table 7.24). At 1%, for example, there is a fall of Rs 25/0.01, or Rs 2500, at all rotations. This merely shifts the Se curve downward, without affecting the rotation of maximum Se. The maximum IRR also falls marginally.

7.3.6 The financial viability of teak plantations: summary

The broad conclusions of our analysis so far are as follows:

i) Teak plantation shows a positive NPV on SQIII hectares for fairly high interest rates, up to 18% for the near, and 15% for distant, hectares. For SQIV, however, even the fully stocked plantation becomes a net loss, if the interest rate is at or above 7% for near, and 5% for distant, hectares.

ii) Long rotations of 75 years or more, though not optimal, still show a positive net present worth, up to moderately high interest rates on SQIII: below 14% for the near, and 11% for distant, hectares. On SQIV, the 75-year rotation has a positive NPV as long as the interest rate is below 6% for the near, and 5% for the distant, hectare. If land is a captive resource with zero hire cost and no alternative use, then even such sub-optimal management options can get by the net present worth criterion, if used in an ad hoc, or piece-meal, manner and especially for the single rotation.

iii) If the cost of postponing future revenues from an infinite series of rotations is also considered, and the internal opportunity cost of the keeping the crop on the land instead of replacing it is also incorporated, the viability of long rotations becomes less assured. The optimal rotation falls to below 75 years for interest rates of around 4%, except for the distant SQIV hectare which however is completely unprofitable at 5%.

iv) The better the expected returns, the greater is the tendency for economic criteria to contract the optimal rotation. Effects which are selective in relation to different products or different ages or time periods, however, have biased effects which may favour lengthened rotations as well. An expectation of continuing inflation in output prices is a good example. While the realism of a perpetual inflation may be questionable, values within the range of recently observed rates of inflation in forest product prices (relative to the general inflation rate) can suffice to make long rotations admissible under fairly high discount rates.

The case for long rotations under sustained yield forestry, if not justified on some 'fundamental' principle that questions the basic premise of economic criteria, can at least be compatible with these criteria under certain combinations of discount and inflation rates. However, we have dealt so far with teak plantation as an investment opportunity, whereas it is not an independent activity in the real context. As seen from the record of management, the planting of teak is intimately bound up with exploitation of the existing forest.

Indeed, the urgency of the need to regenerate and improve the forest is often used as an excuse to make a case for funds for planting. The latter in turn justifies the exploitation of the existing, natural crop. If there had been no teak-bearing forests to clear, it is unlikely that funds would have been continuously provided for raising plantations on any large scale as a purely investment programme. It is to these aspects - the conversion of the existing forest - that we turn now.

7.4 Rotation, conversion, and financial criteria

Plantations are a part of the regeneration programme of the forest department. The aim is, usually, to regenerate the existing forest, converting it into a healthier, faster-growing crop in the process. Thus at least two questions come up immediately: the system of removing the existing crop, and the nature of the successor crop or land use required to achieve some sort of optimality. Sustained yield forestry has traditionally given priority to the second aspect. The ideal is that the whole forest will finally become a self-contained sustained yield unit that will produce the same (maximum) quantity of mature timber year after year in perpetuity. Moving toward the ideal, however, is intimately bound up with the sequence of decisions taken on how to exploit the existing crop.

7.4.1 The planting decision

Long rotations may be permitted even under financial criteria under certain conditions, e.g. low discount rates, continuing inflation in real (relative) price of timber. Even if this is accepted, however, the question remains, of how much plantation to take up.

For a private entity, land is not free. A potential rotation is precisely that - nothing more than a tentative decision that has to be made operational relatively far in the future. It should not, therefore, have much bearing on the decision of how many hectares to plant, as long as land-owners and investors are confident of achieving the predicted yields and returns. On the other hand, there is little probability then of achieving a normal gradation of age classes on each property. The perpetual cycle of inputs and returns aimed at by the sustained yield forester will be sacrificed.

Under such circumstances, it would be left to market forces to ensure adequate supplies to meet future demand in successive time periods. Whether the market can identify gaps in the potential supply of given periods, and whether the response of investors will help in filling such gaps, is difficult to predict.

Suppose investors have gone into current plantations on a large scale, with a potential rotation of, say, 70 years, under given expectations of a continuous inflation. This might indicate to the market that future supplies will be substantial: not just in the 70th year from now, but in earlier or later years as well, since there is great flexibility in the timing of harvest. The assurance of liberal future supplies might in turn dampen the expectation of continuous inflation, slowing down the current rate of planting. The ultimate effect might then be a contraction of the rotation period.

On the other hand, if planting is undertaken on the expectation of a given price in the future, rather than of a steadily increasing price, the market might respond by revising the price expected downward, which results in rotations being lengthened. Thus the ramifications of current decisions might push market prices in either direction, depending on the interplay of resources and expectations.

In either case, however, the competitive strength of forestry as compared with other uses for the resource might well be weakened, and the overall rate of investment in teak plantation reduced.

7.4.2 Sustained yield and the cost of postponing planting

Even if conditions were such as to make the planting of teak on SQIII or even SQIV land profitable, even optimal at long rotations, this does not necessarily defend the decisions that would be taken under (maximum) sustained yield management. For there are costs involved in failing to use all the resources available, like land, for this optimal enterprise.

Two forms of the problem can be met with in our study area. One is that the standing crop is retained for conversion over a long period of a century or more. The other is that the pace of planting up is limited by the annual rate of conversion in order to maintain an approximation to the normal series of age classes (Chandras and Grayson, 1968).

An estimate of the trade-offs involved can be made for some of the hectares in our study area that have been described as completely exploited in the past, but which lie unregenerated under sustained yield management. They comprise some areas in the better quality western blocks, as well as others in the poorer easterly crops (Appendix 1 and Table 6.1).

The Conversion WC was organized as follows. The 4,783 ha of SQIII crops (grouped under two felling series FS1 and FS2) were to be converted to teak over a period of 27 to 30 years, at the rate of 166 ha a year. At this rate, it would take a subsequent 60 years to cover the remaining 60% area, which of course works out to an average conversion period of 100 years (existing plantations were taken to represent 10-13 years' annual crops). The 8,834 ha SQIV areas (FS3, 4, 5) were to be converted over a period of 30 to 40 years (20 years in a few compartments in the extreme south-east), at the rate of 296 ha a year.

If teak plantation were profitable, at <u>any</u> rotation, then it would seem desirable to replant these 13,617 ha in FS1 to 5 as expeditiously as possible, rather than at the rate of 462.2 ha a year over a period of 30 years. This is especially true since a large part of these hectares had been felled in the past, and were now given over to "rank growth and bamboos". At present, these hectares could be assumed to be carrying fairly sparse, not very productive, growth.

The financial viability of the SQIV plantations would, however, depend fairly closely on the rate of discount adopted, though as seen above the optimal rotations might be <u>longer</u> in the case of financially less profitable SQIV hectares than for SQIII hectares. This could, however, be left open to decision in the future; of essence now is the loss implied by keeping all these hectares idle in order to build up a regular series of age gradations under the regular forest model.

Some other land use might conceivably be compatible with the minimal management regime currently followed on the crops awaiting conversion; other possibilities could exist of using the land productively with a higher level of management. Then these forgone opportunities would have to be counted as a cost of conversion to a uniform, regular, 'normal' forest.

From the forestry sphere, the natural exuberance of bamboo suggests the possibility of working it on a 3-year silvicultural cycle. Alternatively, three or more rotations of a fuelwood or pulpwood species could be got through in 20 to 30 years, or fodder and pasture trees could be raised alongside in a multi-purpose plantation. Such possibilities would have to be considered in deciding the best custodial use of these exploited hectares.

7.4.3 Accumulated product in the existing crop

If alternatives of the kind discussed above are ruled out, there is still the cost of delaying harvest of the accumulated product. We first discuss the assumptions regarding output volume and value from the regeneration Periodic Block (PBI) areas of the conversion WC, and then go on in the next section to the costs of a delay in conversion.

The average stocking of teak (above 12"/305 mm dbh) in each of the felling series is displayed in Table 7.25, based on enumeration figures in Wesley (1964). Since the diameter class distribution of teak stems is available, the average unit value of the teak is calculated as in Section 7.1.3, using the FORTRAN programme in Appendix 3. The total log content of teak is again estimated using the previous assumptions on average outturn, etc. The unit values represent the auction rates that would be obtained at the depot.

Teak is not the only species, of course. The biggest stems of teak are probably either remnants in an otherwise heavily exploited crop, or individuals left behind amidst other, more shade-tolerant, species. The latter will probably gradually replace teak, except, of course, for continual disturbance by fire and grazing, which discourages the evergreens (or may ultimately dispose of both).

Since the conversion WC areas have "generally been selected from compartments that were subjected to total exploitation in the past", even the non-teak timber outturn is not expected to be very high. Test plot data are discussed by Kushalappa (1984). Teak timber formed only 0.3% of all timber obtained by clear-felling the existing crop in compartment XXXI-5 (in Yellapur range, but not in our study area), and 1.15% from the natural regrowth on a plot clear-felled once 20 years previously in sub-block 35 of Kirwatti Range, in the northern portion of the study area. Teak timber was a higher proportion, 14.3% of all timber, in compartment XIII-23 (SQIII hectares in the northern part the Conversion WC). Wesley's estimate that junglewood timber would be three times teak seems, if anything, to be on the low side.

One would generally expect the more moist sites in the better quality FS1 and FS2 to bear the higher proportion of junglewoods. The intensity of removal of teak in the past would also have a significant influence on the present composition of the timber output. Accepting the estimate of the Working Plan Officer, which is 3.0 cmt junglewood timber for every cmt of teak, as based on field observations, the teak and junglewood outturn per hectare would be as shown in Table 7.25.

We also need to put a unit value to the junglewood timber. In the absence of detailed data on the diameter class composition of the junglewood crop, we resort to gross estimates of the price of junglewood timber relative to teak from auction sale data. The unit value of non-teak timber was assessed by Wesley at Rs 200 a 'ton' (50 cft), against Rs 650 per 'ton' for teak, a ratio of 0.308. This is probably an under-estimate, especially as the better quality teak would have been largely exploited some years prior to the final fellings in the regeneration block. Auction sale prices obtained in the December 1984 sales in Mundgod and Kirwatti depots (Table 7.6) gives an average price ratio of 0.457. We use an overall ratio of 0.400 for the unit price of junglewood timber relative to that of teak timber.

The output of firewood has not been estimated by Wesley. According to the all-India yield tables for teak (FRI,1959a), for SQIII, the ratio of smallwood volume to 0.75*[standard timber volume] (to approximate the log outturn in place of the standard volume) fell from 11.852 for a 20-year main crop, to 0.339 at 80 years. For the secondary (thinning) yield, it fell from 7.667 at 40 years to 0.471 at 80 years. For the SQIV main crop, it rose from 1.354 at 30 years, to 2.955 at 70 years, falling thereafter to 1.816 at 80 years. For the SQIV thinning yield, it fell from 4.667 at 60 years to 2.333 at 80 years. The crops younger than the lowest ages referred to above, however, would yield only smallwood. For the intermediate SQIII/IV crop, it fell from 70.67 at 10 years, through 11.56 at 30 years, to 0.722 at 80 years for the main crop, and from 21.33 at 45 years to 0.933 at 80 years for the thinning crop.

The wide variation is thus not very reassuring for the prospect of estimating the outturn of firewood in our conversion blocks. In a real crop, however, inclusion of trees below 12" dbh, and of branchwood volumes, would increase the smallwood percentage. In the study by Kushalappa (1984), for instance, 20-year old regrowth on a previously clear-felled plot averaged 4.038 cmt(log, solid) timber per hectare, 11.414 cmt(solid) of firewood, poles and fenceposts, for a ratio of smallwood to timber of 2.827. For another estimate, the logging contracts notification of Yellapur division for 1985-86 indicated average ratio of firewood (solid cmt) to timber (logs, solid cmt) in the conversion WC (FS3) of 0.845 for teak, 0.827 for non-teak, 1.025 for all species (the last covered coupes with a higher proportion of firewood, not included in the separate calculations for teak and non-teak).

For the Selection WC areas in the westerly compartments, the ratio averaged 0.584 for teak, 0.881 non-teak, 0.833 overall; those in the easterly selection coupes were 2.556 for teak, 2.201 non-teak, 2.157 overall. These coupes showed the highest relative proportion of firewood, indicative of the poor timber values.

The range of possible values for the ratio of smallwood to timber is therefore considerable. We choose a figure that is on the higher side, to reflect the generally poor condition of the remnant crop in most of the "completely exploited" regeneration areas, but not too high: the ratio of 1.50 is thought to be a reasonable compromise in this regard.

For unit values of firewood, we use the auction sale rates in December 1984 sales in Kirwatti and Mundgod, Rs 250.64 per cmt(stacked) for teak firewood and Rs 95.35 per cmt(stacked) for junglewood firewood (Table 7.6), for a ratio of 0.380. We use this figure of 0.380 to derive the unit value of junglewood firewood from that of teak firewood.

7.4.4 Sustained yield and the cost of delayed conversion

For the evaluation of the total value per hectare, we use the estimates of average outturn of teak timber in each felling series given in the working plan. These volumes, expressed in 'tons' of 50 cft each (presumably log volume, quarter-girth, underbark, or qgub), are fairly close to the volumes calculated on our derived outturns per tree, if we restrict timber outturn to 'sound' trees (cf., Table 7.25).

We further assume that there will be no increment during the period, a rather pessimistic view, but one supported by the high proportion of overmature and stagnating stems. Apart from this, they are the stems rejected at past fellings, and hence prone to be mishappen, damaged, or otherwise below par.

Using these values, we can work out the loss due to a delay in final felling of the PBI areas in Wesley's plan. For instance, the 1,883.4 ha of SQIII area in FS1 are being carried mainly to provide for an orderly succession of age classes in the future crop instead of being 'liquidated' forthwith. They could yield, on average, about 9.318 cmt/ha of teak, valued at Rs 4,341.68 per cmt (log, solid) at the depot, and 27.95 cmt/ha of non-teak timber, at Rs 1,736.67 per cmt (log, solid). This is the sort of yield expected in a fully-stocked plantation of 35 years or so. The immediate (landed depot) value of the teak and junglewood timber alone is thus about Rs 88,955/ha, at the depot.

Exploitation of each hectare is contingent on the exploitation of other hectares; it can no longer be considered in isolation. The financial analysis presented in Table 7.26 is for a property of 100 ha worked on the 100-year conversion-cum-rotation period of the working plan. The annual costs are only the administrative charges of Rs 50/ha, and the fire protection cost of Rs 19.66/ha, which we assumed for the plantation. It is the NDR of one cycle that is of relevance here. The 'soil expectation value' has been included in the table, however, to demonstrate that it is hardly different from the NDR at higher discount rates (e.g., 10% and above).

We consider the case of the near hectares in Table 7.26(i), in which we restrict the outturn to teak timber. At a 0% rate of discount, the NDR is as high as Rs 32,661/ha; at 5%, the 100-year cycle reduces the net present worth to Rs 6,483/ha. At 10% discount rate, the net present worth of a 100-ha property with this sort of teak crop, when liquidated over a 100-year cycle, would be only Rs 2,178/ha. This loss, merely on account of postponing the exploitation of remnant stock, may be compared with the first year plantation expenditure of about Rs 3,500/ha. The financial return sacrificed by strict adherence to sustained yield, from just the teak component on just one hectare of our property, represents about 7.5 hectares' planting if the discount rate were 5%, and 8.7 hectares' at 10%.

To the loss in present value caused by postponement of exploitation, we may also add the value of a replacement crop, the soil expectation value that can be expected under teak plantation at the same discount rates. At 10%, on a (nearby) SQIII hectare, this is only Rs 7,714/ha, on a rotation of 15 years; for the 80-year rotation, the Se would be Rs 2,446/ha. The present worth of the first 80-year rotation itself would be Rs 2,445, which means that the subsequent rotations add just Re 1 to the NPV, a good indication of how little difference it makes under financial criteria to plan for perpetual flows. At 5%, the Se of the 80-year rotation is a respectable Rs 23,228/ha, and of the optimal, 30-year rotation, Rs 29,404/ha. Added to the cost of postponing current exploitation, therefore, is the cost of postponing the potential gain in net worth from the successor crop as well.

The loss in the liquidation value occurs even in the SQIV areas of FS3 to FS5, though they carry poorer stock than the westerly SQIII compartments. For example, FS3, in the extreme north-east, had much less volume per hectare than FS2, with a lower unit value of teak timber, Rs 4,105.46, than that estimated for FS1. The value per hectare is only about a third of FS1.

The NPV figures are shown in Table 7.27(i). The net value of the teak timber alone would be around Rs 11,404 if exploited immediately. If harvested over a period of 100 years, it would be only Rs 4,573/ha at 0% interest, because of the drain of administrative expenses. These, however, may be in the nature of committed expenditure, to be incurred regardless of the harvesting pace.

At a 5% discount rate, the NDR of the teak timber is only Rs 908/ha, while at 10%, it would be a mere Rs 457/ha. At 5%, the SQIV teak plantation is worth Rs 2,713/ha on a 20-year rotation, and Rs 972/ha on an 80-year rotation. At 10%, the teak option has a negative Se all the way, so that the loss of postponing the replacement crop is not there. But that does not mitigate the loss due to keeping the present, and stagnating, stock on all these hectares.

The burden becomes greater when we add teak firewood (Table 7.26.ii, 7.27.ii), and then junglewood timber and firewood as well. The last case can be derived from that of teak timber plus firewood, as the volume is three-fold but unit value about 0.4 times, so that the overall value added by the junglewood component would be about 1.2 times that of the teak. In other words, all the values mentioned above would be more than doubled if all component product streams were considered. Thus applying the financial criteria will dictate the mining of remnant timber regardless of the future crop.

The loss computed by the above method is lowered if, instead of the 100-hectare property liquidated over 100 years, we limit our consideration to a 30-hectare property exploited over the 30-year average period of the plan. This implies setting aside the question of the hectares representing the remaining 70 years' crops. In the present working plan, as explained above, these hectares were allotted to the selection-cum-improvement working circle, and hence cannot be considered totally unproductive. Even so, the loss is still substantial, and is added to the postponement of potential returns from replacement teak plantation or alternative use of the land.

7.5 Mitigating considerations for sustained yield

7.5.1 The impact of the financial criterion

Applying the financial criterion is bound to create a dramatic impact. Most ominously, by separating the felling and planting decisions, regeneration is likely to be abandoned as financially unviable on inferior hectares.

From the economic point of view, relegating the exploitation of unproductive crops to the future can be justified on one ground only: that the product is unsaleable, and the resources occupied have no opportunity cost. These conditions probably obtained during the early period of the century, and between the world wars. The best timber was then creamed off, leaving the inferior teak and much of the secondary hardwoods in the forest. The present remnant asset was therefore built up more or less without the opportunity cost of the economist.

That, however, is no longer true. Though the present forest might be 'god-given', retaining it today does constitute a cost to society. An optimal use of resources requires that the locked-up capital be converted into other forms. An explanation for the slow pace of conversion might, however, be sought in economic conditions obtaining in the past.

7.5.2 <u>Sustained yield and the interests of stability</u>

A concern for 'stability' is advanced as a defence of the long-term view, zero interest rates, and long rotations. The interpretation of the term, and the aspect of it stressed, would however be variable.

To the colonial government, it might well have meant a stability in the annual revenue or in its growth over time, partly as a reward for the effort put into capturing the territory, partly in order to maintain and expand the process of colonisation. For the colonial ruler, the costs involved in building up the forest or other capital resource could be considered an external cost. Even were they to be internalized, it is probable that the unsettled nature of the times preceding British rule, and the sparsity of population in the interior forests of the plateau, would have rendered the process almost costless in practical terms.

During the first century of British control, the best stems were extracted from the forests of the district. By the turn of the century, what was left was the residue of unsound and inferior growth; hence the concern for stability, expressed by Aitchison (1907) with reference to Blocks XXII and XXIII:

> "...the largest teak appear to have been felled about 25 years ago... The object of the Plan is to regulate the fellings...so as to produce a sustained yield of as large a quantity of large-sized teak timber as possible. It is important that the timber produced should yield large logs. Of late years the demand for large teak logs has been very great, and the larger the log the better the rate obtained".

In point of fact, there was difficulty in disposing of any great increase in production such as would be a consequence of a faster rate of conversion, as the experience with Edie's plan showed (Appendix 1). The consideration of stability, therefore, can be interpreted as the stability of revenue in the colonial context.

Subsequent to the "post-war slump" and with the inception of the national development programme, demand for all types of timber (including some like softwoods which were only of limited use previously) has increased, so that a much higher rate of conversion can probably be sustained by the market. The concern for stability, therefore, is now oriented toward the prospect that the rate of exploitation will be more than the forest can withstand without permanent damage:

> "... There is continuous evidence of gradual degradation of the forest stock due to demands on various types of forest produce, illicit felling, grazing, fire etc. To build up the stocking of natural forests it is desirable to reduce the intensity and quantum of fellings..." (Chetty,1985a).

Underlying this response of the forest department (paralleled by the stoppage of 'green' fellings in the northern state of Uttar Pradesh), is the realisation that the regeneration programme, either natural or artificial, has not succeeded. Thus the predicted growth and yield of the teak plantation is difficult to obtain in practice, not the least because of the long-drawn out process between exploitation and planting in many of the heavily worked areas.

7.5.3 Sustained yield, stability, and the interests of the poor

Thus the quest for stability of future annual yields has been thwarted by this seeming intransigence of the natural forest to respond properly to our silvicultural systems. Unfortunately, preserving the remnant crop and relying on an uncertain future improvement in the amount of regeneration (elsewhere) is not likely to answer the question of how to manage the existing forests in a responsible manner.

One possible defence of the relatively slow rate of conversion or liquidation of remnant stock could be, that it is in the interests of society, whether consumers or industries, to ensure a steady supply of exploitable and commercially useful products into the future; or, as the forester would heroically presume, in perpetuity. A perishable commodity like green logs, even of as durable a species as teak, cannot be preserved for long without being further transformed. The growing stock has to be maintained, unlike the case of an extractive or processing industry which is not required to produce its own raw material.

A charitable interpretation of this concern could be that the forester wishes to safeguard the interests of future communities. To put a definite egalitarian stamp on this possible concern, it could even be suggested that the forester is interested in providing cheap timber, poles, firewood, etc. to the local population for as long a period as possible, before the entire forest is converted into a monoculture dedicated to the commercial interest. The evaluation of such an interest is properly left to the social cost-benefit analysis, which we take up in the next chapter.

CHAPTER EIGHT

THE PARAMETERS OF SOCIAL COST BENEFIT ANALYSIS

The theoretical basis of the Little-Mirrlees methodology has been discussed in Chapter 5. The departure from neo-classical welfare economics is that both economy-wide efficiency considerations and inter-personal utility comparisons are admitted. The final social value arrived at should reflect both the efficiency and the distributive values of a course of action in a consistent framework.

One of the difficulties in applying the methodology rigorously is that it requires a great deal of economic data. It is difficult to predict the impact of changes in public policy, in supply or demand, etc., much more so on different income groups in society. As discussed in Chapter 5, the practical approach is to calculate standard conversion factors (SCFs) for broad aggregates, restricting the detailed estimation of shadow prices to the individual items that are important in the specific project under consideration.

8.1 Standard conversion factor for all traded commodities

The value of the domestic rupee can be expressed objectively by its command over foreign exchange. This is related to the SCF for all traded commodities (TCs) in the manner discussed in Chapter 5.

Table 8.1 presents the aggregate value of imports and exports at border prices (from trade figures), and domestic market prices (from national accounts), for the years 1960 to 1982. These values were used to calculate the summary SCF 'a' for traded commodities.

The SCF calculated from the IMF data (1960 to 1982) averaged 0.86 (with a standard deviation of 0.047, and coefficient of variation 5.4%). It showed no particular trend over time. This estimate was counterchecked by using figures in the RBI Reports on Currency and Finance of aggregate value of imports and exports at border and market prices, for some years between 1970 and 1983. They again yielded an average of 0.86 (SD of 0.02, CV 2.4%). An independent estimate was made by using figures for net revenue from customs duties in conjunction with the value, at border prices, of imports and exports (Table 8.1.c). This gave the average value of 0.85, only marginally different from the previous estimate.

Since the market value includes trade margins which should strictly be valued at social accounting prices, we would expect the SCF a to be somewhat higher, to account for the lower social value (higher social costs) of increased returns to the better-off. We will moreover be using market prices inclusive of all margins for most purposes. It was decided therefore to use the value 0.86 for a in all future calculations.

Thus the SCF to convert domestic market prices to border prices is 0.86. It will be applied especially when no other information is available, and for minor items in the streams of costs and benefits of the project. On the whole, it is expected that deviations of actual ARs from this mean value of 0.86 would tend to compensate for one another, resulting in a negligible error on aggregate.

8.2 Elasticity of marginal utility of consumption, n

The value to society of an additional rupee of consumption depends on the consumption or income level of the person to whom the increase accrues. The change in social marginal utility of consumption would accordingly be reflected by the private elasticity of marginal utility of consumption. The social elasticity of marginal utility is denoted 'n' (Ch. 5; n refers to the algebraical quantity, so that normally it will have a negative value). We apply the method described in Ch. 5 to estimate n for India, from past levels of income, consumption and prices.

8.2.1 Value of n: the method

Referring back to Ch. 5, the value of n is given by the ratio of income elasticity of consumption of 'Food', to the pure price elasticity. The latter is in turn derived from the gross price elasticity, by separating out the income and pure price effects using the fraction, f, of income devoted to Food.

Fellner (1967) used values of income and gross price elasticities in the USA estimated by previous studies. Putting income elasticity e_2 = 0.56, gross price elasticity $e_1 = -0.53$, and fraction of income spent on Food f = 0.25, the pure price elasticity

$$\tilde{e}_1 = -0.53 + 0.25 * 0.56 = -0.39 ,$$

and hence the elasticity of marginal utility of consumption

$$n = e_2/\tilde{e}_1 = 0.56/(-0.39) = -1.44 .$$

Fellner comments that one would expect exceedingly low absolute magnitudes of price elasticity ($|e_1|$) at very low income levels; and near-unitary absolute values among the upper-middle income classes, as the expenditures on Food are "presumably not greatly influenced by moderate changes in food prices" at these levels. Positive complementarities in consumption between Food and Non-food would suggest somewhat lower absolute values of n than 1.5, as the marginal utility of consumption falls at a somewhat lower rate due to the extra utility derived by simultaneous consumption of the two commodities as income rises. On balance, however, Fellner concludes that a value of n = -1.5 can be taken as a reasonable estimate of the elasticity of marginal utility of consumption in the USA.

Instead of using independent estimates of the elasticities, Kula (1984) fitted time series data of consumption, income and relative price of Food to an equation of the form

$$\ln(d) = a + e_2 \ln(y) + e_1 \ln(P),$$

where d is the demand per adult in real terms (constant prices), y is real income per capita, and P the relative price index of Food. Kula derived estimates of $e_2 = 0.51$, $e_1 = -0.37$, $f = 0.25$, whence pure price elasticity $\tilde{e}_1 = -0.37+0.25*0.51 = -0.27$, and elasticity of marginal utility of consumption n is equal to $0.51/-0.27 = -1.89$. Kula further uses this to derive the social time preference rate, STPR, the rate of discount that is to be applied to future consumption at the average level of consumption if it were assumed that the individual and social values were the same.

8.2.2 Elasticity of demand for Food: estimate for India

We apply this method to data for India shown in Table 8.2. The consumption is per adult, so that the total population has to be converted to adult equivalents to calculate per capita levels. The weights used to convert different age classes to adult equivalents are those used by Kula, with some marginal differences in class limits to conform to available demographic data. The adult equivalents work out to 0.765 of the numerical population in 1971, rising to 0.767 in 1980 (Table 8.4).

The data on Private Final Consumption Expenditure on Food and other groups of commodities (Table 8.2) were taken from the Yearbook of National Accounts Statistics, 1982, published by the United Nations Organization. The series of National Income NI (Net National Product NNP at factor cost) at 1970 prices was abstracted from the RBI Reports on Currency and Finance.

For the series of relative prices, the index (with 1970 as base) of wholesale prices was used. Out of a total of 1000 for all commodities, a weight of 297.99 is allotted to 'Primary Foods', and 133.22 to 'Manufactured Foods'. Out of the latter, the group 'sugar, gur and khandsari' (the latter two products being local cane-juice derivatives) accounts for 72.41. The total weight for Food, both primary and manufactured, amounts to 431.21, implying that Food products amount to around 43% of wholesale value.

The wholesale price index includes a number of industrial goods, and thus can be expected to underestimate the importance of food products in the average household budget. According to the national accounts statistics, Food formed from 55% to 63% (average 58.5%) of the final consumption expenditure of households in India between 1970 and 1982. However, micro-level surveys of rural cultivator households like the National Sample Survey, 26th Round, July 1971-June 1972) (NSSO, 1976) showed that Food accounts for almost 72% of consumption expenditure.

Thus the relative price of Food, calculated from the wholesale price index, might exaggerate any trend of divergence of Food from Non-food prices facing the consumer population. On the other hand, the wholesale price index might be expected to reflect the opportunity costs of consumption of food on the farm more closely than other consumer indexes that might be more relevant to urban consumers. This is because wholesale prices can be expected to be closer to the price obtained by farmers for their produce.

On balance, it was decided to use the relative price index calculated by dividing the composite wholesale price index for Food (Primary plus Manufactured, weighted as per the weights in the wholesale price index series) by the wholesale price index for all commodities (Table 8.3),

$$P = WPI_{food}/WPI_{gen} = P_f/P_g.$$

Using these variables, regression equations were estimated relating d, the private final consumption expenditure on Food, in Rs(1970) per adult capita, to y, the income, in Rs(1970) per adult capita. The following results were obtained when income was represented by the <u>disposable income</u>, y_{dis}, per (adult) capita:

$$\ln(d) = 0.665 + 0.812 \ln(y_{dis}) + 1.24 \ln(P)$$

N=9, t= 0.37 3.02 3.48

R^2=57.5%, DW= 1.92

and, without a constant term,

$$\ln(d) = 0.000 + 0.9113 \ln(y_{dis}) + 1.325 \ln(P)$$
$$N=9,\ t= \quad 3.08 \quad 5.46$$
$$DW= 1.84.$$

Neither of the independent variables by itself showed any substantial correlation with Food demand. The high, positive price elasticity is puzzling. Nor did a change in the income variable to national income, Rs(1970) per adult capita, alter the situation:

$$\ln(d) = 1.207 + 0.727 \ln(y_{NI}) + 1.170 \ln(P)$$
$$N=9,\ t= 0.93 \quad 3.78 \quad 4.10$$
$$R^2=68.3\%,\ DW=1.47$$

and, with no constant term,

$$\ln(d) = 0.000 + 0.906 \ln(y_{NI}) + 1.334 \ln(P)$$
$$N=9,\ t= \quad 336.66 \quad 6.01$$
$$DW= 1.40.$$

The possibility that demand would be linked to the previous year's prices in the expected manner was also explored:

$$\ln(d_t) = -1.218 + 1.008 \ln(y_{dis,t}) + 0.500 \ln(P_{t-1})$$
$$N=7,\ t = -0.46 \quad 2.76 \quad 0.95 (0.10<p)$$
$$R^2=48.4\%,\ DW=1.27$$

Here again neither of the independent variables was by itself correlated to the dependent variable, and the reduction in price elasticity, though suggestive, was not really significant. Lagging both the variables, or lagging income alone, was equally unproductive. Similarly, regressions using the relative price index of Primary Foods alone yielded equations with lower R^2 values and little improvement in the positive elasticity with respect to price.

8.2.3 Expected behaviour of income and price elasticity

The pure price effect is expected to be always negative (with respect to the direction of movement of price). Micro-economic theory decomposes the gross price effect into the pure price effect, and the income effect (Green, 1976): a rise in price, for instance, not only changes the relative prices of goods, but also leaves the consumer poorer than before on the whole.

A positive overall price elasticity by itself might be explained if the income effect were very strongly negative (with respect to the direction of movement of real income). In our case, even this rationalization of the positive price elasticity is not available, as the income elasticity is also positive (though less than 1). On the other hand, if consumption of Food were close to subsistence levels, there may be little margin for further reducing it. The pure price elasticity might then well be nearly zero. The overall effect of a price increase would be expected to be a weakly negative or zero variation in the real consumption of the commodity in question.

What we would not expect, however, would be for the income elasticity to be negative at the same time. Whether Food as a whole could be considered an 'inferior' good in the sense of showing a negative income elasticity, at the low levels of consumption prevalent in a poverty-stricken population, is highly doubtful. It may just possibly be true that consumption levels in upper income groups, which wield much of the purchasing power, are so high as to warrant such an assumption. Even then, however, it is probable that some _particular_ foods may be inferior, but unlikely that _all_ Food should behave as an inferior good.

A change in the distribution of occupations may conceivably have a role to play here. As hard manual labour gives place in increasing proportion to mental and light physical jobs, an increase in income may be accompanied by a decrease in the quantity consumed of staple foods. The increased incomes may instead be reflected in a change in the _quality_ of Food intake.

8.2.4 Value of n: the estimate

The fact remains, however, that our regression equations show an overall positive income elasticity for Food as a whole. Thus the compensated price elasticity will come out even more strongly positive. Using the disposable-income based, zero-intercept equation,

$$e_2 = 0.9113 \ ,$$
$$e_1 = 1.3253 \ ,$$
$$\tilde{e}_1 = e_1 + fe_2 = 1.3253 + 0.5847*0.9113, \text{ i.e.,}$$
$$\tilde{e}_1 = 1.8581 \ .$$

Then, the elasticity of marginal utility of consumption

$$n = e_2/\tilde{e}_1 = 0.9113/1.8581 = 0.4905 \cong 0.5$$

8.2.5 Possible rationalization of a positive n

A positive value for n would suggest that the marginal utility of consumption is increasing with the consumption level, contrary to the usual assumptions about consumer behaviour. This may be less implausible than it appears if there were significant complementarities in consumption between Food and Non-food, especially at low levels of consumption.

Presumably, Food is used as the reference commodity in Fellner's method because it is one commodity that is consumed at all levels of income. There ought therefore to be less error in using the average income and consumption levels to derive a single estimate of the elasticities, and applying them over a wide range of income and consumption levels. In a situation where the majority of the population are deprived, this could well be an invalid assumption, and a non-negative value of n might simply be a reflection of this widespread deprivation. A more 'normal' negative value of n might be derived if the consumption patterns of middle- and high-income classes were observed.

A related consideration would be that the composite commodity 'Food' does not indeed behave as if it were a homogeneous commodity. Some evidence in this regard is available in the behaviour of the price index. The data indicate that the inflation rate of the Primary Foods group has been consistently lower than the general rate; that of the Manufactured Foods has been sometimes higher than the general rate of inflation; that of the Sugar sub-group has been particularly high, and violently fluctuating. The Sugar index often moves in the opposite direction to the rest of Food commodities.

Changes in the relative price of staple foods like cereals are not expected to evoke a very strong response in consumption. In contrast, consumption demand of relatively 'superior' commodities like sugar would be expected to be much more sensitive to price fluctuations. The response of Food demand will be less systematically related to the Food price index if two major groups caused contradictory directions of movement. This may be one explanation for the elasticity not coming out as expected.

Table 8.5 shows these directions of movement in qualitative terms. It is apparent that the price index of the sugar group is not usually in consonance with the staple foods. The apparent <u>positive</u> elasticity of consumption of Food with respect to relative price could be simply an artefact of this independence in the price movements of major components of the composite commodity.

An analogous consideration of non-homogeneity concerns the response of different income classes. Since we have used national averages, rather than differentiating between income or consumption classes, the resulting estimates of elasticity may not really reflect the behaviour of consumers at the average level. The per capita incomes are quite close to subsistence levels of consumption, and much of the population is below it. The 'poverty line' was put at around Rs 39 per capita per month (at 1972-73 prices) in rural areas (Epstein et al., 1983), and somewhat higher in urban; in comparison, the final consumption expenditure of resident households was Rs 623 per capita per year, or Rs 51.17 per capita per month. In Karnataka, for example, as many as 45% of the population had an average per capita consumption of less than Rs 1.10 per day (Epstein et al., 1983), which works out to only Rs 33 per month, hence below the poverty line.

Such a wide variation in consumption levels would tend to make our assumption of a uniform elasticity over the whole range of incomes less plausible. It is possible, therefore, that a 'normal', i.e., negative, value of n might be obtained if the consumption data were restricted to a narrower range of consumption levels, rather than aggregating over the whole population.

The possibility remains that, apart from such explanations to do with the aggregation problem, the price index series used might itself be a poor measure of price movements experienced by the consumer. As an alternative, the consumer price index for agricultural labourers in Karnataka was used to calculate the relative price index of Food. The resulting regression equations, however, showed near-zero R^2 values, and zero correlation of relative prices with consumption of Food.

In the event, relative price seems to be but a weak influence on average consumption of Food, at least at the level of aggregation (across products and income levels) implied by the national accounts data used. The relation between price, income and demand might not be as direct as assumed in Kula's formulation. It is often the nominal income that influences consumer decisions, rather than the real income, and <u>expectations</u> of future movements in incomes and prices or of fluctuations in supply are particularly influential in an economy subject to many uncertainties.

The policies of government and of public and private organizations often change the nominal incomes of particular sections of the population. The non-uniformity of these effects can conceal the patterns in consumer response. As discussed in the context of consumption of forest products, supply-side constraints play a major role in setting the level of consumption; the power of consumer preferences is less influential in dictating economy-wide aggregates, at least for articles of basic needs consumption.

8.2.6 Independent estimates of consumption elasticities

The question of income and price elasticities of food consumption was examined by Raj (1966) in his study of price behaviour in India over the period 1949 to 1966. He found that

> "... No estimates are available of the income elasticity of demand for foodgrain but estimates of expenditure elasticity are available (based on data furnished by the National Sample Survey) and it is, therefore, possible to attempt a guess of the approximate value of the income elasticity. An effort has also been made to allow for changes in quality of cereals demanded when incomes rise, and thus to distinguish quantity elasticity ... from value elasticity" (Raj, 1966, p.171).

Raj quotes the following estimates of the 'expenditure elasticities' of demand for cereals, based on Biswas and Bose (1962) (Table 8.6). It is not clear from the paper whether value and expenditure in the paper were expressed in rupees of constant purchasing power, or in nominal rupees. Of interest, however, is the observation that the quantity elasticity is consistently lower than the corresponding value elasticity; and that the urban sector shows a much lower elasticity than the rural.

Since we are interested in the response of consumption in real terms, it is the quantity elasticities that are of interest in our study. A differential weighting of the average elasticity value was done for the urban and rural sectors, the weights being 1 for the urban and 5 for the rural. The weighted average elasticity derived was 0.40 for cereals for the whole economy. Allowing for the slightly higher value expected for pulses, the "income elasticity of the quantity demanded of foodgrains in the economy as a whole (i.e., taking into account both the rural and urban sectors) is 0.45" (Raj, 1966).

As regards price elasticity of demand for foodgrains, Raj found that "much less work has been done". Estimates by the NCAER of -0.34 for the major cereals based on time-series analysis were considered "not satisfactory". More promising were the estimates, based on cross-section data, of the "cross-elasticity of demand for foodgrains" of -0.62 in the rural sector, -1.20 in the urban, yielding a weighted average of -0.70 for the economy as a whole (again in the ratio 5:1 in favour of the rural). For the purposes of his study, Raj felt it judicious to also work out the results with values of -0.60 and -0.80, on either side of the average.

Using these estimates of e_2 (income elasticity) and e_1 (uncompensated price elasticity), and our estimate of f of 58.47%, we find that the value of n would vary between -0.84 and -1.34 (Table 8.7). As the absolute value of e_1 (and hence that of the pure price elasticity, $\tilde{e}_1$) rises, the absolute value n, i.e. the ratio $e_2/\tilde{e}_1$, becomes smaller.

If we assume that the price elasticity figures quoted by Raj are already compensated for the income effect, the absolute values of n are all the lower, with n ranging from -0.56 for e_1 = -0.80 to -0.75 for price elasticity of -0.60. We have further observed that the urban sector shows a much lower income elasticity, as low as 0.16 compared with 0.42 for the rural; and a higher absolute price elasticity (1.20 as compared to 0.62 for the rural sector).

These relatives, which indicate that foodgrains as a group are rather inferior commodities for urban consumers, determine the difference in the values of n for the two sectors. Staying with a value of 0.5847 for f, the proportion of income spent on Food, n for the urban sector, comes out to be a near-zero -0.15 compared to -1.12 for the rural (Table 8.7).

Considering that f is likely to be higher than the national average for the rural sector, and lower for the urban, this gulf would be likely to be even wider. Rural household expenditure on all food was 72% of total household consumption expenditure in Karnataka according to the 26th Round of the National Sample Survey, July 1971 to June 1972 (NSSO, 1976). Using f= 0.72, the rural n goes up in absolute value to -1.32. However, if only the expenditure on cereals and pulses is counted, the value of f for rural household falls to 0.40, and n to -0.93; the corresponding urban n would be -0.14.

On the whole, it appears, even from such independent estimates as are available of the relevant elasticities, that the marginal utility of consumption falls quite moderately among the urban consumer population with increase in income. This could be linked to the greatly expanded opportunities for diversifying consumption of material and aesthetic goods and experiences in the more complex urban environment. Once a certain level of consumption has been attained, survival becomes less of a gamble than in the rural milieu, and these additional consumption opportunities become more attractive.

It might have been expected that the converse ought to be the case, with the rural sector actually showing the near-zero value of n, and the better-off urban sector showing the higher absolute value of n to be in consonance with the expected greater closeness to satiation. The problem is, probably, that we are once again dealing with two quite different sets of consumption opportunities. Conversely, it is also possible that marginal utility rises rapidly as one approaches the survival level from below.

The urban consumer sees a whole world of exciting choices before him, and is far from exhausting or even tasting all of them; the more he consumes, the greater are the nuances and variations he can experience. For the rural population, closer to the subsistence level in all ways, there is probably a smaller range of such opportunities, and a correspondingly rapid fall in the marginal utility afforded by incremental consumption. The process of politicisation, the incursion of urban media and products, and the gradual effects of education and example are all, however, changing these traditionally dualistic patterns of consumer behaviour.

8.2.7 <u>The choice of a value for n</u>

The question might be justifiedly posed, whether a positive or near-zero elasticity of marginal utility of income is necessarily unacceptable. As a guide to public policy, a positive n would imply that society imputed a higher value to a marginal increase in the consumption of the better-off. The objection is that this is not in consonance with the declared egalitarian aims of most populist governments; though some observers might find their actions more consistent with a positive n, at least in societies where economic and political power go hand in hand.

Whatever the record of past policy implies, it is generally accepted that a government which is interested in egalitarian goals should adopt a negative n, between a strongly biased -2 and a moderately egalitarian -0.5. A value of n = 0 would imply neutrality among income classes, as usually assumed in financial or economic analysis. Thus the choice of n is a 'value judgement', imposed by the government (or by those exercising political power).

In India, the emphasis on social justice was given explicit expression in the Fifth Five-Year Plan. The goal was to eradicate poverty, and provide the poorest 30% of the population with adequate nutrition, minimum of public health services, drinking water and urban slum improvement; and with a minimum monthly consumption of Rs 40 per capita (1972-73 market prices).

This is a departure from the preoccupation with production goals. A specific bias toward the poor is justified on the grounds that redistribution of existing wealth, or redirecting income streams by direct transfers through the tax-subsidy system, is seldom feasible, politically or administratively. Hence governments committed to improving the lot of the poor must achieve it by a judicious choice of investment projects that have a bias toward the target groups in the distribution of incremental incomes.

Thus we conclude that there is no objective basis for deciding the value of n. As discussed in Ch. 5, the cost benefit analyst can help the decision maker by presenting a series of 'what if' results. The value of n is a prime candidate for this type of sensitivity analysis. That is the mechanism adopted here. The favoured degree of egalitarian bias could be reasonably high, with n around -1.5 or -2.0.

8.3 Consumption rate of interest, CRI

8.3.1 The method

The role of the interest rate was discussed in Chapter 5. The consumption rate of interest represents the individual's, and hence by extension society's, rate of time preference. The expression we use to estimate the social time preference rate is, after Kula (1984),

$$STPR = CRI,\ i = (c_0/c_1)^n(1/p) - 1.$$

Here c_t stands for the assured consumption stream in time t, and p, the probability of survival to the later time period. The validity of applying this to the social entity being questionable.

An alternative estimate of the CRI would be with p=1, on the basis that society should not be affected by private mortality:

$$STPR = CRI,\ i = (c_0/c_1)^n - 1.$$

The ratio of consumption endowments is equated to the cumulative growth of consumption,

$$c_0/c_1 = (1+g)^{-1},$$

where g is the annual growth rate of consumption per capita.

8.3.2 Estimates of CRI for India

The annual death rate in India was about 15 per thousand, or 0.015 in 1976 (UNO, 1980). The probability of survival p from one year to the next is thus around 0.985.

It was estimated in Chapter 1 that the GDP (in constant prices) was growing at around 3.6% per annum, so that a population growth rate of

2.2% would reduce per capita GDP growth to 1.4%. However, from the figures in Table 8.2, the growth rate of per capita final consumption expenditure was only 0.76% over the period 1972-1982. The high point of per capita consumption expenditure was in 1981, with a cumulative growth rate of around 1.45% over the period 1972-1981. The base year value of 1972 was extremely low, however; if 1970 were the starting point, the overall growth would be equivalent to around 0.86% per year. The sustained growth rate of consumption is therefore taken to be a moderate 1.0% per annum.

The value of i would now depend on the value chosen for n, as illustrated in Table 8.8. The possibility of dying by itself imposes a discount rate of 1.5% even with a neutral n = 0. As the value of n becomes more negative, it indicates a stronger depreciation in the value of a marginal unit of consumption. The rate at which future consumption is discounted becomes higher. But even with n= -2, i works out to only around 3.56%.

If we discard the element of private mortality, the CRI would be equal to -ng, as shown in Table 8.8.

8.3.3 Factors affecting the value of CRI, i

If consumption were to be growing faster than the slow 1% per annum assumed, the STPR would be correspondingly higher. The average individual, however, may be more pessimistic about surviving to enjoy his endowment than implied by the national mortality survival rate. He may also be less confident of the assurance continuing to remain firm in the future, given the high level of uncertainty all around him. With a lower value ascribed to p, the STPR would come out higher.

If the average individual were so placed that he actually anticipates a fall in real income, the STPR would be even lower, even perhaps negative. If we added an element of 'pure' time preference, the value of i would come out even higher. Adding 3%, for instance, for natural impatience, takes i to 6.6% with n= -2 and g= 0.01.

Interestingly, a positive n of 0.5 implies an i of 1% even without any pure time preference element, allowing the uncertainty of survival. Thus a positive elasticity of marginal utility of consumption by itself does not necessarily lead to the economic curiosity of a negative interest rate.

Indeed, if the rate of growth g were expected to be negative, a not unreasonable view of future prospects for the average individual given the state of the economy, a positive n would be helpful in deriving a positive i. For if consumption were expected to fall and the marginal utility of consumption were expected to rise, future consumption would actually be at a premium. This attitude to the inter-temporal problem would be tempered only by the sobering possibility of dying before time, and by any element of 'pure' time preference or 'impatience'.

The value of i ought to be, on balance, fairly low in India. Traditionally, economic and social conditions, and cultural and religious conditioning, have all tended to instil ideals of frugality and abstinence. That not all conformed to the mould is perhaps due to differences in the opportunities to augment present or future incomes, as perceived by different groups or communities. The high uncertainties attached to existing claims to future income streams, meagre as they were to start with, have, instead of increasing the 'impatience' side, only encouraged a respect for frugality and modesty in consumption.

This has perhaps impeded the development of a 'consumerist' culture, and made the average Indian over-cautious and conservative. It is only very recently that the poor are becoming hopeful of an improvement in their standard of living and station in society. Even adding an element of 'pure time preference', the consumption rate of interest is not expected to be higher than 5% or so.

8.4 Opportunity cost of capital, q

The other side of the inter-temporal coin is the potential increase in future consumption streams if some of current consumption is sacrificed for investment. In the case of public income, the opportunity cost of capital is also linked to the value of the numeraire in terms of consumption. We first estimate the marginal product of capital, q, as discussed in Part I.

8.4.1 Marginal product of investment, q, in India

The model we use to estimate the net flow of returns from a rupee of invested funds is given by the equation

$Y_t = Y_{t-1}(1+qs)$ (cf. Chapter 5).

The annual income Y_t is the net product, here represented by the net domestic product (NDP). The annual rate of saving, s, is by definition equal to the rate of investment out of annual income as well. This is defined as the net investment over net product. Thus the replacement of worn-out capital is automatically taken care of. What is being estimated is the fresh investment, the net addition to the productive resources of the economy. The marginal product q is, by definition, something that will be received *ad infinitum* from a single rupee of investment today.

The entity (1+qs) is estimated from the regression of NDP (in constant rupees) on itself, lagged one year. As discussed in Chapter 5, we cannot use the raw data of NDP, as it incorporates increases from year to year not just due to fresh investment, but also due to other factors like labour, technology, natural resources, and so on. These have to be separated out before doing the estimation. Of all factors, labour is the most important one to quantify.

8.4.2 Separation of income shares

It is difficult, however, to do this separation from the existing data. Unfortunately, the national accounts lump together income ascribable to other sources in the category 'mixed income of self-employed', so that it is difficult to say what part of it should go as labour wages, and what part to capital etc. Thus Rao (1983, p.112) concludes that "it is impossible to segregate the whole of the Indian national product, net or gross, into its constituent shares. It is, however, possible to identify the shares of the different factors of production, if the share of the mixed income of the self-employed is excluded".

In spite of this difficulty, some idea of the range of values possible can be obtained. One extreme assumption could be that the entire income of the self-employed consists of wages and salaries. This would give an extreme low limit to the contribution of net fixed capital formation.

The other extreme would be to assume that none of the 'mixed income of the self-employed' should be ascribed to wages. The more reasonable variant, however, is that around half of it goes to wages. A possible basis for this is provided by a Reserve Bank of India survey quoted in Rao (1983). This study found that the proportion of gross value added ascribable to wages was almost the same in unregistered small-scale units as in the registered: about 49.1% in the former, against 51.9% for the latter. Thus we can assume that the ratio of wages to net income in the self-employed sector was also about 50%. Then half of the 'mixed income' of the self-employed is paid out as wages, and the remaining half is the reward to capital.

8.4.3 Estimation of (1+qs)

The above formulation provides a basis for estimating (1+qs) as the rate of increase in NDP with only capital changing, *ceteris paribus*. However, the data series available in the RBI publications is short and discontinuous.

To extend the series, a possible alternative basis is afforded by the fact that estimates of 'compensation of employees' in the organized sector are given separately in the national accounts. It is observed that the sum of 'compensation of employees' and 'mixed income of self-employed' is almost equal to the 'private final consumption expenditure' in the RBI data (Table 8.9). This is used to advantage to extend the limited (and dicontinuous) time series in the RBI accounts.

Thus in the first variant, the whole of private final consumption expenditure stands in as proxy for the aggregate payment to labour. The annual figures are reduced to 1980 prices by applying the implicit GDP deflator calculated from the series in the International Financial Statistics Yearbooks. Then the increase in the labour payments, over the level in the base year (1960-61), is subtracted from the NDP for each year, to arrive at a series of 'constant-labour' NDPs (Table 8.10). This is lagged by a period of one year, and auto-regression yields the equations

$$Y_t = -1.96 + 1.0195\ Y_{t-1}$$

$N=23$, $t= -0.05 \quad 20.56 \qquad R^2=95\%$, $DW=2.00$

and, without constant,

$$Y_t = 1.0168\ Y_{t-1}$$

$N=23$, $DW=2.00$

where Y is the NDP in Rs(1980) billions. Thus we can take as a lower limit the value 1.017 for (1+qs).

'Mixed income' itself is about equal to 'compensation of employees' in the organised sector. In the last variant, we had assumed that the total of the two represented the reward to labour. Now we have a part of 'mixed income' going as returns to capital invested by the self-employed. This means that about one quarter of the total of the two can be ascribed to capital etc., and the remaining three-quarters to wages, as against the whole to labour in the previous formulation.

Using 75% of the 'private final consumption expenditure' as the 'low' measure of the share of labour, a higher estimate of the expression (1+qs) is obtained:

$$Y_t = -10.4 + 1.0367\ Y_{t-1}$$
$$N=23,\ t= -\ 0.35\quad 26.79$$
$$R^2= 97.0\%,\ DW= 2.15\ ;$$

and with no constant term,

$$Y_t = \quad 0.0 + 1.02325\ Y_{t-1}$$
$$N=23,\ t= \quad 185.38$$
$$DW= 2.12.$$

8.4.4 Marginal propensity to save, s, and value of q

The value of s is calculated as the ratio of net fixed capital formation, I, to net domestic product. This ratio was observed to rise from just under 10% in 1960 to just over 15% in 1983. Regression of I against NDP gave the equation

$$I = -56.58 + 0.189\ Y$$
$$N=24,\ t= -\ 7.56 \quad 24.10 \qquad R^2=96.2\%,\ DW=0.7$$

Using the limiting value of s as 15% from the limiting value of I/NDP, q= 0.017/0.15 = 0.112. Thus 11% is a 'low' estimate of q.

The 'high' variant gave, for the zero-intercept case, (1+qs)= 1.0233. Thus, for s= 0.15, q = 15.5%. This is the 'high' estimate of the marginal product of capital.

To the extent that national accounts underestimate the cost of replacement and maintenance of fixed capital, especially of land-based and environmental capital, the value of q would be over-estimated. Further, the increase in product is also in part due to the introduction of new technology, and the marginal product of capital in a case of static technology (the possibility of which is questionable) may be a few percentage points less.

Against this is the possibility that the self-employed sector is less capital-intensive than the organized. The reward per unit of capital would then be higher than estimated above, where the assumption was made that small-scale units in both the self-employed and the organised sectors had the same proportion of income going to wages. In this case, q would be a little higher than estimated.

8.4.5 Comparison of results with other published values

The results of the fairly simple approach above can be compared with other estimates of the parameter q. One comparison is afforded by estimates of the 'capital-output' ratios.

Rao (1983) presents estimates of this ratio based on gross capital formation and real GDP, taking as the base level the gross value of fixed capital in industry as estimated by other workers. The average capital/output ratio rose from 2.50 in 1950-54, to 4.20 in 1975-79; the incremental capital/output ratio rose from 3.5 to 6.4 over the same interval. Rao ascribes some of this to the faster growth of the public sector, and the higher proportion of construction and stocks relative to machinery in the public sector as compared to the private.

One reason for the higher overheads in the public sector may be that the government undertakes investments with longer gestation periods, like irrigation projects and basic and heavy industries. Sector-wise, high average c/o ratios (>10.0) were shown by Electricity, Railways, and Real Estate; the lowest (<3.0) in Agriculture; Trade, hotels, etc.; Banking and insurance; and 'Other services'. Intermediate values (5.0 to 7.0) were found in 'Other transport', Mining and quarrying, Manufacturing, Communications, and Public administration.

The fact that the incremental c/o ratio was as high as 6.4 when the average was only 4.2 in 1975-79, suggests that additional investments are less and less paying, more and more demanding of capital. If we assume an average life of 25 years for the capital assets, then for each rupee of investment, the replacement alone would require Rs 0.04 per year. If the marginal investment yielded 1/6.4 = Rs 0.16 of gross output per year, the net output would be Rs 0.12. Thus the marginal product q would be around 12%; the average, at a gross yield of 1/4.2 =0.24, would be 20%. Admittedly these are extremely crude calculations, and the real situation is extremely complex and variegated. The public sector is also stated to be less efficient in general, and it is likely that this is a part of the explanation (Rao,1983; Bhagwati and Desai, 1970).

A least-squares approach was followed by Trivedi (1987) to estimate the 'bench-mark' capital stock for the base year, using a Cobb-Douglas equation to relate output to capital and labour. The resulting value for the marginal product of capital was around 14.5% (Trivedi, 1987, p.135 et seq.).

The opportunity cost of capital ought to be reflected in the long-term interest rates in the capital market. If it is argued that government undertakings are generally less efficient, it is the private capital rates that are relevant. Well-established private companies paid from 10 to 15% per annum for deposits accepted from the public, but these are subject to ceiling rates imposed by the government.

A ceiling is also operative on dividend rates on preference shares (15% from 18th May 1984). The annual (gross) yield on ordinary shares was between 5 and 6% from 1970-71 to 1983-84 (RBI Report on Currency and Finance, 1983-84). The ceiling rates on lending by commercial banks ranged from 16.5% in 1975-76 to a high of 19.5% in 1982-83, and 18% in 1983-84.

These interest rates are in nominal terms. The average rate of inflation calculated from the GDP deflator between 1970 and 1983 was around 8.9%, which reduces the highest of the above values to about 10.6%, and the lowest (the yield on ordinary shares) to -3.9% to -2.9%. The reason why most capital issues have had little difficulty in being fully subscribed seems to be the expectation that appreciation of share prices (5.4% per year over the same period) would provide a hedge against inflation. The general indication is that the investor is looking for security rather than high returns.

Taking all these considerations into account, a value of q between a low of 10% and a high of 15% will provide an adequate range for a sensitivity analysis. The value of s can be fixed at 15%. The above values are derived from economy-wide variables, and there is no basis to differentiate between the two sectors. We therefore assume that the same ratios apply to private as well as to public investment.

To summarize, 1 Re of investment yields an annual income of Rs 0.10 to 0.15; of this, 15% is saved (Rs 0.015 to 0.0225) and the rest consumed.

8.4.6 Marginal product of capital in terms of the numeraire

So far we have expressed q as a percentage. Strictly speaking, we need to revalue the output and input commodities at their border prices, or at their social prices (if any distributional biases are involved), rather than at domestic prices as hitherto. This is the procedure followed by Lal (1980), but he arrives at a whole set of q values for a number of industries, the average of all of which is around 12.5%.

Bruce (1976) suggests that the domestic value of q should be multiplied by b_c, the conversion factor for consumption. However, the rupee of investment will also have to be revalued at border rupees. As a percentage, q would remain the same if the same conversion factor were used. We could use, instead of b_c, the factor a = 0.86 for all traded commodities. Thus, we could say that Re 1 at domestic prices yields Re 0.10 at domestic prices, for a return of 10%; or that Re 0.86 at border prices yields Rs 0.086 at border prices, a yield of 10% again.

8.5 Social value of public income, v

8.5.1 The link between public investment and public income

As discussed in Chapter 5, the opportunity cost of capital and the social time preference rate together decide the relative value of a rupee of public income in terms of consumption. This gives us a convenient measure of the relative advantage of using public income (strictly, a unit of the numeraire) to increase private consumption immediately, against investing it for future consumption. The convention adopted in SCBA literature is to refer to the 'social' value of public income when the unit of measure is a rupee of private consumption at the reference (mean) level of consumption.

The social value of public income, v, is calculated as per the formula

$$v = (1-s)q/[(i-sq)a],$$

and a zero-reinvestment case with $s = 0$,

$$v = q/[ia],$$

as described in Chapter 5, when it is assumed that all public income is as valuable as public investment, and that the incremental consumption can be treated as though accruing at the average level $\bar{c}$ in society.

8.5.2 Estimates of social value of public income, v

The calculated values of v are shown in Table 8.10(i). Three variants of q are given: q=0.10, 0.125, and 0.15; the value of s is uniformly assumed to be 0.15. The degree of redistributive bias is reflected by n, which ranges from n= -2 to 0.5. The values of i, the consumption rate of interest, are those calculated previously (Table 8.8).

The value of v is seen to be sensitive to our choice of parameters, and on the whole is high. For instance, for q=0.10, the minimum value is 4.8, for a highly egalitarian n=-2 (implying a relatively high CRI, but still only 3.56%), and approaches an extreme 495.0 as we approach n=0 and i=1.5%. For comparison, the minimum values resulting from an assumption of s=0 (thus removing any second-round investment effects) range from 3.3 (n= -2) to 7.7 (n= 0). As the value of q rises, the premium on investment increases.

This is a grim reflection of the limited options open to the government. In the situation obtaining in India, it is not necessarily unrealistic. Abject poverty is widely prevalent, and poverty is likely to increase unless strong measures are taken to curb consumption and increase investment. The relative value of investment is high in comparison with current consumption.

If the CRI is approximated by the values -ng (putting survival probability p= 1), the values of v will be even higher (Table 8.10.ii). Indeed, finite values are obtained only for n= -2, q= 0.10 to 0.125.

8.5.3 Value of public income: between redistribution and growth

The choice of parameters is seen to pose a dilemma. On the one hand, there is the low rate of fall of marginal utility of consumption, consequently a low rate of time preference. It also implies, however, that increasing the consumption of the poor today has a low weight in the social scale of priorities. All this understandably boosts the value of investment relative to present consumption.

On the other, popular judgement and policy statements by the government clearly denote a bias toward redistribution of incremental income. If government projects are to be used as a means of furthering this interest, a degree of distributional bias will have to be built into the cost benefit analysis system. This must be more than that implied by a zero (or positive) n.

There is presumably some concept of what should be a reasonable range for the values of these important parameters (Bruce, 1976). The large range shown by v in the foregoing calculation leaves us with no firm basis for choosing one or the other set of values.

8.5.4 Social value of public investment and critical consumption level

A variant of the above formulation was suggested in Chapter 5. This is that the government considers a rupee of public investment as no more valuable than a rupee of private consumption at the critical consumption level, c*. The resulting values of v are here denoted by the asterisk, v*.

Conveniently, the government of India has identified what it considers to be the minimum level of consumption needed to meet the basic requirements of civilized life. This 'poverty line' is put at a per capita consumption expenditure in domestic market prices of Rs 39 per month (Rs 474.50 per year) in rural areas during 1972-73. Consistent estimates put it at Rs 56 per month (Rs 681.33 per year) at 1977-78 rural prices, and Rs 89 per month (Rs 1082.83 per year) in 1977-78 urban prices (Epstein et al.,1983; NSSO, 1981b).

Assuming that 75% of the population can be considered rural, the overall weighted mean poverty line was Rs 781.71 per year (1977-78 prices). This was 0.78 of the average per capita final consumption expenditure of Rs 1000.37, and 0.58 of the per capita national income (NNP at purchasers' prices) of Rs 1355.85.

The social value of public income, relative to consumption at the average level, is then

$$v^* = d^*(1/a) = (c^*/\bar{c})^{n}/a,$$

where d* is the consumption weight attached to consumption at the critical level c*. The factor 1/a comes in because all values are being assessed at domestic, not border, rupees.

These imputed values of v* are shown in Table 8.11. Now from v*, values of i can be imputed. The difference between these i* values, and those of i calculated previously, gives us an idea of what the 'pure' time preference rate may be for corresponding values of n.

The set of values v* and i* derived by this roundabout fashion seem more 'reasonable' than our previous values. As the value of n becomes less negative, it is seen that the premium on investment decreases. This is in contrast to the previous variant, and is simply due to the particular assumption that public income is only as valuable as consumption at the poverty line. Indeed, if n=0, there is no premium attached to the latter; then the only reason v is also not equal to 1 is that a rupee at border prices is worth 1/0.86 = 1.16 rupees at domestic.

The implied values i* now <u>increase</u> as n becomes less negative and less egalitarian. This is required in order to reduce the present value of the future consumption streams flowing from the initial investment and subsequent reinvestments of savings. If however we revert to the previous estimates of STPR, i, the difference ([i* -STPR] or [i* -i] in our Table 8.11) may be attributed to 'pure' time preference. This is seen to increase as n becomes less negative, and i becomes higher. The implication is that as the egalitarian bias weakens, the private 'short-sightedness' is allowed more influence, and the relative value of investment becomes correspondingly lower.

8.5.5 <u>**Social value of public income and the value of investment, x**</u>

An alternative consideration that would help to moderate the high v values obtained from the previous 'forward' derivation using <u>a priori</u> values of i, was described in Chapter 5. This is that only a part of the income accruing to government is reinvested, while the rest has to be taken as akin to consumption. Thus the latter portion does not generate subsequent reinvestment streams, thereby lowering the social value of a rupee of public income.

We denote this variant as x, the social value (in terms of consumption at the average level of consumption) of public income, as opposed to v, which dealt with only the investment part. If the fraction s of public income is invested, this part can be valued at v, while the part (1-s) is assumed to be on par with social consumption. As per the formula in Chapter 5, a rupee of public income (at border values) is as valuable as Rs x of consumption, where

$$x = ([1-s]/a) + sv$$

The calculated values of x are shown in Table 8.12, for the range of n values from -2.0 to +0.5, and alternative values of q of 10.0%, 12.5%, and 15.0%. The less egalitarian the value of n, the less strongly will future consumption be discounted just because it will be accruing at a higher level of consumption. As before, we find that as n becomes less negative, x rises; but somewhat less precipitately than before.

A slight variant is also computed under each case. This uses the formula v= q/ia for the investment portion, amounting to an assumption that there are no savings out of the incremental income streams coming from the first investment. The social value of public income is, naturally, further reduced by this assumption; it is only 2.71 even at n=0, and a high opportunity cost q=0.15.

8.5.6 Social value of public income and critical consumption level

Just as in the case of v, an alternative approach to evaluating x could be that government investment funds are only as valuable as consumption at the critical level c*. Consumption emanating from government investment or income, however, is assumed to be only as valuable as consumption at the average level, $\bar{c}$. The formula is

$$x^* = ([1-s]/a) + sv^* \qquad \text{(cf. Chapter 5).}$$

The x^* values fall as n approaches zero, as in the case of v^*, but the fall is moderate; indeed, all the x^* values are moderate, ranging from 1.51 at n= -2, to 1.12 at n= +0.5 (Table 8.13). The fall in x^* as n becomes less egalitarian is because less weight is then given to an increase in consumption at c^*, implying that social value of the public investment portion is falling. Again, the implied values of the CRI i now rise as n approaches zero.

8.5.7 Social value of public income and distribution of returns

As discussed in Chapter 5, the distribution of the incremental income stream need not be so balanced that we can assume it to be concentrated at the average consumption level. If it were concentrated at the critical level c^*, the resulting v values would be equal to d^* times the previous values, where d^* is the relative weight of consumption at c^*.

The distribution of project benefits could also be such as to leave the existing distribution unchanged. In such a case, the aggregate distribution weight is given by the formula

$$D = \tilde{s}^N(\tilde{s}-1)^{1-N}/(N+\tilde{s}-1) ,$$

where $\tilde{s}$ is the parameter of the Pareto distribution curve, and N is the negative of the elasticity of marginal utility of consumption, n. The value of the Pareto distribution parameter is approximately

$$\tilde{s} = (1+GINI)/2.GINI ,$$

where GINI stands for the Gini coefficient of the cumulative Lorenz distribution curve of proportion of consumption against proportion of the population (Sec. 1.6.6). We use this basis in the following calculations.

Data on the distribution of per capita income and consumption in Karnataka during 1972-73 were taken from the tables in Epstein et al., 1983 (Table 8.14). These were assumed to be representative of the country as a whole. Since the data were given in fairly broad income classes, the cumulative percentage distribution had to be calculated approximately by assuming the average consumption in each class to be at its mid-point.

The top class was however open-ended at the higher end, so its mid-class average income level was calculated by subtracting the aggregate income in the lower classes from the total income implied by the state-wide average per capita income and population figures given in the same paper. The resulting average income for the top class was, at Rs 4.17 per capita per day, quite close to its lower bound, Rs 4.11.

The Gini coefficient is the ratio of area between the diagonal and the Lorenz curve, measured by counting squares on graph paper, to the area between the diagonal and the axes. The estimated value was:

$$GINI = 0.3733$$

$$\tilde{s} = 1.3733/0.7466 = 1.8394$$

The resulting values of the aggregate consumption weighting factor D for different values of n are shown in Table 8.15. It is seen that, in comparison with the weight d^* imputed to consumption at the 'critical' level, the 'global' distribution weight D is lower for a given value of n. The higher share of the better-off depresses the social value of an investment when its benefits are shared without disturbing the existing income distribution. However, the value of D, though not as high as d^* when all consumption increments go to the critical consumption level, is still better than $d= 1.0$ when they all go to the average level. For $n= 0$, there is naturally no change in the social value whatever the distribution.

The resulting values of v are given in Table 8.15. If the value of v is now assumed to be the same as that of consumption at the critical level ($v^* = d^*/a$), the change occurs in the calculated value of i implied by the formula

$$v^* = (1-s)Dq/(i^*-sq)a \text{ , whence}$$

$$(i^*-sq) = (1-s)Dq/d^* \text{ .}$$

These i^* values are also shown in Table 8.15. The STPR i^* is now higher than that based on the assumption that all incremental consumption accrues at the average consumption level.

As before, if the existing use of capital is socially highly beneficial, new uses have to measure up to higher standards; if not, the standards are modest. The essential point is that the parameters used in the social cost benefit analysis, specially the interest rate, are dependent on the assumptions we make about the distributional and efficiency implications of existing investment in the public (or private) economy.

8.5.8 Social accounting rate of interest, SARI

The value of v indirectly leads to the discount rate to be applied to the numeraire, as discussed in Chapter 5:

$$SARI = i + dv/vdt ,$$

which assumes that the value of public income is changing over time relative to private consumption. Usually, v is supposed to fall over time, so the SARI is higher than the CRI. The rate of fall of v is sometimes specified by assuming that v will fall to 1.0 in a certain number of years.

However this assumption is only valid if the value of q can be expected to fall or the value of i to rise until the two are equal by the end of the specified period. In the case of India this may be questioned. Social needs are increasing at an unprecedented rate and a large number of investment opportunities offer a high marginal social product. This will continue to be so as long as the population growth rate does not fall to a near-zero level, which is still only a distant possibility. There is no evidence either of a trend of changing value of CRI. Thus in the case of India dv/dt may be taken as zero, so that the SARI is equal to the CRI. However, an extensive range of discount rates will be considered in the SCBA proper, which gives the opportunity to inspect the sensitivity of management decisions to variation in SARI.

8.5.9 Choice of values for social parameters

A wide range of values of n, i, and v have been derived with a few initial assumptions. The problem of choosing a consistent set of values remains.

Since both n and i (through the element of 'pure' time preference) are essentially subjective variables, it is probably not a very fruitful exercise to try to find a more 'objective' way of choosing their values. Even if the empirical determination of n as per Fellner is followed, the resulting value may indicate the existing inequalities in society, and not the policy objectives of the government, or even what the 'social' conscience leads people to think is a desirable policy.

In the foregoing analysis, for instance, empirical considerations led to a fairly low distributional bias, low discount rates and high premium on investment. The first two may be incompatible with a strong interest in distributive values, which require that the rate of social return of the project should be fairly high in order to be acceptable. The values of i, the consumption rate of interest, are also the values of r, the accounting rate.

A reasonable combination of values would have a fairly high distributional bias, say $n = -2.0$. The opportunity cost of investible funds would be fairly high, say $q = 0.125$. The *a priori* value of the STPR would then be around 3.5%, also equal to the SARI. If the *reverse* calculation of CRI from the social weight to the critical consumption level is adopted, the CRI, and hence SARI, would be around 5.41%.

The corresponding social value of public *investment* would be 7.33 (v), or 3.50 (v^*). This would also be the value of public income if all of it were assumed to go into investment. If public income were considered as divided between investment and consumption, its value in terms of consumption would be 2.09 (x) or 1.51 (x^*). That is, a rupee (at border values, i.e. of the numeraire) would be socially as valuable as Rs 7.33, or Rs 3.50, etc., at the average level of consumption $\bar{c}$.

If the incremental consumption streams were shared out according to the existing distribution, the social value of public investment would be multiplied D-fold (1.42-fold for n of - 2.0). The CRI would be unchanged at 3.56% on the a priori calculation, but on the reverse calculation the implied i* would be around 6.89% as against 5.41% (for q= 0.125).

It is possible, of course, that the increasing emphasis on 'growth with social justice' will bring greater gains to the poorer classes in future programmes. The recent record of developmental efforts, however, indicates that the benefits of public spending trickle down but slowly to those below the poverty line. For instance, although the 'green revolution' has been one of the success stories of Indian development, it is probably the larger landholders, the 'kulaks', who have reaped the richest benefits (Rao, 1983). Increasing commercialization of agriculture may even lead to impoverishment of landless labour and small and marginal farmers as the inflation in other commodities, including foodgrains, hits them.

8.6 Shadow price of labour, SWR

8.6.1 Social cost of labour and the accounting wage rate

A simplified formulation of the approach to calculating the shadow wage rate or the social conversion factor for a given type of labour was given in Chapter 5 by the equation

$$SWR = m.b_c + dc.b_c - dc.d/v \ ,$$

where $m.b_c$ is the value of net marginal product forgone by withdrawing a worker from the current occupation; $dc.b_c$ is the social cost of providing for the extra consumption, dc; b_c is the consumption conversion factor for the class of people concerned; and d/v is the relative weight attached to their consumption level, which enables us to express the social value of dc in terms of the border numeraire . The conversion factor from the market wage rate w to the accounting wage rate SWR is

$b_L = SWR/w$.

Application of these general principles requires assumptions specific to the project or class of workers and locality in question. These matters are discussed below.

8.6.2 <u>Demand and supply of labour in forestry</u>

Forestry requires unskilled and semi-skilled labour for most of the operations, while technologically skilled labour is restricted to mechanized logging, sawmilling, etc. In contradiction to the usual assumption of widespread unemployment, shortage of labour has been a constraint in carrying through even normal works, let alone more ambitious programmes of harvesting and regeneration (Edie, 1922; Copleston, 1925; Garland, 1935; Wesley, 1964). This is especially true of the interior forests of the Western Ghats:

> "...Except for the Siddis at Bilki, the villagers living in the West of the tract seldom seek employment on felling works, but are sometimes available for plantation works, cultural operations and fire-tracing. In the East of the tract more labour is available locally, especially from the Vaddars and Lambanies. The labour supply is ... generally not adequate" (Wesley, 1964).

The low supply of labour may be ascribed to the low population density in North Kanara district. According to the 1981 census, North Kanara had only 104/sqkm (79/sqkm in rural areas), against the average for Karnataka State of 193 (rural: 140/sqkm).

However, if we accept that agriculture forms the mainstay of the rural population, then the density per unit of agricultural land would be more relevant in the context of the employment situation. This concept suggests that labour is not necessarily scarce compared with the rest of the state. The district had a density as high as 536/sqkm (438/sqkm rural) non-forest land, against the State averages of 239/sqkm (174/sqkm rural) non-forest land. The density of 'cultivators and agricultural labourers' was only 19/sqkm in the district of North Kanara, against 47/sqkm for the

State; but per sqkm of <u>non-forest</u> land, it was as high as 96 in North Kanara against 57 for the State as a whole.

Apart from the availability of labour from a pool of un- or under-employment, it appears that the wages paid by the forest department were simply not high enough to compensate workers for the expense and inconvenience of shifting to remote work-spots in the forest interior. The wage rate in Yellapur Forest Division during 1982-83 was around Rs 6.50, compared with the agricultural field wage of Rs 6.64. The average agricultural wage in 1980-81 was Rs 6.02, the wage in Yellapur Division, Rs 5.00.

Forest department wages may even be marginally, or locally, lower than agricultural wages (cf., Table 8.16). This is probably an important reason why forestry is not able to compete successfully for local labour, except in areas with high under-employment. The local people, therefore, are usually engaged in forestry works only during the slack season in agriculture, and in nurseries, roadside plantations, and afforestation work-spots closer to the villages.

8.6.3 <u>Opportunity cost of labour, m</u>

A basis for predicting the forgone product of the workers employed in the 'project' is required. In the 1981 census, the population was classed under three groups by occupational status: 'main' workers, those who were engaged in economically productive activity for more than half the days of the preceding year; 'marginal' workers, engaged for half the days or less of the preceding year; and non-workers, not engaged at all in productive activity. By relating the labour drawn by the 'project' to these occupational classes, an estimate can be made of the aggregate marginal product forgone per worker-day (or year) in the project.

Data on unemployment in rural India was drawn from National Sample Survey sources (NSSO, 1981b). The report gives the composition of the rural labour-force aged 5 and above, by number of days worked during the week preceding the survey, in increments of a half day (Table 8.17).

To simplify the calculations, we divide the total population into two broad groups: assumed to represent the 'marginal' and 'main' workers of the 1981 census (with a slight error due to using the usual weekly status rather than annual status of employment). The groups were those who worked from 0 to 3.5 days in the preceding 7-day period, and those who worked for more than 3.5 days in the week. The class-wise data were averaged to arrive at the estimates of unemployment for each of these two broad categories (Table 8.18).

In the average week, 'marginal' workers spent 3.2 days unemployed, while 'main' workers were unemployed only 0.125 days out of the 7 days (Table 8.18). The combined average for all workers amounts to 0.511 days unemployed out of 7 days in the week. Thus there is a considerable difference to the results depending on whether the rural work-force is considered homogeneous or not in respect of occupational (unemployment) category (Table 8.18).

The next point considered is the previous occupational class of the workers employed in the 'project'. At first sight, it would appear that the bulk of work-days will be supplied by marginal workers, since these persons were unemployed (and, presumably, both willing to work and seeking work) for as much as 3.2 days in the week; almost 25 times the 0.125 days per week of the main. But some of the time, main workers would also drift in to occupy slack time. The main workers far outnumber the marginal; so they will contribute a greater number of worker days than the time spent unemployed would suggest.

The reasonable assumption is now made that the project will draw its labour input from each category in proportion to the total worker-days of unemployment in each category. The composition of the rural work-force of Karnataka by main and marginal worker categories is also given in Table 8.18. Using these, the final ratio of work-days (wdays) drawn is

$$\text{marginal wdays / main wdays} = 3.42*3.2/36.76*0.125 = 2.379,$$

where the weights are the proportions of the respective categories in the total population (3.42% marginal, 36.76% main workers) in Karnataka state.

We now consider the value of marginal product forgone. In a market economy, the market wage rate ought to represent a full day's value product of the concerned category of worker. This may be broadly true even in the backward economy of rural Karnataka. For it appears that the ruling wages in agriculture are not an over-statement of the marginal product of a main worker; they may even be slightly <u>less</u> than the marginal product, according to farm-level studies conducted during 1953-54 in the old Hyderabad regions of Karnataka (Rao, C.H.H., 1965).

As demonstrated above, the forest wages themselves are not higher than those in the alternative agriculture. These facts suggest that the main variable influencing the opportunity cost in terms of output forgone, is the proportion in which the labour employed in the forest project are drawn from different sub-sectors of the rural population:

The estimate of marginal product forgone in respect of each category is made as follows. The average main worker would have worked 6.56 days, and the marginal, only 1.94 days, in a week (Table 8.18). A full day's work is valued at the going wage, w. The marginal product of the main worker would thus be valued at 6.56/7.00 times w, or 0.937w, and that of the marginal, 1.94/7.00 or 0.277w. The alternative product forgone upon employing a marginal worker is thus only 0.296 times that forgone in the case of a main worker.

Out of every 3.379 worker days employment generated in the project, 1.00 worker day came from main workers, and 2.379 from marginal (as shown above). The total value output forgone by society per worker day in the project is

$$m = (1.00*0.937w+2.379*0.277w)/3.379 = 0.4723w.$$

It is possible that for every worker employed in the project, subsequent realignments would occur in the rural labour force left behind.

This is usually the scenario depicted in models of migration to urban areas as a consequence of job creation in towns. A partially employed worker moves into the slot vacated by the main worker, and so on down the line, so that ultimately one completely unemployed worker becomes partially employed; or even a non-worker waiting on the side-lines, so to speak, joins the work-force, though still remaining unemployed.

On this reasoning, the forgone product could be nothing but zero (Forbes, 1976, pp.19-21; Scott, 1976, pp.131-2; Scott, MacArthur and Newbery, 1976, p.73); or some very low value representing the household duties performed by the lowest employment category. However, the rural work-force is seldom so mobile either socially or locationally, as to enable this type of ripple effect. The attraction of the city does not operate in a rural sector like forestry. More often, forestry works are used by the partially employed to supplement agricultural work, rather than to replace it. Thus the main worker does not leave his existing slot in the rural economy.

Given the barriers to major changes in occupational status, it would be unrealistic to expect marginal adjustments to be induced all the way down to the youngster waiting to enter the work-force. What is likely to happen is that the new wage employment potential of the project will induce some reduction in the ranks of the marginal workers, and some improvement in the earnings of the main workers as well. Correspondingly, the forgone product is unlikely to be zero, but it is also unlikely to be as high as a full marginal product of the fully occupied main worker. The approach adopted above appears to be a suitable via media, and likely to be a reasonable picture of reality.

It remains now to value the forgone product, 0.4723w, at border prices. This is done here by multiplying by the standard conversion factor, a= 0.86. Strictly speaking, we ought to use the value-weighted average accounting ratio (AR) of the commodities actually constituting the marginal product. This would require specific assumptions on which products were affected and how they were affected, for the major components at least. If we assume that production in all sub-sectors is affected to some degree, the adoption of the summary factor 'a' might not be so much off the mark.

An alternative estimate of SWR could be obtained by assuming the population homogeneous for the purpose of estimating m. The combined population was working for 5.98 days in the week, while the main worker worked 6.56 days in the week. We could assume that drawing one worker into the project would result in the loss of 5.98/6.56= 0.9116w worth of product. It is so much higher than the previous figure of 0.4723w because the proportion of marginal workers in the population is low, so that assuming that all categories are represented solely in proportion to their population, and not to the time spent searching and available for work, correspondingly lowers the significance of the under-employed part of the work-force.

8.6.4 Consumption increase of labour employed

The next item to consider is the increase in consumption of the workers employed in the project, in order ultimately to estimate the social costs and benefits of this increase. For this we need to estimate the initial and final consumption levels of those involved, and the border value of the incremental consumption.

Before the project, a marginal worker earned 1.94 days' wages; in the project, the marginal worker adds 3.2 days' earnings (the time unemployed, hence seeking work), to total 5.14 days' work per week. Similarly, the average main worker adds, to 6.56 days' wages, an additional 0.125 days' wages. We further note that for every worker-day in the project, 1/3.379 = 0.296 worker-days are drawn from 'main' workers, and 2.379/3.379 = 0.704 days from 'marginal'.

The increase in consumption of the marginal worker and his dependents is 3.20w for every 5.14 days employed; for 0.704 days, their increase in consumption, dc_{marg}, is $0.704(3.20/5.14)w = 0.4383w$. Analogously, the increase in consumption of the main worker, dc_{main}, is $0.296(0.125/6.685)w = 0.005535w$. The total consumption increase consequent on providing one worker-day of employment in the project is the sum of the two, denoted (dc_{marg}+ dc_{main}) or 0.4438w (Table 8.19.i).

If, however, the entire worker population is considered as one whole, the increase in income would be only 0.511w per week of 6.491 days in the work force, as the aggregate population is unemployed only 0.511 days in a week (Table 8.18). This works out to Rs 0.0787w per worker-day of employment provided, denoted by dc_{gen} in Table 8.19(i).

To express the consumption increase in border rupees, the dc values need to be multiplied by the conversion factor b_c for rural consumption, here assumed to be applicable to the rural marginal product as well.

The sum of the first two terms, the marginal product forgone and the cost of extra consumption, represents the cost side of the SWR. The estimation of b_c is discussed later; before that, the benefit side of the consumption increase is discussed.

8.6.5 <u>Social benefit of consumption increase</u>

The benefit from increased consumption is the social value of any extra consumption, which is related to per capita consumption. According to the 1981 census, the dependency load in Karnataka was 1.485 non-workers to every worker. We assume that this ratio applies to our study area, and equally to main and marginal workers.

Assuming the increased wages are shared equally among the immediate dependents, each worker's weekly earnings are shared among 2.485 persons. The equivalent incomes per capita per year are shown in Table 8.18.

In Chapter 5, two formulae were discussed to estimate the distributional weight, one (d_1) for non-marginal, the other (d_2) for marginal changes in the income level. Each of these formulae was applied to the respective consumption levels, under different values of n, for a number of years (from 1960 to 1984) for which estimates of w were available. The reference consumption levels at which d = 1, are the per capita national incomes at market prices (NNP at market prices) of the respective years. The difference in the value of d was negligible in the case of main workers, even for n= -2, but appreciable in the case of marginal workers, the change in whose consumption was large relative to the previous consumption level.

We therefore use the weights d_2. These were observed to be generally rising over time (for negative n), indicating the gradual worsening of the relative position of rural labour. To arrive at a constant d rather than any trend, we calculate the simple average for the years 1980 to 1984; d is observed to show no particular trend during this latter period.

Resulting values, of d_{main} for main and d_{marg} for marginal workers, and for each value of n, are as given in Table 8.19. Composite estimates for the undifferentiated work-force, d_{gen}, are also shown in all the relevant tables.

The next step is to calculate the social value of the consumption increase consequent on providing one worker-day of employment in the project. This is done by dividing it by the social value of the numeraire to express it in border rupees, then applying the relevant d weight to each component of the increase in consumption. The results are presented in Table 8.19.

Three variants are presented in Table 8.19. In the first, the disaggregated consumption increase of each category of workers is used in combination with its specific distribution weight, and the two resulting social values are added to yield a 'segregated' overall social value $(dc.d/v)_{seg}$. In the second, the consumption increase based on a homogeneous worker population, dc_{gen}, is used in conjunction with the 'homogeneous' distribution weight d_{gen}. Finally, the worker population is disaggregated for calculating the total consumption increase, $(dc_{marg}+ dc_{main})$, but homogeneous for purposes of the distribution weight d_{gen}. All these variants are calculated using v and v* values, as well as the x and x* values discussed in the previous section.

The social value of the numeraire is lower when x is used (Table 8.19.iii) than with v, the social value of investment alone (Table 8.19.ii). It is expected that the social value of consumption increases will be higher. This is seen (for negative values of n) in Table 8.19. The d/x values are three to six times the corresponding d/v values. As in the case of v, the x values also rise as n approaches zero, so that the d/x values fall; but not to such a low proportion as do the d/v values using the a priori v values.

Next, we compare the d/x* values (Table 8.19.v) with the d/v* values (Table 8.19.iv) obtained by the 'backward' calculation of the social value of the public numeraire. We expect that the d/x* values will show a higher weightage to consumption increases, and this is true for negative values of n; at n= 0, there is no difference. However, now the numerator d and denominator x* or v* are falling as n approaches 0. The very gradual fall in the x* values preserves much of the steep fall in d, whereas the steeper fall of v* neutralizes it to some extent. The result is that d/x* falls more steeply than d/v* as n moves from -2 to 0.

Comparing the d/v* values with d/v values, we find that the latter start at lower values right from n= -2 and q at the 'low' limit of 10% itself. Moreover, the latter also fall precipitately as n approaches zero; the fall in d is only magnified by the rise in the denominator v, rather than being neutralized by a fall as in the case of v*. Similar is the observation with d/x and d/x*, though the effects are more muted here.

8.6.6 The social cost of consumption increases

It is reasonable to assume that the composition of the marginal consumption basket is the same for both marginal and main workers, both being so near the poverty line. Moreover, it is likely that individuals shift frequently from one to the other group according to local conditions, and there is little likelihood of any consistent differences in tastes developing and persisting over any appreciable length of time. The rural worker population is, therefore, considered homogeneous as far as the composition of the marginal consumption bundle is concerned.

The social cost of the extra consumption is measured by $dc.b_C$, where b_C is the conversion factor for the marginal basket of commodities. A simple expedient would be to adopt the standard conversion factor a= 0.86 for all the commodities involved. This would at least give us an initial estimate of the SWR.

A better estimate of the conversion factor may be obtained by calculating the accounting ratios of at least the major components of the consumption bundle. Strictly speaking, we need to know the composition of the bundle of commodities purchased with the <u>marginal</u> rupee of income in the hands of the respective classes, but here it is approximated by the <u>average</u> consumption basket of rural households. At these low levels of consumption, it is not likely that any significant change in tastes results from increased wages.

The details of the procedure are given in Appendix 5. The major items for which ARs were calculated (Table 8.20) are staple foods, pulses, edible oils, and sugar; all other items (49.76% of rural consumption expenditure) were valued at the SCF 0.86 (Appendix 5).

The weighted mean AR of all the items works out to 0.8139, plus $0.0064*wb_L$ for the labour content (Table 8.20). If we choose to ignore the latter completely, the AR for all consumption goods of rural labour, the b_C we are aiming at, can be taken as 0.8139, or approximately, 0.81, only marginally different from the SCF a, 0.86.

If the labour cost is retained, a particular value is adopted for the domestic wage rate, w, =Rs 5.25 in 1981. The equation can then be solved for b_C, and subsequently for the SWR or for b_L, as the case may be. This is discussed in the next section.

8.6.7 Rural shadow wage rate and consumption conversion factor

We now have a basis for estimating each of the three components of the shadow wage rate: the forgone marginal product, the cost of increased consumption, and the social benefit of increase in workers' consumption. We use the formula already given,

$$SWR = w.b_L = m.b_C + dc.b_C - dc.d/v ,$$

to calculate the conversion factor b_L for the SWR, and the labour consumption conversion factor b_C as follows.

A number of variations are possible in the assumptions on each component of the SWR. First of all, the value of v used could be any of the variables denoted in this chapter by v, x, v*, or x*. For each of these, as usual, the full range of n values, from -2 to +0.5, is possible. For v and x, we also consider the three levels of marginal product of capital q, 0.10, 0.125, and 0.15. The marginal savings ratio is set at 15% as before. The conversion factor for rural consumption could be either the SCF a= 0.86, or the specially calculated b_C (Tables 8.21.i to 8.21.iv).

The second source of variation is the particular assumption on distribution patterns. Two variants are considered. One is that the rural population is essentially homogeneous for estimating m, dc, and d. In this case, the forgone marginal product m tends to be high, increase in consumption dc low, and distributive weight d low, as the marginal workers are given less weightage. The implied SWR would thus tend to be high, closer to the market wage rate. Using x values, the SWR is lower, as now the relative value attached to public income is lower.

The second variant is that that the population is disaggregated only for m, and homogeneous for dc and d. The opportunity cost of labour m is thereby reduced, and the SWR correspondingly lower.

Further variations on the theme can be considered. For illustration, two other combinations are included in the calculations using

v^*. Very low (even negative) values of the SWR are obtained when the population is disaggregated for purposes of estimating m, dc, and d. This is because disaggregation gives due recognition to the low opportunity costs of unemployed workers, as well as to the very low levels of per capita consumption at the wage rates prevalent. A lower importance to distributive gains is implied by the last variant, under which the population is disaggregated for m and dc, with homogeneous d.

. The results presented in Table 8.21 (i) to (iv) serve the purpose principally of answering the "what happens if..." questions that arise in sensitivity analysis. The calculation in the case of full homogeneity, using v values based on q= 0.10 in Table 8.21(i), is followed through here for illustration.

The conversion factor for rural consumption is first approximated by the SCF a= 0.86. The forgone m was shown to be 0.9116 times the marginal product of a day's work by a main worker (Section 8.6.3). Assuming the daily wage rate, w (Rs 5.25 in 1981), measures the value of this product, $m.b_c$ works out to (0.86)(0.9116w). The increase in consumption, dc_{gen} in Table 8.19, was 0.0787w Rs (domestic) per worker-day of employment for the undifferentiated population. The social cost of this, in border Rs, is $dc_{gen}.b_c$, or here (0.0787w)0.86. The cost side thus totals to 0.86(0.9116+0.0787)w. On the benefit side, each Re(domestic) of consumption is worth Rs d_{gen}/v or Rs 1.6004 (border) as shown in Table 8.19. In fact, the social value, $dc_{gen}.d_{gen}/v$, of the increase dc is already available in Table 8.19: it was Rs(border) 0.1259w for n= - 2.

Thus the net social cost of one worker day,

$$\begin{aligned} SWR &= 0.86(0.9116+0.0787)w - 0.1259w \ , \\ &= 0.86(0.9903)w -0.1259w = (0.8517 -0.1259)w \ , \end{aligned}$$

or 0.7258w. The conversion factor b_L is thus 0.7258.

If the newly computed conversion factor for rural consumption is used in place of SCF a= 0.86, the process is as follows. The value b_c is used for both the marginal rural product and the marginal rural consumption basket. Putting

$b_c = 0.8139 + 0.0064$ SWR, and substituting for SWR,
$b_c = 0.8139 + (0.0064)w.b_L$. With w= Rs 5.25,
$b_c = 0.8139 + (0.0336)b_L$.

Since $SWR = w.b_L = m.b_c + dc.b_c - dc.d/v$,

$$wb_L = (m + dc)(0.8139+0.0336\ b_L) - dc.d/v;$$

Putting $m = 0.9116w$, $dc = dc_{gen} = 0.0787w$,

$(m+dc) = (0.9116+0.0787)w = 0.9903w$; then
$wb_L = 0.9903w\ (0.8139+0.0336\ b_L) - dc.d/v;$
$b_L = 0.9903\ (0.8139+0.0336\ b_L) - dc.d/vw;$
$= 0.8060 + 0.033274\ b_L - dc.d/vw;$
$0.9667b_L = 0.8060 - dc.d/vw;$ whence b_L is calculated as
$b_L = 0.8337 - dc.d/0.9667vw$; for $dc.d/v= 0.1259w$, this is
$b_L = 0.8337 - 0.1259/0.9667 = 0.8337 - 0.1302$,
$= 0.7035.$

From the value of b_L, in turn, the consumption conversion factor b_c can be computed,

$b_c = 0.8139 + 0.0064wb_L = 0.8139 + 0.0064(5.25)0.7035$
$= 0.8375.$

The results are displayed in Table 8.21(i). The value of b_L depends on whether we consider the rural population as homogeneous or not for the purposes of estimating the social value of marginal product forgone, the increase in consumption, and the social value of consumption increases. The positive aspect of the latter is so prominent as to more than neutralize the costs, when the population is disaggregated for the purpose of valuing the social benefit of the increase in consumption (for values of n from -2 to -1). The benefit of increased consumption becomes less marked if calculated for the rural work-force as a whole, without differentiating between main and marginal workers. If the population is considered as homogeneous for purposes of estimating the marginal product forgone as well, this increases the cost side of employing labour, and the SWR is positive even for n= -2, ranging from 0.42 (with x*) to 0.78 (with v for q=0.15) of the domestic wage rate. For n=0, the above limits are, respectively, 0.76 and 0.83. This last set of values appears to conform to the value of b_L= 0.70 used by the World Bank in its appraisal of the social forestry project in Karnataka (World Bank,1983).

As mentioned, the lowest values of b_L are those using x* values; for instance, for disaggregated m, with n= -2, and q=0.10, it falls to 0.05 with x*, compared with 0.10 with x and 0.28 with v*. For n=0, the SWR using x* or v* is 0.39, while that using x or v (q=0.10) is 0.46.

8.6.8 <u>Choice of the social wage rate</u>

Objections could be raised to the specific assumptions made here. For instance, the dependency load may be lower among the younger age classes. Since youngsters are expected to predominate among marginal workers, the distribution weight attached to the corresponding increments in consumption would be that much lower. On the other hand, the main workers would then have to bear more than their proportionate share of dependent non-workers. The distribution weights applied to their consumption increases would be higher, though to a small extent seeing that marginal workers form only 3.4% of the rural population.

Not surprisingly, therefore, the SWR, even for a given value of n, depends fairly crucially on the way we treat the population for purposes of estimating the production and consumption effects. On the whole, the more disaggregated our treatment, the greater is the weight given to the distributive aspect, and the lower is the resulting SWR, given our assumption of a correlation between unemployment and low consumption. The stronger the egalitarian bias, the better would labour-intensive projects perform, if choice of technique were at issue. Whether such considerations will make a major difference in project choice would depend, presumably, on whether the alternative projects or uses differed much in labour-intensity.

Since SCBA needs to be acceptable to policy-makers as well as theoretically consistent, a negative SWR might be a case of over-stating the case for distributive considerations. A reasonable compromise is afforded by the basis of a differentiated marginal product, but homogeneous increase in consumption (dc_{gen}) and homogeneous distribution weight (d_{gen}).

The justification for such a treatment is that there need not necessarily be a strong link between the social value of consumption and unemployment, such as there is between marginal product and unemployment. The marginal product forgone cannot be equal to that of a fully employed worker for the simple reason that wage employment of the type contemplated by us affords no increase in the earnings or consumption level for such a worker. The marginal product forgone has to be less than that of a fully employed worker, as long as there is a growing labour force and some amount of unemployment. On the other hand, there is no guarantee that the identity of the under- and the fully-employed will remain constant, and it is likely that society does not differentiate between the two for the purpose of assigning distribution weights. Further, the lower dependency load expected for younger age-classes makes up, to some extent, for the higher incidence of unemployment, so that there is not that clear a link between per capita consumption and employment. Self-employment is also expected to reduce the gap in consumption between the 'main' and the 'marginal' workers.

The resulting SWR, ranging from 0.049w to 0.402w (w being the domestic wage) for n= -2, or 0.388w to 0.457w for n= +0.5, is considerably below the value, 0.70w, used by the World Bank (1983). Our analysis thus gives greater weight to social aims and to the employment situation. This is not unjustified in view of the explosive possibilities inherent in the existing situation. Whether it will give a positive bias toward the forestry sector, which is often advanced as a fit avenue for creating rural employment, would depend on the performance of alternatives presented, under the selected SCBA criteria. The same could be said with reference to the question of sustained yield forestry in general.

CHAPTER NINE

SOCIAL ANALYSIS OF SUSTAINED YIELD MANAGEMENT OF TEAK

The central forestry option in the Yellapur forests has been the conversion of mixed forest to uniform teak under a sustained yield regime. We turn our attention now to the social costs and benefits of this management system.

9.1 Teak plantation as a social investment

9.1.1 Cost streams

For the social cost benefit analysis, the same schedule of expenditures (inputs) is used as for the financial analysis. Expenditure on planting and silvicultural operations is kept apart from that on logging and transport of the product. The wage and non-wage streams are differentiated under either head. Each item has its own accounting ratio to convert values at domestic market prices into border values. This is applicable for expenditure on material inputs too. To limit the number of run-time variables, non-wage inputs of each year are expressed as a composite input with a single accounting ratio, which varies from year to year.

9.1.2 Shadow wage rates

The accounting prices used for the major input, wage labour, are the market wages multiplied by the conversion factors b_L discussed in the previous chapter. Generally, the same SWR was used for both plantation and logging works.

Strictly speaking, distribution weights and opportunity costs may be different for the two groups. Logging is done by specialist skilled workers often from other states. They may expect higher earnings than the local labour, who are drawn from the sedentary agricultural work-force.

However, differences in living standards are probably not significant, especially if the greater costs of mobility and effort of the logging worker are taken into account. In any case, logging is also undertaken to some extent by local villagers. It is difficult, therefore, to make a distinction between plantation and logging labour.

9.1.3 Discount rates

The social accounting rates of interest (SARI) calculated in Chapter 8 are used for sensitivity analysis under different levels of distributive bias (represented by the elasticity of social marginal utility n). The SARI is first set equal to the consumption rate of interest CRI (or the social time preference rate, STPR); the discount rates would be quite low, from 1.52% for n= 0, to 3.56% for n= -2 (cf. Table 8.8).

The second variant abandons this *a priori* interest rate for the rates *implied* by policy pronouncements. These are the i* values presented in Table 8.11. Compared with the previous i, SARI values are now fairly high: for q= 0.10, for instance, i* ranges from a high value of 10.00% for n= 0, to a low of 4.32% for n= - 2.

Further, the *a priori* STPR i does not depend on the value of q, but only on the value of n. The i* values however do; if the opportunity cost of capital is high, q= 0.15, the i* values are also higher (15.0% and

6.49% respectively for n= 0 and n= -2). Then along with the SWR, the SARI also is determined by the set of assumptions on n, q, and the social value of the numeraire.

Thus, when the calculations are based on the v* or x* values, both the SWR and the CRI rise as we move toward less egalitarian values for n. The SARI also rises as q rises, indicating the higher opportunity cost of using capital. When, however, the analysis is based on the *a priori* values of the CRI, as we move to less egalitarian n, the SWR increases as before, but the SARI falls. The latter is independent of the q assumed, but the SWR increases as q rises, owing to the rise in the relative value of public income.

9.1.4 **Material inputs**

Among the material inputs, the major identifiable items are barbed wire, insecticide and pesticide, and fertilizer. Petroleum fuel and oils are an indirect input in transport, and a direct input for water pumps; but they do not figure explicitly in the inputs here due to the assumption that teak stumps are raised in rain-fed nurseries. As in the case of capital and labour, we make the assumption that 'project' demand for these will not be so substantial as to have any effect on the marginal resource costs of providing them.

The results are summarized in Table 9.1. As before, the border prices were taken from the latest available report of the Statistics of Foreign Trade, 1981-82 (Government of India, 1982b). For galvanized iron wire, we did not have information on domestic prices for 1981-82. The 1985-86 domestic price, to the forest department, was around Rs 14,000 per MT (personal communication from KFD). The rate of inflation of domestic wholesale price of iron and steel was around 11.66% per annum over the period 1970-71 to 1984-85. The price of Rs 14,000 was deflated at this rate to arrive at the 1981-82 domestic market price, Rs 9,006.92. The AR is the ratio of domestic to border price, or 1.157.

For fertilizer, the 1981-82 border prices per MT fertilizer were converted to price of nitrogen, by taking the average N content of ammonium sulphate and ammonium nitrate as 20.6%, and of urea as 45% (Kumar, et al., 1963) for a weighted average of 44.79%. The domestic price is calculated as follows. According to the FAO Fertilizer Yearbook 1985 (FAO, 1986c), the price paid by farmers in India, with subsidies deducted where possible, at the statutorily controlled maximum retail price inclusive of excise duty, was Rs 7,280 per MT of N for ammonium sulphate, Rs 4,920 per MT N for urea, and Rs 6,400 per MT N for calcium ammonium nitrate (during 1981-82). The weighted average price, using the figures for the quantity of N imported in each of the forms, works out to Rs 4,931.22 per MT of N. Dividing the border price by the domestic, gives an estimate of around 1.12 for the AR of nitrogen.

It appears, however, that the FAO figures might underestimate some local handling and other costs and margins. The eucalyptus project report of the Karnataka Forest Plantation Corporation (KFPC) uses a price of Rs 1.60 per kg for ammonium sulphate in 1981-82, which, at an average 20.6% N-content, works out to Rs 7,767 per MT N, compared with Rs 7,280 above. Increasing the estimated domestic price in the same proportion, i.e. 7,767/7,280 or 1.0669, the estimate of the AR for fertilizer is reduced to 1.051, or approximately 1.05. This is the figure we use for the lump-sum expenditure on fertilizer, and we also extend it to that on pesticide and insecticide.

These estimated ARs are slightly higher than those estimated by Lal (1980) for 1973: 1.00 for iron and steel, 1.00 for fertilizer, and 0.91 for insecticide. This indicates the generally tighter market conditions in the wake of the oil crisis. For other minor items, the ratios arrived at by Lal (1980) were adopted: 0.663 for agricultural implements, 0.816 for motor transport. For all other items, and for general cash flows, we use the SCF a= 0.86 to convert from domestic market rupees to border rupees.

The expenditure statements are contained in Tables 9.2 (general), and 9.3 to 9.5 (SQII, III, and IV plantations). They are entirely analogous to the financial cost tables in Chapter 7.

9.1.5 Accounting prices for output commodities

On analogy with the financial analysis, we assume that the auction prices are determined by the free play of competitive forces. There is enough potential demand to absorb the incremental output at prevailing prices. Thus there is no change in the market prices, and no change in the consumers' surplus of the purchasers (who are mostly merchants and producers of further processed wood products).

The price producers are willing to pay ought to be a good measure of the additional net revenue they expect to get by using each additional unit of the commodity. The change in "consumer" surplus of producers, measured in the market for the factor input, is a suitable measure of the change in producer surplus, or 'quasi-rent', even if the quantities of other factor inputs are not held constant (Just et al., 1982). This suggests that all we have to do to measure the net social benefit of increasing timber production, is to wait for the market to arrive at a new equilibrium; the change in the demand of timber-using industries, along with the change in market price, ought to be enough to calculate change in social value.

However, this simple approach might not be entirely satisfactory, as we would have to trace the distributive aspects of changes in consumers' and producers' surplus in different markets. For instance, if the output were a Traded Commodity, an additional unit produced in the project might increase exports, depressing the export price if the demand were not elastic. It might also replace some part of other imports. In the case of a NTC, the additional unit produced in the project might augment domestic supply, perhaps leading to a fall in price; or it might cause the contraction of production elsewhere. Changes in producers' profits or consumers' surplus might also induce changes in the production and consumption of other goods.

A process of estimation that takes into account all such possibilities would require a great deal of information, especially in view of the long time scale and diversity of products and uses associated with forestry. In practice, one would inevitably have to make fairly drastic simplifying assumptions.

In our analysis, accordingly, we do not enquire into the end-uses of the teak purchased in the auctions, or their respective distributional effects. We accept the auction price as a good measure of the net value product that producers would obtain by using a marginal unit of the commodity. By assuming an infinitely elastic producers' demand, we are effectively assuming that the marginal willingness to pay is not in excess of actual price paid, and thus there is no change in consumer surplus in the finished goods market.

To the auction prices, government taxes of 12% are to be added. The resulting values, which are in domestic market rupees, are converted to border rupees by simply multiplying by the SCF of 0.86. In effect, the question of the distributional biases involved in the production and consumption of teak timber is by-passed, by assuming that the market price is expressed in domestic rupees of the same relative value as a rupee of consumption at the average level of income in the economy, $\bar{c}$. These aspects can be explored by a sensitivity analyses to variation in the AR of timber or smallwood. Indeed, if there no change in consumer surplus, there would be no distributional effects whoever gets the product.

The yield and unit value tables are the same as those used for the financial analysis (Tables 7.14 to 7.16). We first take up the case of teak plantation on a hectare of bare land.

9.2 The social cost benefit analysis of teak plantations

9.2.1 The combinations of parameter values

A number of combinations of n, i, b_L, and other parameters are plausible. To make the discussion manageable, we concentrate on b_L, the shadow wage conversion factor, as wage labour constitutes the major input factor.

The greatest departure from the market wage is caused by assuming a highly egalitarian value for n, of -2, disaggregated marginal product forgone m, and the lower x values of public income. We do not take up the case of disaggregated dc and d, for the reasons already discussed in the previous chapter.

For such a combination, with a low marginal product of capital q of 0.10, the SWR is only b_L= 0.096 of the market wage rate (cf. Table 8.21). For q= 0.15, this rises to 0.228w. For the neutral value of n= 0, b_L is 0.456 or 0.457 respectively. If the CRI values with probability of survival p= 1.00 were used, the SWR would be somewhat higher than these values, to allow for the higher value of public investment.

It would be confusing to deal with individual values of the SWR as above. Hence a sensitivity analysis is made for a number of hypothetical b_L values, namely, 0.25, 0.5, and 0.75, in Tables 9.6 (SQIII) and 9.7 (SQIV).

9.2.2 Optimal rotations under SCBA: SQIII

The following discussion assumes that taxes of 12% are added to revenues, and the lead to the depot is 10 km (Table 9.6).

For n= -2, the a priori discount rate (STPR) would be 3.56%, without any allowance for 'pure' time preference, but allowing for a non-zero mortality. Disregarding this for the moment, we find that the maximum

35%. However, it is only the 5-year rotation that shows the optimal soil expectation value from a discount rate of 10% and upward for a SWR of 0.0 (lead 10 km). For SWR 0.25, the optimum rotation is 10 years from 8% and up; for SWR 0.5 and 0.75, these rates are 9% and 10% respectively.

The optimal rotation follows the same pattern as for financial cost benefit analysis, with a tendency to shorter rotations. Consider the results for SWR of 0.25. The Se-optimizing rotation is 75 years at 1% (against 80 for the FCBA); at 30 year at 4% (against 55), 20 years at 5% (the same for FCBA).

The optimal rotations are very marginally longer for the far hectare (80 km lead), and slightly shorter than under financial cost benefit analysis. The results are not displayed for reasons of space. For SWR 0.25, the Se is maximized at over 80 years for STPR of 1%; at 4% 55 years (60 for the financial).

As the SWR is raised, the trend is for the optimal rotations to become a little longer. Thus the fall from relatively long rotations, of 60 years or more, to extremely short rotations of the order of 30 years, is deferred to slightly higher interest rates with a higher cost stream. At 4%, the optimal rotation with SWR 0.25 has already fallen to 30 years (lead 10 km), while still remaining at a fairly long 60 years with SWR of 1.00; at 5%, the optimal rotations are respectively 20 and 30 years.

The fact remains, however, that the fall in rotation length occurs between discount rates of 3% and 5% , indeed at slightly lower discount rates than for the financial analysis. Thus using social shadow prices only increases the pressure for shortening the rotation. This is a phenomenon entirely parallel to all the other rotation-contracting effects of any improvement in prospective returns.

Thus the special social benefit from forestry, implied or real, is unlikely to lend much support to the maximum sustained yield regime, although it may well bolster the case for forestry as a whole in comparison with alternative uses of the land. In parenthesis, it must be remarked that, as in the financial analysis, the peaks in NDR or Se value are not very clear-cut; the curves show a broad plateau over a wide range of rotation lengths, so that not all the 'optimal' rotations may be so robust in practice.

The significant element introduced in the social framework is the introduction of the social time-preference rate. The highest value is only 3.56% for n= -2. Even this, however, does not guarantee the optimality of the longer rotation, for the transition to short rotations occurs precisely between 3% and 4% when the lead is short, or SWR low. The higher the egalitarian bias (e.g., n= -2), the lower is the SWR likely to be (cf. Table 8.21). Thus the case for longer rotations may pass muster only by a narrow margin, even if the discount rate were as low as this.

The factor which might still revive the case for long rotations is that as n approaches zero, the value of i drops: it is just 1.52% for n=0. For as low an interest rate as this, the Se-maximizing rotation remains at 75 years or above whatever the SWR. The low social discount rate is in favour of the 75-years rotation up to n= -1.5 as well, when i= 3.05%.

An important observation here is that the discount rate would be just 2.01% for n= -2, if mortality were ignored (survival probability p= 1.00). This would make all the difference for the long rotations. Even at 3% discount, the optimal rotation does not fall below 75 years for SQIII, whatever the SWR (Table 9.6). With n= 0, the discount rate reduces to zero, and we have essentially the sustained yield case.

A low interest rate understates the cost of time, thereby penalizing society less for postponing returns. It is this consideration that is decisive in most of these cases, rather than the use of a low shadow wage rate. The latter is seen to work in the opposite direction, toward shorter rotations, and a consequent faster throughput of physical effort and a greater benefit to the worker population.

An interesting combination of parameter values is afforded by the alternative derivation of the STPR, from the d* and v* values (Table 8.11). Now, as we move from more to less egalitarian values of n, the implied STPR i* increases. For example, for q= 0.10, i* rises from 4.32% with n= -2 to 10.0% with n= 0. The SWR, using x* and disaggregated m, ranges from 0.0486w for n= -2, to 0.3876w with n= 0 (Table 8.21.iii). The lower SWR forces the rotation to even shorter lengths (than the corresponding SWR based on x-values of public income). Thus the implied social discount rate of 4.32% is too high to sustain any long rotation; for q= 0.125, i* is even higher, 5.41%, and thus precludes rotations shorter than 20 years.

For higher values of the SWR, say 0.7035w, (under assumptions of homogeneous m, using v with q=0.10, n= -2) there is but a slight easing of the pressure to shorten the rotation. With a SWR of 0.75w, it is 60 years at 4%, but still falls to 20 years at 5% (for the near hectare). The *a priori* interest rate being 3.56% for n= -2 and lower for less egalitarian n, the case for fairly long rotations is stronger. Thus it is again primarily the discount rate, and not the SWR, that is decisive.

For all the above examples, the rotation for optimal NDR of one rotation is discernibly longer, paralleling the case of the financial rotations. With a SWR of 0.0484w, for instance, the single-rotation NDR peaks at 50 years at 5.4% (against 20 years for Se), thereafter falling to 35 years. With SWR of 0.6548w, optimal rotation remains at 75 years up to 4.2% , then at 60 years up to 4.8%, whereas it is 30 years already at 4.1% for maximizing the Se. However, the single-rotation NDR ignores the gain in social value that could be obtained by replacing the crop more often, and is not an operationally sound criterion.

9.2.3 Optimal rotations under SCBA: SQIV

Analogous results are obtained in the case of a SQIV hectare, except that here the margins are narrower. Once again, the curves do not show sharp peaks and troughs: the tendency for two peaks in the net present value, seen already in the case of SQIII, is accentuated. The result is that there is a sharp fall in the optimal rotation from the later peak (beyond 80 years in most cases) to the earlier, as the discount rate crosses a certain borderline; there is no gradual transition.

It is difficult in some cases to be certain that the trend of the net present value to the later peak would not take it above the earlier, if the crop were retained beyond 80 years. Due to the absence of information on the growth for the subsequent decades, we have to settle for the highest peak within the range of ages available, and this might result in some sharp reversals in the direction of movement of the optimal rotation as we increase the STPR.

Sample results are displayed in Tables 9.7. The lower values of the SWR are obtained, as before, using the x values of the public income numeraire with q=0.10: the lowest being b_L= 0.0961 with n= -2, disaggregated m, and i= 3.56%. With a low SWR of 0.0, the optimal rotation for the near hectare falls dramatically from over 80 years at 2.0%, to the lower peak at 15 years at 3.0%, although the Se is only marginally different. The longer rotation could possibly be optimal if the rotation were to be prolonged beyond 80 years. At higher interest rates, however, this becomes less likely, and the optimal rotation is firmly at 15 years. For the far hectare, this dramatic shift occurs a little later. In either case, the a priori interest rate of 3.56% is too high to allow the long rotation.

As n approaches 0, two factors work to lengthen the rotation: the SWR increases, to 0.456 for n= 0; and the a priori interest rate falls, to 1.52% at n= 0. For a higher SWR, the transition occurs at a slightly higher discount rate; with SWR= 0.50 or 0.75, for instance, between 3% and 4%, rather than 2% and 3%. It is, however, the reduction of the STPR to 1.52%

that is decisive in supporting the long rotation; if it were to remain at 3.56% as for n= -2, there would be a considerable uncertainty over which way the rotation went, the balance favouring the shorter.

The latter case of ambiguity in the optimal rotation would arise if we regarded the rural population as homogeneous for assessing m as well as c and dc. The SWR starts at 0.7035w for n= -2 (v values based on q= 0.10). For this SWR, the optimal rotation stays over 80 years up to 3.5% for the near hectare, and up to 4.1% for the far. The highest such SWR goes to 0.8335w for n= 0; now the optimal rotation remains at over 80 years to 3.7% on the near, and 4.3% on the far hectare, thereafter falling to 20 years from 3.8% and 4.4% respectively. If, however, the discount rates based on p= 1.00 (no mortality) were followed, the case for the 80-year rotation would be very strong.

When we come to the set of parameters based on the <u>reverse</u> calculations using c*, we see that the <u>minimum</u> discount rate, for n= -2, is 4.32%. The corresponding SWR (for disaggregated m) is 0.049 based on x*, or 0.281 based on v*, neither of which can sustain a long rotation at such a rate of discount. Even the maximum SWR of 0.388 for n= 0 for either basis is too low.

When we revert to the assumption of homogeneous m, the SWR starts at 0.419w (on x*, n= -2), or 0.655 (on v*, n= -2), neither of which is high enough to support the case for long rotations above a discount rate of 3.5% on the near, or 4.1% on the far, hectare. The maximum such SWR is around 0.763w for n= 0, 0.796w for n= +0.5; long rotations are supported to a discount rate of 3.6% for the near, 4.2% for the far, hectare.

Thus even on the SQIV hectares, although the general tendency is for optimal rotations to be prolonged due to the lower cost of postponing future harvests, this is still not enough to tilt the balance in favour of the long rotations. The decisive factor is again the discount rate, and this has to be really low to justify waiting for 60 or more years for the harvest.

9.2.4 Price change, inflation, and optimum rotation

A moderate inflation of 2% per annum in the output prices relative to all other prices is able to bring about a moderate improvement in the performance of longer rotations. With a SWR of 0.50w, for instance, the optimal rotation on the near SQIII hectare is 75 years even at 5% discount, but has fallen to 20 years by 6% (compared with 4% without inflation). On the far hectare, it falls from 75 years at 5% to 30 years at 6%; without inflation, it is already 60 years at 4%, and 30 years at 5%.

For the *a priori* discount rates, it is again the low STPR that gives a comfortable margin of safety to the longer rotations. For the alternative *backward* interest rates, this does extend the range of parameter values under which longer rotations are optimal, but not to any great extent. With interest rates of 10%, for instance, even a 5% rate of annual inflation can sustain only a 20-years rotation for optimal Se. An inflation of 8%, however, extends Se-optimal rotations to 75 years at 10% to 11% discount rate, and 60 years at 12% discount; while a 10% inflation sustains rotations of over 80 years for discount rates of 10 to 11%, and 75 years for 12%.

In the case of SQIV hectares, with an inflation of 2% per annum, and, for instance, a SWR of 0.50w, the optimal rotation stays at over 80 years to an interest rate of 4%; but drops to 15 years at 5%, owing to the inherent double peak referred to above. To sustain long rotations under high social discount rates, however, considerably higher rates of inflation are needed. At 6% inflation, the optimal rotation at 10% discount rate is 80 years, but still as short as 15 years at 11% and 12%. At 8% inflation, the optimal rotation is 80 years at 11% discount as well, but still 15 years at 12% discount rate; at 9% inflation, the optimal rotation is 80 years for a discount rate of 12% as well.

Under the *a priori* derivation of the social discount rates, this problem does not come up because the *maximum* discount rate is 3.56%, unless we add a premium for 'pure' time preference or uncertainty. Under the *reverse* calculation of i*, higher discount rates result under less egalitarian n values, and as the marginal product forgone of capital, q, rises.

The above examples can be judged against recorded rates of inflation of various timber products (cf. Table 2.3.ii for some such values calculated from data in the FAO publications on Forest Products Prices, FAO, 1981, 1982, 1983, 1985). The wholesale price of teak logs in Andhra Pradesh (expressed in current rupees) registered an annual rate of increase of 6.2% per year over the period 1967-1977, compared with 9.25% per year for the general wholesale price index over 1970-1977. The wholesale price of teak logs (girth class 60-90 cms) in Gujerat rose by 28.6% per year over 1979-82 compared with the general wholesale prices increase of 10.71% per year; teak logs of girth class 120-150 cms rose by 25.8% per year over 1978-82, against general inflation of 12.28% per year. Increase in the average auction price of teak logs in Dandeli depot (in the Haliyal Division of Kanara district, adjacent to our study area) was 18-19% per annum over the period 1971-1984, compared with the wholesale price increase of 9.5% per annum.

Though the rates of inflation in teak prices touch high values over the short term, it is doubtful whether they could be maintained over long periods. This is especially true of the historic past. The general impression of the decades preceding the present era of high developmental efforts, was one of sluggish demand. If, however, the recent acceleration in price increase causes an expectation of increasing scarcity in the future, and thus of continuing increase in price, the traditional long rotations may be justifiable even under economic criteria.

As before, however, the optimal rotation is linked to the context of conversion of the existing, often stagnating, crop. An acceleration in the rate of conversion might increase current timber supply sufficiently to cause a fall in the market price. Once the mature forest has been liquidated, however, there might well be a substantial fall in the annual stream of products, for the land base is limited to the existing territory under the forest department. The prospect of a continuing future scarcity might well justify the lengthening of rotations, perhaps even while the liquidation is still in progress.

The converted teak crop would be entirely commercial. The local community would have no benefit from it except in casual wage employment; with some concessional supply of firewood or fodder from pockets of natural forest left in the area, or perhaps from failed plantations. This loss in consumption benefits may be socially costly, as the local community is presumably poor, and the social weight attached to their consumption high. The next chapter assesses this aspect, and its possible influence on the rate of conversion of the existing forest.

CHAPTER TEN

BASIC NEEDS AND SUSTAINED YIELD MANAGEMENT OF TEAK

10.1 Basic needs and sustained yield management

10.1.1 Conversion of the crop and production of basic needs goods

Under constant price assumptions, the faster the rate of liquidation of the crop, the higher would be the present value. If there were no annual increment, there would be no gain in value on retaining the crop. Under such circumstances the 'cut and run' policy would appear to be economically optimal.

What could introduce a different result would be the possibility that 'mining' the remnant resource would reduce the flow of consumption benefits to the local community. If the annual outturn were suddenly increased (by sudden liquidation), the major portion of the increase in output would be supplied to the commercial market. The stream of benefits flowing to the local community would not be increased proportionately.

This might not result in an actual decrease in the annual flow of socially desirable consumption benefits to the local community, unless the rate of exploitation were so high as to exhaust the resource in the medium or long run. It is the latter situation that would introduce the distributive aspect in the context of liquidation of the remnant stock.

Thus, it is possible that the community will not just be denied a share in the increased annual outturn, but will in future not have access even to the current level of benefits. It is this that may be justify reconsidering the NPV-maximizing policy of mining the remaining crop.

10.1.2 Local privileges and the satisfaction of basic needs

The "Code of Forest Privileges sanctioned for the Kanara District" (in recent times, approved by Government order in 1942, and amended in 1948 and 1950), provides the local villagers with "small quantities of round timber for huts and agricultural implements, fuel, bamboos for fencing and other purposes, grass for thatching and grazing for cattle..." (Wesley, 1964).

Some data on annual removals for local consumption are given in Table 10.1. Timber issued was mostly of junglewoods, and occasionally teak; "...the class of timber issued ... generally of poles, posts, rafters and logs". It is apparent that recorded free grants dropped sharply over the period covered in Table 10.1. By 1959-60, free grants of timber amounted to less that 10% of their level in 1951-52. The total of free grants and issues to "rights and privilege holders" was about half the 1951-52 level. The recorded issues of firewood declined sharply from the early 1950's, when grantees and rights and privilege holders removed many times that removed by 'purchasers', to the early 1960's, when this was less than 50% (6.6% in 1959-60). This seems to mirror the general lower priority to local needs in the new forest policy after independence.

At present, there is much concern about the damage caused to young growth by unsupervised removal of firewood and brushwood. The alternative is to distribute or sell fuelwood, bamboos, etc., through depots run by the forest department, co-operative societies, and State Forest Corporations.

In practice, this programme has concentrated on urban demand. Some smaller market centres have now been covered, but these are usually situated in the highly agrarian tracts in the maidan region. The idea of meeting the needs of forest villages through sale depots does not usually appear practicable. It is often doubted whether the villagers would be willing to pay money for a commodity available hitherto merely for the effort of collection.

There is thus an uneasy stalemate between the interests of protecting the forest and the unsatisfactory nature of alternative arrangements to supply basic needs goods. The social forestry plantations in the maidan districts may meet the needs of the agricultural tracts, but once again the forest villages are seldom covered. North Kanara itself is not one of the "priority" districts for the social forestry programme (World Bank, 1983); this is not too strange considering the extent of forest in this district.

Out of total removals of non-teak timber (including that 'extracted by purchasers' and that 'brought to Government depots'), the volume allotted to grantees and right-holders was between 10% and 5% during the first half of the 1950s, and between 1% and 3% since 1955-56. Thus it appears that as far as recorded removals go, local needs are met by a very small percentage of annual removals. A fairly high estimate for current years would thus be that 10% of total non-teak timber removals served the socially valuable purpose of meeting basic needs. In terms of quantity, the ruling figure corresponding to the 10% level might be taken as 50,000 cft or under 1,500 cmt (log, solid) a year.

As for fuelwood, the quantity released to grantees and rights- and concession-holders was 59.19% in 1958-59, but only 5.86% in 1959-60, of total removals. In terms of quantity, it was around 207,580 cft or 5,880 cmt, and 88,258 cft or 2,500 cmt (solid) in the two years respectively. Since the data in Wesley (1964) are incomplete as regards firewood, another estimate is obtained as follows.

According to the state-wide statistics of production and distribution, over the period 1980-81 to 1982-83, the total production of firewood was 4,029,140 cmt(r). The quantity allotted to domestic consumption either directly or through depots, was 685,856 MT (metric tonnes) (Annual Administration Reports). At 1.3 cmt(solid) to a tonne (density of 0.75), this works out to 891,613 cmt(r), or 22.13% of total production, comparable to the figure of 23.84% for the logging contracts notification of Yellapur Division for 1985-86.

For the purpose of local communities, however, unrecorded removals would qualify the above estimates. It is difficult to judge the local population's dependence on the forest. The allotment of fuelwood through formal channels is not likely to cover more than a fraction of the overall removals from the forest. This is especially true in the case of firewood, both at the national and at a local level. For the purpose of assessing the social value of non-commercial products, it might therefore be better to use the basic needs level of per capita consumption rather than the recorded removals or allotments.

The annual consumption of fuelwood in 1977-78 was 0.318 cmt(r) per cap for rural, and 0.336 cmt(r) per cap for urban, Karnataka (Subramanian, 1984; expressed in volume terms on the basis of 1.3cmt(r) to a metric tonne). The aggregate consumption demand for the two taluks of Mundgod and Yellapur, for the estimated population of 118,734 (based on the 1981 census), would be 38,163 cmt(r) per year. At the higher district-wide per capita consumption level of 1.144 cmt(r) for rural, and 1.036 cmt(r) per year for urban, areas, the aggregate consumption would be 133,443 cmt(r) for the two taluks.

The annual outturn as predicted by the working plan amounts to around 6,548 cmt(r) of teak (log, solid volume), and 28,293 cmt(r) of non-teak logs. At the rate of 1.5 cmt (solid) of smallwood for every cmt(r) of timber logs, the accompanying outturn of smallwood would be around 9,822 cmt (solid) of teak, and 42,439 cmt (solid) of non-teak, firewood. Thus if the annual consumption demand of 0.321 cmt(r) of firewood were to be met from the recorded outturn of the working plan forests, then almost the entire predicted outturn of non-teak firewood would have to be allotted to this function.

At a lower level of production of firewood, the current outturn would satisfy only part of the local consumption demand. For example, if the ratio of firewood to timber outturn were 1.0 instead of 1.5, then the current annual outturn of non-teak firewood would only be 28,293 cmt(r), satisfying only 74% of the estimated demand. The higher the per capita consumption, the greater would the shortfall be: at the per capita levels of consumption of North Kanara district, for instance, the above output of 28,293 cmt (r) would satisfy only 21% of the aggregate demand of 133,443 cmt(r).

For the purposes of the case study, it is assumed that the entire current annual production of non-teak firewood, estimated at 42,439 cmt (solid), is needed, and sufficient, to satisfy the bona fide requirements of the rural population. Any increased production would go to socially less meritorious consumption, and might not be so valuable from society's point of view.

A similar exercise for timber results in a value not far off the previous estimates of around 10% or less. We start from the 1984 consumption of 'other industrial roundwood' of 5.686 cmt(r) per thousand capita (ptc) and of 'sawlogs and veneer logs' of 19.549 cmt(r) ptc (Table 2.1.ii), for a total of 25.235 cmt(r) ptc, (or, roughly, 25 cmt(r) ptc). For the 1981 population of Yellapur and Mundgod taluks together, the aggregate local demand for timber would then be in the neighbourhood of 2,968 cmt(r) per year. This would be 10.49% of the predicted non-teak timber outturn of 28,293 cmt(r), or 8.52% of all timber, 34,843 cmt(r).

It is assumed, therefore, that only 10% of annual yield of non-teak timber as per the working plan would be serving a social purpose, the rest going to commercial demand. If, moreover, the rate of conversion of the existing crop were accelerated, any increase in annual outturn would also go to the open market, so that the proportion diverted to socially desirable channels would be lower.

10.1.3 <u>Social valuation of local benefits</u>

Benefits to the local community may be in the shape of material goods, but there are also many other services that contribute to the well-being of the community. No attempt is made, however, to impute a value to the 'intangible' benefits, as they are difficult to quantify with the existing information.

Thus the analysis is restricted to the identifiable goods that can be considered to be drawn regularly by the local community from the forest. To value these 'tangible' benefits, we could adopt the 'marginal social cost' approach, except for the fact that the cost of the main input, land, is itself not known.

Alternatively, the willingness to pay (wtp) of the consumer could be used as a measure of value to the recipient (Margolis, 1970). This is likely to be quite low merely because of the very low levels of income assumed for the beneficiaries in general. Indeed, the wtp for local rights of user and other benefits has been, traditionally, little more than the costs of collection and transport. Even this cost is minimized by using less productive members of the family and the relatively free time in the off-peak season.

For products that are exchanged commercially, the market price may be used for the consumption benefits granted to user communities. It is difficult, however, to specify their value from the recipients' point of view, in terms of rupees of consumption at their level of income. This is evident in the response of the beneficiaries to a change in local custom. The exercise of local rights and concessions rests often on a tenuous relation between the local community and government. For groups with low political influence, such as isolated communities, there is a tendency to slowly 'squeeze' out such privileges in practice. The recipients either forgo the benefits, or switch to alternative modes of procuring them, legally or illegally. In any case, they rarely pay the market price to replace the hitherto free goods. The wtp is low in terms of monetary units, a reflection of their low incomes.

Concession-holders are known to sometimes sell their privileges in the market, either illegally (as when timber granted for private use is resold) or legally (when, for instance, the government purchases the right of user for a cash compensation or 'composition'). The exchange price in such cases is often very low in relation to the market price. While this may be due to the difficulties involved in setting up such transactions, the more acceptable reason is the relatively high marginal value of general purchasing power to the poor villager. Prohibition by the government of such expressions of normal market behaviour may make these transactions difficult, but is also likely to induce higher levels of consumption of 'merit' goods than the private optimum.

In the case of the financial analysis, concessional or free supplies to privilege and right holders would be fairly simple to evaluate, as the revenue forgone by the firm. In the social analysis, however, the cost element is balanced by the social benefit of increased consumption.

As we are concerned throughout with society's relative valuation, we avoid the question of a possible divergence between the individual's perception of marginal utility and society's, by accepting the market price of the good in question, weighted by the relative distributional weight attached by society to the target individual's consumption increase, as an appropriate measure of the marginal social unit value of the commodity. The analysis is limited to benefits and commodities that are exchanged in the open market as well, which enables us to put a unit value on them.

10.1.4 <u>Distribution and social value of consumption benefits</u>

The stage is set now to consider the social value of a rupee's worth of consumption added to the local community. As mentioned earlier, different assumptions are possible regarding the distribution of incremental consumption streams. For the general public investment, they were considered to be as valuable socially as consumption at the average level. Thus projects or activities specially meant to benefit the poorest sections would come to have a relatively high social value.

Such a distributive advantage can be ascribed with justification to the objective of meeting the basic needs of the rural population. Access to the resource is usually not monopolized by the better-off. This is because all are usually allotted the same quantity regardless of their income level, merely by virtue of being members of the local community.

In fact, at least in relatively forest-rich localities, it is possibly the landless labour who draw the higher benefit from collection in the forest; because they are more likely to take up wage labour in the forest, or because their opportunity cost of time spent in moving into the forest and collecting material is lower (cf., the survey of the Tamil Nadu social forestry project, Tamil Nadu Agricultural University, 1982).

In contrast to the case of the general public investment, therefore, the distribution of firewood and other forest produce to members of the local community can be assumed, with much less scepticism, to be uniform across the lower range of income levels.

Such a distribution of benefits would be proportional to the relative frequency of population in successive per capita income classes, rather than to the percentage of aggregate income at each per capita income level. In a highly inegalitarian society, any move toward a more equal distribution of benefits would increase the overall social value of the undertaking.

This is borne out by estimating the population-weighted social consumption weighting factor. Table 10.2 gives the percentage distribution of the rural and urban population by household monthly per capita expenditure classes during 1977-1978, based on the National Sample Survey, 32nd Round (NSSO, 1981a). The aggregate distribution was computed assuming a rural population of 79.93% to an urban of 20.07% (the ratio for the population in Yellapur and Mundgod taluks according to the 1981 census). The notional mean value of the top class is computed to be consistent with the overall per capita Private Final Consumption Expenditure of Rs 1000.37 in 1977-78. The top consumption class, whose lower limit was Rs 200.00 per month per capita, constituted only 1.51% of the rural, and 1.55% of the urban, all-India population in 1977-1978. The contribution to social value of incremental consumption would be minimal. Thus the uncertainty in the mean expenditure of this class is not expected to seriously affect the population-weighted averages.

In Table 10.3[fn] are given the aggregate consumption weighting factors, D, the contribution of each expenditure class being proportional to the percentage of total population in that class. The symbol D denotes that it is a measure of aggregate distributive value. We use the formula for marginal increases in consumption, $(c/\bar{c})^n$, rather than that for non-marginal changes used for our computations of the shadow wage rate. This approximation is justified as the value of forest produce is likely to be small in relation to total consumption at most levels of consumption.

Differences between rural and urban values were negligible, so computations were made only for the aggregate population. Against each consumption class in Table 10.3, the value of D is the weighted sum of the contributions of that class and all classes <u>below</u> it; i.e., as if the distribution of benefits were to be restricted to people at or below that level of consumption.

If the rupee's worth of incremental consumption were distributed uniformly over the entire population, the overall D value would be around 6.12 for n= -2,; this may be compared with the 'global' D value if the distribution were to be in proportion to aggregate consumption, 1.42 (cf. Table 8.15).

If the public distribution system were so designed as to limit benefits to some lower level, the D value would be higher. For instance, if it were to stop at the mean $\bar{c}$ class, thereby covering only about 94.4% of the population, $D(\bar{c})$ would be 6.46 (n= -2); for the consumption-proportional distribution, for comparison, $D(\bar{c})$ would be around 3.88 (not tabulated).

If we further assumed that, under the minimum needs programme of the government, a conscious attempt is made to identify only beneficiaries at or under the poverty line, then D(c*) [or D*] would be as high as 8.82 (n= -2), against 6.46 for the consumption weighted distribution. The expenditure classes included would cover about 64.5% of the population (36.2% of consumption). If we restricted the sharing of benefits to only the poorest class, D(c0) [D_0] would be as high as 491.53 (for n= -2),

Footnote: Upper case D is used hereonward to denote an aggregated distribution weight.

covering however only 0.09% of the population. The aggregate D/v values (social values in terms of the numeraire) are given in Table 10.4(i) using v and v*, and in Tables 10.4(ii) using x and x*, values of public income.

An alternative approach would be to assume that the beneficiaries are restricted to rural workers, and so to use the d values for main and marginal workers. Instead of the values derived on the formula for non-marginal changes in income, however, we use the formula for marginal changes. Further, instead of assuming the worker population as homogeneous for consumption, we now assume that society values the consumption increase accruing to the marginal workers (3.42% of the total) higher than that to the main (36.76%). We therefore derive the weighted average of d_{marg} (weight 3.42) and d_{main} (weight 36.76), to arrive at what we call d_{work}, for various values of n (Table 10.4.iii). For n= -2, for instance, d_{work} is 13.10, compared with D(c*) of 8.82.

Having thus calculated a wide range of d values, we use these with corresponding estimates of the social value of public income numeraire, variously denoted v, x, v*, and x* in our previous discussion, to arrive at the d/v values needed to turn the consumption value of local benefits into border rupees. The range of values thus obtained is displayed in Table 10.4.

As expected, the relative value of 'minimum needs' benefits falls quite low in comparison with public income, as |n| falls to zero. Apart from this, the highest values are obtained under the assumption of the highest distributional bias to the poorer classes. Under the range of options considered, that using the d_{work} values for rural workers yields the highest d/v values, around 8.68, corresponding to a value of d of 13.10, under a strongly egalitarian n of -2. Some idea of the distributional implications is obtained by noting that D is a comparable 12.5 for the population-proportional distribution if the benefits are limited to the poorest five classes (Table 10.3); these cover only 38.4% of the population.

Even higher values would be obtained if the beneficiaries were restricted to lower levels of consumption. However, this is not very likely, as putting the boundary at the critical consumption level c* itself yields lower d values than for the worker classes. Accepting the cut-off level c* as about the limit of egalitarian bias, the corresponding value of D*/x* would be around 5.84.

10.1.5 **Pace of conversion and social accounting prices**

In the previous section, we have derived the plausible range of d/v values for the consumption benefits that may be flowing to the local population from the existing forest. We use these d/v values to derive the social accounting prices of timber and firewood. In a later section, these ARs will be used to test how far the basic needs interest can justify slowing down the rate of liquidation of the remnant crop in Conversion WC areas FS1 to FS5.

It is assumed that 30 years is the normal conversion or liquidation period (this varies, however, in Wesley's plan from 20 years to 30 years). Further, it is assumed that no increment or ingrowth occurs; there is consequently no return to retaining the crop, a condition that probably penalizes the sustained yield regime. All hectares in a given felling series are considered to carry the same standing volume. The only variable factor is the proportion of the outturn that can be considered to serve the basic needs objective.

The accounting ratio for junglewood timber and firewood depends on the conversion period. The accounting ratio is calculated by the formula

$$AR = f.p(d/v) + 0.86(1-f.p),$$

where f is the conversion period as a fraction of the 'normal' length of 30 years, and p is the proportion of the product that, under the 'normal' conversion rate, would be considered to be satisfying basic needs. Thus, f.p is the fraction of the annual product that goes to satisfy basic needs, and hence to be valued at the chosen (d/v) value.

For instance, if conversion rate were doubled, household consumers could not take up the extra annual production, and the proportion of the annual product going to them (f.p) would be halved. The fraction (1-f.p) is taken up as usual by commercial demand, to be valued simply on par with other government revenue (at the standard conversion factor 0.86).

As explained already, p has been fixed at 0.10 for junglewood timber, 1.00 for junglewood firewood, and 0.0 for teak of all descriptions. Taking the case of junglewood firewood, for instance, it is seen that when the conversion period is 30 years, f= 1, and all the annual production is valued at the social premium. If conversion period is contracted to say 10 years, f= 1/3 of the 'normal' 30 years, and the annual production would be thrice the previous level; but the proportion considered socially valuable would be only 1/3rd the annual production, f.p= 1/3.

The reason lies in our assumption that there is a gross limit to the quantity that can be considered going to meet basic needs every year; the requirements of future years cannot be fulfilled in earlier years, and hence the supplies in excess of the current basic needs requirement are not socially as valuable. In essence, this gives importance to the aspect of maintaining basic life functions, rather than of increasing the enjoyment of consumption in current time periods.

The resulting values of accounting ratios for junglewood timber and firewood are shown in Table 10.5(i), for a range of d/v values, and under conversion periods of 30 years (the 'normal'), and accelerated conversion periods of 20, 10, 3 and 1 year(s). The main change is in the AR for firewood. Rather than use the d/v values of table 10.4, ARs have been calculated for d/v values fixed arbitrarily at intervals of 0.5, from 0.5 to 10.0. At the bottom of the table, however, ARs have been computed from two specific d/v values, denoted D*/x* and d_{work}/x^* respectively, for illustration. For teakwood, the AR is uniformly 0.86 for both categories of products.

10.2 Basic needs, sustained yield, and conversion rates

The social value of distributive measures has been worked out under a wide range of conditions and assumptions. The possible trade-off between social and economic ('efficiency') objectives is now explored in the context of exploitation of the conversion felling series in the study area. Only the FS1 crop is considered; other felling series are however similar.

10.2.1 Pattern of conversion of remnant crop

To make the results more meaningful, rather than taking the case of a single hectare, we consider a property of 30 hectares under conversion. The crop is characterized by the respective diameter (breast height, dbh) distributions in FS1 to 5 (Table 7.25), with the same teak and junglewood timber and firewood volume outturns per hectare, and the same unit values. The unit value of junglewood timber is 0.4 times that of teak timber; for junglewood firewood, 0.38 (cf. Sec. 7.4.3).

The annual administrative charges of Rs 50/ha, and fire tracing expenses of Rs 19.66/ha, are considered to be loaded on the teak component. For the 30-ha estate, the social value of the former would be Rs 1,500*0.86, or Rs 1,290 per annum; and of the latter, Rs 589.80b_L per annum. The net present value of the junglewood component is net only of the extraction and transport costs.

The felling of this standing crop can be done over a period of 30 years, as provided in the working plan, in which case the AR of junglewood firewood and timber would be relatively high; or over shorter periods, when the ARs would be lower. The trade-off between early returns and low social value is the subject of the discussion here.

10.2.2 **Optimal rate of exploitation: single harvest**

We first consider a high degree of distributive bias, associated with a specific d/v value: d_{work} of 13.10 in combination with the low x* values of public income for a high $d1_{work}/x*$ value of 8.68 for n= -2. This results in a fairly high AR for junglewood firewood: 8.68 on a 30 year conversion period, falling to 6.12 for 20 years, 3.44 for 10 years, 1.64 for 3 years. The AR for junglewood timber is, respectively, 1.6416, 1.52, 1.12, and 0.94. The AR for teak is 0.86 uniformly (Table 10.5.i).

Similarly for the SWR, the specific values derived previously (Table 8.21) are used. The SWR, for n= -2, is as low as b_L= 0.0486 with x* value of public income, and disaggregated marginal product of rural labour (since main and marginal workers contribute separately to d/v value) (Table 8.21.iv).

At low rates of discount, the NPV of the junglewood component alone is highest on the longest conversion period of 30 years, and falls as the rate of conversion is accelerated (Table 10.6.i). At 5%, for instance, the NPV of junglewood timber and firewood outturn over the 30-year conversion period is around Rs 2,467,700 (for the 30-hectare property); this falls to Rs 2,465,300 for a conversion period of 20 years, Rs 2,035,300 for 10 years, and Rs 1,713,500 for 3 years.

At higher social discount rates, however, future consumption benefits are less valuable, and the advantages of accelerated exploitation more pronounced. For example, at 10%, the NPV of the junglewood products alone is around Rs 1,513,400 on the 30-year conversion, rising to Rs 1,684,100 when the conversion is accelerated to 20 years; it falls, however, to Rs 1,619,600 for 10 years, and 1,564,700 for 3 years. In this case, the longest conversion period is seen to be unable to compete with the shortest, although the optimal is somewhere in-between the extremes.

There is, however, a moderately high percentage of teak in the crop. The gain in social value by stretching out basic needs supplies would have to be weighed against the loss due to delaying the teak harvest.

For a discount rate of 5%, the NPV of the teak is approximately Rs 666,700 over the 30-year period, but rises to Rs 1,213,360 for the 3-year conversion period (Table 10.6.i). The loss in social value of the junglewood component tempers this effect; so that, among the options considered, the 20-years period is highest valued.

At the 10% discount rate, however, any such consideration is far outweighed by the immediate gains from accelerated realization of teak. The shortest conversion period is more attractive than the longer options. Thus the choice of social discount rate once again exercises a commanding influence on the outcome under the economic criterion.

When using the critical consumption level as the benchmark for the social value of public income, the social accounting rate of interest was derived indirectly (Table 8.11). The CRI values were closer to 5% than to 10%: with n= -2, 4.32% for q= 0.10, 5.41% for q= 0.125, and 6.49% for q= 0.15. We can reasonably expect, therefore, that the optimal period of liquidation is nearer 20 years than 3 years, although the present 30-year norm would probably not be justifiable.

For a lower d/v value, the relative social advantage of drawing out the liquidation of basic needs products is weakened. For D* of 8.8218, the D*/x* value comes out to be 5.8423. The ARs for junglewood are correspondingly lower than considered so far (Table 10.5.i). The AR for teak timber and firewood remains at 0.86 as before. The results for the 10-km lead are as follows.

For a discount rate of 5%, the NPV of the junglewood component falls from Rs 1,863,200 on the 30-year conversion, to Rs 1,606,300 on the 3-year conversion period. Against this is the successive rise in the NPV of the teak component, from Rs 666,700 on the 30-, to Rs 1,213,360 on the 3-year, conversion period (Table 10.6.i). Any advantage to the longer periods is even less on a discount rate of 10%. Lengthening out of the liquidation period would then not appear to be justifiable solely on the basic needs ground. At 4%, however, the 10-year period is best (against the 20-year for the higher d/v of 8.6764); and at 3%, the 30-year period is favoured.

Similar patterns are observed with the higher SWR of 0.4192w if the population is considered homogeneous for valuing the marginal product of labour. On the whole, the higher the SWR, the lower is the potential gain in the value of the teakwood component, and the more is the potential loss in the value of the junglewood component due to the basic needs consideration. The tendency would be to improve the case for the longer liquidation period, but the actual effect on the optimal period would usually be marginal. In fact, no perceptible change resulted in the relative performance of the options taken up for the present discussion.

On balance, therefore, the lengthening of the liquidation period would be justified only if there were a strong bias toward the basic needs interests, or if the proportion or unit value of the non-basic needs products were relatively low.

10.2.3 Optimal rate of exploitation: recurring harvest

Some advantage might accrue to the basic needs interest if the forest was capable of supplying these products beyond the first period, e.g. from coppice or regeneration of miscellaneous species. This could be set against the certain absence of teak regeneration, and the high probability of failure of teak plantations.

Clearing the crop over a shorter period does not automatically guarantee that the same returns would recur at the same interval, especially in the case of very short periods like 10 years. What may be expected is a deterioration in the replacement crop, which would be expected to yield successively diminished returns at the end of each cycle. This deterioration would be the faster, the shorter the conversion period. Acting analogously to a negative inflation rate in output prices, it would tend to reduce the net present value of the shorter period options, thereby improving the case for the longer period. This is really a question of the options open for the replacement crop.

A simplified way of incorporating this aspect in the analysis is as follows. The annual junglewood returns from the 30-year conversion option are assumed to repeat to perpetuity, so that the usual calculation of the present value of the infinite series (the 'soil expectation value') is valid. For shorter conversion cycles, however, we assume that the NDR recurs every 30 years from the coppice crops, rather than at every 20, 10, or 3 years as the case may be.

Thus for the shorter conversion periods, the infinite-cycle NPV is not the 'soil expectation value', but the single-cycle NDR inflated by the same ratio as that obtaining between the 30-year soil expectation value and NDR. This is applied only for the junglewood component; the teak component is assumed to be available only in the first cycle.

Applying this method for a d/v value of 8.6764, (SWR of 0.0486w, lead 10 km, area 30 ha), we find that although there is an increase in the value of the junglewood component, it is not so dramatic as to reverse the previous results (Table 10.7). For a discount rate of 5%, the junglewood value for a 30-year cycle now is Rs 3,210,600, against the previous single-cycle value of Rs 2,467,740, up by a factor of 1.301. This is the factor applied to the NPVs calculated for the other periods as well, so that in effect the difference in the NPVs between successive periods is also multiplied by 1.301. The gain in the value of the teak component on contracting the conversion period from 30 to 20 years is, however, over 60 times the potential loss in value of the junglewood component, and the above increase in social value hardly begins to make any difference; the optimal conversion period is still 20 years (Table 10.7).

At a higher discount rate, the contribution of succeeding cycles of junglewood returns makes even less difference. For 10%, the ratio is only 1.061; in any case this only <u>increases</u> the positive gain in the junglewood value on contracting the period to 20 years, while it adds little to the potential loss over successive reductions in the period. As before, it is the 3-years cycle that is most advantageous.

It is possible, however, at intermediate discount rates and conversion periods, that there may be cases wherein the relative losses and gains are so closely balanced that inclusion of multiple cycles for the junglewood might tip the scales in favour of longer conversion periods. This would be all the more probable, the lower the proportion of teakwood expected.

10.2.4 <u>Optimal rate of conversion: interaction of SARI, SWR, ARs</u>

As can be seen from the sample of results presented in Table 10.6(i), the 30-year conversion period has a higher NPV with high d/v values and discount rates below 4%. As may be recalled, the discount rate derived on the <u>a priori</u> basis was 3.56% for n= -2, falling to 3.05% for n= -1.5, etc. When used with the corresponding x-values of public income, high values of the 'basic needs' consumption weighting factor d/v were obtained (Table 10.4): for instance, d_{work}/x works out to 7.6616, and D*/x to 5.1590 (for q= 0.10, n= -2.0). It is possible, therefore, that once we accept the low STPR as above, a high social weightage to distributive effects might favour lengthening of the conversion period under the constraints specified so far. It is difficult to predict the outcome with any degree of certainty, however, because the switching value of the discount rate seems to centre around the interval 3% to 4%.

Even with an intermediate D*/x* of 5.8423, at 4% discount, the 3-year period was no longer optimal, although this only raised the optimal period to something between 10 and 20 years (Table 10.6.i). At 3%, however, the potential gain in social value through junglewood supplies more than justifies the sacrifice in value of the teak component, and the 30-year period was optimal. The 'switching' value of the discount rate for the two options 30 years and 20 years must, therefore, lie somewhere between 3% and 4%. For d/v values higher than 5.8423, it is likely that a SARI of 3.5% would favour the 30-year option.

For lower d/v values, the discount rate would probably have to be lower than 3.5% to justify the 30-year option over the 20-year. If we are to use the a priori STPR of 3.56% with q= 0.10, and n= -2, the highest distributive value would be D*/x of 5.159 (Table 10.4) (the reverse calculation of x* would not be compatible with fixing the discount rate independently). The corresponding SWR values are 0.0961 (for disaggregated m) and 0.4675 (for homogeneous m of the rural work force).

The D*/x value is approximated by 5.000, the accounting ratios for junglewood timber and firewood for which can be read off in Table 10.5. At n= -2, the a priori SARI is 3.5%. At 3.5% discount rate, and d/v of 5.000 (for SWR 0.0961, 10 km lead), we find that although the NPV of the junglewood component is highest for the 30-year option, the gain in value of teak dictates a lower optimal period of 10 years (Table 10.6.ii). At 3%, however, the 30-year option has a slight edge.

Thus bringing in a low discount rate to justify the lengthening of the liquidation period is not entirely straightforward, as one has to settle for a lower d/v value. This makes the outcome highly sensitive to the specific combination of parameters, and it is difficult to pass generalisations about it.

On the higher side of d/v, we may choose the value d_{work}/x (q= 0.10) of 7.6616, which we approximate as 7.5. The ARs for the junglewood components now range from a higher 7.500 under the 30-year option downward (Table 10.5). At a discount rate of 3.5% (and SWR 0.0961, 10 km lead), the combination of parameters is one that clearly favours the longer liquidation period (Table 10.6.ii). The operational parameter is, however, the discount rate, for with the same high d/v of 7.500, a higher discount rate of 5% gives the edge to the 20-year period over the 30-year.

10.2.5 Basic needs interest and variable coverage

In the foregoing discussion, it was assumed that the value of p (the proportion of 'normal' annual output going to augment basic needs consumption rather than commercial demand) would be the same, whatever the d/v value. Strictly speaking, when the d/v value of products is varied by changing the cut-off income level, the proportion of the population covered under basic needs distribution would also change.

For instance, to justify using the $D(c^*)/x$ values, the distribution is supposed to be restricted to those at and below the critical consumption level c^*, which implies that at most 65% of the population would be so benefited. To justify using the even higher d_{work}/x values, the coverage would have to be even more restricted, to about 38.4% of the population (for the consumption level of main workers was estimated to be only 1/2.46 of the average $\bar{c}$, even lower than c^*).

The results are now considered if the coverage were assumed to be only the bottom 65% of the population. It had been estimated previously that, on a per capita requirement of 0.321 cmt(r) of firewood, almost the entire 'normal' annual production of junglewood firewood, and 10% of timber, would be required to satisfy local demand. Now, however, only 65% of the population is covered, so that on the same per capita consumption, only 65% of the annual 'normal' production of junglewood firewood, and 6.5% of junglewood timber, can be taken as going to satisfy the local demand. Provided it is reasonable to say that the rest of normal annual production is only as valuable as other government income, the accounting ratio of junglewood firewood and timber can be calculated using the previous formula, but with p= 0.65 instead of 1.00 for junglewood firewood, and p= 0.065 instead of 0.10 for junglewood timber.

Consequently, the ARs are reduced (Table 10.5.ii for sample values). A d/v value as high as 7.5 is obtained, even for highly egalitarian n of -2, only by using the d_{work}/x value, which would require coverage to be restricted to 38.4% of the population. For 65% coverage of the population and 30-year conversion period, the highest value is D^*/x of 5.159, or roughly, 5.0; the AR for junglewood firewood is only 5.1760, against 7.5000 previously, and so on (Table 10.5.ii).

This would be likely to weaken the basic needs interest further. As an illustration, for a SWR of 0.0961, lead 10 km, and 3.0% discount rate, imposing the 65% coverage limit, the loss in NPV of the junglewood component is negligible compared with the potential gain in teak. Bringing the period down to 3 years would result in an overall loss in junglewood of Rs 201,190, against a handsome gain in the teak component of Rs 450,240 (Table 10.6.iii). For the 100% coverage case, the loss in junglewood value at 3% discount rate was at Rs 575,440, so that the 30-year period gave the highest total NPV. With the 65% coverage condition, we would have to go down to something like 2% to justify the longer conversion period.

However, use of the lower discount rate would require, on our a priori basis of deriving the STPR (and hence the CRI and SARI), that a less egalitarian value were used for n, -1.5 instead of -2. This immediately means that the weightage given to consumption benefits would be reduced, thereby lowering the permissible range of d/v values. For example, d_{work}/x (for q= 0.10) is only 3.1183 for n= -1.5 (with corresponding SWR of 0.2695w with disaggregated m and 0.6434w with homogeneous m), compared with the previous value of 7.6616 for n= -2.0. Similarly, D(c*)/x (for q= 0.10) is only 2.3712 for n= -1.5 (with SWR of 0.2695w or 0.6434w), in place of 5.1590 with n= -2.0.

There is thus the catch that the advantage claimed for the longer conversion period, on the basis of a low social discount rate, would have to be paid for by the lower social weight imputed to basic needs consumption benefits. This was already apparent in the comparison of results for d/v of 7.500 and 5.000. A final example is provided by the results for d/v value of 2.5 in Tables 10.6(ii) and (iii).

Here the starting point is the SARI of 3%, which is justified on a priori grounds if n is around -1.5. The social value of welfare benefits is low, as can be seen from Table 10.11(ii): D_{gen}/x is 1.729 at the most for n= -1.5, while D*/x is 2.371. For d/v of 2.5, assuming basic needs benefits are restricted to the bottom 65% of the population (p is 0.65 for junglewood firewood, 0.065 for timber), the ARs turn out to be quite low (Table 10.5.ii): that of junglewood timber ranges from 0.967 to 0.864, and of firewood, from 1.975 to 0.896. There would not be much loss in social value by contracting the exploitation period. For SWR 0.0961w, d/v 2.5, at 3% SARI, the junglewood component by itself has the highest social NPV on a

30-year period (Table 10.6.iii); but the potential gain in the commercial value of teak overwhelms this, and the combined, overall, NPV is maximized on the shortest conversion period.

10.2.6 The basic needs argument and sustained yield exploitation

The case for lengthening the conversion period to approach those prescribed under sustained yield principles does not seem to be strengthened by choosing a lower SARI, if it means adopting a less egalitarian value of n and thereby weakening the social value of benefits to the poor. It would therefore appear that, under the restricted range of conditions posited, the gain in NPV of the existing teakwood is so high that even a strong egalitarian bias would not take the social value of the non-commercial component high enough to favour drawing out the liquidation process.

However, this does not mean that the basic needs interest should necessarily be sacrificed to the commercial. If there were a higher proportion of junglewood in the expected output, the compensating gain in value of the teak component would be lower, so that any options registering an overall loss in the social value of the non-teak component would get an advantage. In the case of crops previously exploited mainly for teak, the ratio of non-teak to teak output might be expected to be higher than 3.0 as assumed. Indeed, the more moist the site conditions, the sparser is the teak component. Some of the hectares actually belonging in the conversion working circle were relegated to the selection system; when the time comes to start converting such crops, the high proportion of junglewoods would be prone to improve the performance of the longer conversion period.

Other products and services would also have to be added to the stream of social benefits in addition to firewood and timber (the basic needs proportion of which might itself be higher than the 10% we have assumed). For example, bamboos and canes for cottage industry, fodder supply, and other products are important to the welfare of socially and economically deprived groups. It is difficult to envisage a continuing supply of these under the cultural regime needed for teak monoculture.

Against this, one would have to set off the loss due to postponement of the returns from teak plantation that could be raised on the cleared hectares. The net loss in social value between the 30-year conversion period and the 3-year conversion period is, even for high d/v (7.5), and low discount rate (3.5%), around Rs 684,000 (Table 10.6.ii), and this for a 30-hectare property. Per unit area, this reduces to around Rs 22,800 per hectare. Between a 1-year and a 30-year conversion period, the difference in NPV is around Rs 771,840 for the 30-ha property (or Rs 25,700 per ha).

The social NDR of one rotation on a SQIII hectare at 10 km lead, on a SWR of 0.25w, and at 3% discount, is Rs 79,000/ha on a 75-year rotation (the Se is Rs 88,600). This makes it likely that plantations will be the favoured course for SQIII hectares, in spite of a strong egalitarian bias.

For SQIV, however, matters are finely balanced, even at a low 3% discount rate. The NPV is Rs 19,700/ha on an 80-year rotation (Se Rs 21,700/ha) for a SWR of 0.25w. For zero SWR, it is Rs 21,600/ha (Se Rs 23,900/ha). If, for instance, there were little or only inferior teakwood in the existing crop, the advantage of drawing out its liquidation would be heightened. Further, if the junglewood were of reasonably high density, the values could well be multiplied many fold. At higher discount rates, SQIV plantations have quite low, even negative, values. Under such circumstances, it is probable that the optimal decision for many of the hectares would be in favour of retaining the junglewood, thereby continuing the flow of basic needs goods to the poorer sections of the population.

10.3 Sustained yield management, basic needs, and alternatives to teak

One of the important considerations in cost benefit analysis is the performance of alternatives under the chosen criterion. So far, we have restricted the analysis to alternatives internal to the teak option. Due to limitations on space, non-forestry alternatives are not taken up here. However, for illustrative purposes, at least one forestry alternative needs to be compared with the teak option.

We choose the option of planting *Eucalyptus* (hybrid) in Karnataka for this comparison. The social value of eucalypts is estimated, first as pulpwood, and then as fuelwood for distribution to the poor. The last alternative is more illustrative than realistic; as already discussed, many observers feel that commercial species cannot serve the basic needs interest in social forestry projects. There is some truth in these fears; the following analysis must therefore be somewhat hypothetical.

10.3.1 Eucalyptus plantations: cost streams

The sequences of operations and cost streams are very briefly summarized here. Details of administrative, nursery, and plantation costs are given in Tables 10.8 (i to vii) for the first crop, and 10.9 (i to iv) for coppice crops. These are in domestic market prices (mostly following the departmental schedule of working rates for 1984-85 to 1986-87). Expenditures in **accounting rupees** are detailed in Tables 10.10 (first crop) and 10.11 (coppice crop). Labour and non-labour items are shown separately, as in the case of teak, to facilitate drawing up the cost streams in accounting prices. The summary statement of annual costs is contained in Table 10.12.

10.3.2 <u>**Eucalyptus plantations: product and benefit streams**</u>

Standard yield and useful outturn of <u>Eucalyptus</u> (hybrid) plantations have been discussed by Pande and Chaturvedi (1972), Sharma (1978, 1979), Chaturvedi (1981, 1983), among others. For the purposes of the present analysis, we use the yield tables for SQI through SQV in Chaturvedi (1983).

These yield tables give the outturn of the first crop at ages 3 to 15 years, in volume (underbark and overbark) per hectare, at a density of 1,000 stems/ha. This volume, presumably standard (solid) volume, is converted to commercial outturn (solid volume) by multiplying by 0.75 (as in the case of teak). The resulting figures of outturn per ha (in cmt, solid, ub) are given in Table 10.13.

According to observations made by the Karnataka Pulpwood Corporation (personal perusal of the Eucalyptus Project Report), Karnataka plantations can be divided into 'A' class, in regions of annual rainfall 800-1300 mm, and 'B' class, in regions below 800 mm rainfall. The yield in the 'A' class crops is about 50 MT/ha (7th year), that in 'B' class, about 25 MT/ha (7th year). At 0.75 MT/cmt, these would be, respectively, 66.67 and 33.33 cmt (solid, ub) per ha in the 7th year. This would put 'B' class plantations at about SQII, and 'A' class a little better than SQI of Chaturvedi (1983).

The annual precipitation (average 1950 to 1959) was around 2,859 mm at Yellapur in the west, and about 1,310 mm at Mundgod, in the east of our tract (Wesley, 1964, p.91). Thus, judging by rainfall alone, both parts would fall in the 'A' class for eucalyptus. To allow for the generally greater biotic disturbance in the east, however, we assume here that the site quality for eucalyptus corresponds broadly to Chaturvedi's SQI in the western, and SQII in the eastern part of the Yellapur-Mundgod forests.

For unit values, we use the rate sanctioned by the Government of Karnataka for release at stump to the industry. This was Rs 385 per MT (metric tonne) underbark: at an average density of 0.75 MT/cmt (airdry, solid, ub), this works out to Rs 288.82, or roughly Rs 290, per cmt (solid, ub) **at stump.** This is the value (Rs 290) that we use in the analysis. For comparison, the depot auction price of junglewood firewood was Rs 95.35 per cmt (stacked), usually overbark, which is equivalent to Rs 179.90/cmt (solid, ub) at the previous conversion ratio of 0.53 cmt (solid, ub) per cmt (stacked) (cf. Appendix 2, Sec. A2.2.3).

According to Chetty (1985b), however, for eucalyptus wood, the volume of 1 MT (debarked pulpwood, airdry) is 1.779 cmt (stacked, ob); or, conversely, 1 cmt (stacked, ob) yields 1/1.779 = 0.562 MT (airdry, ub). Thus the depot auction rate of Rs 95.35 per cmt (stacked, ob) would, if applicable to eucalyptus wood as well, be equivalent to 95.35/0.562 or Rs 169.63 per MT (ub), less than half the industry rate (even disregarding the extraction charges on the depot material).

10.3.3 Eucalyptus versus teak plantation: social value

The detailed results of the analysis are not presented due to the limitation on space. We are interested mainly in the comparison between teak and eucalyptus plantation as alternative investment opportunities. Some sample results are presented in Table 10.14, for SWR 0.5 (for illustration). We assume that each planting of eucalyptus yields one main and two coppice crops, and that the yield streams are the same for all three crops (thus ignoring the possibility of a drop-off in yield).

If eucalyptus wood were only as valuable socially (rupee for domestic rupee) as the rest of the commercial outturn (including teak timber), we would apply the same SCF (standard conversion factor), 0.86, as for teak timber and smallwood. We can compare the soil expectation under the single-crop teak and triple-crop eucalyptus, from the figures in Table 10.14.

For the easterly hectares, teak of SQIV performs better than eucalyptus of SQII, only at very low SARI. For discount rates of 2% and up, eucalyptus has the advantage. The optimal rotation for eucalyptus falls from 15 years (*3 crops) at 0%, to 6 years (*3 crops) at 10%; while that for teak falls from 80 years (or above) up to 3%, to 15 years at 4% and up.

For the westerly hectares, teak of SQIII is better than eucalyptus of SQI for SARI below 10%. The gap, however, narrows at the higher range of the SARI. At 10%, eucalyptus (rotation 6 years*3crops) has a slight advantage over teak (rotation 10 years).

If eucalyptus were raised, not as pulpwood, but as fuelwood for basic needs distribution, its social value would be considerably higher. For illustration, suppose the accounting ratio for eucalyptus were now 5.00, against the previous 0.86. With the same market values, the social value of eucalyptus would obviously be much higher than previously. Now eucalyptus of SQII is better than teak even of SQIII, from SARI of 1% and up. Even SQIII eucalyptus is socially more valuable than teak SQIII from 2% and up. The higher returns, as expected, tend to shorten the optimal rotations of eucalyptus; but the difference is marginal at moderately high interest rates.

The question is, of course, whether the AR of Eucalyptus hybrid (or other fast-growing species, e.g. Acacia auriculiformis or Casuarina equisetifolia) raised for fuelwood can be put at 5.0 or a comparably high value. In a comprehensive analysis, a number of other social and environmental effects may have to be considered. But there is no basis for making a general statement that long-lived teak is better for society than short-lived eucalyptus, or any other combination of alternatives we would care to name.

CHAPTER ELEVEN

CONCLUSION

Since the details of the financial, economic, and social analyses of teak monoculture, as an activity in itself, have been covered in detail in the individual chapters, an attempt is not made here to recapitulate them. The topic of interest here is the wider one of the role and relevance of the economic approach in choosing between alternatives in the forest sector.

The shortcomings of the sustained yield forest management system reside primarily in the maximum, non-declining, physical yield principle usually assumed as an almost obligatory condition of responsible forestry. In the extreme case, this imposes sacrifices by delaying the harvesting of overmature stock. In rare cases, it may cause the premature clearing of young crops. Usually, however, the conservational instinct of the forester leads to a compromise, so that immature crops are retained even though they will cause a deviation from the regular forest structure aimed at under the 'normal' forest and yield model.

Economists have tended to criticize the (maximum) physical sustained yield model especially strongly in the context of liquidating the reserve of natural forest. According to the economic critique, these reserves should be treated as so much realizable capital, rather than as an investment committed for all time. This is because timber has the uncommon property of being both the factory and the product. It is thus easily transformed into other forms of capital without the 'round trip' costs that are involved in disinvestments in, say, plant and machinery.

The application of economic criteria in a conservative forest environment generally forces the liquidation of standing growth. The decisions taken under economic criteria are seen to be extremely sensitive to the discount rate chosen. If the prescription of economists to apply market rates of return is followed, the discount rates will usually be high enough to warrant liquidation without renewal of the forest.

The optimal rotations are highly sensitive to the discount rate. A crucial consideration is whether the social discount rate should be influenced by private mortality. The change in the SDR caused by this element may be small in absolute terms, but it makes all the difference to the viability of long-term forestry alternatives, that approach the sustained yield management regimes in many respects.

Forests have the nature of an environmental asset. Their worth to society is not solely in the material, specifically **marketable** goods produced, but also in the maintenance of the ecological integrity of the environment. The question of inter-personal and inter-temporal **externalities** is inevitably dragged in. Society does not usually stand by quietly when decisions involving huge stretches of common property resources are being taken.

Society may decide to bear the economic cost of retaining the mature stock because there is no assurance that regeneration will follow felling. Once regeneration has been delayed for a few years, the site becomes so degraded that there is much less probability of getting the new crop established. This is especially the case on tropical soils, which are thin and easily washed off, and the nutrients leached, when the canopy is opened up by heavy fellings.

The very possibility of achieving the returns predicted by the yield models would be lost (and, one suspects, has already been lost on most of the hectares described as completely exploited in the past in our study area) if the economic principle of separating the felling decision from the planting decision were followed to its logical conclusion.

Foresters, however, will not be entirely successful in meeting future demand for forest products if they are restricted to the existing productive base by the sustained yield model. The response of curtailing fellings, in a period of almost exploding demand both for forest products and for the land resource base, is counter-stabilising as far as the supply-demand situation is concerned. This is a reversal of the situation in the past, which was akin to the mining of an accumulated stock.

Starving the market only pushes up prices further. This usually hastens the exhaustion of private timber stands, as well as possibly shortening rotations. On the other hand, retention of under-productive old growth reduces the returns from the forest resource, thereby further intensifying popular pressure to relinquish the land for other uses.

The crisis in sustained yield forestry may be due to the increase in demand for forest products, but some of the responsibility must be ascribed to the failure of regeneration rather than to the rapid removal of overwood. It is perhaps the silvicultural and ecological knowledge that is lacking on how best to get the forest to recover its past glory; or, more probably, it is the social and demographic conditions that have changed so much as to make this almost impossible in practice.

Curtailing the felling of mature trees in response to the growing paucity of young age-classes can be viewed as an 'allowable cut effect' in reverse. In the ACE, inclusion of fresh plantation led to a faster rate of conversion of the natural forest, as the aggregate annual increment of the estate was expanded. Here we have the failure of regeneration leading to contraction in fellings in the natural crop. Regeneration activities are then diverted to non-forest areas in an effort to compensate for the apparent inability of the natural crop to reproduce itself.

It appears, now, that the forests are being preserved not so much as a productive resource as because of their unique scientific and aesthetic interest. This may have little to do with either the distributive or the stability interest, unless some conception of the possible future use, for study, recreation, local community welfare, or production for the market, is provided.

Finally, we look at some of the limitations in cost benefit analysis, and in the economic criterion, in general, that speak for caution in accepting the results of economic analyses uncritically.

The first problem is that we can never be sure that all factors have been taken into account in the cost benefit balance sheet. For instance, the NPV criterion by itself would admit all rotations that showed a positive NPV or Se, even many of the non-optimal options if any of them were taken as an individual case. If decisions are taken on an incomplete analysis of possible repercussions or plausible alternatives, the economy might well move toward a less optimal position than anything else.

This calls for a certain scepticism in taking decisions that would cause major changes in policy. It could well be argued that reducing rotations or even mining the forest resource, as dictated by the economic criterion, falls into this category.

Related to the above, but a bit more general in its import, is a certain lack of realism in the 'marginal' principle on which the concept of opportunity costs is based. These are calculated on a broad economy-wide or at best regional level. Consequently, they cannot really be expected to account for the peculiarities of the situation in each location and point of time.

This is especially true of factor units which are not exchanged often in market transactions, and which display considerable heterogeneity, like land. It must also be remembered that net present values presented are usually not the 'pure' profit, but more often the residual to a set of factors whose marginal value product cannot be assessed directly. In forestry, plantation crops, and to a certain extent in agriculture, this is usually land. In manufacturing, it may well be the indefinable qualities of entrepreneurship and business leadership that are the crucial factor. Thus it is never very clear what exactly the NPV measures in a given situation.

If the economy were really perfect in the marginalists' sense, then we could accept that the marginal costs or benefits of individual resource units are a measure of real value. Then the net present worth of an enterprise thrown up by economic analysis could well be the true measure of project returns.

However, it is precisely because markets are not perfect, and information neither complete nor costless, that economic analysis, and economic theory, are around at all. Otherwise, the surviving market solutions would be the truly optimal solutions, and neither would be needed. This fact, that the market mechanism by itself does not lead to perfect knowledge of production possibilities and market opportunities, is the motivation behind a fresh look at the range of options available. Thus merely specifying that the net present value should be positive, and depending on the marginal cost concept to throw up 'optimal' solutions, does not guarantee that alternatives do not exist that would perform better under the given criterion.

This limitation could be extended to the cost of capital as well, so that different rates of discount might well have to be applied in the case of different activities or commodities. Capital, especially of the 'real', or 'locked-up' type which is the bane of the forestry sector, is not really homogeneous. The discount rate applied need not be 'the' market interest rate. Whether it would be lower or higher would depend on the range of alternative uses available.

It is therefore important to consider as wide a range of options as possible, both within the forestry sector and outside of it, and both on the benefits and the costs side. Real problems are rarely so amenable, or economic solutions so perfect, as economic literature seems to portray.

The difficulty arises, when we move from the marginal analysis to making policy recommendations, that the original conditions and assumptions of the former become suspect. This is seen with especial impact in the forestry sector, where the limited problem of optimising use of a hectare in isolation is transformed into a decision of clearing hundreds or thousands of hectares of forest.

Unless the future integrity of the productive capacities of natural systems is safeguarded, the result might well be their complete loss, beyond possibility of recovery. There are certain resources that are so basic to human and other life itself, that it would not be irrational to put them in a special category. Economic efficiency in the narrow sense may have to be sacrificed under such circumstances.

For a private entity, such considerations cannot be said to be either feasible or even relevant, for by our assumption, the entity is not in a position to materially affect the rest of the economy by its actions. When, however, it comes to a question of the management policy to be adopted for the national forests, the sphere of incidence of the consequences is considerably expanded.

For society as a whole, the decision to 'mine' the remnant resource may impose costs on future generations that are considered incommensurate with the benefits enjoyed by the present generation. This is not a contingency provided for in the more limited sense of economic efficiency analysis.

The <u>social</u> perspective introduces many new considerations and factors. Ultimately, the parameters of the SCBA method rest on what are essentially political judgements. The analysis of alternatives within the forestry sector itself shows, however, that there are situations in which the simple economic prescription (to mine the resource) need not be optimal, even under economic criteria.

Thus, the conclusion of market economists that anything that does not yield 10%, or 15%, or whatever, rate of return should be thrown overboard, regardless of social consequences, is not acceptable, even within the framework of economic analysis. The framework of <u>social</u> cost benefit analysis holds the promise of enabling us to compare 'custodial' possession with other forms of land and biosphere use.

It is this promise that has been explored in the preceding pages. The experience shows, if nothing else, that a very wide spectrum of alternatives can be justified on economic grounds. Thus foresters, traditionally mindful of the wider ecological role of the resources under their management, need not be entirely overcome by the onslaught of neo-classical economics. They will, however, be better able to serve society by understanding social needs more sympathetically.

Economists, on the other hand, need to point out more clearly the subjective basis of their 'objective' prescriptions. By broadening their horizon beyond the narrow confines of the 'free' market mechanism, they may be better able to help policy-makers, especially in the imperfect economies of developing countries, use their limited resources wisely and responsibly.

APPENDICES

APPENDIX ONE

MANAGEMENT HISTORY OF THE YELLAPUR-MUNDGOD FORESTS

The many potentially conflicting considerations that come up in forest management are well exemplified by the forest area chosen for the case study. In the present Appendix, we describe in detail the record of sustained yield management in the Yellapur-Mundgod forests of Karnataka.

A1.1 The study area

Yellapur forest division is one of the five forest divisions in the district of North Kanara. The forests straddle the Western Ghats and stretch eastward to the boundary of the drier plateau region. The 'High Forest' blocks of Yellapur and Mundgod taluks have traditionally been managed as independent units. A fairly complete, continuous series of working plans is available, a primary consideration in choosing the area for the case study.

A1.1.1 Physiography of the study area

The forests occupy a compact area roughly shaped like a parallelogram, between $74^{\circ}41'$ and $75^{\circ}10'$ east longitudes, and $14^{\circ}45'$ and $15^{\circ}09'$ north latitudes. The northern boundary is marked by the rivers Kalinadi and Thattihalla, to which the land slopes steeply down; elsewhere the topography is generally undulating.

The northern part is divided into two water catchments by a moderate crest running west to east along the main Yellapur-Kirwatti-Dharwar road. The northern aspect drains into the afore-mentioned rivers on the north-western boundary, and the southern aspect, southward into the Bedti river which bisects the tract. South of the Bedti, a ridge culminating at Gunjavati, the highest point in the tract, separates the catchment of the Kaulgi river. The average elevation of the tract is around 1,650'(503 m), rising higher in the south-east to 1,900' (579 m) compared with the north-east (1,700', 518 m).

The underlying rock is "very generally granitoid gneiss, a grey medium grained crystalline rock. On the North-West border and extreme South-East, laterite soils occur. Quartzite rock and gravel are common." (Garland, 1935). The soil is generally of better quality in the west, where the climatic conditions favour the formation of a humus-rich, loamy soil under forest. Where cultivation had apparently been carried on in the recent past, however, there was compaction of the soil and a tendency to waterlogging. Lateritic soil is mostly poor, "but where it is mixed with quartz gravel it supports teak of medium quality". Teak does better on light well-drained soils, such as schist soil, and red hematite mixed with quartz schists.

The humidity falls from west to east. The annual precipitation (total of monthly averages, 1950 to 1959) was 2,859 mm at Yellapur (in the west), 2,495 mm at Manchikeri (south), and 1,310 mm at Mundgod (in the east) (Wesley, 1984).

A1.1.2 The forests

The vegetation is typical of the mixed deciduous teak-bearing peninsular forest. It ranges from the luxuriant wet association in the west (with a high proportion of jambe, *Xylia xylocarpa*), to the dry, pole-sized crop in the east, associated with an underwood of dindal, *Anogeissus latifolia*. Grazing, shifting cultivation and past working have modified the vegetation, with the 'true' climatic climax being found only in places.

In the western parts of the tract, covered by Blocks XIII, XV, XVI, XVIII and XXIII, the forest is of the moist deciduous type, comparable to the Southern Tropical Moist Deciduous (type 3B) of Champion's classification (Champion and Seth, 1968). It merges into the Southern Tropical Semi-Evergreen (2A) and Wet Evergreen (1A) near perennial streams. Teak reaches a height of 80' to 100'(24.38 to 30.48 m); Xylia xylocarpa, Terminalia paniculata are common, Dalbergia latifolia and Lagerstroemia lanceolata less so. The overall density of the crop is 0.5 to 0.7, and the site quality of teak, comparable to the All-India SQIII (FRI, 1959a) by top height in plantations (Wesley, 1964).

The forests in the east are poorer, of the Southern Tropical Dry Deciduous type (5A). Teak occurs chiefly in low-lying areas; it reaches a height of 45' to 70' (13.72 to 21.34 m); it corresponds to All India SQIV. The percentage of teak is, however, higher in the poorer crop, rising to a maximum in the teak pole crop in the driest eastern boundary of Block XXII.

Bamboo is prevalent throughout the area. Big bamboo, Bambusa arundinacea, occurs throughout, and is luxuriant in low lying areas and along watercourses. Small bamboo, Dendrocalamus strictus, is more prevalent in the drier parts to the east.

Natural regeneration of teak is not adequate, while that of other species is "fairly satisfactory" (Wesley, 1964). Coarse grass comes up in profusion on open hill tops and all open areas in the east and north-east, less so in the west. Grazing and fires have been cited as the two most serious causes of damage, especially to young growth. Fires are mostly caused by the graziers, who use it as a tool to force the flush of tender new grass shoots, ignoring the damage to other growth. Indeed, a closed canopy would reduce the fodder, so graziers have no great affection for the dense tree crop favoured by the forester.

A1.1.3 Forests in the local economy

The requirements of timber, bamboos, fuelwood, thatching, etc. of the local population are described as moderate. They have been met by grant of standing trees (mostly of non-teak species) and by free removal from the forest. Of late, there has been growing concern both among foresters and others, over the rising demand for exercise of these privileges, especially over the enormous incidental or intentional damage and disturbance to the forest crop that accompanies such exercise. The trend has been to discourage the direct exercise of rights and concessions by the people. This has increased the pressure on the forest department, which has now become responsible for supply of basic needs through its depots.

As regards grazing, it is the activities of the semi-nomadic Gowli population that causes most concern. These professional cattle-breeders, originally from Maharashtra, move from village to deserted village with their large herds of buffaloes. Grazing and deliberate burning to improve the growth of grass is considered inimical to proper management of forests, and "...any attempt to develop the land simultaneously for forest crops and pasturage is definitely uneconomic" (Garland, 1935). Wesley (1964) recommends that, while a curb on the traditional freedom of movement of the Gowli cannot be envisaged, it would be desirable to eventually "concentrate all grazing on a much smaller area, specifically set apart and developed to its maximum carrying capacity. The remainder of the land could then be properly developed under remunerative forest crops."

The bulk of the timber extracted is purchased by timber merchants, while railway sleepers (cross-ties) are supplied to the railways. Plywood and matchwood species go to the industry through direct extraction by the concessionary factories.

Bamboo, once considered a weed, is now a favoured raw material for manufacture of paper. There is also a considerable demand for green bamboos for cottage industries all over the state, for fabrication of rearing trays for silkworms in the sizeable silk industry, and for a host of other uses, both household and commercial. Gregarious flowering and mass dying out of both the species, added to the increasing damage to regeneration from fires and grazing, has caused serious decrease in the bamboo resource of the state. The former attitude of chagrin at the "virulent" spread of bamboos to the detriment of teak (Copleston, 1925) has now been replaced by concern about the future availability of the resource (Annual Report of Karnataka Forest Department, 1983-84, 1984-85, etc.).

A brief account of close on two hundred years of past exploitation and management is now given.

A1.2 Management in the early colonial period

A1.2.1 Exploitation for revenue: early 19th. century

From the time the British acquired supremacy in the Kanara region, about the year 1799, concessions were given to various timber syndicates to exploit the timber. In 1807 a proclamation was issued vesting the royalty rights over teak in the East India Company. In 1823, general trading was again made subject to an export duty (5% by land, 8% by sea); in 1843, a heavy surcharge was imposed on all small sized timber exported, in order to check the exploitation of immature trees. In 1848, however, this was rescinded by an Act which abolished all duties on internal trade.

The suppression of shifting cultivation (kumri) in 1847 in the adjoining Mysore territory on the south led to the influx of a large number of people into the Kanara forests. About 8000 acres were felled annually between 1854 and 1864 until the practice was suppressed (Copleston, 1925).

A1.2.2 Start of organized management: later 19th. century

In 1862, the district was transferred from Madras to Bombay Presidency. Forestry was made a special branch of the Revenue Department. The previous unregulated system was replaced by extraction of timber under the supervision of a forest officer, and sale by public auction in government depots. However, permit holders were still allowed to enter the forest and themselves extract timber other than teak and rosewood to meet local demand.

From 1870, when Dr. Brandis, the founder of scientific forestry in India, visited the area, the Forest Department was established on an independent basis in stages. The forests covered by this study were all declared reserved forest in 1879, and the settlement proposals sanctioned between 1879 and 1910. It was left to the working plan to provide for the exercise of local privileges, though in some areas a distinction was made between forest proper and minor forest within the reserved forest. A revision settlement was conducted in 1922, wherein the privileges of cutting firewood by the villagers was restricted to minor forests, while all other privileges like grazing were allowed to be exercised in both the forest proper and in minor forest.

A1.2.3 <u>The early working plans: 1905 to 1920</u>

The organisation of the forest into Blocks, each subdivided into Compartments of approximately 640 acres (259 ha) each, was taken up in 1879. The first systematic working plan was that for Blocks XIII to XVI, XVIII and XXI, the "Yellapur Above-Ghat Working Plan" (Copleston, 1905); for the two Blocks XXII and XXIII in the east and south-east, it was the "Working Plan of the Mundgod High Forest", 1907-1922 (Aitchison, 1907).

Under Copleston's plan, the system was mainly selection fellings confined to mature trees (breast-height girth 7'/2.13 m or over) of teak, matti, honne, nandi and rosewood, and of small quantities of other species, on a felling cycle of 24 years. Operations to favour teak were to be carried out in some compartments: cutting back of bamboo and inferior species, lopping and girdling of interfering growth, and cutting back of mishappen or damaged teak saplings.

Under Aitchison's plan, the minimum exploitable girth for selection fellings was fixed at a lower 6'6"/1.98 m, on a felling cycle of

20 years. In addition, unsound teak trees were to be removed in improvement fellings in all sizes above 15"/0.38 m diameter at breast height (dbh); it was estimated that 30% to 40% of the total number of standing trees would be removed in the improvement fellings.

Parts of the eastern side of Blocks XIV and XV were put under a separate plan, Miller's "Kirwatti Teak Pole Plan" of 1916. This plan adopted a system of coppice with standards (aimed at producing a 'two-storeyed' forest) on a rotation of 80 years. Thus 1/80th of the area was sold every year as a standing crop; improvement fellings were done at the same time in the areas not under felling and regeneration, the whole area being worked in 20 years.

A1.3 <u>The experience of scientific management: 20th. century</u>

A1.3.1 <u>Teak regeneration the focus: Edie's plan, 1922</u>

In 1921, the areas covered by all the three plans were reorganised under Edie's "Working Plan for the Yellapur and Mundgod Teak High Forests" (Edie, 1922). Edie found that, by 1918-19, hardly two-thirds of the prescribed area had been worked over under the existing system of selection-cum-improvement. The shortfall was due to poor demand for any but the best timber, and scarcity of labour. Further, healthy growth of teak regeneration was found to require on adequately open canopy, which suggested the need for a change from the coppice- with-standards or selection systems followed so far.

The allocation of area under Edie's plan was as follows (Table 6.3). Out of 156,117 acres (63,181 ha) 'total forest' area, some 31,833 acres (12,883 ha), distributed all over the estate, were consigned to 'potential grazing', under a separate working circle, WC4. They would ultimately be retained in the working plan area or excluded completely depending on whether agriculture developed or not, but in the meantime would be worked under a system of improvement fellings only. Damage to the forest by cattle had to be minimized by confining them to these open acres, plus the 11,584 acres (4,688.1 ha) of additional land permanently allotted for grazing (hence outside the working plan area).

The remaining 124,284 acres (50,298 ha) constituted the 'forest proper'. This was demarcated into seventeen 'treatment' blocks under Edie's plan. The overall objective would be to achieve a normal forest with a high proportion of teak, with other valuable associates present to a lesser extent.

The 61,103 acres (24,728 ha) of better quality teak-bearing forest in the west (Edies's Blocks 1 to 6, WC1) were to be converted to predominantly teak crops over a period of 120 years. Suppression by junglewoods hindered teak regeneration here.

The 57,012 acres (23,073 ha) "medium class" forests in the east (Treatment blocks 7 to 15, WC2) were put under a conversion period of 90 years. They had a poorer, more open crop with, however, a higher proportion of teak, 20 to 25%. Frequent fires, exacerbated by the build-up of dry bamboo after gregarious flowering, and intensive cattle grazing by the Gowli, were the main reasons for the deterioration of the crop.

Treatment blocks 16 and 17 in the extreme south-east contained the poorest crop, akin to the teak pole forest in Dharwar to the east. These 6169 acres (2,497 ha), constituting Edie's WC3, were to be worked on a rotation and conversion period of 60 years, again by sale of the standing crop.

The rotations were referred to past observations of the time required to reach certain 'exploitable' dimensions: e.g., 160 years for 24.5"/62.2 cm dbh (ca. 6.6'/202.2 cm girth at breast-height, gbh) in the above-ghat forest, 136 years for 24.0"/61.0 cm dbh (ca. 6.5'/198.1 cm gbh) in the Kirwatti teak pole forest, and 80 years to reach 18"/45.7 cm dbh (4.9'/148.6 cm gbh) in the Mundgod high forest. The rotations prescribed were however much lower than these by intention, and could be even further contracted at subsequent revisions (Edie, 1922).

In addition to clear-felling and planting teak in an annual coupe in each of the 17 treatment blocks, improvement fellings would be carried out every year, in the rest of the area. The aim would be to remove inferior trees, and free young teak trees from competition. The minimum exploitable dimensions were 6'/182.9 cm gbh in WC 1 and 4, 5'/152.4 cm gbh in the medium crops of WC 2 and 3.

The shortage of labour was a well-known and entirely expected feature. To the sustained yield forester, however, fellings are but a tool to fashion the successor crop, as the chisel is to the sculptor. Edie therefore gave priority to the regeneration fellings. Improvement fellings could be limited to half or less of the remaining area in WC 1 to 3, and to the extent possible after this in WC4.

Unfortunately, implementing Edie's plan depended on the demand and transportation facilities that would be afforded by the building of the Yellapur-Hubli and Katur-Kirwatti railway lines. In the event, neither the railway line nor the increase in staff required to carry out the "elaborate works prescribed" (Wesley, 1964) materialized. Neither did the high rate of increase in timber prices continue as expected. The market would not absorb the increased outturn of secondary species. In these conditions, it was selective felling that continued, so that by the time of Wesley's plan there were only about 105 cft standing per acre, compared with Edie's estimate of 350 cft per acre (Wesley, 1964).

A1.3.2 <u>The dilemma of sustained yield forestry in the Kanara forests</u>

The disappointment with Edie's plan illustrates the perpetual dilemma facing the sustained yield forester among the realities of economic compulsions. On the one hand, it was desirable to convert the mixed crop as rapidly as possible to teak, the most valuable and saleable species the forests could produce.

On the other, as teak is intolerant of shade, the entire overwood had to be removed to ensure its regeneration. Unfortunately, it was difficult to sell any but the best non-teak logs "at any price which would cover even the bare cost of felling and extraction" (Garland, 1935). The envisaged pace of conversion was thus too ambitious. Over the first 12 years of Edie's plan, only 4,596 acres (1,860 ha) of plantation had been raised, against the average annual area prescribed of about 800 acres (323.7 ha) (Garland, 1935).

There were also problems in artificial regeneration of teak, e.g. on areas with outcrops of laterite or sheet rock on or near the surface, poor drainage, heavy grazing, constant fires or cultivation in the past, and a profusion of weed and bamboo growth on clear-felling. All these made plantation a costly affair, encouraging the drift to selective felling in place of the elaborate regeneration prescriptions. The forest was being converted into a "predominantly bamboo forest" from being a moderately well stocked teak forest (Wesley, 1964, p.22).

A1.3.3 Nature the ally: Garland's plan, 1935

The solution offered by Garland (1935) was to reduce the planting area, depending to a greater extent than previously on the natural regenerative capacity of the forest. Clear-felling and planting were to only supplement natural regeneration, where it appeared to be tardy or deficient.

Garland formed three working circles for the teak crops, and one for the grazing areas, broadly conforming to those of Edie (Table 6.1). Conversion periods were on the whole a little longer than in Edie's plan, respectively 120, 105, and 90 years in WC1 to 3. The regeneration period for the "Uniform" system was fixed at 15 years, as a suitable compromise between the time needed for the regeneration to establish itself, and the need to minimise the departure from strict regularity of the crop. Only one-third of the regeneration periodic block (PBI) would be clear-felled and replanted. The remaining two-thirds would be regenerated by gradually lightening the canopy in a series of "replacement fellings", retaining teak trees of under 4'/121.9 cm gbh in the west, 3'/91.4 cm gbh in the eastern blocks.

No work of any sort was to be done in the pre-maturity crops assignable to PBII, in order to avoid depleting the yield for the succeeding period. In remaining areas, selection (with a uniform girth limit of 6'/182.9 cm gbh in all felling series) and improvement fellings were to be done, subject to an overall volume limit calculated for the entire forest including the PBI areas.

As before, the prescription for the temporary grazing grounds was to continue a system of selection-cum-improvement fellings. Starting with unsound trees, these were to gradually extend to sound trees above 7'/213.4 cm gbh, and finally to sound trees between 6'/182.9 cm gbh and 7'/213.4 cm gbh, until the overall volume limit of the harvest was reached. This was one case where the conflict of interests was marked, for according to Garland, either forestry or livestock could be supported here, but not both.

A1.3.4 <u>The parsimony of the ally: results of Garland's plan</u>

Garland's plan was not much more successful than Edie's, despite the more modest targets for clear-felling and planting. Natural regeneration failed to come up in response to Garland's "replacement" fellings in the 2/3rds area given over to the uniform (shelterwood) system, leaving nothing but bamboo, except in the planted areas (Wesley, 1964, p.23). In the remaining portions of the regeneration PB, teak regeneration was deficient because of the shade of the retained overwood, or competition from bamboo and other growth.

The selection-cum-improvement fellings did not fare much better. Sleeper supply operations, saw mills and supplies for the two world wars had removed sound timber down to a low girth limit, leaving behind an an accumulation of unsound stock (Wesley, 1964, p.22). Thus most of the areas supposed to have been regenerated under the Edie and Garland plans finally came to contain "only bamboos and other useless growth". Over the two plans, 30,834 acres (12,479 ha) had been totally exploited, of which only 8,235 acres (3,373 ha) had been planted up, and the hoped-for natural regeneration had been disappointing in the rest of the area.

A1.4 Management after Independence

A1.4.1 Post-war working of the Yellapur-Mundgod forests

The subsequent years were ones of stress and change, with the unsettled conditions of the war, the independence movement, and the transition to the new political situation. The record of management is less clear during this period.

A draft report prepared by Coelho in 1949 was followed up to the time of Wesley's revision in 1964. Coelho grouped the totally exploited areas into a "Final Regeneration Block", and prescribed that a large part of this area should be planted up. The remaining area was to be gone over by "final regeneration fellings".

For Garland's PBII areas, the pre-regeneration class, he prescribed "advance regeneration fellings". These were to consist mostly of improvement fellings and felling of sound selection trees, coupled with early burning, cutting and burning of bamboo clumps, and diffused planting. These areas would come under "main" fellings after 20 years. Coelho found it unnecessary to prescribe a volume check for the fellings in this category.

A1.4.2 Sustained yield for development: Wesley's plan (1964)

The most recent plan, of Wesley (1964), was for a period of 20 years, from 1961-62 to 1980-81, but the sequence of operations was specified for 30 years. This was the period of intense developmental efforts by the government, and the twin aims of self-reliance and industrial development were reflected in the forest sector through the development of forest-based industries. As the pace of development quickened, demand rose; almost anything coming out of the forest could be sold or used in some process. Bamboos were now a precious resource instead of a weed, and the shortage of pulpwood brought a new impetus to the propagation of exotic hardwoods like *Eucalyptus* species.

In the areas covered by valuable high forest like Yellapur, however, the traditional bias toward timber continued; what was different was, perhaps, a diminished expression of concern for the interests of the local agriculturists.

As Coelho's "final regeneration fellings" were no more successful than previous attempts at inducing natural replacement of the crop, the uniform system had to be abandoned. The selection system, coupled with improvement fellings, would have to suffice over the greater portion of the area (Wesley, 1964, p.26). Clear-felling and planting would be mainly in the areas previously exploited and left in a state of disrepair.

There was now no talk of relinquishing any of the areas which had been temporarily earmarked as grazing grounds (cf. Table 6.1). The entire area under the plan, 167,256 acres (67,689 ha), was to be managed mainly for timber production. The first objective of management was "to set apart areas which are pre-eminently suited for the growth of Teak ... for the production of that species only; and convert the same into regular series of plantations by artificial planting".

Established plantations (dating from 1929 onwards) were grouped together under a Plantation WC of 15,489 acres (6,268 ha), with around 3,199 acres (1,295 ha) in the 'first' class westerly Blocks of AISQIII, and the remaining 12,290 acres (4,974 ha) of AISQIV (FRI, 1959a). The rotation was tentatively pegged at 100 years for the former, and 80 years for the latter, though as Wesley pointed out, the mean annual increment culminated beyond 80 years as per the all-India yield and stand tables. A thorough inspection once in 5 years was recommended, to decide the intensity and need for cultural operations, mainly to free the teak from interfering growth, especially bamboo and climbers. Assuming 100 years a reasonable period to effect the conversion of the first class forests, the existing plantations represented some 13 years' conversion already accomplished.

Some 11,818 acres (4,783 ha), or 29.7%x of better quality forest in the study area, had been creamed of their best growth, and only inferior stems were remaining; they were allotted to the Conversion WC. They represented only 30 years' proportionate area of the first class forests, as per the above reckoning. The remaining 24,763 acres (10,022 ha), or 62.2%, of first class forests, had been put under the Selection WC, to reduce the loss of postponed exploitation.

To these first class crops in the Conversion WC, Wesley added 21,829 acres (8,834.2 ha) totally exploited but left fallow, mainly in the easterly portions of Blocks XIV, XV, XVI, XXIII and XXII. The total area of the Conversion WC was thus brought to 33,647 acres (13,617 ha). The remaining 93,357 acres (37,782 ha), or 73.2% of the second class (AISQIV) crops were put under the Selection-cum-improvement system.

No conversion period was fixed for the inferior crops, but the estimated area would be replanted over a period of 30 to 40 years in the better areas (483 acres/ 195.5 ha a year), and 20 years in the poorest acres in the extreme south-east corner of Block XXII (249 acres/ 100.8 ha per year). The aggregate area to be planted each year in the Conversion WC was thus 1,142 acres (462 ha). This reversed the downward trend in plantation targets after the unhappy experience with Edie's plan. Although it was unlikely that insufficient demand would be a dampener on extraction and thus on regeneration, it was not all that much easier to convince the administration that the extra staff required to achieve the higher targets was justified.

The major portion of the forest, 93,357 acres (37,782 ha), was to be in the Selection-cum-Improvement WC. The rotation for teak worked out to 100 to 125 years (touching extremes of 150 years in the north-western corner just outside our study area, where the exploitable girth was fixed at 7'/213.4 cm gbh, and a low of 80 years in the worst area in the south-eastern corner where it was 6'/182.9 cm gbh). The felling cycle was 20 to 25 years. Under the accompanying improvement fellings, unsound stock would be removed, and underplanting of "useful" species undertaken.

Regeneration would follow logging, by planting of teak, rosewood, silk-cotton (Bombax malabaricum), and other hardwoods and softwoods according to suitability of the site. Even bamboo would now have to be exploited on a sustained yield basis, with the establishment of paper and rayon factories in the region. "Thus it will be possible to improve the intrinsic value of the forest without destroying its composition, in which not only teak... but other secondary hardwoods, softwoods, and bamboos will have their place" (Wesley, 1964, p.41).

A1.4.3 Performance under Wesley's plan: indicators

Wesley's plan contains detailed schedules of felling and tending operations right to 2003, but it was due to be revised after the 20 year period 1961-62 to 1980-81. The revision has still not been completed, so it is difficult to say whether the forest is in the condition expected. Information gleaned from the Annual Plans of Operations, 1980-81 to 1983-84, indicates that in recent years at least, the annual planting area seems to have met the working plan target of 1,142 acres (462 ha), although the earlier years show a tendency to fall substantially short of it.

There was, however, one crucial way in which the plantation activity had changed in nature over the decades. This was that plantations were now mainly to be taken up in areas already cleared and exploited long back. It was no longer necessary to actually clear an area in order to start the fresh crop. The link between felling and regeneration had thus been effectively broken.

This in turn implied a considerable flexibility about the load of plantation work taken up in any year. Teak plantations were now an investment activity, which could be appraised independently of harvesting the existing crop. This was good in the sense that the forester could advance a case for a more active investment policy.

The other side of the coin was that the success of the plantations was also less assured. Planting was now being taken up on exposed, depleted sites, on which rank _Lantana_ or _Eupatorium_ had made rapid advances. Further, felling was now divorced from the need to wait for natural regeneration. The forester could not now justify the long conversion periods merely by the failure of regeneration. Thus more was expected of the forester, in a less favourable ecological and social environment.

APPENDIX TWO

TEAK PLANTATIONS: MATERIAL AND FINANCIAL FLOWS

A2.1 Sequence of operations

Teak plantations are raised on sites that have been previously logged and clearfelled by the end of January or February every year. The standard operations generally start with clearing of the undergrowth and remnant woody growth. The debris is heaped and burned completely by the end of March. By this stage, the site is clear of all interfering material and a good source of nutrients is available in the residue of ash on the ground.

Teak stumps are prepared in the nearby nursery, usually raised in the field under rain-fed conditions the previous year, by trimming the uprooted plants to a root length of 9" and shoot of 1". The stumps are planted out at a spacing of 2m by 2m as soon as the 'pre-monsoon' showers are received in May. It is important to time this carefully, as stumps planted later, when the heavy rains have set in , usually suffer from excessive moisture, and fail to establish themselves.

Weedings recommended are three in the first year, two in the second, and one in the third year, along with a cleaning (including cutting back of malformed or damaged stems); and another cleaning if necessary in the 7th or 8th year. This is followed by the first thinning in the 10th year and subsequent thinnings every tenth year until the 50th year, and beyond if necessary.

A2.2 Growth and yield under teak monoculture

A2.2.1 Growth patterns and yield of plantation teak

Teak is a highly light-demanding species, and benefits from thinning of a fairly high intensity. The All-India Stand and Yield Tables (FRI, 1959a) were based on the 'C' grade of thinning. Not all the sample plantations, however, conformed to the pattern of thinning portrayed, because of the inevitable variations in the thinning treatment accorded to them in different regions over the decades.

Thus, teak plantations in the old Mysore territory (to the south of Kanara district) were underthinned in the early years; "owing probably to the relatively dry type of forest where teak is grown in Mysore, the variation in the method of early tending and weeding and the practice of delaying the first thinning the rate of height growth of plantation teak is relatively small in the earlier years, compared to that indicated for the all-India standard site qualities for the same quality of soil" (Kadambi, 1945).

Kadambi's assessment of site qualities (SQ) was that the "Mysore SQ" I, II and III corresponded roughly to all-India SQ III/IV, IV and V of the older all-India yield tables (Laurie and Sant Ram, 1940), with the very best plantations approaching SQIII . The all-India site qualities were reduced to four in the 1959 tables, which rejected the under-thinned samples from Burma. The corresponding site quality classes of 'Mysore SQ' I, II, and III are roughly III(upper half), III(lower half), and IV.

The growth of teak in our study follows a similar pattern. The top height of mature trees (assumed to be of 80 years or over in age) in the westerly Blocks was from 75' (22.9m) to as much as 100' (30.5m) in the northwest corner of Block XIII (Edie, 1922), which puts them in the 1959 all-India SQIII. The height of the remaining crops in the east, in Blocks XIV, XV, and XXIII, was 45' (13.7m) to 70' (21.3m), putting them in a low SQIV. The poorest crop, in Block XXII in the southeast, was 40' (12.2m) to 50' (15.2m) tall, a little worse than the minimum of SQIV.

A2.2.2 Material output flows: the yield tables

We use as our basis the FRI yield tables (1959a). The westerly crops in the study area are broadly characterised as SQIII, and the easterly ones as SQIV. It is assumed that thinning, though in practice often a negelected and delayed operation, broadly follows the 5-year cycle portrayed in the yield tables (Table 7.1 to 7.3). There is, therefore, a periodic income from thinnings right through the life of the plantation.

The specification of the output stream, it must be admitted, is subject to many ambiguities. For a start, a wide range of product mixes and time profiles could be envisaged. The yield tables, however, give only two categories of output. One is the standard stem timber , defined as the solid cylindrical volume, underbark, of the 'standard' timber in the main bole. This is the portion of the stem from ground level to a height at which the limiting mean diameter overbark (dob) of 8" or 20cm is attained. The second is the standard stem smallwood. This is the solid volume, overbark, of the 'standard' smallwood in the main bole, from the point at which the dob is 8", down to a limiting dob of 2" or 5cm.

These are the categories adopted through the age of the crop, for intermediate as well as final fellings. Since thinning yields accrue at an earlier age, they may make a substantial impact on financial returns. It would therefore be desirable to assess their unit value realistically. Unfortunately, the yield tables give no information on the composition of the subsidiary crops by size classes. Even total thinning volume outturn figures have been derived, not from direct measurements on the thinning material, but by subtracting the volume of the 'main' crop (the crop that would be retained after thinning) from the volume of the 'total' crop (the crop as it stands before thinning).

Considerable smoothing and harmonizing of the curves, usually by visual or free-hand methods, has gone into the preparation of the published yield tables. Therefore assumptions on the nature of individual crops at particular ages may be subject to a margin of error.

A2.2.3 Units of measurement of outturn and conversion factors

The units used for expressing the quantity of material are various, and cause some confusion. Log girths are usually measured at their mid-length underbark. In the forest department depots, log volume is calculated by the quarter-girth formula, so that the solid, or full-girth, cylindrical, volume is related to the qg volume of a log by

qg volume = 0.7854 (solid volume),

and solid volume = (qg volume)/0.7854,

where 0.7854 = pi/4.

For stacked firewood, the relationship we use is

solid volume = 0.53 (stacked volume),

on the basis that 2.5 cmt (stacked) of firewood billets of standard length (around 0.9 m to 1 m) weigh, on average, 1 MT air-dry. Hence 1 cmt(stacked) weighs approximately 0.4 MT, which, on an average specific gravity of 0.75, corresponds to a solid volume of 0.4/0.75 = 0.53, or roughly, 0.5 cmt(solid). The density figure used is comparable to average figures quoted in the FAO Yearbook of Forest Products 1972, 750 kg/cmt for non-coniferous pulpwood, 800 kg/cmt for non-coniferous other industrial roundwood, solid volume underbark.

The output figures in the yield tables are, of course, the standard volumes as defined above. For a financial appraisal, however, what we are interested in is the commercial volume, whether of logs, firewood, or whatever. In our context, the timber yield would have to be measured by log outturn; the smallwood, by stacked volume of firewood.

According to Sant Ram's tables for the Central Provinces (1942), the ratio between log outturn and standard stem volume of trees of various dimensions ranges between 64% and 85%, with no clear correlation with such likely factors as tree dbh or height. A mean value of 0.75 was therefore used to convert the standard timber volume into log outturn (solid volume) in subsequent analysis. By applying the appropriate unit values and costs, the expected financial returns and costs of the plantation are derived.

A2.3 Unit values of benefit and cost items

A2.3.1 Unit costs of operations

The unit costs of various forestry operations are based on the schedule of working rates prevalent in the Kanara forest divisions sanctioned in late 1984-85, extended to the initial part of 1986-87. These are based on a daily wage rate of Rs 9.75 for heavy, and Rs 7.80 for light, manual labour (applicable from 1.1.1985 onward).

The rates for transportation by truck are calculated on the basis of data in the schedule of rate for Mercara (Coorg) division (not in the study area). There is a fixed minimum for leads up to 10 km, plus an additional charge per km of additional distance over 10 km, per unit quantity of timber or firewood transported.

The cost of materials is a minor component of total costs compared with wage labour. Such figures as have been used, eg. for barbed wire, are based on personal communication from officers in Karnataka Forest Department (KFD). The unit rate and amount of each input used in raising a hectare of teak plantation is given in the cash flow statements later in this Appendix.

On the whole, the pattern of operations portrayed here is likely to conform closely to the practice in the study area. It is true that some of the operations would be neglected or dispensed with in practice; but it would be equally likely that in the absence of at least this level of care, the full stocking and growth predicted by the yield tables would not be attained.

Unfortunately, there seems to be no basis to predict the trade-off between expected yield and the level and type of inputs. Chatterjee (1978) did undertake an exercise to correlate neglect of weeding and cleaning operations to subsequent loss of growth; but he fell back upon ad hoc assumptions that were not based on empirical observation. Such deficiencies in our knowledge however serve the useful purpose of suggesting future research directions and areas.

A2.3.2 Marketing and distribution of forest produce

Much of the better quality material is sold by public auction twice or thrice a year. Firewood, poles and inferior timber are usually brought to minor depots for sale by auction as well as retail sale on ration cards to domestic consumers. This has become a regular activity of the forest department (the Forest Industries Corporation taking over the job of retail sale in urban areas), under the 'minimum needs' policy of the government. The rates are usually subsidized, often by loading the costs of extraction and delivery on the timber logging contract.

The major depots are at Kirwatti in the north, and Mundgod in the east. They are about 30 miles (48 km) from the main demand centre at Hubli, the railhead from which timber and other products are exported over the districts of Karnataka and its neighbours. The lead from coupe to depot ranged, in 1985-86, from as close as 7 km (from a coupe in Block XIV) to 26 km (from Block XIII) in the case of Kirwatti depot; and from 14 km (from Block XXIII) to 35 km (from Block XXII) in that of Mundgod depot.

Material is also released by allotment from either the forest (as in the case of plywoods, pulpwood, bamboos, etc. to industry) or the depots (as to cottage industry, hostels, 'bona fide domestic' consumers for house construction, etc.). The rates for such sales are based on recent auction rates or on administrative considerations. The infant-industry and import-saving arguments have loomed large in dictating fairly low rates (till recently) for supplies to industry. Shortage of government supplies has however induced the industry to look for other sources of raw material.

Such factors however are not very important in the marketing of teak in Karnataka. It is the rates obtained in open auctions that serve as starting point for valuing the output.

A2.3.3 **Auction sale rates of timber and other produce**

Timber in the depots is classified by log quality and by dimensions, i.e., length and mid-girth classes. The specifications for these classes are summarised in Table 7.4. As can be seen, the limits are different for teak and for junglewoods.

The quality class composition of teak logs sold in recent depot sales is given in Table 7.5. Overall, the contribution to volume was 1% from class A, 15% from B, 84% from C. This is the composition we assume for all the size classes, although, among other interactions, A class logs are unlikely to be found amongst the lowest dimensions and vice-versa.

Next, the available figures of recent auction sale rates obtained in Kirwatti and Mundgod depots (Table 7.6) are used to calculate the average rates expected (excluding sales and other taxes) for each size class for the 'average' quality. (Table 7.7).

Finally, these rates, which are per cmt (quarter-girth, qg), are converted into rates per cmt(round, or solid), by multiplying by 0.7854 in the case of timber. For smallwood, assumed to be represented by teak firewood, the auction rates per stacked cmt are converted into rates per solid cmt by dividing by 0.53, the conversion factor derived as explained above.

A2.3.4 <u>Yield table outputs and unit values</u>

In order to attach an average unit value to the timber or smallwood coming out of a plantation at a given age, one would have to predict the variation in unit value of the timber produced with the ageing and growth of the plantation. We would expect some sort of price-age gradient, both due to the growth in average dimensions of the logs and due to an overall improvement in quality.

As regards quality, there is no real basis for predicting the change in quality class composition of the wood removed at any age, either in the subsidiary or in the main crop. The best that can be done is to assume that the proportion in each quality class is the same as presently observed in the overall arrivals in the depots. This would ignore the possibility of correlations between age, size, growth environment, and quality (e.g., the possibility that A class logs are more likely to be found in slow-grown, knot-free timber of large dimensions, and less likely to be found in fast-grown, heavily thinned plantation teak than in the natural uneven-aged forest).

The average auction sale rates per unit of average quality material in different size classes given in Table 7.7 cannot be used directly to value the expected outturn as per the yield tables. The composition of the outturn by these size classes is expected to vary with age of the crop, if not with other factors like cultural operations, thinning treatment and so on.

In other words, the price-size curve implied by the above auction rates for the converted output has to be tranformed into a price-<u>age</u> curve for the crop. This is not so necessary for smallwood, which probably has the same unit value whatever the age of the crop from which it is derived, its dimensional limits being narrow. Timber dimensions, however, are limited only by the growth of the crop. Hence some account has to be taken of the variation of unit value with age of the crop.

Moreover, the yield tables give the content of standard timber in the stems. The commercial, or useful, outturn would however depend on local standards and practices of conversion, extent of wastage in conversion, felling damage, etc. We thus need to correlate the yield table figures with the commercial log (and firewood) outturn that can be valued at the depot rates.

We do not, however, have any commercial yield tables, or even commercial volume tables for the study area. We therefore fall back upon the data given for teak in the Central Provinces (the tri-junction of Maharashtra, Madhya Pradesh, and Andhra Pradesh) by Sant Ram (1942).

A2.3.5 Price-size data for teak standing trees

We first derive a table of unit values for trees of different breast-height diameters (dbh) and height classes. Subsequently, we will use this schedule to value the stand of given diameter and height distribution.

The average size class of the log outturn from a tree of mid-class dbh and mid-class height are calculated as follows. It is assumed that a stump of height 1' (30.48cm) from ground level is left behind. The over-bark diameter (dob) at the mid-length of the commercial bole is calculated on the assumption of a straight-line taper (for the limited purpose of assigning the size class only; not for estimating the volume) from the ground level, through the central dbh(ob) at 4'6" (1.37m) from ground level, to the thin-end (top) dob of the commercial bole as given by Sant Ram (1942).

We now need the underbark dimensions for calculating the log volume. We relate the overbark diameter to the underbark value using the regression (based on data in Sant Ram, 1942),

$$\ln(\text{twice bark thickness}) = -1.03017 + 0.32468*\ln(\text{dob}),$$

$$n=13,\ df=12,\ t= \quad -27.59 \qquad 22.77 \quad,\ R^2=97.7\%,$$

where dob is the diameter overbark, in inches (since this relationship was developed from Sant Ram's data on twice bark thickness in inches versus dob of logs in inches, Table 7.8).

Having thus estimated the average length and mid-length dub (diameter underbark) of the whole-tree 'log', we now place it in the appropriate length-girth class class as per the classification used in Karnataka depots. This gives us the basic relationship between size of the tree and the class of log outturn (Table 7.9).

The assumptions made in the course of the above calculations appear fairly crude, and attempts were made intially to develop a programme to derive the optimal, value-maximising, assortment of log dimensions from the mid-class tree. The discontinuous nature of log classification, and arbitrary reversals in the price-size gradient, however, made these attempts unsuccessful. However, the gain in diameter, and hence in unit value, of the butt-end logs by making cross-cuts lower down in the bole, would be balanced by a decrease in diameter, and hence in unit value, of the upper portions. It is expected, therefore, that on the aggregate, the unit value of each size of tree might not be very much different under either procedure.

A problem which occurred in some of the smaller tree sizes was that the mid-bole diameter was lower than the minimum mid-length diameter for timber (as per the forest department's classification). In such cases the unit value of the lowest length-girth class of timber was applied.

A2.3.6 Price-size relationship for teak standing crop

The yield and stand tables for teak plantation (FRI, 1959a) give, for each entry age, the number of stems in each dbh class. These stand tables are given in Tables 7.10 to 7.12 for SQII, SQIII and SQIV respectively. The above tariff of unit value against tree size is applied to the whole stand at each entry age in the yield tables, to derive the unit value of the crop at each age. The height class was assumed to be that of the crop height, for all the dbh classes at a given entry age.

To assess the unit value of the crop, we need to know, not just the value per cmt of each tree, but also the log outturn that will be obtained from each tree (of a given size class). As mentioned above, the log content calculated on the assumption of the straight-line taper was not used for the volume estimation. What was used for the log outturn from the average tree in each height-diameter class was the solid volume as given by Sant Ram (1942), here displayed in Table 7.13.

Thus we have assembled the stand tables, the unit tree values, and the individual tree outturn tables. This information was used to estimate the volume outturn of the crop by log classes, and hence the aggregate stand log outturn and the total value of the crop per hectare at each entry age. The unit value was then calculated by dividing total value by total log outturn. A small routine in FORTRAN was written for this (Appendix 3).

A point that has not been emphasized so far is that the stand tables strictly apply only to the 'main' crop, that is, the crop left immediately after thinning, and not to the final (total) crop, that obtaining before thinning. It is not, therefore, possible to say much about the diameter class distribution or unit value of the thinning yield.

It was considered useful, however, to make even an educated guess. To this end, use was made of the data given by Mathauda (1954), on the correlation between crop diameters of the main and subsidiary crops in teak plantations, a correlation that was found to be quite stable and independent of the site quality. The average (crop) diameter of the thinning yield at each crop age was derived from the main crop diameter using Mathauda's tables. The unit value of the thinning yield was then assumed to be represented by the unit value of the main crop that was closest in its crop diameter. Thus a (slightly) different unit value could be placed on each of the two crops at any age, with the thinning yield having the lower unit value, as would be expected in practice (Tables 7.14 to 7.16 for SQII, SQIII, and SQIV respectively).

A2.3.7 <u>The role of market prices</u>

The question arises whether depot auction rates can be taken as a true measure of the <u>marginal</u> net benefit to the enterprise of producing and offering a unit of the product. This would not be true in case an increase in timber supply were to result in a fall in market equilibrium price, at any time period now or in the future. We would then have to set off, against the additional net revenue from the additional unit sold, the loss of revenue on all the previous production due to the fall in price. An additional complication would be that to calculate the <u>net</u> revenue, we would have to have some estimate of the <u>marginal</u> costs at various levels of production, i.e. we would need to know the shapes of the supply functions of the firm to calculate the producer's surplus.

We avoid these problems, however, by assuming that the changes in supply induced by the management decisions of our 'firm' are so small in relation to the market, that there is no appreciable effect on the price. The auction price, in essence, is something outside the influence of our enterprise.

Another way of interpreting this is that there so much unsatisfied demand at these prices that any increase in (timber) supply achieved by our enterprise can be absorbed without influencing the price. We may think of a host of potential purchasers waiting in the sidelines, who will snap up any incremental supply at this prevailing market price, but are unwilling to pay any more (hence refrain from forcing the price up).

An analogous assumption is made in the case of other commodities and services, whether of inputs or outputs. We assume, for instance, that the wage rate is not forced up; the same applies to the rate of interest on capital borrowed, prices of other inputs, prices of foodstuffs and other wage goods consumed by the workers, and so on.

These assumptions, which are made commonly in cost-benefit analyses, would appear to seriously circumscribe any inference drawn from the analysis of such a 'marginal' project. Caution would have to be exercised, for instance, in extending it to the policy to be adopted by government over the whole range of related activities.

A2.4 Aggregate cash flows of cost and benefit items

A2.4.1 Costs

The details of silvicultural operations over the life of the plantation are presented in Table 7.17(i) to (iv), and cash flow statements in Tables 7.18 to 7.20 for SQII, III, and IV respectively. The unit and total costs are also given, separated into wage and non-wage expenditure.

A few remarks are in order here. The first is about the convention in timing expenditures and revenues. All cash flows occur as if at the end of the year in question. We assume that all expenditure on planting is incurred at the end of year 1. This is also the point in time at which all present values are calculated, i.e. the zero point in time for the financial analysis.

The age of the first crop is thus zero at this reference point in time. The rotation T of the crop refers to the time elapsed from this zero point. The convention assures that the crop will be replaced in the same year that it is felled. The yield tables, however, enter the age of the crop, rather than the year, in the first column: the age at the end of the year of planting is zero, though the chronological time is year 1, year T+1, and so on. This is allowed for in the analysis by computing the historical year as well as the crop age.

The second point concerns the annual recurring costs. The administration costs have been calculated on the average territorial load of executive and supervisory staff up to the level of the divisional forest officer. The administrative cost for the first year (year of planting) have not been included in the cash flow statement. This is to avoid a double counting of this item at the rotation year (once for the crop that is being harvested, once for the crop being planted). If the first year's administrative costs must be accounted for, the net present value can be simply reduced by this amount.

Since the expenditure on marking and thinning is negligible after the fourth or fifth such operation, this cost is not shown separately in the "cash flow" statement beyond age 30 or so, but subsumed under the felling and extraction costs. This, it is expected, will reduce the error implied by taking thinning yields right to the rotation year.

A2.4.2 Revenues

The outturn flows and unit values are presented in Tables 7.14 to 7.16. The commercial volume outturns of timber and firewood are based on the FRI yield tables for plantation teak (FRI, 1959a), with standard volumes converted to commercial as discussed above. The unit values derived above have been used to value the commercial outturn in money terms.

Since the calculations have been discussed already in detail, little needs to be added by way of comment here. The revenues are generally representative of the landed value at the depot, so that extraction and transport should figure as costs. Taxes can also be added to the depot value if it is assumed that the firm represents the government.

A2.4.3 Net benefit

The actual net benefit calculation was carried out using a FORTRAN program (Appendix 4). It lays no claim to being well structured or overly efficient. Part of its inefficiency or redundancy is intentional, to keep the routines simple and straightforward, avoiding 'smart' tricks that would make it difficult to extend and modify it.

A provision is incorporated for inflation of different variables at different rates. The net present value of a single rotation, and of the infinite series of rotations (the soil expectation value), can be computed over a range of values of extraction costs, transport costs (representing the lead), rotation periods, and discount rates, which can be altered as desired during the running of the programme. Yield and unit value figures, as well as other cash flow items, need to be input through separate data files. (If inflation rate of any unit value is equated to any of the values assumed by discount rate, the infinite series will become infinitely large, and the program will crash.)

The results of the cost benefit analyses are discussed in the main text.

APPENDIX THREE

PROGRAM TO CALCULATE UNIT VALUE OF TEAK CROP

```
      PROGRAM UNITVAL
C     TO ESTIMATE UNIT VALUE OF STEM TIMBER
C     IN STANDING CROP AT SUCCESSIVE AGES
C     USING STAND TABLES AND LOG OUTTURN DATA
      CHARACTER XOPT*1
C     NO OF ROWS IN STAND TABLE NROWST; NO OF DBH CLASSES NDCLST
C     DCLST(J) IS THE REFERENCE NO OF THE J'TH DBH CLASS;
      INTEGER NROWST, NDCLST, DCLST(25)
C     STAND TABLE ENTRY AGES AGEST; TOTAL STEMS PER AREA NSTEMST
C     HCLST(I) IS THE REFERENCE NO OF HEIGHT CLASS IN ROW I.
      REAL AGEST(150), NSTEMST(150)
      INTEGER HCLST(150)
C     AVERAGE DBH AVDST, AVERAGE HEIGHT AVHST
      REAL AVDST(150), AVHST(150)
C     NO OF STEMS IN ROW I, AT AGE AGEST(I),
C     IN J'TH DBH CLASS DCLST(J) IS N(I,J)
      REAL N(150,25)
C     TO CONVERT N TO NUMBER PER HECTARE,
      REAL NFACT
C
C     NO OF HEIGHT CLASSES IN VOL TABLE NHCLVT;
C     NO OF DBH CLASSES IN VOLUME TABLE NDCLVT;
C     REFERENCE NUMBER OF J'TH DBH CLASS IN VOL TAB DCLVT(J).
      INTEGER NHCLVT, NDCLVT, DCLVT(25)
C     REFERENCE NUMBER OF HEIGHT CLASS IN ROW I HCLVT(I)
      INTEGER  HCLVT(25)
C     LOG OUTTURN OF TREE (SOLID PI R**2) LOGVTREE(I,J)
C     STANDARD TIMBER VOL OF TREE(SOLID,PI R**2) STDVTREE(I,J)
C   WHERE I IS THE HT CLASS, J IS THE DBH CLASS REF NO
      REAL LOGVTREE(25,25), STDVTREE(25,25)
C     TO CONVERT VOLUMES IN VOLUME TABLE TO CMT, SOLID,
      REAL CONFACT1
C     TO CONVERT PRICES TO RS PER CMT, LOG, SOLID,
      REAL CONFACT2
C     UNIT PRICE, RS PER SOLID(PI R**2) LOG VOLUME IN DEPOT,
C   PRICE(I,J) WHERE I, J REFERENCE NOS OF HT, DBH CLASSES
      REAL PRICE(25,25)
C     CROP VOLUME(STANDARD,PI R**2)IN I'TH ROW OF STAND TABLE
      REAL VOLCROP(150)
C     CROP VALUE IN I'TH ROW OF STAND TABLE
      REAL VALCROP(150)
C     UNIT VALUE OF CROP RS PER SOLID CMT LOG VOLUME
C     UNITVAL(I) AT CROP AGE AGEST(I), I'TH ROW OF STAND TABLE
      REAL UNITVAL(150)
C     INPUT FILES:  STAND TABLE TIN1, VOL+PRICE TABLE TIN2
C     OUTPUT FILE TOUT1
      CHARACTER TIN1*30, TIN2*30, TOUT1*30
C
      DATA CONFACT1, CONFACT2, NFACT /3*1./
C     INPUT STAND TABLE DATA
      DATA N/3750*0./
 10   CONTINUE
 100  WRITE(5,*) ' NAME OF INPUT FILE FOR STAND TABLE? '
      READ(5,1000) TIN1
 1000 FORMAT(A20)
      WRITE(5,2000) NFACT
```

```
 2000   FORMAT (1X,' TO CONVERT NO OF STEMS TO PER HECTARE, '/
    1         ' PRESENT NFACT= ',F5.3,' ENTER NEW NFACT: '$)
        READ (5,*) NFACT
        OPEN(33,FILE=TIN1,STATUS='OLD',ERR=100)
        READ(33,*) NROWST, NDCLST, (DCLST(J),J=1,NDCLST)
        DO 200 I=1,NROWST
         READ(33,*) AGEST(I), AVDST(I),AVHST(I),
    1     HCLST(I), NSTEMST(I), (N(I,DCLST(J)),J=1,NDCLST)
         NSTEMST(I)= NSTEMST(I)*NFACT
         DO 200 J=1, NDCLST
          N(I,DCLST(J))= N(I,DCLST(J))*NFACT
 200   CONTINUE
 300    WRITE(5,*) ' NAME OF INFILE TIN2,VOL-PRICE TABLE? '
        READ(5,1000) TIN2

        WRITE(5,2001) CONFACT1
 2001   FORMAT (1X,' TO CONVERT VOLUME TO CMT CONFACT1= ',F7.3/
    1         ' ENTER NEW CONFACT1: '$)
        READ(5,*) CONFACT1
        WRITE(5,2002) CONFACT2
 2002   FORMAT (1X,' TO CONVERT PRICE TO RS PER CMT LOG, SOLID '/
    1         ' CONFACT2= ', F7.3, ' ENTER NEW CONFACT2: '$)
        READ(5,*) CONFACT2
        OPEN(34,FILE=TIN2,STATUS='OLD',ERR=300)
        READ(34,*) NHCLVT, NDCLVT,(DCLVT(J),J=1,NDCLVT)
        DO 350 I=1,NHCLVT
C       INPUT TREE VOL BY HT & DBH CLASS, LOG OUTTURN (SOLID PI R2)
         READ(34,*) HCLVT(I), (LOGVTREE(HCLVT(I),DCLVT(J)),J=1,NDCLVT)
          DO 350 J= 1, NDCLVT
          LOGVTREE(HCLVT(I),DCLVT(J))= LOGVTREE(HCLVT(I),DCLVT(J))*CONFACT1
 350    CONTINUE
C       INPUT VOL BY HT & DBH CLASS, STANDARD TIMBER VOLUME(PI R2)
        DO 400 I= 1, NHCLVT
         READ(34,*) HCLVT(I), (STDVTREE(HCLVT(I),DCLVT(J)),J=1,NDCLVT)
         DO 400 J= 1,NDCLVT
          STDVTREE(HCLVT(I),DCLVT(J))= STDVTREE(HCLVT(I),DCLVT(J))*CONFACT1
 400    CONTINUE
C       INPUT DEPOT PRICES OF LOGS PER SOLID(PI R**2) VOL UNIT
        DO 450 I= 1,NHCLVT
         READ(34,*) HCLVT(I), (PRICE(HCLVT(I),DCLVT(J)),J=1,NDCLVT)
         DO 450 J= 1, NDCLVT
          PRICE(HCLVT(I),DCLVT(J))= PRICE(HCLVT(I),DCLVT(J))*CONFACT2
 450    CONTINUE
 500   CONTINUE
C       FOR EACH AGE, CALCULATE CROP VOLUME AND VALUE
        DO 700 I=1,NROWST
                VOLCROP(I)=0.
                VALCROP(I)=0.
          DO 600 J=1,NDCLST
          VOLCROP(I)=VOLCROP(I)+N(I,DCLST(J))*LOGVTREE(HCLST(I),DCLST(J))
          VALCROP(I)=VALCROP(I)+N(I,DCLST(J))*LOGVTREE(HCLST(I),DCLST(J))*
    1         PRICE(HCLST(I),DCLST(J))
 600      CONTINUE
C       VOLCROP(I)=VOLCROP(I)*CONFACT1
C       VALCROP(I)=VALCROP(I)*CONFACT1*CONFACT2
        IF(VOLCROP(I).EQ.0.) UNITVAL(I)=0.
        IF(VOLCROP(I).NE.0.) UNITVAL(I)=VALCROP(I)/VOLCROP(I)
C       UNIT VALUE IS RS, PER CMT SOLID LOG TIMBER VOLME
 700   CONTINUE
        WRITE(5,*) 'OUTPUT FILE NAME? '
        READ(5,1000) TOUT1
        OPEN(35,FILE=TOUT1,STATUS='NEW')
        WRITE(35,1005) TIN1, NROWST, NDCLST
        WRITE(5,1005) TIN1, NROWST, NDCLST
 1005   FORMAT(1X,'STAND TABLE DATA USED: FILE ',A20/
    1   ' NROWST=',I3,' NDCLST=',I3,11X,' DCLST(J):')
        WRITE(35,1006)( DCLST(J),J=1,NDCLST)
        WRITE(5,1006)( DCLST(J),J=1,NDCLST)
 1006   FORMAT('0  AGEST  AVDST AVHST HCLST NSTEMST ',25I6/
    1     '                          PER HECT    PER HECT  ')
```

```
      DO 625 I=1,NROWST
      WRITE(35,1007)AGEST(I),AVDST(I),AVHST(I),HCLST(I),NSTEMST(I),
     1         (N(I,DCLST(J)),J=1,NDCLST)
      WRITE(5,1007)AGEST(I),AVDST(I),AVHST(I),HCLST(I),NSTEMST(I),
     1         (N(I,DCLST(J)),J=1,NDCLST)
1007  FORMAT(1X,F7.2,F6.2,F6.2,I6,F6.1,4X,<NDCLST>F8.3)
625   CONTINUE
      WRITE(35,1008) TIN2, NHCLVT, NDCLVT, (DCLVT(J),J=1,NDCLVT)
      WRITE(5,1008) TIN2, NHCLVT, NDCLVT, (DCLVT(J),J=1,NDCLVT)
1008  FORMAT(1X,'_______________________________________'/
     1 ' VOLUME TABLE DATA USED: FILE ',A20//
     1 ' NHCLVT=',I3,' NDCLVT=',I3,' DCLVT: '/
     2 ' HCLVT ',25I8//)
      WRITE(35,*)('       LOG VOLUME PER TREE, SOLID CMT        ')
      WRITE(5,*) ('       LOG VOLUME PER TREE, SOLID CMT        ')
      DO 650 I=1,NHCLVT
      WRITE(35,1009) HCLVT(I),(LOGVTREE(HCLVT(I),DCLVT(J)),J=1,NDCLVT)
      WRITE(5,1009) HCLVT(I),(LOGVTREE(HCLVT(I),DCLVT(J)),J=1,NDCLVT)
1009  FORMAT(1X,I6,25F8.2)
650   CONTINUE
      WRITE(35,*) ('       STD VOLUME PER TREE, SOLID CMT       ')
      WRITE(5,*)  ('       STD VOLUME PER TREE, SOLID CMT       ')
      DO 675 I=1,NHCLVT
      WRITE(35,1010) HCLVT(I),(STDVTREE(HCLVT(I),DCLVT(J)),J=1,NDCLVT)
      WRITE(5,1010) HCLVT(I),(STDVTREE(HCLVT(I),DCLVT(J)),J=1,NDCLVT)
1010  FORMAT(1X,I6,25F8.2)
675   CONTINUE
      WRITE(35,*) ('        PRICE  RS PER CMT SOLID LOG VOLUME     ')
      WRITE(5,*)  ('        PRICE  RS PER CMT SOLID LOG VOLUME     ')
      DO 685 I=1,NHCLVT
      WRITE(35,1011) HCLVT(I),(PRICE(HCLVT(I),DCLVT(J)),J=1,NDCLVT)
      WRITE(5,1011) HCLVT(I),(PRICE(HCLVT(I),DCLVT(J)),J=1,NDCLVT)
1011  FORMAT(1X,I6,25F8.2)
685   CONTINUE
      WRITE(35,1001)
      WRITE(5,1001)
1001  FORMAT(1X,'____________________________________________'/
     1       ' AGE     VALUE    VOL/HECTARE     UNIT VALUE '/
     1       ' YEARS     RS      CMT LOG SOL  RS/CMT LOG SOLID')

      WRITE(35,1003) (AGEST(I),VALCROP(I),VOLCROP(I),
     1 UNITVAL(I),I=1,NROWST)
      WRITE(5,1003) (AGEST(I),VALCROP(I),VOLCROP(I),
     1 UNITVAL(I),I=1,NROWST)
1003  FORMAT(1X,F4.1,1X,2F13.2,F10.2)
      WRITE(5,*) ' TO EXIT, Y, ELSE RETURN - '
      READ (5,1020) XOPT
1020  FORMAT (A1)
      IF (XOPT.NE.'Y') GOTO 10
      STOP
      END
```

APPENDIX FOUR

PROGRAM FOR SOCIAL COST BENEFIT ANALYSIS

```
      PROGRAM SCBA
C     CALCULATES SOCIAL VALUES AT BORDER PRICES
C     CALCULATES NPV & SOIL EXP VALUE FROM YIELD TABLE TYPE DATA
C     STEM TIMBER AND SMALLWOOD DATA AVAILABLE SEPARATELY
C     FOR FIRST [SEEDLING] CROP PLUS (NYT-1) COPPICE CROPS
      INTEGER FAGE,FYEAR
C     NO OF CROPS NCROPS; UPTO 20 ALLOWED
C     NO OF INPUT YIELD TABLES NYT; CASH FLOW TABLES NCSH; MAX 20
      INTEGER NCROPS, NYT, NCSH
C     NO OF ROWS N(*) IN YLD TAB, M(*) IN CASH FLOW T; MAX 150
      INTEGER M(20),N(20),INDEV1,INDEV2,OUTDEV1,AGE, K1, IC, I
C     ROTNZ=LOWER LIMIT,ROTNL=UPPER LIMIT,ROTNI=INCREMENT
      INTEGER ROTNZ(20),ROTNL(20),ROTNI(20)
C     YROTN IS YEAR CORRESPONDING TO END OF FIRST ROTATION
C     YTAGE(IC,I) IS AGE IN ROW I OF YIELD TABLE OF CROP IC
C     CSHAGE(IC,I) IS AGE IN ROW I OF CASH FLOW TABLE OF CROP IC
      INTEGER ROTN(20),YROTN,YEAR, YTAGE(20,150), CSHAGE(20,150)
C     REFYR= YEAR FOR NPV VALUATION; DEFAULT IS (END OF) YEAR 1
C     REFAGE= AGE AT REFYR; DEFAULT IS ZERO (AT END OF YEAR 1)
      INTEGER REFYR, REFAGE, DIFREF
C *****  CONVENTION IN VARIABLE NAMES AS FOLLOWS: *****
C     M MAIN CROP,TH THINNINGS,CRP TOTAL CROP(M+TH)
C     TM TIMBER,SW SMALLWOOD
C     XW EXTRACTION LABOUR COSTS, XT TRANSPORT COSTS;
C     XP EXTRACTION COST PER UNIT VOLUME;
C     Xa EXTRACTION COST PER ACRE/HECT
C     Z LOWER LIMIT(ZERO),L UPPER LIMIT(LAST),I INCREMENT
C     r INFLATION RATE; d DOMESTIC (PRICES); a AREA (ACRE or HECT)
C     T TOTAL,DT DISCOUNTED TOTAL
C     V INFLATED VALUE,IN INFLOW,UT OUTFLOW
C     ****************************************************
C     DISCZ=LOWER LIMIT,DISL=UPPER LIMIT,DISCI=INCR IN DISC RATE
C     DISC= DISCOUNT RATE IN USE AT PARTICULAR STAGE
      REAL DISCZ,DISCL,DISCI,DISC
C     AR's WAGES, TRANSPORT, NON-WAGE EXPEND, TIMBER, SMALLWOOD:
      REAL ARW, ARXW, ARXT, ARNW, ARTM, ARSW
C     EXTRACTION LABOUR COSTS PER UNIT VOLUME, DOMESTIC VALUES:
      REAL MTMXWd, THTMXWd, MSWXWd, THSWXWd
C     EXTRACTION LABOUR COSTS PER UNIT VOLUME, BORDER VALUES:
      REAL MTMXW, THTMXW, MSWXW, THSWXW
C     EXTRACTION TRANSPORT COSTS PER UNIT VOLUME, DOMESTIC VALUES:
      REAL MTMXTZ, MTMXTL, MTMXTI, MTMXTd
      REAL MSWXTZ, MSWXTL, MSWXTI, MSWXTd
      REAL THTMXTZ, THTMXTL, THTMXTI, THTMXTd
      REAL THSWXTZ, THSWXTL, THSWXTI, THSWXTd
C     EXTRACTION TRANSPORT COSTS PER UNIT VOLUME, BORDER PRICES:
      REAL MTMXT, MSWXT, THTMXT, THSWXT
C     EXTRACTION TOTAL COSTS PER UNIT VOLUME, DOMESTIC VALUES:
      REAL MTMXPd, MSWXPd, THTMXPd, THSWXPd
C     EXTRACTION COSTS PER UNIT, TOTAL, BORDER VALUES:
      REAL MTMXPZ,MTMXPL,MTMXPI,MTMXP
      REAL MSWXPZ,MSWXPL,MSWXPI,MSWXP
      REAL THTMXPZ,THTMXPL,THTMXPI,THTMXP
      REAL THSWXPZ,THSWXPL,THSWXPI,THSWXP
```

```
C       VOLUMES PER HECTARE/ACRE
        REAL MTM(20,150),MSW(20,150),THTM(20,150),THSW(20,150)
C       DEPOT PRICES PER UNIT VOLUME, DOMESTIC VALUES
        REAL MTMPd(20,150), MSWPd(20,150), THTMPd(20,150), THSWPd(20,150)
C       DEPOT PRICES PER UNIT VOLUME, BORDER VALUES:
        REAL MTMP(20,150),MSWP(20,150),THTMP(20,150),THSWP(20,150)
C       LANDED VALUE PER HECT/ACRE
        REAL MTMV,MSWV ,THTMV ,THSWV
C
C       DISCOUNTED LANDED VALUE PER HECT/ACRE
        REAL DMTMV,DMSWV ,DTHTMV ,DTHSWV
C       DISCOUNTED EXTRACTION COSTS PER HECT/ACRE
        REAL DMTMXW , DMTMXT , DMTMX
        REAL DMSWXW , DMSWXT , DMSWX
        REAL DTHTMXW , DTHTMXT , DTHTMX
        REAL DTHSWXW , DTHSWXT , DTHSWX
C       DISCOUNTED NET VALUE ON STUMP PER HECT/ACRE
        REAL DMIN
C       CSH FLOWS, BASE YEAR CURRENCY
        REAL CSHINd(20,150), WUTd(20,150),NWUTd(20,150), CSHUTd(20,150)
        REAL CSHIN(20,150), WUT(20,150), NWUT(20,150), CSHUT(20,150)
C       DISCOUNTED CSH FLOWS, BASE YEAR CURRENCY
        REAL DCSHIN ,DCSHUT
C       DISCOUNTED CSH FLOWS, INFLATED
        REAL DCSHINV , DWUTV , DNWUTV , DCSHUTV
C       CUMULATED DISCOUNTED  TOTALS
        REAL DTTHTMV , DTTHTMXW , DTTHTMXT , DTTHTMX
        REAL DTTHSWV , DTTHSWXW , DTTHSWXT , DTTHSWX
        REAL DTTHIN ,DTCRPIN ,DTIN
        REAL DTCSHINV , DTWUTV , DTNWUTV ,DTCSHUTV
C       NET DISCOUNTED VALUE
        REAL DNET
C       NOW FOR INFINITE SERIES OF ROTATIONS
C       DISCOUNTED LANDED VALUE PER HECT,CUMULATED TOTAL
        REAL DMTMVSe ,DTHTMVSe ,DMSWVSe ,DTHSWVSe
C       DISCOUNTED EXTR COSTS PER HECT, CUMULATED
        REAL DMTMXWSe , DMTMXTSe , DMTMXSe
        REAL DTHTMWSe , DTHTMTSe , DTHTMXSe
        REAL DMSWXWSe , DMSWXTSe , DMSWXSe
        REAL DTHSWWSe , DTHSWTSe , DTHSWXSe
C       DISCOUNTED NET VALUE ON STUMP,PER HECT, CUMULATED
        REAL DMINSe ,DTHINSe ,DCRPINSe
C       DISCOUNTED CASH FLOWS, INFLATED, CUMULATED
        REAL DCSHINSe , DWUTSe , DNWUTSe , DCSHUTSe
C
C       SOIL EXPECTATION VALUE=DISCOUNTED NET VALUE
        REAL DNETSe
C       FILE NAMES
        CHARACTER TIN1*30,TIN2*30,TOUT1*30,TOUT2*30
        CHARACTER YNOPT*1, PLTOPT*1, ESCOPT*1, TTYOPT*1, OUTOPT*1
C       MULTIPLYING FACTORS FOR ONE-TIME SCALING OF OUTPUT QUANTITIES
        REAL TMSFACT, SWSFACT
C       MULTIPLYING FACTORS FOR ONE-TIME JUMP IN DOMESTIC PRICES
        REAL TMPFACT,SWPFACT
C       DEPOT PRICE INFLATION RATES, DOMESTIC VALUES
        REAL MTMPr,MSWPr,THTMPr,THSWPr
C       EXTRACTION UNIT COST INFLATION RATES
        REAL XWr, XTr
C       GENERAL WAGE INFLATION RATE
        REAL Wr
C       CSH INFLATION RATE
        REAL CSHr, NWUTdr
C       FUNCTIONS DEFINED
C       AGE OF CROP IS 0 AT END OF YEAR 1, ETC.
        FAGE(I)=I-1
C       WHEN AGE OF CROP IS 0, YEAR IS 1, ETC.
        FYEAR(I)=I+1
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
        DATA ESCOPT/'N'/
 50     CONTINUE
```

```
C       INITIALISE ALL RELEVANT VARIABLES
        DATA INDEV1, INDEV2 /31,32/
        DATA OUTDEV1,OUTDEV2/33,34/
C       NUMBER OF CROPS, INCLUDING SEEDLING CROP [1]
        DATA NCROPS/1/
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C       INPUT YIELD TABLE VARIABLES
 75     CONTINUE
        WRITE(5,*) ' NEW NO OF CROPS - Y, ELSE RETURN '
        READ(5,1022) YNOPT
        IF(YNOPT.EQ.'Y') THEN
         WRITE(5,2018)
 2018    FORMAT(1X,' NO OF CROPS INCLUDING SEEDLING CROP, NCROPS? '$)
         READ(5,*,ERR=750) NCROPS
        ENDIF
        WRITE(5,*)' NEW YIELD TABLES - Y, ELSE RETURN '
        READ(5,1022) YNOPT
        IF(YNOPT.NE.'Y') GOTO 95
        WRITE(5,1004)
 1004   FORMAT(1X,'NAME OF INPUT FILE 1 YT VALUES '$)
        READ(5,1005,ERR=750)TIN1
 1005   FORMAT(A30)
 95     OPEN(UNIT=INDEV1,STATUS='OLD',FILE=TIN1,ERR=750)
C       INITIALISE YIELD TABLE VARIABLES
C       VOLUMES PER HECTARE/ACRE
        DO 55 IC=1,20
          DO 55 I=1,150
        MTM(IC,I)=0.
        MSW(IC,I)=0.
        THTM(IC,I)=0.
        THSW(IC,I)=0.
C       DEPOT PRICES PER UNIT VOLUME
        MTMPd(IC,I)=0.
        MSWPd(IC,I)=0.
        THTMPd(IC,I)=0.
        THSWPd(IC,I)=0.
        MTMP(IC,I)=0.
        MSWP(IC,I)=0.
        THTMP(IC,I)=0.
        THSWP(IC,I)=0.
 55     CONTINUE
        READ (INDEV1,*) NYT
        DO 100 IC=1, NYT
          READ (INDEV1,*) N(IC)
          DO 100 I=1,N(IC)
                READ(INDEV1,*) YTAGE(IC,I),
     1  MTM(IC,FYEAR(YTAGE(IC,I))), MTMPd(IC,FYEAR(YTAGE(IC,I))),
     1  MSW(IC,FYEAR(YTAGE(IC,I))), MSWPd(IC,FYEAR(YTAGE(IC,I))),
     2  THTM(IC,FYEAR(YTAGE(IC,I))), THTMPd(IC,FYEAR(YTAGE(IC,I))),
     3  THSW(IC,FYEAR(YTAGE(IC,I))), THSWPd(IC,FYEAR(YTAGE(IC,I)))
 100    CONTINUE
        CLOSE(UNIT=INDEV1, ERR=750)
        IF (NCROPS.GT.NYT) THEN
           DO 105 IC= (NYT+1), NCROPS
           N(IC)= N(NYT)
             DO 105 I= 1, N(IC)
                YTAGE(IC,I)= YTAGE(NYT,I)
        MTM(IC,FYEAR(YTAGE(IC,I)))= MTM(NYT,FYEAR(YTAGE(NYT,I)))
        MTMPd(IC,FYEAR(YTAGE(IC,I)))= MTMPd(NYT,FYEAR(YTAGE(NYT,I)))
        MSW(IC,FYEAR(YTAGE(IC,I)))= MSW(NYT,FYEAR(YTAGE(NYT,I)))
        MSWPd(IC,FYEAR(YTAGE(IC,I)))= MSWPd(NYT,FYEAR(YTAGE(NYT,I)))
        THTM(IC,FYEAR(YTAGE(IC,I)))= THTM(NYT,FYEAR(YTAGE(NYT,I)))
        THTMPd(IC,FYEAR(YTAGE(IC,I)))= THTMPd(NYT,FYEAR(YTAGE(NYT,I)))
        THSW(IC,FYEAR(YTAGE(IC,I)))= THSW(NYT,FYEAR(YTAGE(NYT,I)))
        THSWPd(IC,FYEAR(YTAGE(IC,I)))= THSWPd(NYT,FYEAR(YTAGE(NYT,I)))
 105       CONTINUE
        ENDIF
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
 110    CONTINUE
```

```
C       INITIALIZE VARIABLES DERIVED FROM YT VARIABLES
C       LANDED VALUE PER HECT/ACRE
        MTMV=0.
        MSWV=0.
        THTMV=0.
        THSWV=0.
C       DISCOUNTED LANDED VALUE PER HECT/ACRE
        DMTMV=0.
        DMSWV=0.
        DTHTMV=0.
        DTHSWV=0.
C       DISCOUNTED EXTRACTION COSTS PER HECT/ACRE
        DMTMXW=0.
        DMTMXT=0.
        DMTMX=0.
        DMSWXW=0.
        DMSWXT=0.
        DMSWX=0.
        DTHTMXW=0.
        DTHTMXT=0.
        DTHTMX=0.
        DTHSWXW=0.
        DTHSWXT=0.
        DTHSWX=0.
C       DISCOUNTED NET VALUE ON STUMP PER HECT/ACRE
        DMIN=0.
        DTTHIN=0.
C       CUMULATED TOTALS
        DTTHTMV=0.
        DTTHTMXW=0.
        DTTHTMXT=0.
        DTTHTMX=0.
        DTTHSWV=0.
        DTTHSWXW=0.
        DTTHSWXT=0.
        DTTHSWX=0.
        DTTHIN=0.
        DTCRPIN=0.
        DTIN=0.
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
 150    CONTINUE
C       INITIALIZE CASH FLOW DATA VARIABLES
C       CSH FLOWS, BASE YEAR CURRENCY
        DO 155 IC=1,20
          DO 155 I=1,150
                CSHINd(IC,I)=0.
                WUTd(IC,I)=0.
                NWUTd(IC,I)=0.
                CSHUTd(IC,I)=0.
                CSHIN(IC,I)=0.
                WUT(IC,I)=0.
                NWUT(IC,I)=0.
                CSHUT(IC,I)=0.
 155    CONTINUE
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C       INPUT CASH FLOW DATA
        WRITE(5,*) ' NEW CASH FLOW TABLE - Y, ELSE RETURN '
        READ(5,1022) YNOPT
        IF(YNOPT.NE.'Y') GOTO 195
        WRITE(5,1006)
 1006   FORMAT(1X,'NAME OF INPUT FILE 2 FOR CSH FLOWS? '$)
        READ(5,1005,ERR=750)TIN2
 195    OPEN(UNIT=INDEV2,STATUS='OLD',FILE=TIN2,ERR=750)
        READ(INDEV2,*) NCSH
        DO 200 IC= 1, NCSH
           READ(INDEV2,*) M(IC)
           DO 200 I= 1, M(IC)
        READ(INDEV2,*) CSHAGE(IC,I), CSHINd(IC,FYEAR(CSHAGE(IC,I))),
     1  WUTd(IC,FYEAR(CSHAGE(IC,I))), NWUTd(IC,FYEAR(CSHAGE(IC,I))),
     2  CSHUTd(IC,FYEAR(CSHAGE(IC,I)))
 200    CONTINUE
        CLOSE(UNIT=INDEV2, ERR=750)
```

```
        IF (NCROPS.GT.NCSH) THEN
        DO 205 IC= NCSH+1, NCROPS
          M(IC)= M(NCSH)
          DO 205 I= 1, M(IC)
                 CSHAGE(IC,I)= CSHAGE(NCSH,I)
                 J= FYEAR(CSHAGE(IC,I))
        CSHINd(IC,J)= CSHINd(NCSH,J)
        WUTd(IC,J)= WUTd(NCSH,J)
        NWUTd(IC,J)= NWUTd(NCSH,J)
        CSHUTd(IC,J)= CSHUTd(NCSH,J)
 205    CONTINUE
        ELSE
         CONTINUE
        ENDIF
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
 207    CONTINUE
C       INITIALIZE VARIABLES DERIVED FROM CASH FLOW VARIABLES
C       CUMULATED TOTALS
        DTCSHINV=0.
        DTWUTV=0.
        DTNWUTV=0.
        DTCSHUTV=0.
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C       NET DISCOUNTED VALUE
        DNET=0.
C       FOR INFINITE SERIES
C       DISCOUNTED LANDED VALUE PER HECT,CUMULATED TOTAL
        DMTMVSe=0.
        DTHTMVSe=0.
        DMSWVSe=0.
        DTHSWVSe=0.
C       DISCOUNTED EXTR COSTS PER HECT, CUMULATED
        DMTMXWSe=0.
        DMTMXTSe=0.
        DMTMXSe=0.
        DMSWXWSe=0.
        DMSWXTSe=0.
        DMSWXSe =0.
        DTHTMWSe=0.
        DTHTMTSe=0.
        DTHTMXSe=0.
        DTHSWWSe=0.
        DTHSWTSe=0.
        DTHSWXSe=0.
C       DISCOUNTED NET VALUE ON STUMP,PER HECT, CUMULATED
        DMINSe=0.
        DTHINSe=0.
        DCRPINSe=0.
C       DISCOUNTED CASH FLOWS, INFLATED, CUMULATED
        DCSHINSe=0.
        DWUTSe=0.
        DNWUTSe=0.
        DCSHUTSe=0.
C       SOIL EXPECTATION VALUE=DISCOUNTED NET VALUE
        DNETSe=0.
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C       INITIALIZE PARAMETERS FIRST TIME ROUND
        IF(ESCOPT.EQ.'Y') GOTO 210
C       OUTPUT SCALING FACTORS
        TMSFACT=1.
        SWSFACT=1.
C       PRICE MULTIPLICATION FACTORS
        TMPFACT=1.
        SWPFACT=1.
C       DEPOT PRICE INFLATION RATES
        MTMPr=0.
        MSWPr=0.
        THTMPr=0.
        THSWPr=0.
C       EXTRACTION UNIT COST INFLATION RATES
C       EXTRACTION WAGE INFLATION RATE
        XWr=0.
```

```
C       EXTRACTION TRANSPORT COST INFLATION RATE
        XTr=0.
C       WAGE INFLATION RATE, GENERAL
        Wr=0.
C       CSH INFLATION RATE
        CSHr=0.0
        NWUTdr=0.
C       ACCOUNTING RATIOS
        ARTM=1.
        ARSW=1.
        ARXW=1.
        ARXT=1.
        ARW=1.
        ARNW=1.
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
 210    CONTINUE
        WRITE(5,*)  ' NEW OUTPUT SCALING FACTORS- Y, ELSE RETURN '
        READ (5,1022) YNOPT
        IF (YNOPT.EQ.'Y') THEN
                WRITE(5,*)  ' TMSFACT, SWSFACT ? '
                READ(5,*,ERR=750) TMSFACT, SWSFACT
        ENDIF
        DO 211 IC= 1, NCROPS
         DO 211 I= 1, N(IC)
          J= FYEAR(YTAGE(IC,I))
          MTM(IC,J)= MTM(IC,J)*TMSFACT
          MSW(IC,J)= MSW(IC,J)*SWSFACT
          THTM(IC,J)= THTM(IC,J)*TMSFACT
          THSW(IC,J)= THSW(IC,J)*SWSFACT
 211    CONTINUE
        WRITE(5,*)  ' NEW PRICE FACTORS - Y, ELSE RETURN '
        READ(5,1022) YNOPT
        IF(YNOPT.NE.'Y') GOTO 213
        WRITE(5,1018)
 1018   FORMAT(1X,'TIMBER PRICE FACTOR, SW PRICE FAC, FRACTIONS? '$)
        READ(5,*,ERR=750)TMPFACT,SWPFACT
 213    CONTINUE
C       NOW ONE-TIME JUMP IN DOMESTIC PRICES
        DO 214 IC=1,NCROPS
        DO 214 I=1,N(IC)
         J= FYEAR(YTAGE(IC,I))
         MTMPd(IC,J)=MTMPd(IC,J)*TMPFACT
         MSWPd(IC,J)=MSWPd(IC,J)*SWPFACT
         THTMPd(IC,J)=THTMPd(IC,J)*TMPFACT
         THSWPd(IC,J)=THSWPd(IC,J)*SWPFACT
 214    CONTINUE
 215    CONTINUE
        WRITE(5,*)  ' NEW EXTR TRANSPORT COST - Y, ELSE RETURN '
        READ(5,1022)YNOPT
        IF (YNOPT.NE.'Y') GOTO 217
        WRITE(5,1007)
 1007   FORMAT(1X,'MIN,MAX,STEP IN MAIN TIMB EXTR
     1  TRANSP UNIT COST domest? '$)
        READ(5,*,ERR=750) MTMXTZ, MTMXTL, MTMXTI
        WRITE(5,1008)
 1008   FORMAT(1X,'MIN,MAX,STEP IN THIN TIMB EXTR
     1  TRANSP COST/UNIT domestic? '$)
        READ(5,*,ERR=750) THTMXTZ, THTMXTL, THTMXTI
        WRITE(5,1009)
 1009   FORMAT(1X,'MIN,MAX,STEP IN MAIN SW EXTR
     1  TRANSP COST/UNIT domestic? '$)
        READ(5,*,ERR=750) MSWXTZ, MSWXTL, MSWXTI
        WRITE(5,1010)
 1010   FORMAT(1X,'MIN,MAX,STEP IN THIN SW EXTR
     1  TRANSP COST/UNIT domestic? '$)
        READ(5,*,ERR=750) THSWXTZ, THSWXTL, THSWXTI
 217    CONTINUE
        WRITE(5,*)  ' NEW EXTR LABOUR COST - Y, ELSE RETURN '
        READ(5,1022) YNOPT
        IF(YNOPT.NE.'Y') GOTO 220
        WRITE(5,2011)
 2011   FORMAT(' MAIN TIMB, THIN TIMB EXTR UNIT LABOUR COST domestic? '$)
```

```
      READ(5,*,ERR=750) MTMXWd, THTMXWd
      WRITE(5,2012)
 2012 FORMAT(' MAIN SW, THIN SW EXTR LABOUR COST/UNIT domestic? '$)
      READ(5,*,ERR=750) MSWXWd, THSWXWd
 220  CONTINUE
      WRITE(5,*) ' NEW DEPOT PRICE INFL RATES - Y, ELSE RETURN '
      READ(5,1022) YNOPT
      IF(YNOPT.NE.'Y') GOTO 222
      WRITE(5,1013)
 1013 FORMAT(1X,' MAIN TIM,SW DEPOT P INFL RATES,DECIMAL? '$)
      READ(5,*,ERR=750)MTMPr,MSWPr
      WRITE(5,1014)
 1014 FORMAT(1X,' THIN TIM,SW DEPOT P INFL r,DECIMAL? '$)
      READ(5,*,ERR=750)THTMPr,THSWPr
 222  CONTINUE
      WRITE(5,*)' NEW COST INFL RATES - Y, ELSE RETURN '
      READ(5,1022) YNOPT
      IF (YNOPT.NE.'Y') GOTO 225
      WRITE(5,1015)
 1015 FORMAT(1X,' EXTR TRANSPORT COST/UNIT,INFL rate XTr? '$)
      READ(5,*,ERR=750) XTr
      WRITE(5,2015)
 2015 FORMAT(1X,' EXTR LABOUR WAGE INFL rate XWr? '$)
      READ(5,*,ERR=750) XWr
      WRITE(5,1016)
 1016 FORMAT(1X,' GENERAL WAGE INFL rate Wr? '$)
      READ(5,*,ERR=750) Wr
      WRITE(5,1017)
 1017 FORMAT(1X,'CSH INFLATION RATE? NONWAGE EXPEND INFL RATE?  '$)
      READ(5,*,ERR=750)CSHr, NWUTdr
 225  CONTINUE
      WRITE(5,*)' NEW ROTATION LIMITS - Y, ELSE RETURN '
      READ(5,1022) YNOPT
      IF(YNOPT.NE.'Y') GO TO 230
      WRITE(5,1012)
 1012 FORMAT(1X,' MIN,MAX,AND STEP IN ROTATION PERIOD: '/
     1       ' SEEDLING CROP [CROP 1]: '$)
      READ(5,*,ERR=750) ROTNZ(1),ROTNL(1),ROTNI(1)
      DO 227 J= 2, NCROPS
       WRITE (5,4012) J
 4012  FORMAT (1X,'DIFFERENT VALUES FOR CROP ',I3,'? -Y, ELSE RETURN'$)
       READ(5,1022) YNOPT
       IF (YNOPT.NE.'Y') GOTO 226
       WRITE(5,3012) J
 3012  FORMAT (1X,' ROTNZ, ROTNL, ROTNI FOR CROP',I3,'? ')
       READ(5,*) ROTNZ(J), ROTNL(J), ROTNI(J)
      GO TO 227
 226   ROTNZ(J)= ROTNZ(J-1)
       ROTNL(J)= ROTNL(J-1)
       ROTNI(J)= ROTNI(J-1)
 227  CONTINUE
 230  CONTINUE
      WRITE(5,*)' NEW DISCOUNT RATE LIMITS - Y, ELSE RETURN '
      READ(5,1022) YNOPT
      IF(YNOPT.NE.'Y') GOTO 235
      WRITE(5,1011)
 1011 FORMAT(1X,' MIN,MAX, AND STEP IN DISCOUNT RATE, DECIMAL? '$)
      READ(5,*,ERR=750)DISCZ,DISCL,DISCI
 235  CONTINUE
      WRITE(5,*) ' NEW ACC RATIOS FOR TM, SW - Y, ELSE RETURN '
      READ(5,1022) YNOPT
      IF(YNOPT.NE.'Y') GOTO 240
      WRITE(5,2017)
 2017 FORMAT(' ACCOUNTING RATIOS FOR TIMBER, SMALLWOOD? '$)
      READ(5,*,ERR=750) ARTM, ARSW
 240  CONTINUE
C     NOW CALCULATING BORDER PRICES
      DO 2472 IC= 1,NCROPS
      DO 2472 I= 1,N(IC)
      J= FYEAR(YTAGE(IC,I))
      MTMP(IC,J)= MTMPd(IC,J)*ARTM
      MSWP(IC,J)= MSWPd(IC,J)*ARSW
```

```
      THTMP(IC,J)= THTMPd(IC,J)*ARTM
      THSWP(IC,J)= THSWPd(IC,J)*ARSW
 2472 CONTINUE
 242  CONTINUE
      WRITE(5,*) ' NEW ACC RATIOS FOR COSTS - Y, ELSE RETURN '
      READ(5,1022) YNOPT
      IF(YNOPT.NE.'Y') GOTO 243
      WRITE(5,2026)
 2026 FORMAT(' ACC RATIOS FOR EXTR WAGES ARXW, EXTR TRANSP ARXT? '$)
      READ(5,*,ERR=750) ARXW, ARXT
      WRITE(5,2027)
 2027 FORMAT(' AR FOR WAGES, AR FOR NON-WAGE EXPENDITURES?  '$)
      READ(5,*,ERR=750) ARW, ARNW
 243  CONTINUE
      WRITE(5,*) ' NOW CONVERTING CASH FLOWS INTO BORDER VALUES '
      DO 244 IC= 1,NCROPS
       DO 244 I=1,M(IC)
        J= FYEAR(CSHAGE(IC,I))
        CSHUTd(IC,J)= WUTd(IC,J)+NWUTd(IC,J)
        CSHIN(IC,J)=  CSHINd(IC,J)*ARNW
        WUT(IC,J)=    WUTd(IC,J)*ARW
        NWUT(IC,J)=   NWUTd(IC,J)*ARNW
        CSHUT(IC,J)=  WUT(IC,J) + NWUT(IC,J)
 244  CONTINUE
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
 245  CONTINUE
      WRITE(5,*) ' FORM PLOT FILE - Y, ELSE RETURN '
      READ(5,1022) PLTOPT
      IF(PLTOPT.NE.'Y') GOTO 247
      WRITE(5,*) ' NEW PLOTFILE - Y, ELSE RETURN '
      READ(5,1022) YNOPT
      IF(YNOPT.NE.'Y') GOTO 247
      WRITE(5,*)' NAME OF PLOT FILE 34? '
      READ(5,1005,ERR=750) TOUT2
      OPEN (UNIT=OUTDEV2,STATUS='NEW',FILE=TOUT2,ERR=750)
 247  CONTINUE
      WRITE(5,*) ' RECORD OUTPUT IN FILE - Y, ELSE RETURN '
      READ(5,1022) OUTOPT
      IF(OUTOPT.NE.'Y') GO TO 252
      WRITE(5,*) ' NEW OUTPUT FILE - Y, ELSE RETURN '
      READ(5,1022)YNOPT
      IF(YNOPT.NE.'Y') GO TO 249
      WRITE(5,1003)
 1003 FORMAT(1X,'NAME OF OUTPUT FILE 33 ?' $)
      READ(5,1005,ERR=750)TOUT1
      OPEN (UNIT=OUTDEV1,STATUS='NEW',FILE=TOUT1,ERR=750)
 249  CONTINUE
 80   WRITE(5,2019)
 2019 FORMAT(' PRINT YIELD TABLE DATA IN OUTFILE? '$)
      READ(5,1022) YNOPT
      IF(YNOPT.NE.'Y') GO TO 252
C     NOW DISPLAYING YIELD DATA USED
      WRITE(OUTDEV1,1019) TOUT1, TIN1, TMSFACT, SWSFACT,
     1                                 TMPFACT,SWPFACT,NYT
 1019  FORMAT('1____OUTPUT FILE ',A30,'____________________________
     1 ___________________________'/
     1 '     YIELD TABLE DATA USED: FILE ',A30/
     1 ' OUTPUT QUANTITIES *BY TMSFACT= 'F7.3' SWSFACT= 'F7.3/
     1 ' DOMESTIC PRICES   *BY TMPFACT= 'F7.3' SWPFACT= 'F7.3/
     1 ' NO OF TABLES= ',I3/
     1 ' AGE    [______MAIN____________CROP_____][______SUBSIDIARY_
     1 __________CROP_________]'/
     2 '           TIMBER      SMALLWOOD        TIMBER
     2  SMALLWOOD'/
     3 '       M3     RSPM3      M3     RSPM3     M3     RSPM3
     3 M3      RSPM3'/
     3 '           (DOMESTIC)        (DOMESTIC)       (DOMESTIC)
     3       (DOMESTIC)'/
     4 '_______________________________________________________________'$)
      DO 250 IC= 1,NYT
      WRITE(OUTDEV1,*)' NO OF ROWS= ',N(IC)
C
```

```
      DO 250 I=1,N(IC)
      J= FYEAR(YTAGE(IC,I))
      WRITE(OUTDEV1,1020) YTAGE(IC,I),
    1 MTM(IC,J), MTMPd(IC,J),
    1 MSW(IC,J), MSWPd(IC,J),
    2 THTM(IC,J), THTMPd(IC,J),
    3 THSW(IC,J), THSWPd(IC,J)
 250     CONTINUE
 1020     FORMAT(1X,I3,1X,8(F8.2,1X))
      WRITE(OUTDEV1,*)' ____________________________________________
    1 '
 252  CONTINUE
      WRITE(5,1021)
 1021 FORMAT(1X,'DISPLAY YLD TAB DATA-Y ELSE RETURN '$)
      READ(5,1022,ERR=750)YNOPT
 1022 FORMAT(A1)
      IF(YNOPT.NE.'Y') GOTO 260
      WRITE(5,1019) TOUT1, TIN1, TMSFACT, SWSFACT,
    1                     TMPFACT,SWPFACT, NYT
      DO 257 IC= 1,NYT
      WRITE(5,*) 'NO OF ROWS= ',N(IC)
      DO 257 I=1,N(IC)
      J= FYEAR(YTAGE(IC,I))
      WRITE(5,1020) YTAGE(IC,I),
    1 MTM(IC,J), MTMPd(IC,J),
    1 MSW(IC,J), MSWPd(IC,J),
    2 THTM(IC,J), THTMPd(IC,J),
    3 THSW(IC,J), THSWPd(IC,J)
 257  CONTINUE
      WRITE(5,*) ' ____________________________________________
    1 '
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
 260  CONTINUE
      IF (OUTOPT.NE.'Y') GOTO 302
      WRITE(5,2023)
 2023 FORMAT(' PRINT CASH FLOW DATA IN OUTFILE - Y, ELSE RET? '$)
      READ(5,1022,ERR=750) YNOPT
      IF(YNOPT.NE.'Y') GO TO 302
C     NOW DISPLAYING CSH FLOW DATA USED
      WRITE(OUTDEV1,1023) TIN2, NCSH
 1023 FORMAT('  _______________________________'/
    1     ' CASH FLOW DATA USED: FILE ',A30/
    1     ' NO OF TABLES= ',I3/
    1     ' CASH FLOWS IN DOMESTIC VALUES: '/
    1     ' AGE  CSHIN   WAGE EXP  NONWAGE EXP TOTAL CSHUT'/)
      DO 300 IC= 1, NCSH
      WRITE(OUTDEV1,*) 'NO OF ROWS= ',M(IC)
      DO 300 I=1,M(IC)
      J=FYEAR(CSHAGE(IC,I))
      WRITE(OUTDEV1,1024)
    1 CSHAGE(IC,I),CSHINd(IC,J),
    1 WUTd(IC,J),NWUTd(IC,J),
    1 CSHUTd(IC,J)
 300  CONTINUE
 1024  FORMAT (1X,I3,1X,F8.2,1X,F8.2,1X,F12.2,1X,F12.2)
      WRITE(OUTDEV1,*)' _____________________________'
 302  WRITE(5,1025)
 1025 FORMAT(1X,'DISPLAY CASH FLOW DATA-Y ELSE RET ? '$)
      READ(5,1022,ERR=750)YNOPT
      IF(YNOPT.NE.'Y') GOTO 310
      WRITE(5,1023) TIN2, NCSH
      DO 305 IC= 1, NCSH
      WRITE(5,*)' NO OF ROWS= ',M(IC)
      DO 305 I= 1, M(IC)
      J= FYEAR(CSHAGE(IC,I))
      WRITE(5,1024)
    1 CSHAGE(IC,I),CSHINd(IC,J),
    1 WUTd(IC,J), NWUTd(IC,J),
    1 CSHUTd(IC,J)
 305  CONTINUE
      WRITE(5,*)' _____________________________'
 310  CONTINUE
```

```
      WRITE(5,*) ' DISPLAY OUTPUT - Y, ELSE RETURN '
      READ(5,1022) TTYOPT
 350  CONTINUE
C     NOW CONVERTING DOMESTIC EXTRACTION UNIT COSTS TO BORDER VALUES
C        A) EXTRACTION WAGE COSTS/UNIT VOLUME:
      MTMXW= MTMXWd * ARXW
      MSWXW= MSWXWd * ARXW
      THTMXW= THTMXWd * ARXW
      THSWXW= THSWXWd * ARXW
C     NOW SETTING EXTRACTION TRANSPORT COSTS LIMITS, DOMESTIC PRICES
      MTMXTd= MTMXTZ-MTMXTI
      THTMXTd= THTMXTZ-THTMXTI
      MSWXTd= MSWXTZ-MSWXTI
      THSWXTd= THSWXTZ-THSWXTI
 360  CONTINUE
C        IF(MTMXTd.GE.MTMXTL) MTMXTd=MTMXTL
              IF(MTMXTd.LT.MTMXTL) MTMXTd= MTMXTd+MTMXTI
C        IF(THTMXTd.GE.THTMXTL) THTMXTd= THTMXTL
              IF(THTMXTd.LT.THTMXTL) THTMXTd= THTMXTd+THTMXTI
C        IF(MSWXTd.GE.MSWXTL) MSWXTd= MSWXTL
              IF(MSWXTd.LT.MSWXTL) MSWXTd= MSWXTd+MSWXTI
C        IF(THSWXTd.EQ.THSWXTL) THSWXTd= THSWXTL
              IF(THSWXTd.LT.THSWXTL) THSWXTd= THSWXTd+THSWXTI
 395  CONTINUE
C     NOW CONVERTING DOMESTIC EXTRACTION UNIT COSTS TO BORDER VALUES
C        B) EXTRACTION TRANSPORT COSTS/UNIT VOL:
      MTMXT= MTMXTd*ARXT
      MSWXT= MSWXTd*ARXT
      THTMXT= THTMXTd*ARXT
      THSWXT= THSWXTd*ARXT
C     NOW CALCULATING TOTAL EXTR COST PER UNIT, domestic VALUES
      MTMXPd= MTMXWd+MTMXTd
      MSWXPd= MSWXWd+MSWXTd
      THTMXPd= THTMXWd+THTMXTd
      THSWXPd= THSWXWd+THSWXTd
C     NOW CALCULATING TOTAL EXTRACT COST PER UNIT, BORDER VALUES
      MTMXP= MTMXW+MTMXT
      MSWXP= MSWXW+MSWXT
      THTMXP= THTMXW+THTMXT
      THSWXP= THSWXW+THSWXT
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C     NOW DISPLAYING RESULTS
      WRITE(OUTDEV1,1027)
      WRITE(5,1027)
 1027 FORMAT
     1 ('1','____________________________________________________________
     1 _____________________________________________________'/
     1        ' DISCR  ---ROT---   MAIN CROP   THINCROP    OTHER INFLO
     1  TOT INFLO TOT OUTFLO     NDR        SOIL EXP'/
     2       '                   DISCOUNTED    (BORDER)
     2    VALUES '/
     3 '
     3  ___________________________________________________________
     3 _____________________________________________________')
      WRITE(OUTDEV1,1028) MTMXWd, MTMXTd, MTMXPd,
     1                    THTMXWd, THTMXTd, THTMXPd,
     2                    MSWXWd, MSWXTd, MSWXPd,
     3                    THSWXWd, THSWXTd, THSWXPd,
     4                    ARXW, ARXT,
     5                    MTMXW, MTMXT, MTMXP,
     6                    THTMXW, THTMXT, THTMXP,
     7                    MSWXW, MSWXT, MSWXP,
     8                    THSWXW, THSWXT, THSWXP
      WRITE(5, 1028) MTMXWd, MTMXTd, MTMXPd,
     1                    THTMXWd, THTMXTd, THTMXPd,
     2                    MSWXWd, MSWXTd, MSWXPd,
     3                    THSWXWd, THSWXTd, THSWXPd,
     4                    ARXW, ARXT,
     5                    MTMXW, MTMXT, MTMXP,
     6                    THTMXW, THTMXT, THTMXP,
     7                    MSWXW, MSWXT, MSWXP,
     8                    THSWXW, THSWXT, THSWXP
C
```

```
 1028   FORMAT(1X,'___________________________________________'/
     1         ' UNIT EXTRACTION COSTS: DOMESTIC VALUES '/
     1         '                  WAGES    TRANSPORT TOTAL'/
     1         '       TIMBER MAIN ',F8.2,3X,F8.2,1X,F8.2/
     1         '      "    THIN ',F8.2,3X,F8.2,1X,F8.2/
     1         '       SMALLW MAIN ',F8.2,3X,F8.2,1X,F8.2/
     1         '      "    THIN ',F8.2,3X,F8.2,1X,F8.2/
     2         ' ACCOUNTING RATIOS:      '/
     2         '       ARXW= ',F8.3,' ARXT= ',F8.3/
     3         ' UNIT EXTRACTION COSTS: BORDER VALUES '/
     3         '                  WAGES    TRANSPORT TOTAL'/
     3         '       TIMBER MAIN ',F8.2,3X,F8.2,1X,F8.2/
     3         '      "    THIN ',F8.2,3X,F8.2,1X,F8.2/
     3         '       SMALLW MAIN ',F8.2,3X,F8.2,1X,F8.2/
     3         '      "    THIN ',F8.2,3X,F8.2,1X,F8.2/
     3         '______________________________________')
        WRITE(OUTDEV1,1026) MTMPr,THTMPr,MSWPr,THSWPr,
     1                XWr, XTr, Wr,
     2                TMSFACT, SWSFACT,
     2                TMPFACT,SWPFACT,
     3                ARTM, ARSW, ARXW, ARXT, ARW,ARNW
C  C C C C C C C  C C C C C C C C C C C C  CC C C  C C C C C C
        WRITE (5,1026) MTMPr,THTMPr,MSWPr,THSWPr,
     1                XWr, XTr, Wr,
     2                TMSFACT, SWSFACT,
     2                TMPFACT,SWPFACT,
     3                ARTM, ARSW, ARXW, ARXT, ARW,ARNW
 1026  FORMAT('_________________________________________'/
     1 ' INFLATION RATES:'/
     1 '   DEPOT PRICES: TIMBER MAIN ',F7.3,' THIN ',F7.3/
     2 '            SMALLW MAIN ',F7.3,' THIN ',F7.3/
     3 '   EXTR UNIT COSTS: WAGES XWr 'F7.3'TRANSP XTr ',F7.3/
     4 '   GENERAL WAGES Wr ',F7.3/
     5 '_______________________________________________'/
     6 ' SCALING FACT: TMSFACT ' F7.3 ' SMSFACT ' F7.3/
     6 ' MULT FACT: TIMB PRICE ',F7.3,' SMALLW PRICE ',F7.3/
     7 '_______________________________________________'/
     8 ' ACCOUNTING RATIOS: '/
     9 '   TIMBER ARTM= 'F7.3' SMALLWOOD ARSW= 'F7.3/
     1 '   EXTR WAGES ARXW= 'F7.3' TRANSPORT ARXT= 'F7.3/
     2 '   GENERAL WAGES ARW= 'F7.3' NONWAGE EXP ARNW= 'F7.3/
     3 ' -----------------------------------------------')
C       NOW SETTING DISCOUNT RATE
        DISC=DISCZ-DISCI
 400    DISC=DISC+DISCI
        WRITE(5,*) ' '
        WRITE(OUTDEV1,*) ' '
C       NOW SETTING ROTATION PERIOD
        DO 410 IC=1, NCROPS
        ROTN(IC)= ROTNZ(IC)- ROTNI(IC)
 410    CONTINUE
 415    CONTINUE
        DTTHTMV=0.
        DTTHTMXW=0.
        DTTHTMXT=0.
        DTTHTMX=0.
        DTTHSWV=0.
        DTTHSWXW=0.
        DTTHSWXT=0.
        DTTHSWX=0.
        DTTHIN=0.
        DMTMV= 0.
        DMTMXW= 0.
        DMTMXT= 0.
        DMSWV= 0.
        DMSWXW= 0.
        DMSWXT= 0.
        DTCSHINV=0.
        DTWUTV=0.
        DTNWUTV=0.
        DTCSHUTV=0.
        DTHTMVSe= 0.
```

```
      DTHTMWSe= 0.
      DTHTMTSe= 0.
      DTHSWVSe= 0.
      DTHSWWSe= 0.
      DTHSWTSe= 0.
      DMTMVSe= 0.
      DMTMXWSe= 0.
      DMTMXTSe= 0.
      DMSWVSe= 0.
      DMSWXWSe= 0.
      DMSWXTSe= 0.
      DCSHINSe= 0.
      DWUTSe= 0.
      DNWUTSe= 0.
 450  CONTINUE
C     NOW CALCULATING PER ACRE/HECTARE VALUES
      L= -1
      DO 540 IC= 1,NCROPS
      ROTN(IC)= ROTN(IC)+ ROTNI(IC)
      YROTN= FYEAR(ROTN(IC))
      DO 500 K= 1, FYEAR(ROTN(IC))
       L= L+ 1
        DF= (1.+DISC)**L
         DTTHTMV= DTTHTMV+ THTM(IC,K)*THTMP(IC,K)*(1.+THTMPr)**L/DF
         DTTHTMXW= DTTHTMXW+ THTM(IC,K)*THTMXW*(1.+XWr)**L/DF
         DTTHTMXT= DTTHTMXT+ THTM(IC,K)*THTMXT*(1.+XTr)**L/DF
         DTTHSWV= DTTHSWV+ THSW(IC,K)*THSWP(IC,K)*(1.+THSWPr)**L/DF
         DTTHSWXW= DTTHSWXW+ THSW(IC,K)*THSWXW*(1.+XWr)**L/DF
         DTTHSWXT= DTTHSWXT+ THSW(IC,K)*THSWXT*(1.+XTr)**L/DF
         DTCSHINV= DTCSHINV+ CSHIN(IC,K)*(1.+CSHr)**L/DF
         DTWUTV= DTWUTV+ WUT(IC,K)*(1.+Wr)**L/DF
         DTNWUTV= DTNWUTV+ NWUT(IC,K)*(1.+NWUTdr)**L/DF
 500  CONTINUE
C     NOW COMPUTING FINAL YIELD CSH INFLO
      DMTMV= DMTMV+ MTM(IC,YROTN)*MTMP(IC,YROTN)*(1.+MTMPr)**L/DF
      DMTMXW= DMTMXW+ MTM(IC,YROTN)*MTMXW*(1.+XWr)**L/DF
      DMTMXT= DMTMXT+ MTM(IC,YROTN)*MTMXT*(1.+XTr)**L/DF
      DMSWV= DMSWV+ MSW(IC,YROTN)*MSWP(IC,YROTN)*(1.+MSWPr)**L/DF
      DMSWXW= DMSWXW+ MSW(IC,YROTN)*MSWXW*(1.+XWr)**L/DF
      DMSWXT= DMSWXT+ MSW(IC,YROTN)*MSWXT*(1.+XTr)**L/DF
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
 530  L= L-1
 540  CONTINUE
C     NOW CUMULATED TOTALS
         DTTHTMX= DTTHTMXW+ DTTHTMXT
         DTTHSWX= DTTHSWXW+ DTTHSWXT
         DTTHIN= DTTHTMV-DTTHTMX+ DTTHSWV-DTTHSWX
         DTCSHUTV= DTWUTV + DTNWUTV
         DMTMX= DMTMXW+ DMTMXT
         DMSWX= DMSWXW+ DMSWXT
         DMIN= DMTMV- DMTMX+ DMSWV- DMSWX
C     NOW THE TOTAL DISCOUNTED INFLO
      DTCRPIN= DTTHIN+ DMIN
      DTIN= DTCRPIN+ DTCSHINV
C     NOW THE TOTAL DISCOUNTED NET FLOW
C     EQUAL TO NET DISCOUNTED VALUE
      DNET= DTIN- DTCSHUTV
C     NOW CHECKING THE DISCOUNT RATE
C     IF DISC GREATER THAN 0, PROCEED TO SOIL EXPECTATIONS
      IF (DISC.GT.0.) GOTO 545
      IF (OUTOPT.EQ.'Y') THEN
      WRITE(OUTDEV1,2029) DISC,(ROTN(IC),IC=1,NCROPS),DMIN,DTTHIN,
     1    DTCSHINV, DTIN, DTCSHUTV, DNET
 2029 FORMAT(1X, F5.4,1X, <NCROPS>I3,1X, F12.2,1X,
     1        F10.2,1X, F10.2,1X, F12.2,1X, F10.2,1X, F12.2)
      ENDIF
      IF(TTYOPT.EQ.'Y') THEN
        WRITE(5,2029) DISC, (ROTN(IC),IC=1,NCROPS), DMIN, DTTHIN,
     1    DTCSHINV, DTIN, DTCSHUTV, DNET
      ENDIF
      IF (PLTOPT.EQ.'Y') THEN
        WRITE(OUTDEV2,4029) DISC, (ROTN(IC),IC=1,NCROPS),DNET
```

```
 4029   FORMAT(1X,F5.4,1X,<NCROPS>I3,1X,F12.2)
        ENDIF
        GO TO 565
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
 545    CONTINUE
C       NOW SOIL EXP VALUE
        L= L+1
        DF= (1.+DISC)**L
C       NOW THINNING YIELDS
        DTHTMVSe= DTTHTMV/(1.-((1.+THTMPr)**L)/DF)
        DTHTMWSe= DTTHTMXW/(1.-((1.+XWr)**L)/DF)
        DTHTMTSe= DTTHTMXT/(1.-((1.+XTr)**L)/DF)
        DTHSWVSe= DTTHSWV/(1.-((1.+THSWPr)**L)/DF)
        DTHSWWSe= DTTHSWXW/(1.-((1.+XWr)**L)/DF)
        DTHSWTSe= DTTHSWXT/(1.-((1.+XTr)**L)/DF)
C       NOW MAIN CROP
        DMTMVSe= DMTMV/(1.-((1.+MTMPr)**L)/DF)
        DMTMXWSe= DMTMXW/(1.-((1.+XWr)**L)/DF)
        DMTMXTSe= DMTMXT/(1.-((1.+XTr)**L)/DF)

        DMSWVSe= DMSWV/(1.-((1.+MSWPr)**L)/DF)
        DMSWXWSe= DMSWXW/(1.-((1.+XWr)**L)/DF)
        DMSWXTSe= DMSWXT/(1.-((1.+XTr)**L)/DF)

C       NOW CASH FLOWS
        DCSHINSe= DTCSHINV/(1.-((1.+CSHr)**L)/DF)
        DWUTSe= DTWUTV/(1.-((1.+WUTr)**L)/DF)
        DNWUTSe= DTNWUTV/(1.-((1.+NWUTdr)**L)/DF)
C       NOW AGGREGATED TOTALS
        DTHTMXSe= DTHTMWSe + DTHTMTSe
        DTHSWXSe= DTHSWWSe + DTHSWTSe
        DTHINSe= DTHTMVSe- DTHTMXSe+ DTHSWVSe- DTHSWXSe
        DMTMXSe= DMTMXWSe+ DMTMXTSe
        DMSWXSe= DMSWXWSe + DMSWXTSe
        DMINSe= DMTMVSe - DMTMXSe
     1  + DMSWVSe - DMSWXSe
        DCRPINSe= DTHINSe + DMINSe
        DCSHUTSe= DWUTSe + DNWUTSe
        DNETSe= DCRPINSe+ DCSHINSe- DCSHUTSe
C       DNETSe IS THE SOIL EXPECTATION VALUE FOR ROTN(IC), IC=1 TO NCROPS
 550    CONTINUE
        IF (PLTOPT.EQ.'Y') THEN
        WRITE(OUTDEV2,3029) DISC, (ROTN(IC),IC=1,NCROPS), DNET, DNETSe
 3029   FORMAT(1X,F5.4,1X,<NCROPS>I3,1X,2F12.2)
        ENDIF
 560    CONTINUE
        IF (OUTOPT.EQ.'Y') THEN
        WRITE(OUTDEV1,1029) DISC,(ROTN(IC),IC=1,NCROPS), DMIN, DTTHIN,
     1     DTCSHINV, DTIN, DTCSHUTV, DNET, DNETSe
 1029    FORMAT(1X,F5.4,1X,<NCROPS>I3,1X,F12.2,
     1      2F10.2,F12.2,F10.2,2F12.2)
        ENDIF
        IF (TTYOPT.EQ.'Y') THEN
        WRITE(5,1029) DISC,(ROTN(IC),IC=1,NCROPS), DMIN, DTTHIN,
     1      DTCSHINV, DTIN, DTCSHUTV, DNET, DNETSe
        ENDIF
 565    CONTINUE
C       NOW REPEAT FOR NEXT VALUE OF ROTATION PERIOD
C       TEST WHETHER ANY ROTN(IC) LESS THAN ITS MAX ROTNL(IC)
        ITEST= 1
        DO 570 IC=1,NCROPS
        IF (ROTN(IC).LT.ROTNL(IC)) ITEST= 0
 570    CONTINUE
C       IF ITEST IS 0, GO BACK TO START OF LOOP, ELSE FORWARD
        IF (ITEST)  415, 415, 650
 650   CONTINUE
C       NOW REPEAT FOR NEXT DISCOUNT RATE
        IF(DISCL-DISC)700,700,400
 700   CONTINUE
        WRITE(OUTDEV1,2033)
        WRITE(5,2033)
 2033   FORMAT(' ________________________________________')
```

```
C       NOW REPEAT FOR NEXT EXTRACTION TRANSPORT COSTS PER UNIT
        IF((MTMXTd.GE.MTMXTL).AND.(THTMXTd.GE.THTMXTL)
     1  .AND.(MSWXTd.GE.MSWXTL).AND.(THSWXTd.GE.THSWXTL))GOTO 750
        GO TO 360
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
 750    CONTINUE
C       NOW REVERSE ONE-TIME SCALING OF OUTPUT QUANTITIES
        WRITE(5,*) ' NOW REVERSING ONE-TIME SCALING OF OUTPUTS: '
        DO 780 IC=1, NCROPS
         DO 780 I= 1, N(IC)
           J= FYEAR(YTAGE(IC,I))
           MTM(IC,J)= MTM(IC,J)/TMSFACT
           MSW(IC,J)= MSW(IC,J)/SWSFACT
           THTM(IC,J)= THTM(IC,J)/TMSFACT
           THSW(IC,J)= THSW(IC,J)/SWSFACT
 780      CONTINUE
C      NOW REVERSE ONE-TIME JUMP IN PRICES
        WRITE(5,*) ' NOW REVERSING ONE-TIME JUMP IN PRICES: '
        DO 800 IC= 1,NCROPS
          DO 800 I=1,N(IC)
           J= FYEAR(YTAGE(IC,I))
           MTMPd(IC,J)= MTMPd(IC,J)/TMPFACT
           MSWPd(IC,J)= MSWPd(IC,J)/SWPFACT
           THTMPd(IC,J)= THTMPd(IC,J)/TMPFACT
           THSWPd(IC,J)= THSWPd(IC,J)/SWPFACT
 800      CONTINUE
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
        WRITE(5,*) ' TO RESTART -Y, ELSE RETURN '
        READ(5,1022) ESCOPT
        IF(ESCOPT.NE.'Y') GO TO 900
        GOTO 50
 900    CONTINUE
        STOP
        END
```

APPENDIX FIVE

STANDARD CONVERSION FACTOR FOR RURAL CONSUMPTION

In Section 8.6.6, reference was made to the social cost of consumption increases of the rural workforce. The marginal increase in income is expended on a basket of commodities, so that the social cost of providing for each rupee of this increased consumption is the weighted average of all the commodities going into the marginal basket. This is explained in the present Appendix.

A5.1 Rural consumption patterns

Data on rural household consumption in Karnataka State was drawn from the National Sample Survey, 26th Round, July 1971 to June 1972 (NSSO, 1976). Out of a per capita consumption of Rs 41.04 per month of 30 days, eight major items accounted for just over 50% of the expenditure. Accounting ratios were estimated for these, and the SCF 0.86 used for the rest (Table 8.20).

A5.2 Border prices

For the border transactions, we use the trade figures pertaining to 1981-82, the latest year for which they were available (Government of India, March 1982). Some were identified as importables, and valued at the cif import prices at official exchange rates. To this are added 12% handling charges, valued at par. Transport charges for an average 1000 kilometres, from Bombay port to North Kanara, were estimated at the average rail freight rates of Rs 0.137 per tonne prevailing in 1981-82 (cf. Statistical Abstract of India, 1982), valued at par.

Other commodities were expected to be produced locally, for which inputs would need to be provided. Table 8.20 presents the calculations in a tabular form; here some explanatory notes are added on individual products.

A5.3 Accounting ratios of individual commodities

A5.3.1 Rice and its products (16.30% of expenditure)

Imports of rice have been marginal in recent years, and exports outweighed imports by a factor of 2.75 in 1981-82. Still, increased demand may be met by imports in the short run. The average cif value of all types of rice was Rs 2,262 per metric tonne (MT) in 1981-82. The prevailing domestic wholesale price (from the 'Bulletin of Food Statistics', 1981-82 and 'Agricultural Situation in India', April 1981), was Rs 2,228.30 per MT of coarse rice in the Shimoga market, to give an AR of 2670.44/2228.30 = 1.198 ≅ 1.20.

A5.3.2 Wheat (1.97% of expenditure)

This constitutes only a minor part of food consumption in South India. Calculations similar to those above gave an AR of 1.207 (the wholesale domestic price being that prevailing at the Amraoti market in neighbouring Maharashtra).

A5.3.3 Jowar (Sorghum) (11.89% of expenditure)

This is one of the major staples in the State, especially in North Karnataka which is expected to be the source of labour. This is not a traded commodity, nor expected to become one. Jowar being such an important product in the local economy, there is a considerable expertise and organisation devoted to its cultivation. The most probable response would be one of more intensive practices on the existing cropped area.

Hybrid sorghum raised in the southern high plains of Texas gave 30 kg/ha increase in grain yield per kg/ha of N added (Arnon, 1972). Within the framework of a traditional, primitive agriculture, in the semi-arid region south of the Sahara, relatively low rates of fertilizers have generally given modest but economic increase in yields, ranging from 625 to 1000 kg/ha for 12 kg/ha of N and 30 kg/ha of P. The average response of various Indian crops to fertilizer application was from over 30 times the weight of ammonium sulphate added in the case of paddy, to 1.03 times for bajra, and 2.75 times for ragi (Kumar et al., 1963).

A most pessimistic prediction would be that the addition of 1 kg/ha of fertilizer, possessing a 20% content of N, would give an increase of grain yield of at least 1.03 kg/ha. To achieve an increase in yield of 1.00 kg/ha, we would need to apply about 0.2 kg/ha of N.

The usual sources of N are ammonium sulphate (20.6%), ammonium nitrate (20.6%), and urea (45%). The average cif price, as per the trade statistics of 1981-82, worked out to Rs 2,088.64 per MT of fertilizer; the average content of N was 44.75%, reflecting the preponderance of urea in the imports. The cif cost per tonne of N works out to Rs 2,088.64/0.4475, or Rs 4,667.61 per MT of N. Adding the handling and freight charges at 12% of cif value and at Rs 137/MT as before, we arrive at the landed cost of fertilizer of Rs 2,476.28 per MT, which works out to Rs 5,533.90 per MT N.

The landed cost, in border prices, of 0.2 tonnes of nitrogen is, therefore, Rs 1,107.00, and this is the requirement per MT of grain. Some element of the additional labour costs are to be allowed for. The costs of harvesting (including cutting, threshing, winnowing, transport to the farm house) of ragi (the other important staple cereal in Karnataka) was around 41.2 man-days of labour per MT of grain (calculated from data in Government of India, 1972); the same figure is adopted for jowar as well. These are valued at the money wage rate for 1981, Rs 5.25, multiplied by the (as yet unknown) conversion factor for the SWR, b_L.

To the sum of these two -- the cost of nitrogen, and the cost of harvesting -- we add 10% toward local margins, wastage, etc., to arrive at the overall resource cost of Rs 1,217.70+ 45.32*wb_L per MT of grain. The domestic cost is taken to be the rate prevailing in the wholesale market at Hubli, very close to our study area, Rs 1,400 per MT. Thus,

$$\text{AR for jowar} = (1217.70 + 45.32*wb_L)/1400.00$$
$$= 0.8698 + 0.0324wb_L \ .$$

A5.3.4 <u>Ragi (finger millet, Eleusine coraccina) (10.58%)</u>

This is the other cereal that is extremely important locally, but which is not traded. According to Kumar et al., 1963, an addition of 150 lb/acre of ammonium sulphate (20.6% N) resulted in an increase of 412 lb/acre in yield of grain. This implies a yield of 13.33 kg of grain per kg of N added. To obtain an additional MT of grain, therefore, we need to apply 0.075 MT of N. The resource cost of this would be Rs 5,533.89*0.075 = Rs 415/MT of grain. To this we add the harvesting costs of Rs 41.2wb_L, as well as 10% for local margins, wastage, etc., to give the final figure of Rs 456.50+45.32wb_L; dividing by the local wholesale price of Rs 1,833/MT, we arrive at the AR of 0.2491+0.0247wb_L.

Thus consumption can generally be increased economically by local production. The above three cereals account for around 40% of household expenditure. The other items for which we calculate individual ARs are relatively minor compared with the remaining miscellaneous items valued at the SCF. They are discussed briefly below.

A5.3.4 <u>Pulses (3.90% of expenditure)</u>

These are treated as traded commodities, and the ARs calculated as the landed cost of imports divided by the domestic wholesale prices. The mean AR of this group, weighted by the cif value of imports of the respective species and varieties, works out to 0.86. The fact that most of the ARs are less than 1.00 points to the lower degree of control on domestic prices by the government procurement and distribution system. This is in contrast to rice and wheat, where the domestic market price was generally lower than the landed price of imports (AR >1.00).

A5.3.5 Hydrogenated oils (Vanaspati) (0.05% of expenditure)

The cif price of imports was Rs 510.01 per quintal, as against the domestic price of Rs 1,163.64 per quintal (Madras). The AR worked out to 0.503, again indicating the high domestic inflation in the prices of these items of consumption of the better-off middle classes.

A5.3.6 Other edible oils (1.99% of expenditure)

Represented by groundnut oil, the AR worked out to 0.583.

A5.3.7 Sugar (3.56% of expenditure)

The domestic wholesale price in the Madras market was Rs 6,478.30/MT, against a cif import price of Rs 3,938.45. The AR was calculated to be 0.702.

A5.3.8 **All other items (49.76% of expenditure)**

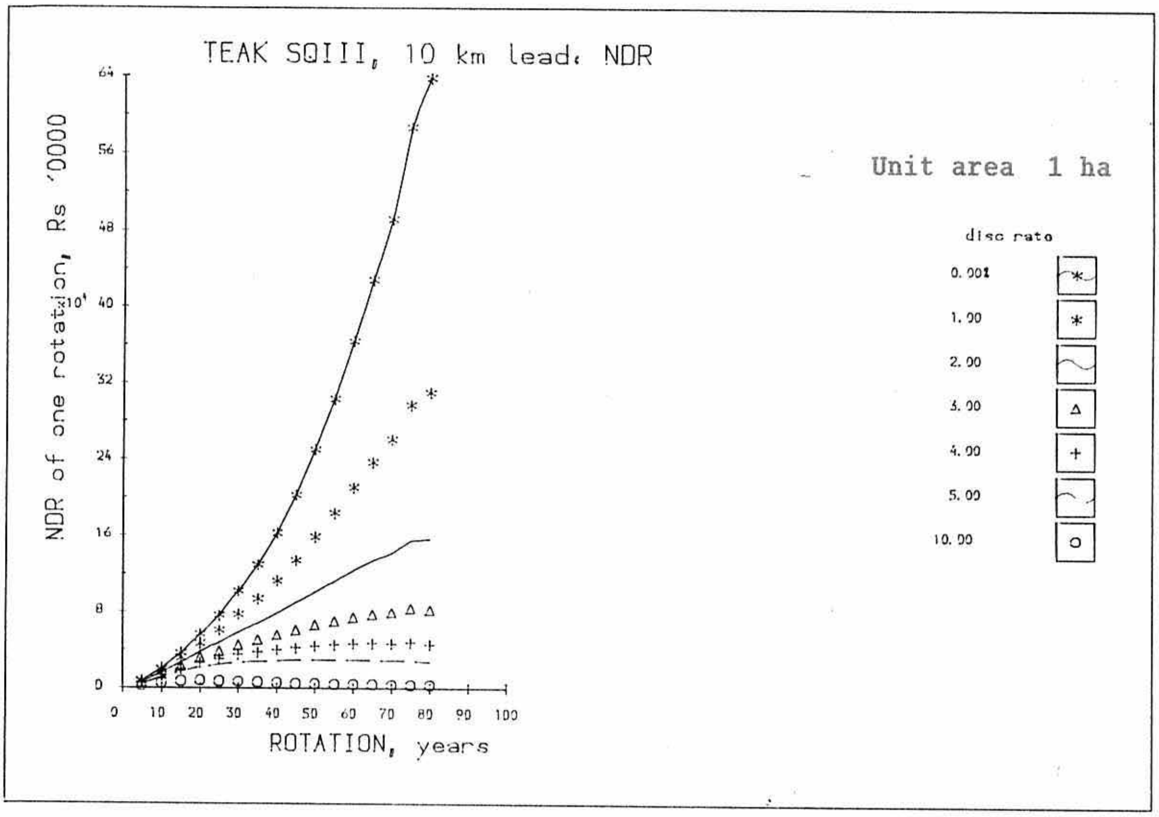
The SCF a= 0.86 was used.

A5.4 Aggregate accounting ratio for rural consumption

The weighted mean AR of all the items works out to 0.8139, plus $0.0064{*}wb_L$ for the labour content. If we choose to ignore the latter completely, the AR for all consumption goods of rural labour, the b_c we are aiming at, can be taken as 0.8139, or approximately, 0.81, only marginally different from the SCF a, 0.86.

If the labour cost is retained, a particular value is adopted for the domestic wage rate, w, =Rs 5.25 in 1981. The equation can then be solved for b_c, and subsequently for the SWR or for b_L, as the case may be (Table 8.21). This is discussed in the main text.

FIGURES



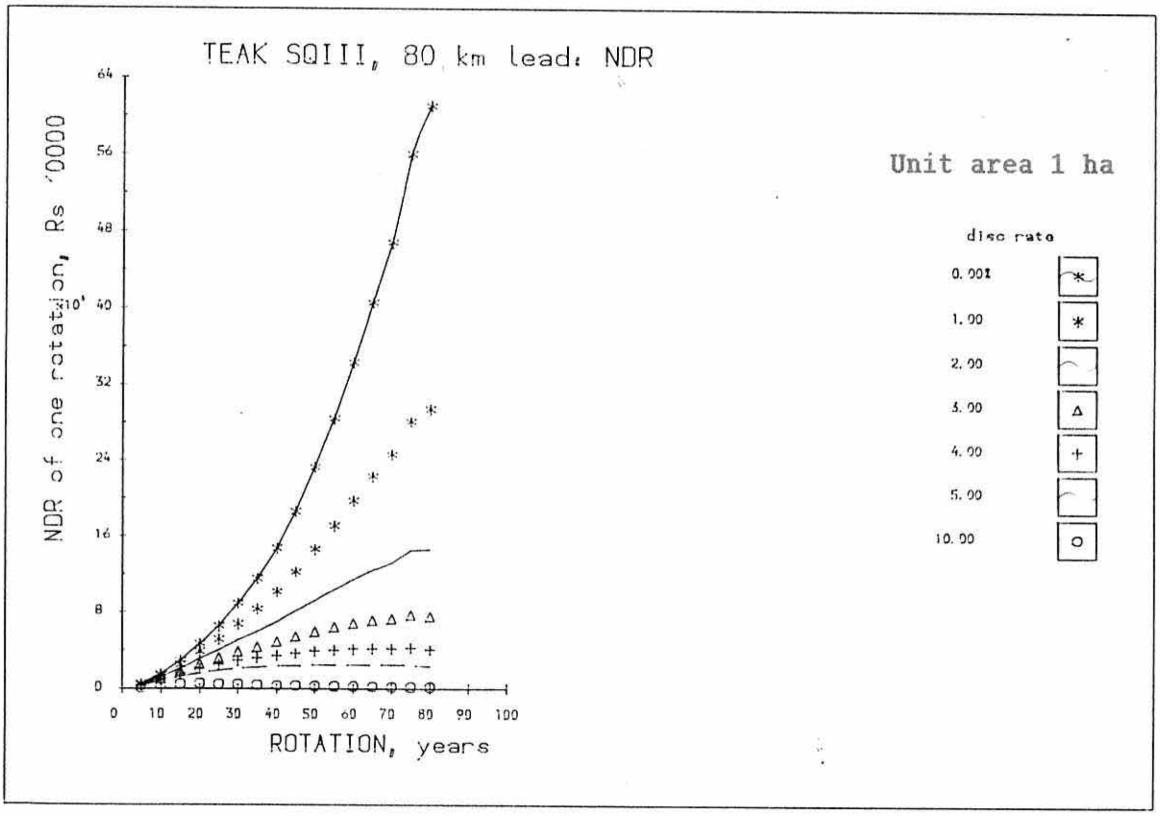
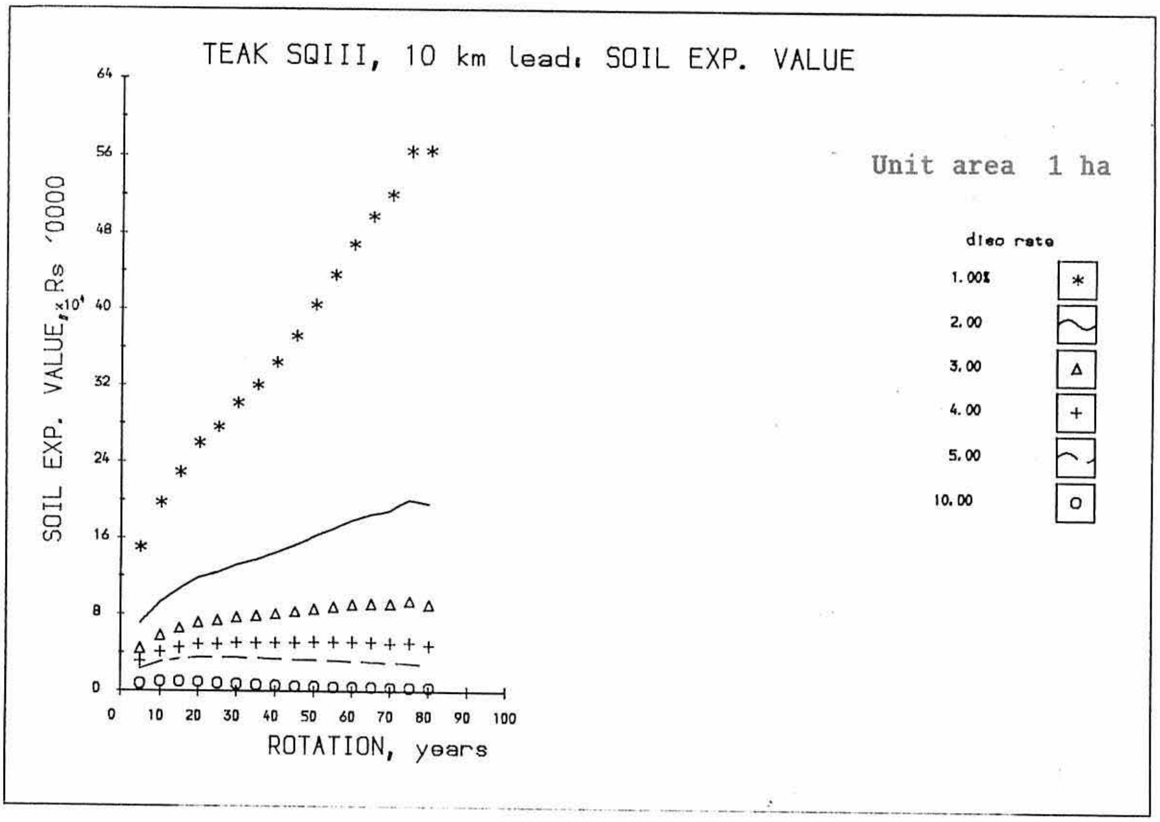


Figure 1. Teak SQIII: NDR (NPV of first rotation) under financial cost benefit analysis, at different rotation periods; discount rates 0% to 10%; lead 10 km (top), 80 km (bottom) (Table 7.21.ii).



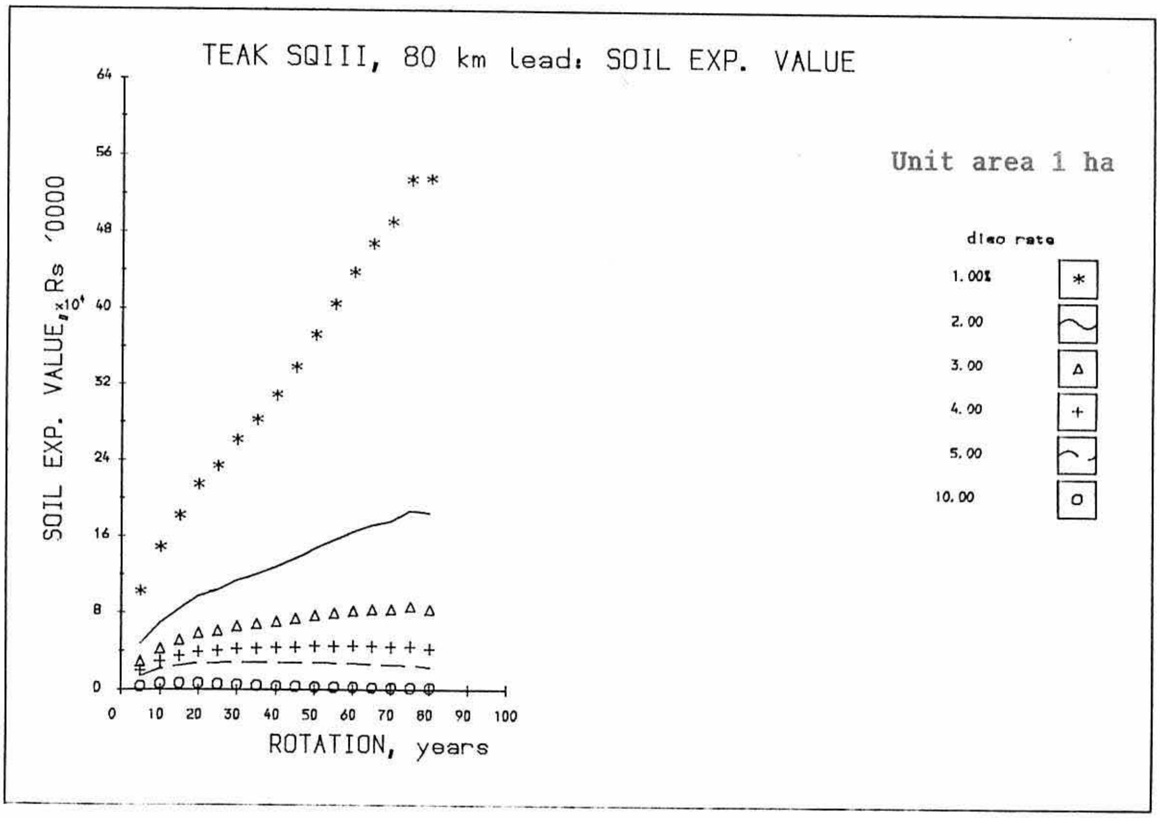
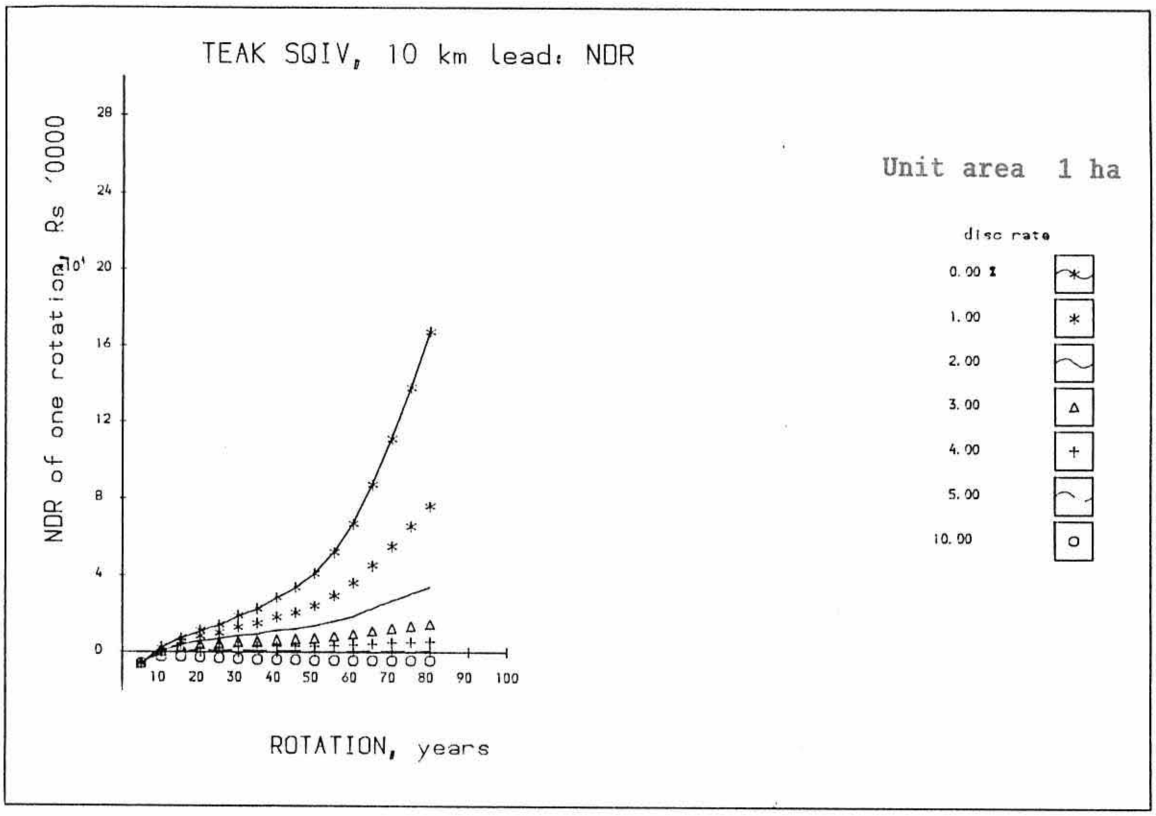


Figure 2. Teak SQIII: Soil expectation value (NPV of infinite series of rotations) under financial cost benefit analysis at different rotation periods; discount rates 1% to 10%; lead 10 km (top), 80 km (bottom) (Table 7.21.ii).



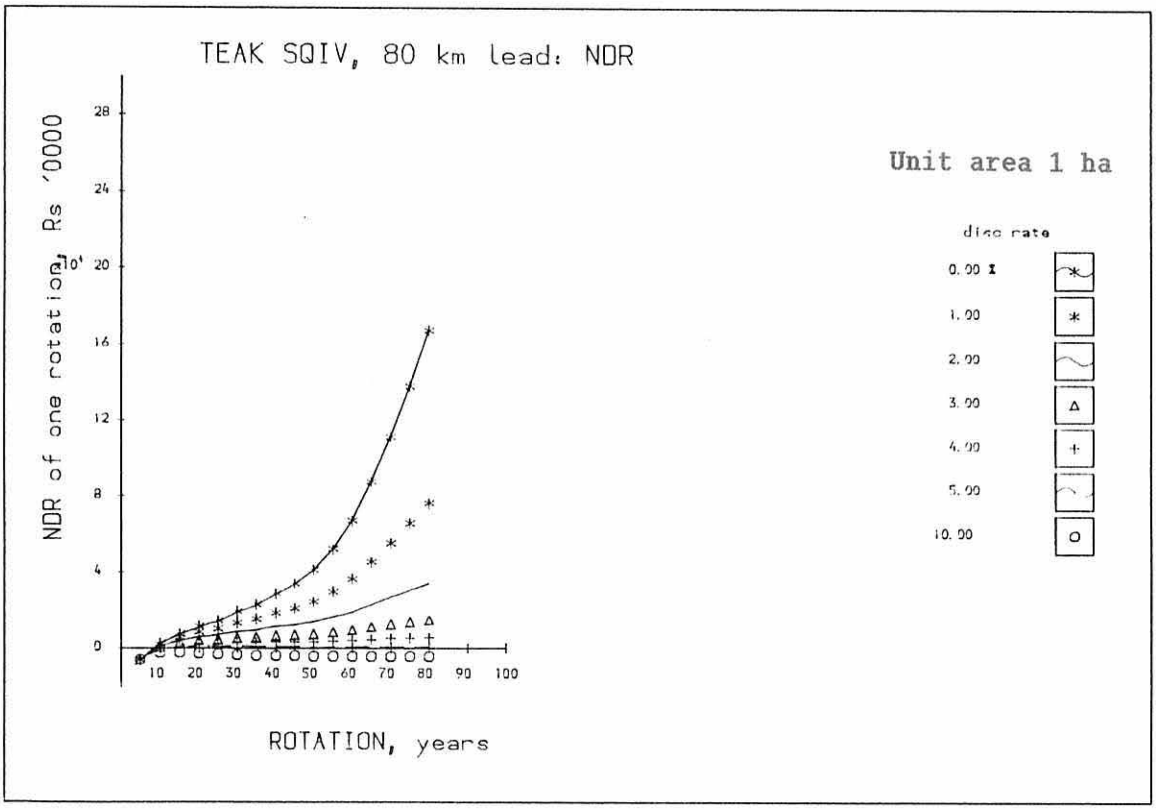
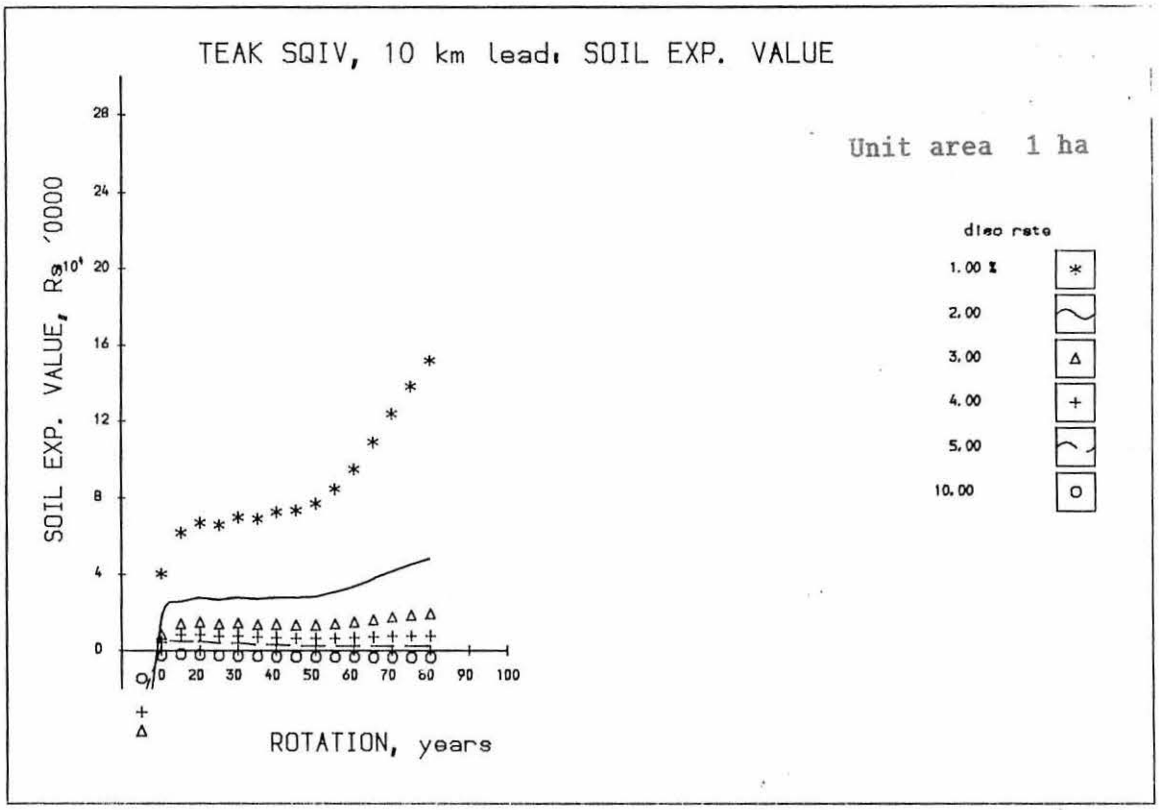


Figure 3. Teak SQIV: NDR (NPV of first rotation) under financial cost benefit analysis, at different rotation periods; discount rates 0% to 10%; lead 10 km (top), 80 km (bottom) (Table 7.22.ii).



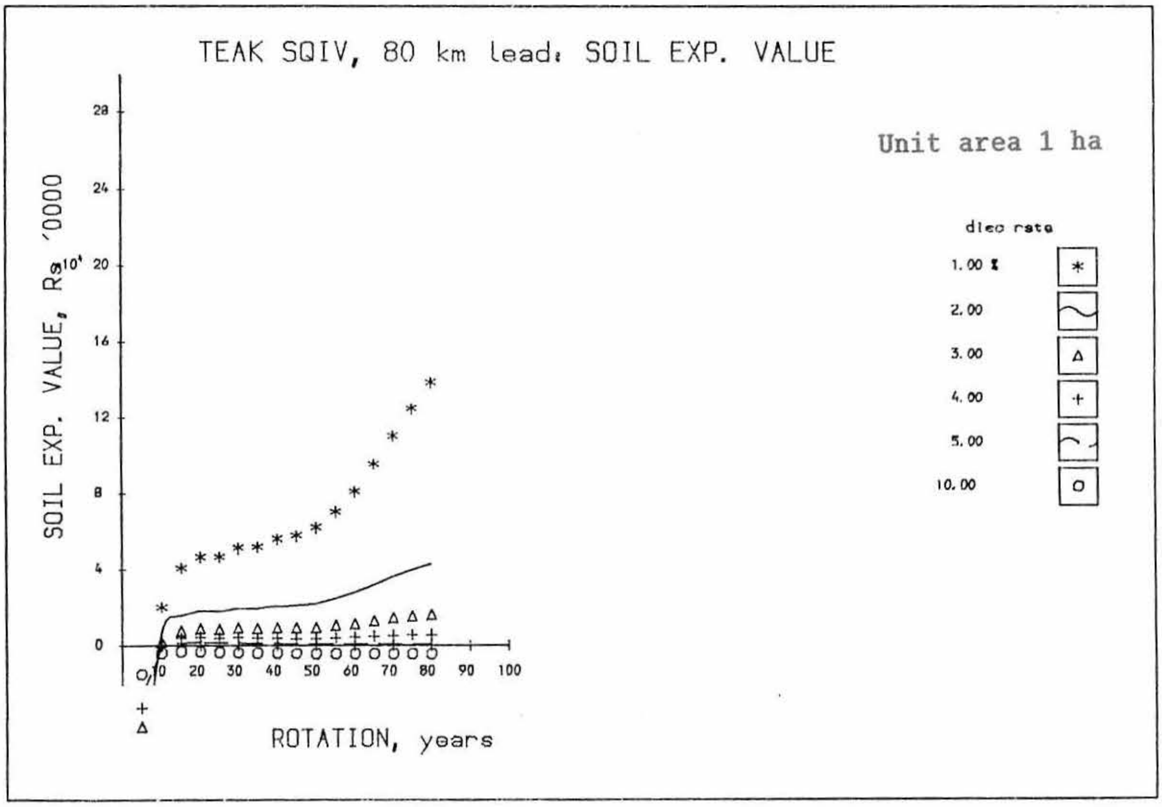


Figure 4. Teak SQIV: Soil expectation value (NPV of infinite series of rotations) under financial cost benefit analysis at different rotation periods; discount rates 1% to 10%; lead 10 km (top), 80 km (bottom) (Table 7.22.ii).

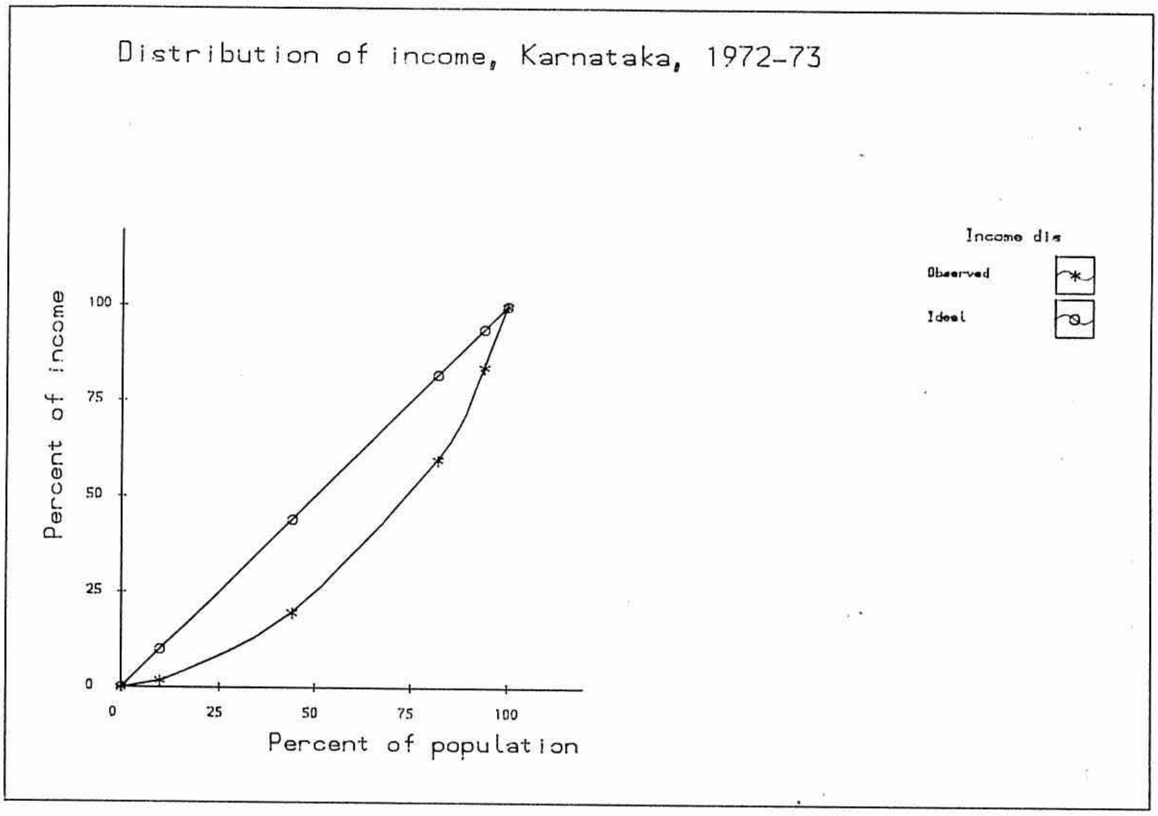
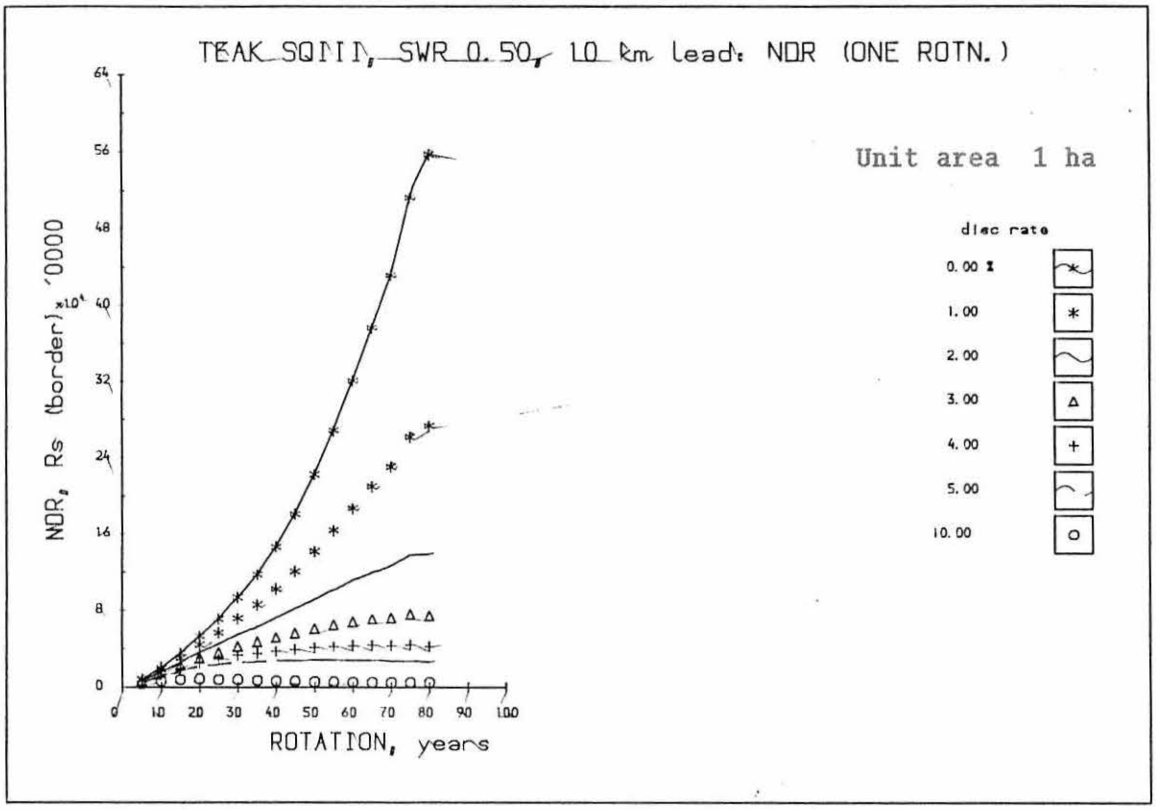


Figure 5. Income distribution in Karnataka (Table 8.14).



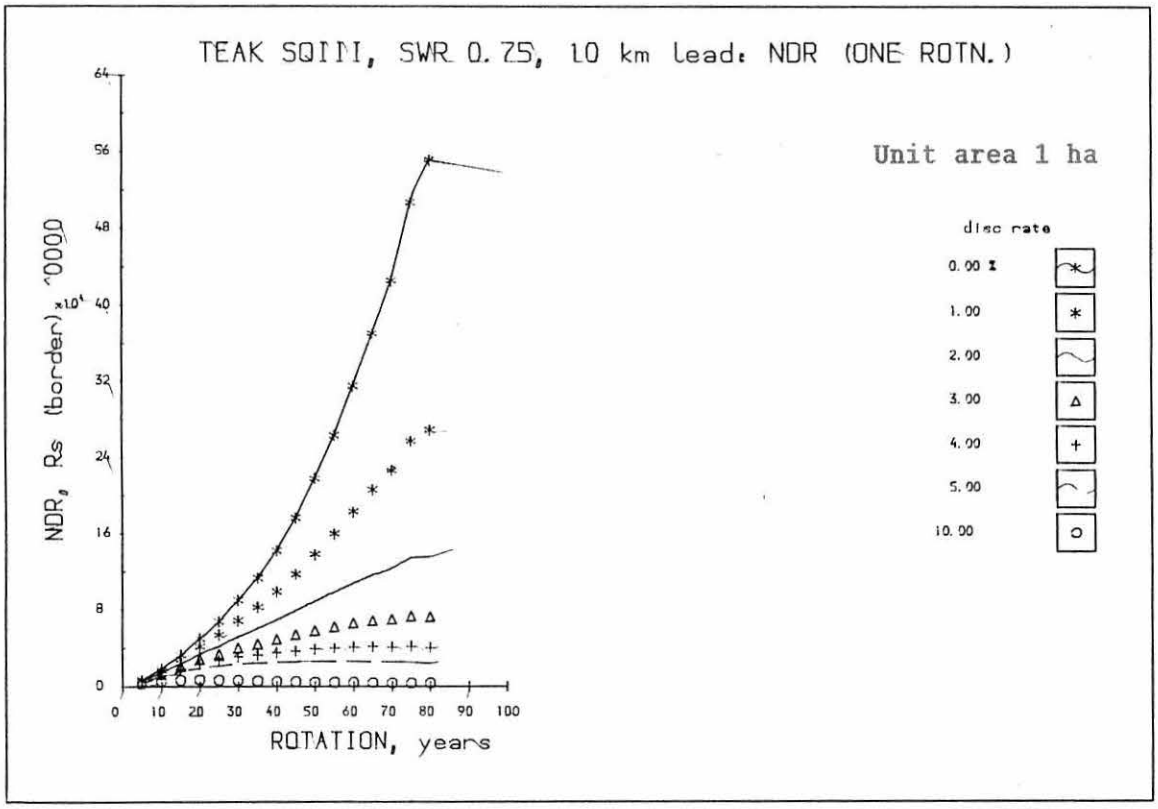
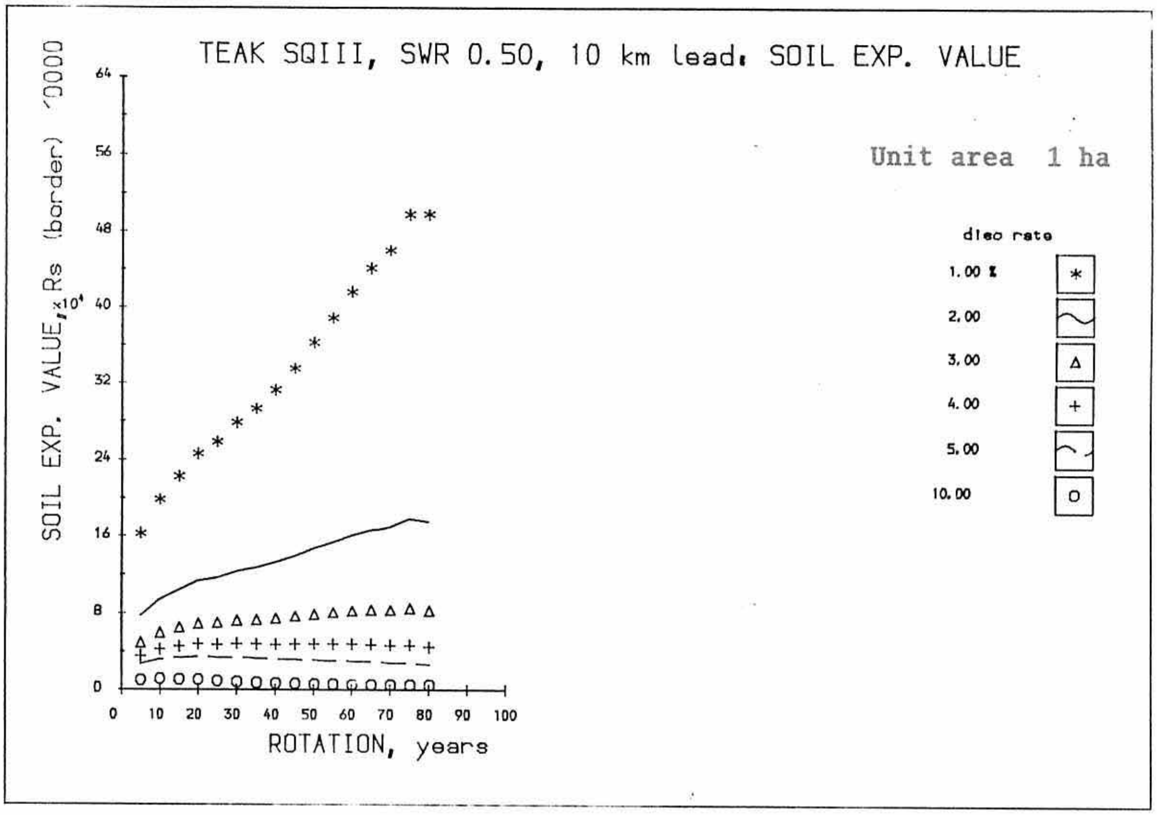


Figure 6. Teak SQIII: NDR (NPV of first rotation) under social cost benefit analysis, at different rotation periods; discount rates 0% to 10%; lead 10 km; accounting wage ratio 0.50 (top), 0.75 (bottom) (Table 9.6).



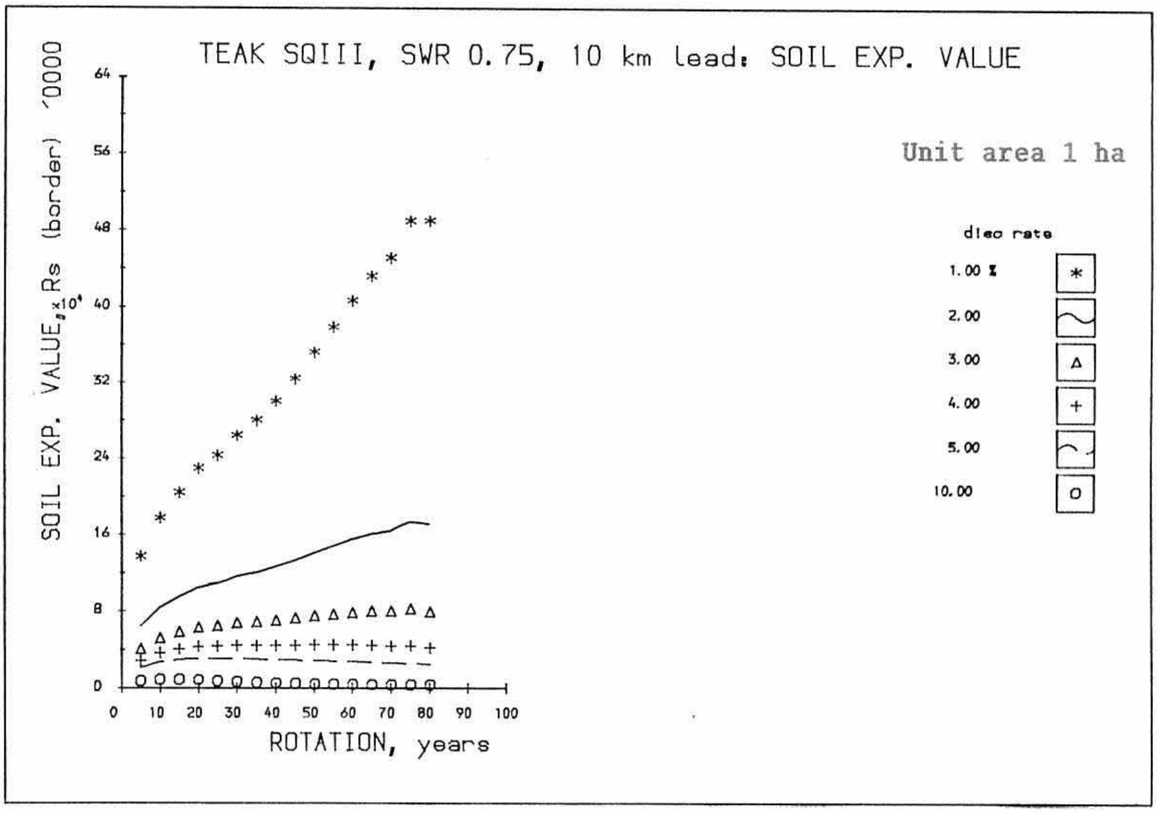
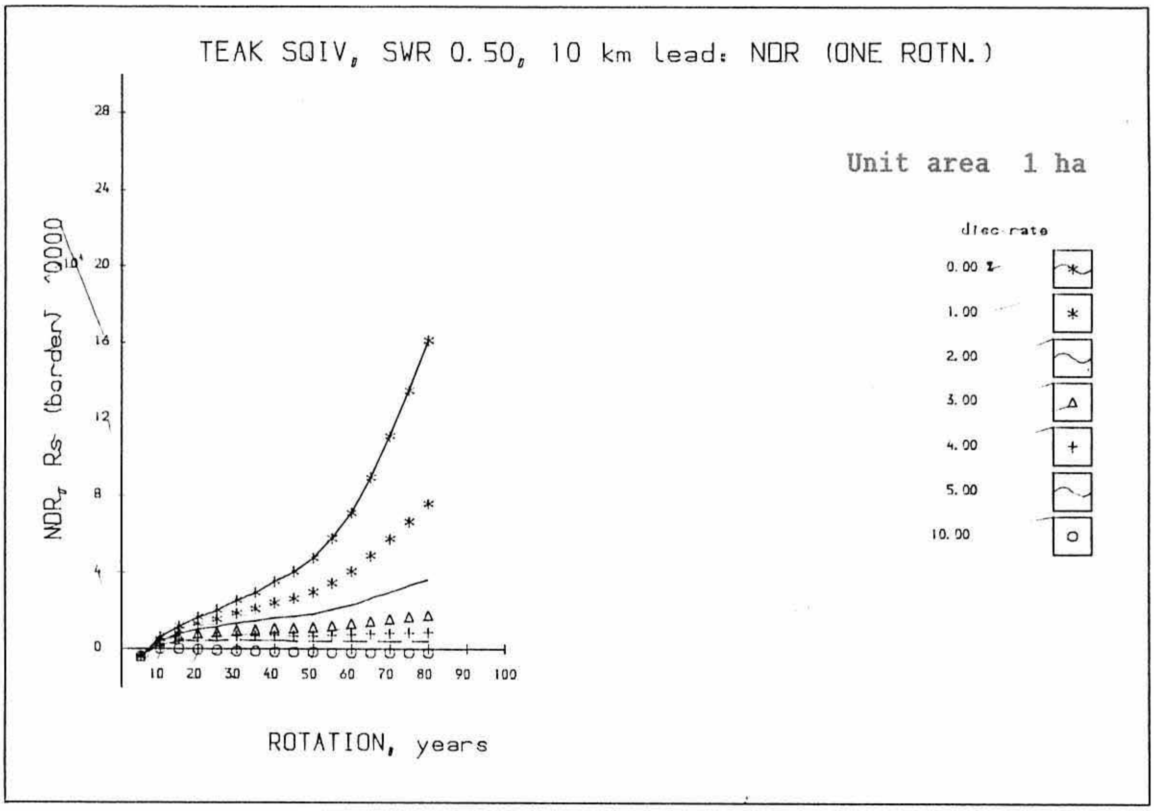


Figure 7. Teak SQIII: Soil expectation value (NPV of infinite series of rotations) under social cost benefit analysis at different rotation periods; discount rates 1% to 10%; lead 10km; accounting wage ratio 0.50 (top), 0.75 (bottom) (Table 9.6).



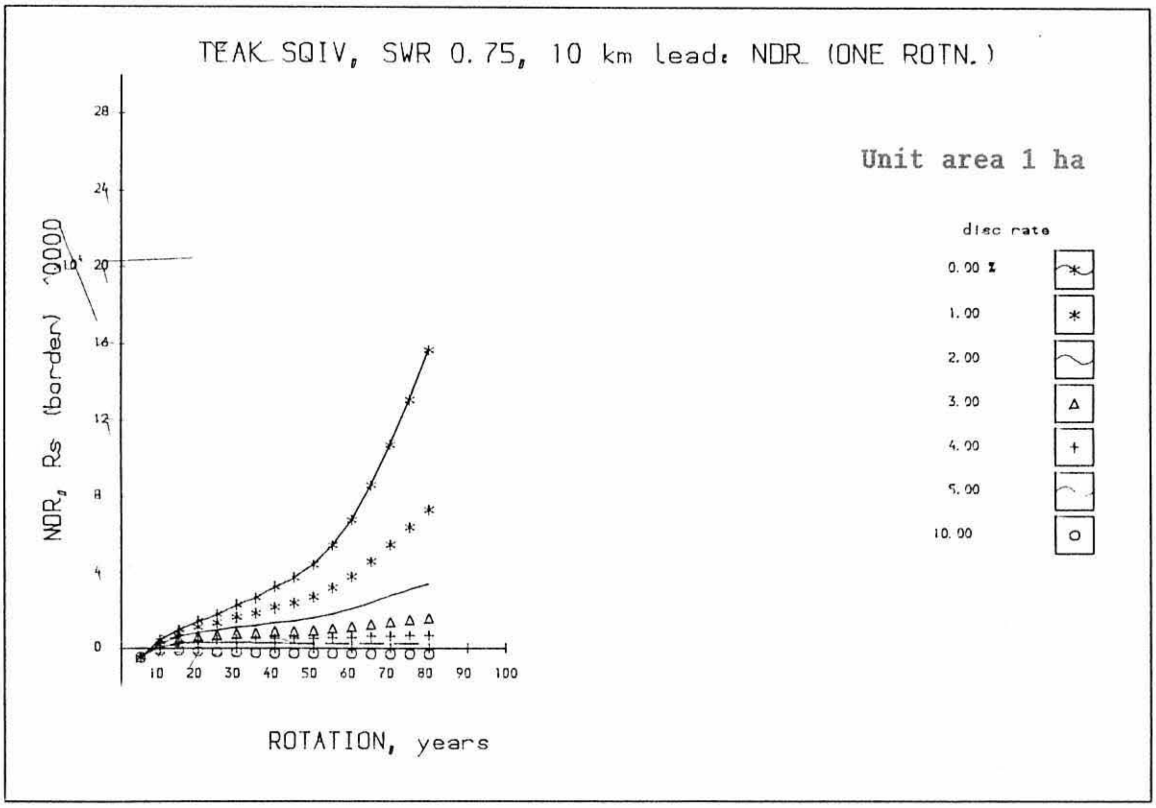
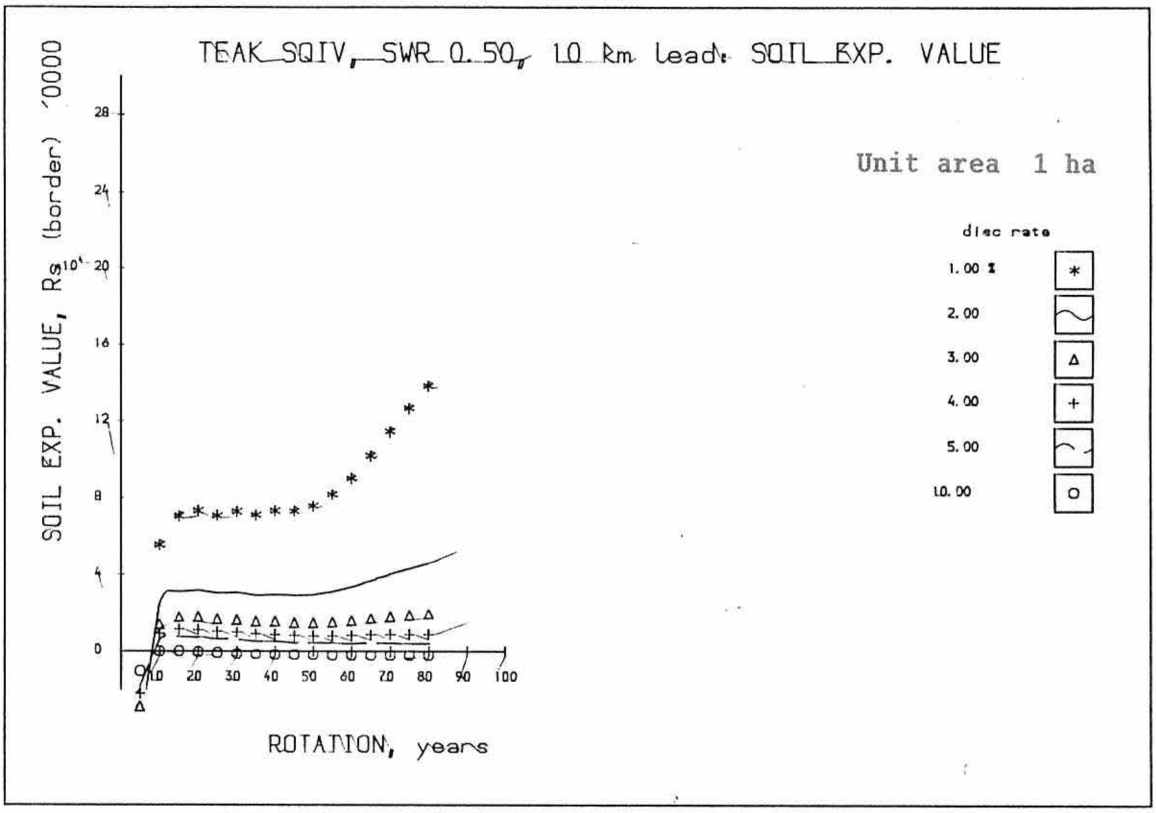


Figure 8. Teak SQIV: NDR (NPV of first rotation) under social cost benefit analysis, at different rotation periods; discount rates 0% to 10%; lead 10 km; accounting wage ratio 0.50 (top), 0.75 (bottom) (Table 9.7).



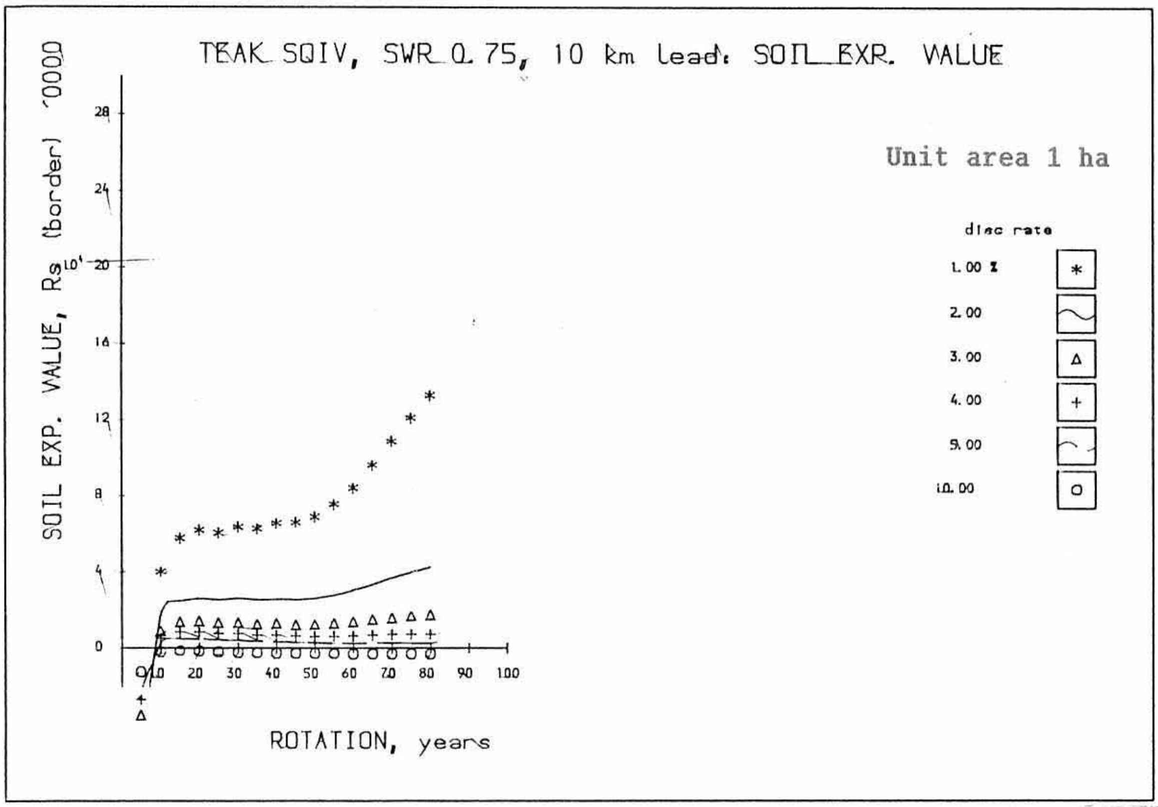


Figure 9. Teak SQIV: Soil expectation value (NPV of infinite series of rotations) under social cost benefit analysis at different rotation periods; discount rates 1% to 10%; lead 10km; accounting wage ratio 0.50 (top), 0.75 (bottom) (Table 9.7).

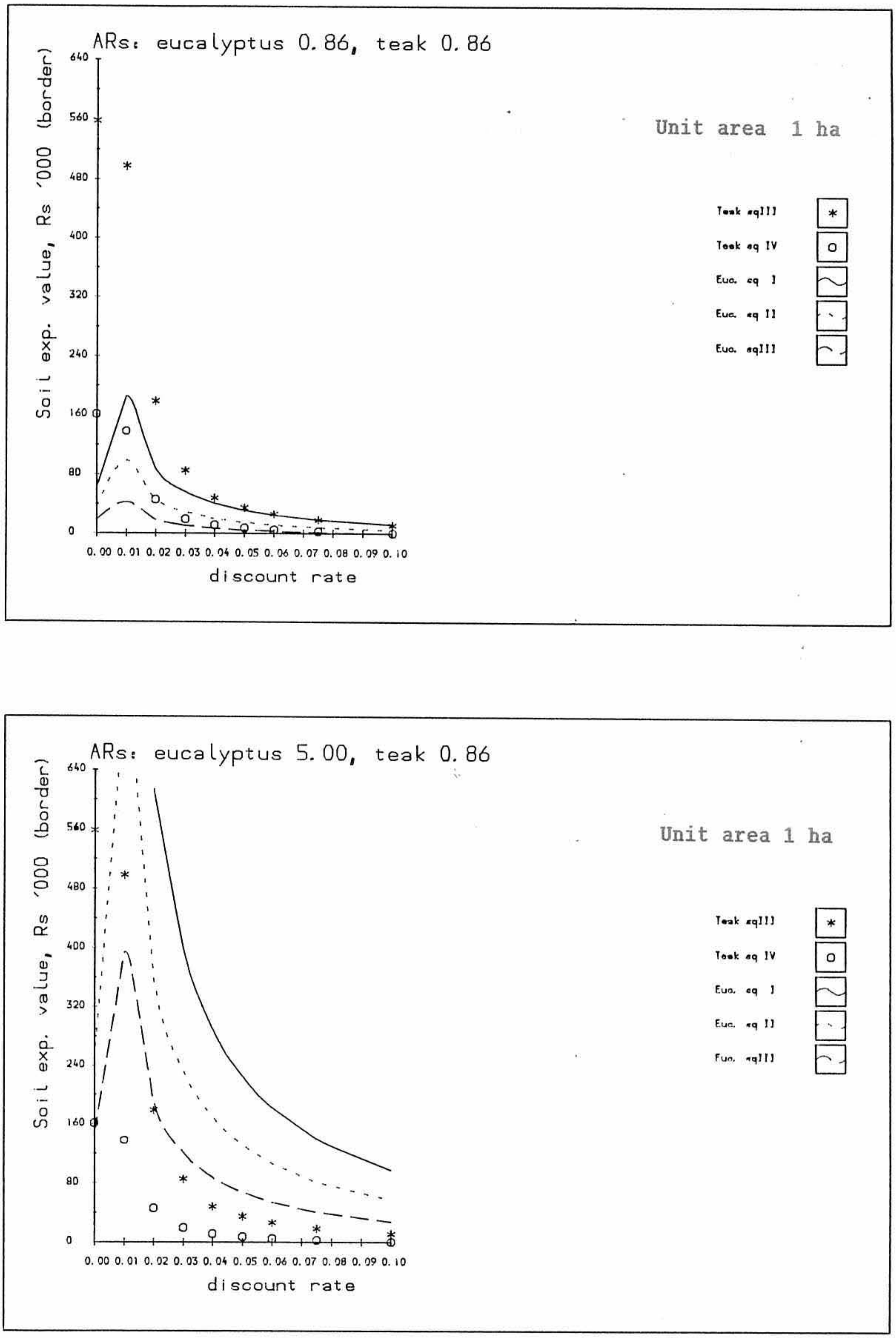


Figure 10. Optimal soil expectation values of Eucalyptus hybrid versus teak plantations under SCBA: accounting ratios 0.86 for both species (top); 5.00 for Eucalyptus and 0.86 for teak (bottom) (Table 10.14).

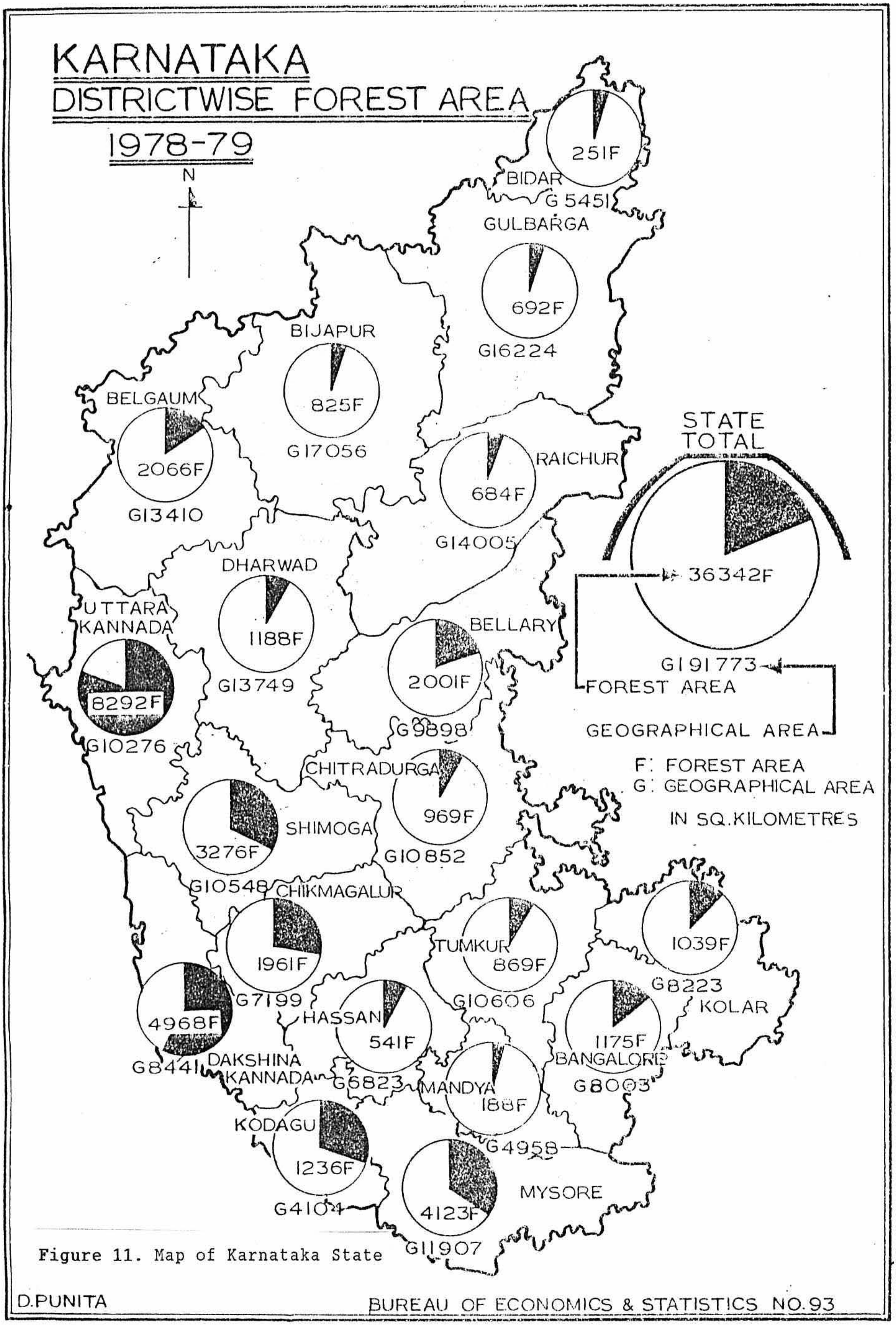


Figure 11. Map of Karnataka State

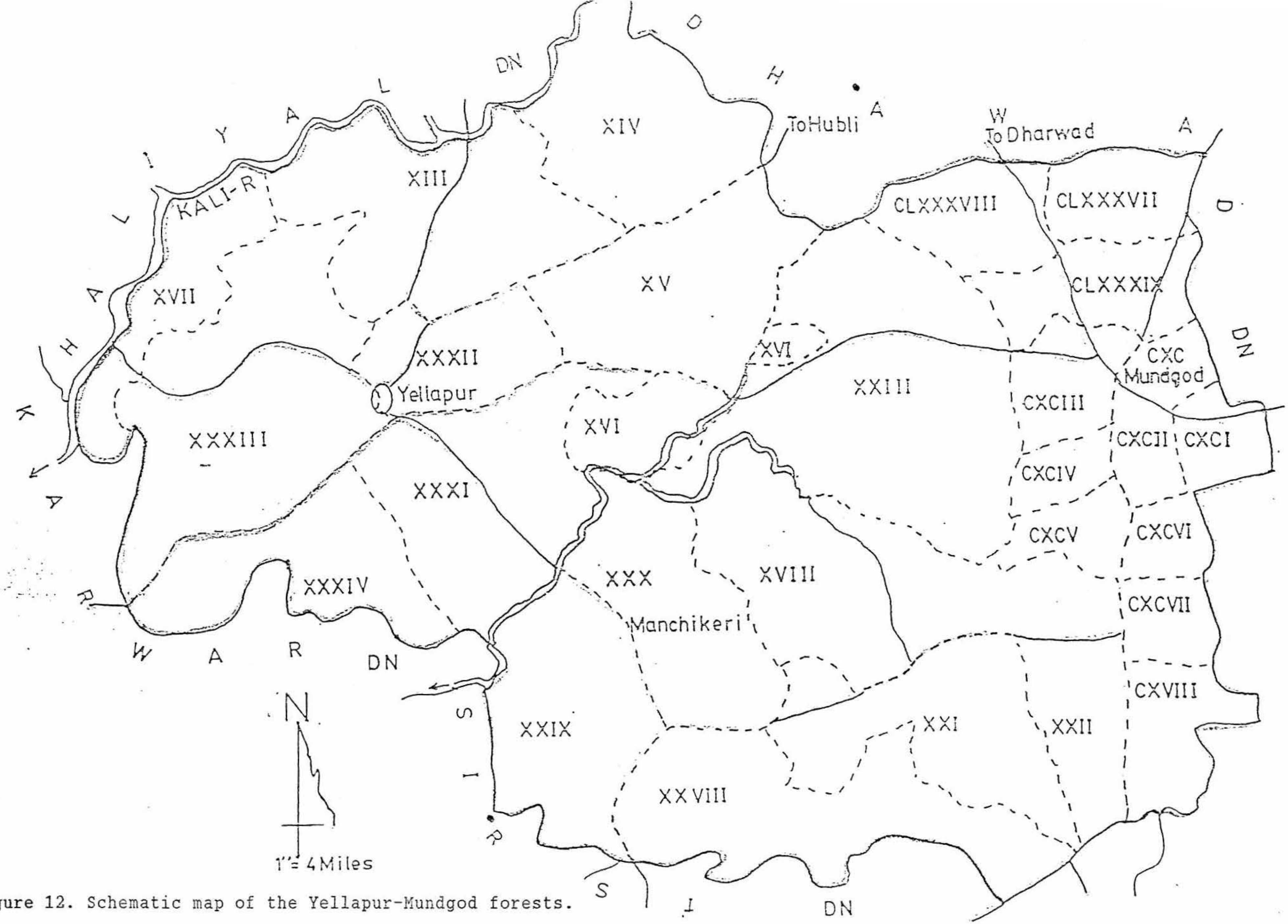


Figure 12. Schematic map of the Yellapur-Mundgod forests.

TABLES

TABLE 1.1 Crude birth rates, per 1000 population; Karnataka State, 1970 to 1980 (sec. 1.2.2)

PERIOD	Rural	Urban	Total
1970-72	33.9	27.0	32.0
1971-73	32.3	26.4	30.7
1972-74	30.8	26.1	29.4
1974-76	29.7	24.3	28.2
1975-77	29.3	23.9	27.8
1976-78	29.5	25.2	28.3

Source: Government of India, 1979. (Levels, Trends, and Differentials in Fertility).

TABLE 1.2 Mid-year population, 1950 to 1985 (sec. 1.2.2)

YEAR (mid)	POPULATN millions	YEAR (mid)	POPULATN millions	YEAR (mid)	POPULATN millions	YEAR (mid)	POPULATN millions
1950	358.29	1960	429.02	1970	539.08	1980	663.60
1951	360.18	1961	439.00	1971	551.23	1981	676.22
1952	366.30	1962	451.01	1972	563.53	1982	716.88
1953	372.75	1963	462.03	1973	575.89	1983	730.98
1954	379.57	1964	472.13	1974	588.30	1984	745.01
1955	386.62	1965	482.71	1975	600.76	1985	750.90
1956	394.22	1966	493.39	1976	613.27		
1957	402.23	1967	504.34	1977	625.82		
1958	410.69	1968	515.60	1978	638.39		
1959	419.61	1969	527.18	1979	650.98		

Source:

PERIOD	REFERENCE
1979 to 1985	International Financial Statistics, July 1986.
1970 to 1978	IFS Suppl. no. 10, 1985.
1955 to 1969	IFS Yearbook, 1984.
1950 to 1954	IFS Yearbook, 1980.

TABLE 1.3 Decennial population data, as on 1 March (sec. 1.2.2)

YEAR (Mar 1)	--- POPULATION --- millions	growth rate, per 000
1901	238.40	
1911	252.09	5.58
1921	251.32	-0.31
1931	278.98	10.44
1941	318.66	13.30
1951	361.09	12.50
1961	439.24	19.59
1971	548.16	22.15
1981	683.81	22.11

Source: Population: Government of India, 1982a. (Statistical Abstract of India, 1982). Decadal growth rates calculated on exponential basis; provisional estimate of population as on 31-3-1981 685.185 millions. The figure of 683.81 million is from the RBI Report on Currency and Finance, 1981-82, Vol. II. Though also provisional, this is closer to the figure of 676.22 million in International Fin. Stat., July 1986, for 1 July 1981.
The estimates are as on 1 March, except for 1971, which is on April 1st 1971.
Demographic Yearbook of the UNO yielded the following figures:

Demog. Yb. 1975:	Census figure as on 1 Apr 1971	548.16
-do-	Estim. mid-year (1 Jul 1971)	551.02
Demog. Yb. 1981:	Census (prov.) as on 1 Mar 1981	683.81
-do-	Estim. mid-year (1 Jul 1981)	683.81 (sic)

TABLE 1.4(i) Equations to describe population growth (sec. 1.2.3)

A. Logistic growth, $P = K\ [1 + (K-P_0)e^{-rT}/P_0]$

1) On annual time series, 1950-1985:
   asymptotic limit K = 370.66, hundred millions;
   annual growth rate r = 21.11 per 000;
   base population P_0 = 358.33 millions in 1950;
   time T = years from T_0, 1950.
2) On annual time series, 1950-1981:
   asymptotic limit K = 391.67, hundred millions;
   annual growth rate r = 20.68 per 000;
   base population P_0 = 358.33 millions in 1950;
   time T = years from T_0, 1950.
3) On decennial time series, 1911-1981:
   asymptotic limit K = 290.48, hundred millions;
   annual growth rate r = 12.99 per 000;
   base population P_0 = 252.09 millions in 1911;
   time T = years from T_0, 1911.
4) On decennial time series, 1921-1981:
   asymptotic limit K = 300.06, hundred millions;
   annual growth rate r = 15.95 per 000;
   base population P_0 = 251.32 millions in 1921;
   time T = years from T_0, 1921.

B) Linear regression equations (with transformed variates)

5) based on annual series for 1950-1985:
   $P = 3951.3 + 31.22(T) - 1318.0(\ln T)$; R-sq = 99.82%;
   P = population, millions; T = years since 1900.
6) based on decennial series, 1901-1981:
   $P = 4329.78 + 20.30(T) - 1298.0(\ln T)$; R-sq = 98.17%;
   P = population, millions; T = years since 1850.

TABLE 1.4(ii) Projections of population (millions) (sec. 1.2.3)

YEAR	UN PROJECTIONS			NCA	Eqns. of Table 1.4(i)			ACTUAL
	high	medium	low		eq.(5)	eq.(6)	eq.(4)	
1980	688.956	688.956	688.956	660	673.4	650.7	635.62	663.60
1985	767.892	761.175	754.319	725	749.6	703.2	687.17	750.90
1990	847.028	831.948	816.769		830.4	757.5	742.80	
1995		899.131			915.2	813.5	802.80	
2000	1003.607	961.531	926.685	935	1003.7	871.0	867.51	
2005					1095.5	929.9	937.26	
2010	1139.182	1065.22	1007.851		1190.3	990.2	1012.43	
2015					1287.8	1051.8	1093.40	
2020		1154.456			1387.8	1114.5	1180.58	
2025	1317.381	1188.504	1091.15		1490.1	1178.4	1274.41	

Source: UNO, 1985; NCA, 1976.

TABLE 1.5 Pattern of land utilization (sec. 1.3.2)

YEAR	TOTAL REPORT. AREA	FORESTS	NOT AVAIL. for CULT.	PERMAN. PAST. & other GRAZING	MISC. TREE CROPS	CULTR. WASTE LAND	FALLOW NON-CURRENT	FALLOW CURRENT	NET AREA SOWN
	000 hectares								
50-51	284,315	40,482	47,517	6,675	19,828	22,943	17,445	10,679	118,746
55-56	291,917	51,343	48,396	11,473	5,885	21,537	12,544	11,583	129,156
60-61	298,458	54,052	50,751	13,966	4,459	19,212	11,180	11,639	133,199
65-66	305,535	61,543	49,497	14,810	4,076	16,965	9,262	13,184	136,198
70-71	303,758	63,917	44,640	13,262	4,298	17,500	8,759	10,598	140,784
74-75	304,150	65,867	40,768	12,853	4,145	16,657	9,261	16,214	138,384
75-76	304,339	66,895	39,469	12,623	3,979	17,364	9,527	12,458	142,224
76-77	304,784	67,163	39,683	12,529	3,976	17,149	9,696	14,405	140,183
77-78	304,181	67,125	39,253	12,359	4,040	16,809	9,723	12,936	141,936
78-79	304,681	67,441	39,299	12,155	3,910	16,948	9,547	12,443	142,938

Source: Govt of India, 1982a. (Statistical Abstract of India, 1982).
Note: Figures for 1977-78 and 1978-79 provisional.
TOTAL refers to reporting area according to village papers for land utilization purposes. Total area is classified under forests, land not available for cultivation, permanent pastures and other grazing lands, land under miscellaneous tree crops, culturable waste land, and fallow lands (current fallows plus other than current fallows).

TABLE 1.6 Pattern of land utilization as per Forest Department sources. (sec. 1.3.2)

YEAR	TOTAL	FORESTS	BARREN and UNCULT-URABLE LAND	LAND UNDER NON-AGRIC. USES	AGRI-CULTURE (CULTI-VATED LAND)	OTHER CULTIV-ATED LAND
	million hectares					
1975-76	328.8	74.7	39.1	17.2	154.7	43.1
[%	100.0%	22.7%	11.9%	5.3%	47.0%	13.1%]
1976-77	328.8	74.8	38.3	17.4	154.7	43.6
[%	100.0%	22.7%	11.7%	5.3%	47.0%	13.3%]

Source: Govt of India, 1980. (India's Forests, 1980).

TABLE 1.7 Gross Domestic Product (GDP) at market prices for year beginning 1 April (sec. 1.6.2)

YEAR	GDP at current prices	GDP at 1980 prices	INDEX OF REAL GDP 1960=100	1970=100	GDP at 1970 prices	GDP/cap 1970 prices
	------------	Rs billions		--------------------		Rs/cap
1950	95.6					
1951						
1952						
1953	104.5					
1954	96.8					
1955	102.6					
1956	118.2					
1957	119.9					
1958	134.4					
1959	139.8					
1960	150.18	638.1	100.00	68.66	276.28	643.979
1961	159.77	660.8	103.56	71.10	286.11	651.731
1962	170.99	678.9	106.39	73.05	293.95	651.759
1963	196.56	715.1	112.07	76.94	309.62	670.130
1964	230.44	769.4	120.58	82.79	333.13	705.590
1965	241.11	736.1	115.36	79.20	318.71	660.251
1966	276.62	744.4	116.66	80.10	322.31	653.256
1967	322.9	805.1	126.17	86.63	348.59	691.181
1968	332.8	827.9	129.74	89.08	358.46	695.229
1969	368.5	880.7	138.02	94.76	381.32	723.320
1970	402.63	929.3	145.65	100.00	402.63	746.884
1971	433.56	950.9	149.02	102.32	411.96	747.347
1972	478.65	944.1	147.95	101.58	409.01	725.800
1973	589.40	978.01	153.27	105.23	423.70	735.731
1974	695.95	979.56	153.51	105.40	424.37	721.350
1975	740.84	1075.05	168.48	115.68	465.74	775.251
1976	801.98	1091.76	171.10	117.47	472.98	771.243
1977	898.15	1180.93	185.07	127.07	511.61	817.503
1978	978.60	1259.78	197.43	135.55	545.77	854.916
1979	1076.6	1197.4	187.65	128.84	518.75	796.875
1980	1279.3	1279.3	200.49	137.65	554.23	835.187
1981	1475.0	1345.3	210.83	144.75	582.82	861.879
1982	1647.4	1401.2	219.59	150.77	607.04	846.781
1983	1938.4	1508.2	236.36	162.28	653.40	893.869
1984	2131.8	1562.3	244.84	168.10	676.83	908.484

Source for 1980 price series: 1950-52 and 1955-69 Int. Fin. Stat., Yb 1984; 1953-54 IFS Yb 1983; 1970-78 IFS Supp. 10, 1985; 1979-84 IFS July 1986. The index of real GDP was calculated based on 1970 = 100 and 1960 = 100, respectively, from the 1980 prices series. The GDP at 1970 prices for 1960 was taken to be Rs 276.28 billion, from IFS Suppl., May 1977. Using this as the base, GDP at 1970 prices for the years 1961 to 1969 was calculated by applying the index at 1960 base. GDP at 1970 prices for 1970 was taken as Rs 402.63 billion; the GDP at 1970 prices from 1970 to 1984 was calculated using the index of real GDP based on 1970.

TABLE 1.8 Sectoral composition of Net Domestic Product (sec. 1.6.5)
(Per cent of total at 1960-61 prices)

YEAR: SECTOR	1950-51	1960-61	1965-66	1970-71	1973-74
	[per cent of total NDP at 1960-61 prices]				
Agriculture	54.1	49.3	40.4	42.7	39.6
Forestry & fishing	2.0	1.9	2.2	2.0	2.0
Mining	0.9	1.0	1.2	1.1	1.2
TOTAL PRIMARY	**57.0**	**52.2**	**43.8**	**45.8**	**42.8**
Manufacturing	11.7	13.9	16.8	15.6	16.0
Construction	4.5	4.7	5.7	5.5	5.2
Public utilities	0.2	0.5	0.8	1.0	1.2
TOTAL SECONDARY	**16.4**	**19.1**	**23.3**	**22.1**	**22.4**
Transport, commun.	3.6	4.3	5.1	5.1	5.4
Trade, hotels	8.5	9.7	11.1	10.5	10.7
Banking, insurance	0.9	1.2	1.5	1.6	1.9
Real estate, etc.	3.1	3.0	2.9	2.4	2.4
Public admin. & defence	3.6	4.0	5.4	5.9	7.3
Other services	6.9	6.5	6.9	6.6	7.1
TOTAL TERTIARY	**26.6**	**28.7**	**32.9**	**32.1**	**34.8**
TOTAL (Rs million)	**91,220**	**133,350**	**152,340**	**192,190**	**199,100**

Source: Johnson (1979), p. 36.

TABLE 1.9 Five year plans: proportionate outlay by major activities
(per cent total outlay, Rs current) (sec. 1.7.4)

ACTIVITY	FIRST 1951-1956	SECOND 1956-1961	THIRD 1961-1966	FOURTH 1969-1974	FIFTH 1974-1979	SIXTH 1980-1985 (Public)
Agriculture	14.8	11.7	12.7	16.9	14.4	13.6
Irrigation	22.2	9.2	7.8	7.4	5.0	9.7
Power	7.6	9.7	14.6	17.8	11.8	19.8
Village, small industry	2.1	4.0	2.8	1.5		1.8
					28.4	
Industry & minerals	2.8	20.1	20.1	18.5		20.9
Transport & communic.	26.4	27.0	24.6	18.4	16.8	15.9
Education	7.6	5.8	7.7	5.6	3.5	2.6
Health & family planning	5.0	4.6	2.9	3.6	3.3	2.9

Source: Johnson (1979); Sixth Plan public outlay from RBI, 1984.

TABLE 2.1(i) Apparent consumption of roundwood: aggregate (sec. 2.2.3)

YEAR	Saw & veneer logs	Pulp wood	Other indus. roundw.	Total indus. roundw.	Fire- wood & charcoal	Populatn.
	---------------		000 cmt(r)	---------------		millions
1954	2743.9	*	*	*	*	379.57
1955	3388.0	*	762.0	*	10810	386.62
1956	3349.0	*	335.0	*	10636	394.22
1957	3760.1	*	896.9	*	10981	402.23
1958	3713.2	*	978.6	*	11972	410.69
1959	3751.2	*	895.8	*	10977	419.61
1960	*	*	*	*	*	429.02
1961	3998.0	45.0	2455.0	6498.0	83201	439.00
1962	4461.0	50.0	2520.0	7031.0	85209	451.01
1963	4815.0	60.0	2591.0	7466.0	87262	462.03
1964	5054.0	62.0	2660.0	7776.0	89372	472.13
1965	5251.0	300.0	2736.0	8287.0	91494	482.71
1966	5379.0	311.0	2829.0	8519.0	93791	493.39
1967	5611.0	310.0	2936.0	8857.0	96107	504.34
1968	5741.0	310.0	3042.0	9093.0	152619	515.60
1969	5944.0	320.0	3103.0	9367.0	156590	527.18
1970	9142.0	370.0	3232.0	12744.0	160742	539.08
1971	9572.0	380.0	3335.0	13287.0	165501	551.23
1972	10031.0	580.0	3430.0	14041.0	169303	563.53
1973	10495.0	838.0	3563.0	14896.0	173195	575.89
1974	11011.0	1125.0	3668.0	15804.0	177234	588.30
1975	11524.0	1220.0	3724.0	16468.0	181376	600.76
1976	12069.0	1355.0	3780.0	17204.0	185397	613.27
1977	12652.0	1263.0	3835.0	17750.0	189480	625.82
1978	13254.0	1208.0	3892.0	18354.0	193584	638.39
1979	13877.0	1208.0	3948.0	19033.0	197773	650.98
1980	14536.0	1208.0	4004.0	19748.0	201949	663.60
1981	14555.0	1208.0	4062.0	19825.0	206127	676.22
1982	14564.0	1208.0	4120.0	19892.0	210369	716.88
1983	14564.0	1208.0	4178.0	19950.0	214621	730.90
1984	14564.0	1208.0	4236.0	20008.0	218865	745.01

Data based on FAO Yearbooks of Forest Products; * missing values.
apparent consumption= production + imports - exports.
Population: see Chapter 1.

TABLE 2.1(ii) Apparent consumption of roundwood: per (000) capita (sec. 2.2.3)

YEAR	Popul.	Saw & veneer logs	Pulp wood	Other indus. roundw.	Total indus. roundw.	Firewood & charcoal
	mill.	-----------		cmt(r)/000 cap.		-------------
1954	379.57	7.23	*	*	*	*
1955	386.62	8.76	*	1.97	*	27.96
1956	394.22	8.50	*	0.85	*	26.98
1957	402.23	9.35	*	2.23	*	27.30
1958	410.69	9.04	*	2.38	*	29.15
1959	419.61	8.94	*	2.14	*	26.16
1960	429.02	*	*	*		*
1961	439.00	9.11	0.10	5.59	14.80	189.52
1962	451.01	9.89	0.11	5.59	15.59	188.93
1963	462.03	10.42	0.13	5.61	16.16	188.87
1964	472.13	10.71	0.13	5.63	16.47	189.30
1965	482.71	10.88	0.62	5.67	17.17	189.54
1966	493.39	10.90	0.63	5.73	17.27	190.10
1967	504.34	11.13	0.62	5.82	17.56	190.56
1968	515.60	11.14	0.60	5.90	17.64	296.00
1969	527.18	11.28	0.61	5.89	17.77	297.03
1970	539.08	16.96	0.69	6.00	23.64	298.18
1971	551.23	17.37	0.69	6.05	24.10	300.24
1972	563.53	17.80	1.03	6.09	24.92	300.43
1973	575.89	18.22	1.46	6.19	25.87	300.74
1974	588.30	18.72	1.91	6.24	26.86	301.27
1975	600.76	19.18	2.03	6.20	27.41	301.91
1976	613.27	19.68	2.21	6.16	28.05	302.31
1977	625.82	20.22	2.02	6.13	28.36	302.77
1978	638.39	20.76	1.89	6.10	28.75	303.24
1979	650.98	21.32	1.86	6.07	29.24	303.81
1980	663.60	21.91	1.82	6.03	29.76	304.32
1981	676.22	21.52	1.79	6.01	29.32	304.82
1982	716.88	20.32	1.69	5.75	27.75	293.45
1983	730.90	19.93	1.65	5.72	27.30	293.64
1984	745.01	19.55	1.62	5.69	26.86	293.78

TABLE 2.2 Projections of roundwood demand ('000 cmt(r))
(sec. 2.3.2 et seq.)

	NCA (1976)						ACTUAL
	HIGH			LOW			1980
	1980	1985	2000	1980	1985	2000	
	'000 cmt(r)						
Sawnwood	14,100	18,300	29,650	13,145	15,665	22,940	
Panel products							
plywood, veneer	600	965	2,155	520	700	1,345	
fibreboard	95	125	200	85	105	155	
Matchwood	535	680	1,415	535	680	1,415	
TOTAL LOGS	15,330	20,070	33,420	14,285	17,150	25,855	14,536
Pulp & paper	4,175	6,055	17,695	3,675	4,715	9,680	1,208
Wood used in round	7,390	9,055	13,335	7,045	8,165	11,645	4,004
TOTAL INDUSTRL.	26,895	35,180	64,450	25,005	30,030	47,180	19,748
Fuelwood	184000	202000	225000				
Fuelwood+ charcoal, at	--- 0.35 cmt(r)/cap --			--- 0.30 cmt(r)/cap ---			
[using UNO population projections, medium variant]	241135	266411	336536	206687	228353	288459	201949

Source: NCA (1976) for projections, except that of fuelwood + charcoal which is calculated on per cap. basis together with UN population projections, medium variant. Actual consumption from Table 2.1.

TABLE 2.3(i) Status of India's forests, 1950 and 1975 (sec. 2.5.1)

	1950-51		1975-76	
TOTAL FOREST		**68.82 (100.%)**		**74.74 (100.%)**
LEGAL STATUS>	Reserved	43.16 (62.7%)	Reserved	38.97 (52.1%)
	Other	25.66 (37.3%)	Protected	23.19 (31.0%)
			Unclassed	12.58 (16.9%)
UTILISATION>	Exploitable	39.26 (57.1%)	Exploitable	45.96 (61.5%)
	Potential	8.81 (11.9%)	Potential	16.16 (21.6%)
	Other	21.38 (31.1%)	Others	12.62 (16.9%)
OWNERSHIP>	State	54.45 (79.1%)	State	71.53 (95.7%)
	Communal	0.27 (0.4%)	Corporate	2.01 (2.7%)
	Private	14.10 (20.5%)	Private	1.20 (1.6%)

Source: For 1950-51, Govt of India (1952); 1975-76, Govt of India (1980).
Notes: Reserved forest explained as that "permanently dedicated to production of timber or other forest produce or for protective purposes". Protected forest indicates a lower level of protection than reserved forest. Exploitable forest refers to forest in use. Potential denotes potentially exploitable forest, which may be opened up to exploitation "if such factors as demand, transport, etc. become favourable" (Government of India, 1952).

TABLE 2.3(ii) Growing stock and increment in India's forests, 1950-51 (sec. 2.5.2)

CROP TYPE	VOLUME million cmt(r)	DENSITY cmt(r) per ha	GROSS ANN. INCREMENT mill cmt	GROSS ANN. INCREMENT cmt(r) per ha	NATUR. LOSS mill cmt	ANN. HARVEST mill cmt	ANN. DECR. cmt(r) per ha	NET ANNUAL INCREMENT mill cmt	NET ANNUAL INCREMENT cmt(r) per ha
EXPLOITABLE FORESTS									
STATE									
i) conifers	142.91	118.97	1.86	1.53	0.012	1.557	1.30	0.286	0.24
ii) broadlvd.	2000.68	69.98	30.11	1.05	2.128	11.391	0.40	16.594	0.58
Total	2143.59	68.34	31.97	1.02	2.140	12.948	0.41	16.880	0.54
COMMUNAL									
i) conifers	0.01	22.42	0.00	0.54	--	0.001	3.94	-0.001	-3.40
ii) broadlvd.	0.58	2.73	0.03	0.15	0.000	0.056	0.26	-0.024	-0.11
Total	0.58	2.73	0.03	0.15	0.000	0.057	0.27	-0.025	-0.11
PRIVATE									
i) conifers	---	--	--	--	--	--	--	--	--
ii) broadlvd.	153.15	20.01	10.25	1.37	1.960	8.324	1.37	-0.034	-0.005
Total	153.15	20.01	10.25	1.34	1.960	8.324	1.09	-0.034	-0.004
TOTAL EXPLOITABLE									
i) conifers	142.92	118.86	1.86	1.53	0.012	1.558	1.30	0.285	0.24
ii) broadlvd.	2154.41	59.37	40.40	1.11	4.088	14.407	0.55	16.536	0.46
Total	2297.33	58.50	42.25	1.08	4.100	15.966	0.54	16.821	0.43

Source: Govt of India (1952). Converted to metric units.

TABLE 2.4(i) Index of wholesale prices, 1970 to 1985 (1970 =100)

	Weight	71-72	72-73	73-74	74-75	75-76	76-77	77-78	78-79	79-80	80-81	81-82	Jun82	Mar83	Mar84	Mar85	INFL. RATE
All commodities	1000.0	105.6	116.2	139.7	174.9	173.0	176.6	185.8	185.8	217.6	257.3	280.6	287.8	295.3	321.7	345.4	8.62%
I Primary articles	416.67	100.9				165.8	167.2	183.8	181.4	206.5	237.2	260.9	274.2	281.6	308.1	322.0	8.11
1. Food articles	297.99	101.1	111.3	136.6	172.1	163.6	155.3	173.6	172.4	186.6	207.8	234.5		263.2	281.1	297.4	7.54
2. Non-food articles	106.21	98.6				139.8	167.4	178.0	170.4	194.6	217.7	239.5	239.7	249.9	301.4	310.7	7.85
of which Logs, timber and bamboos	3.34								266.5	350.5	392.2	454.3	633.8	780.2	971.7	1018.2	16.73
3. Minerals	12.47	115.4				440.4	449.4	477.0	490.7	779.9	1109.6			989.4	1010.5	1005.2	16.63
II Fuel, power, light and lubricants	84.59	105.9				219.2	230.8	234.3	244.7	283.1	353.9			484.0	508.6	554.6	12.10
Mineral oils, of which Kerosene oil	8.35								233.5	252.1	272.8		320.5	341.1	343.2	382.7	9.36
III Manufactd. products	498.74	109.5				171.2	175.2	179.2	179.5	215.8	257.0			274.8	301.4	329.5	8.27
4. Paper & products	8.51	110.4				183.8	180.1	184.5	196.0	237.4	260.8		302.4	302.0	339.7	368.2	9.08
8. Non-metallic mineral products, of which Cement	7.03	105.4	109.5	112.3	147.9	170.5	173.6	187.8	226.7	233.4	231.7		357.2	400.4	433.1	501.3	11.35
11.Miscellaneous products	7.20	102.5				167.8	166.0	179.4	187.8	209.8	232.1						8.00
of which Wood & wood products	1.74	103.7				163.1	160.4	178.9	192.9	219.2	266.4						9.32
Particle board		102.9	116.4	140.7	195.9	196.0	198.1	216.9									10.16
Board		100.9	104.4	127.2	196.1	168.9	154.2	160.6									6.10
Pulp		103.2	106.4	136.6	219.0	241.5	244.3	244.7									11.84
Paper		113.6	117.2	127.2	177.1	172.1	176.6	173.8									7.15
Newsprint		112.0	120.6	138.6	178.1	223.0	245.0	228.8									10.90
Plywood		102.4	103.9	110.7	152.3	159.1	156.0	175.4									7.28
Timber		105.8	114.0	133.1	168.0	164.6	155.3	219.8									10.35

Source: information on wood product groups from India's Forests, 1980 (originally from Economic Advisor's Office, Min. of Industries). Rest from RBI Reports on Currency and Finance, various issues. Index for 1970 = 100.0. Figures for 'logs, timber & bamboos' refers to end-June for 1978-79 to 1981-82; remaining as per column heading. Where heading states the year, e.g. 1980-81, this is meant to be the average of the indexes of the 12 months of the financial year (April to March).

TABLE 2.4(ii) Overall rate of inflation per annum in market price of various forest products (sec. 2.5.4)

PRODUCT	Market	Period	INFL. RATE, % per annum	General wholesale infl rate	
1. Fuelwood	wholesale, Cuttack	1969-76	12.9%	(1970-76)	9.94%
2. "	retail, Bombay	1971-81	11.9	(1971-81)	10.27
3. "	retail, South Hyderabad	1972-81	11.0	(1972-81)	10.29
4. Charcoal	retail, Bombay	1976-82	13.6	(1976-82)	8.95
5. "	retail, S. Hyderabad	1973-81	8.2	(1973-81)	9.11
6. Timber, sal	wholesale, W. Bengal	1967-76	9.2	(1970-76)	9.94
7. Teak logs	wholesale, Andhra Pradesh				
girth 90-120 cm		1967-77	6.2	(1970-77)	9.25
8. Teak logs	wholesale, Gujerat				
girth 60-90 cm		1979-82	28.6	(1979-82)	10.71
120-150 cm		1978-82	25.8	(1978-82)	12.28
9. Non-teak logs	wholesale, Gujerat				
girth 60-90 cm		1979-82	24.6	(1979-82)	10.71
girth 120-150 cm		1979-82	10.7	(1979-82)	10.71
10. Sal planks	wholesale, W. Bengal	1968-76	6.3	(1970-76)	9.94
11. Teak planks	wholesale, Andhra P.	1967-80	13.1	(1970-80)	9.91

Source: Calculated from price data in Forest Products Prices, 1981, 1982, 1983, 1985, FAO. Wholesale inflation rate calculated from wholesale price index of corresponding or overlapping period. Both based on simple compound interest formula of price increase.

TABLE 6.1 Pattern of land utilization in Karnataka, 1970-71 to 1981-82 (sec. 6.1.3)

YEAR	CLASSIFICATION OF REPORTING AREA								
	FORESTS	LAND UNDER NON-AGRIC. USES	BARREN & UN-CULTIV--ABLE	PERMAN. PASTUR. & other GRAZING	MISC. TREE CROPS	CULTUR--ABLE WASTE LAND	FALLOW: NON-CURRENT FALLOWS	FALLOW: CURRENT FALLOWS	NET AREA SOWN
	000 hectares								
1970-71	2,890	938	839	1,619	311	615	672	811	10,248
1971-72	2,895	968	861	1,592	311	593	644	850	10,331
1972-73	2,889	973	865	1,575	311	594	644	1,359	9,808
1973-74	2,885	968	867	1,558	309	594	635	1,006	10,230
1974-75	2,876	974	876	1,540	307	597	602	972	10,306
1975-76	2,901	994	872	1,515	322	585	618	950	10,360
1976-77	2,914	1,026	874	1,499	330	559	716	1,939	9,206
1977-78	2,919	1,031	872	1,452	329	555	677	1,010	10,218
1978-79	3,015	1,052	853	1,398	315	530	625	967	10,315
1979-80	3,019	1,054	869	1,365	343	506	554	1,009	10,330
1980-81	3,033	1,066	844	1,346	342	502	558	1,459	9,899
1981-82	3,030	1,082	847	1,314	329	495	519	1,043	10,391

Source: Government of Karnataka, Bureau of Economics and Statistics, figures, quoted in Rama Prasad and Malhotra, 1984.

TABLE 6.2 Karnataka forests: legal status and forest types (sec. 6.2.1)

		AREA (ha)	PERCENT
A) **Legal status**	Reserved	2,794,710	76.90
	Protected	457,794	12.60
	Unclassed	338,585	9.32
	Village	12,275	0.34
	Private	30,842	0.85
	TOTAL	3,634,206 ha	100.00 %
B) **Forest types**	Evergreen	435,000	11.97
	Semi-evergreen	145,000	3.99
	Moist deciduous	578,000	15.90
	Dry deciduous	727,000	20.00
	Scrub and thorn	818,000	22.51
	Unwooded	931,200	25.63
	TOTAL	3,634,200 ha	100.00 %

Source: Government of Karnataka, 1980. (Karnataka Forest Statistics).

TABLE 6.3 Yellapur-Mundgod forests: allocation to working circles (sec. 6.2.5)

WORKING PLAN EDIE (1922-1942) acre (ha)	 GARLAND (1934-1949) acre (ha)	 WESLEY (1961-1981) acre (ha)
TOTAL FOREST 156,117 (63,181)	**TOTAL FOREST** 172,896 (69,971)	**TOTAL FOREST** 167,256 (67,689)
FOREST PROPER 124,284 (50,298)	**FOREST PROPER** 128,376 (51,954)	
CONVERSION	**CONVERSION**	**CONVERSION WC** 33,647 (13,617)
WC1 61,103 (24,728) (120 yrs; west; Edie's Blocks 1-6)	**WC1** 69,461 (28,111) (120 yrs; west)	**CLASS I** 11,818 (4,783) (100 yrs; west)
WC2 57,012 (23,073) (90 yrs; east; Edie's Blocks 7-15)	**WC2** 51,626 (20,893) (105 yrs; east)	**CLASS II** 16,846 (6,817) (Not fixed; east)
WC3 6,169 (2,497) (60 yrs; s.-east; Edie's Blocks 16-17)	**WC3** 7,289 (2,950) (90 yrs; s.-east)	**CLASS III** 4,984 (2,017) (Not fixed; s.-east)
GRAZING, POTENTIAL **WC4** 31,833 (12,883) (Selective felling; scattered all over)	**GRAZING, TEMPORARY** **WC4** 32,788 (13,269)	**PLANTATION WC** AISQIII 3,199 (1,295) (100 yrs; west) AISQIV 12,290 (4,974) (80 yrs; east)
GRAZING, PERMANENT (Excluded from Plan) 11,584 (4,688)	**GRAZING, PERMANENT** 11,731 (4,748) Minor Forest 3,107 (1,257) Reserved Forest 8,624 (3,490)	**SELECTION-cum-IMPROVEMENT WC** 118,120 (47,803) CLASS I 24,763 (10,022) (West) CLASS II 93,357 (37,782) (East and s.-east)
NON-FOREST (Includes villages outside Plan area) 9,025 (3,652) Govt. waste 2,235 (905) Occupied: Fallow 3,266 (1,322) Cultivation 3,424 (1,386)	**NON-FOREST** 13,988 (5,661) Govt. waste 3,565 (1.443) Occupied: Waste 5,006 (2,026) Cultivated 5,417 (2,192)	

TABLE 7.1 Yield table for 1 hectare teak (<u>T. grandis</u>) plantation AISQII (Top height 30.5-24.4 m at 50 years) (sec. 7.1.3, App. 2)

AGE	CROP		NO.	MAIN CROP STEM		THINNING STEM		----TOTAL YIELD---- STEM			MEAN ANNUAL INCREMENT	
yrs	DIA. cm	HT. m	of STEMS	TIMB. cmt (solid)	SW.	TIMB. cmt (solid)	SW.	TIMB.	SW. cmt (solid)	TOTAL	TIMB. cmt (solid)/yr	TOTAL
5	7.62	7.92	1530	0.00	25.89	0.00	18.19	0.00	44.08	44.08	0.00	8.82
10	11.68	12.50	857	0.70	51.08	0.00	23.44	0.70	92.71	93.41	0.07	8.38
15	15.75	15.54	531	8.40	64.37	0.00	23.44	8.40	130.85	139.25	0.56	9.31
20	19.81	18.59	373	26.59	66.47	1.40	23.79	27.99	156.74	184.73	1.40	9.24
25	23.62	20.42	292	46.88	55.98	4.55	19.59	52.83	165.83	218.66	2.10	8.75
30	23.43	22.25	225	66.47	36.38	7.35	11.89	79.77	158.14	237.91	2.66	7.91
35	30.73	23.47	193	86.07	28.69	8.75	8.75	108.11	159.19	267.30	3.08	7.63
40	34.04	24.99	165	105.66	23.79	9.10	5.95	136.79	180.24	297.03	3.43	7.42
45	37.08	26.21	151	125.95	20.99	8.75	4.20	165.83	161.63	327.46	3.71	7.28
50	39.80	27.13	136	143.44	18.89	8.40	3.15	191.72	168.68	354.46	3.85	7.07
55	42.42	28.04	128	161.63	17.49	7.35	2.45	217.26	163.03	380.29	3.92	6.93
60	44.98	29.26	121	179.13	16.79	7.00	2.10	241.40	165.13	406.53	4.06	6.79
65	47.24	30.17	114	193.82	16.09	6.65	1.75	263.09	166.18	429.27	4.06	6.58
70	49.29	30.78	109	207.82	15.39	6.30	1.40	283.39	166.88	450.27	4.06	6.44
75	51.56	31.70	104	221.81	14.69	6.30	1.40	303.58	167.58	471.26	4.06	6.30
80	53.85	32.31	99	235.11	13.99	6.30	1.05	327.27	167.93	491.20	4.06	6.16

TABLE 7.2 Yield table for 1 hectare teak (<u>T. grandis</u>) plantation AISQIII (Top height 24.4-18.3 m at 50 years) (sec. 7.1.3, App. 2)

AGE	CROP		NO.	MAIN CROP STEM		THINNING STEM		----TOTAL YIELD---- STEM			MEAN ANNUAL INCREMENT	
yrs	DIA. cm	HT. m	of STEMS	TIMB. cmt (solid)	SW.	TIMB. cmt (solid)	SW.	TIMB.	SW. cmt (solid)	TOTAL	TIMB. cmt (solid)/yr	TOTAL
5	6.38	5.49	2174	0.00	16.79	0.00	13.64	0.00	30.44	30.44	0.00	6.09
10	9.40	8.14	1166	0.00	34.99	0.00	14.69	0.00	63.32	63.32	0.00	6.37
15	12.48	11.58	736	2.10	47.58	0.00	15.04	2.10	90.97	93.07	0.14	6.23
20	14.73	13.72	551	6.30	55.98	0.00	13.99	6.30	113.35	119.65	0.35	6.82
25	17.02	15.24	425	11.19	58.78	0.00	13.29	11.19	129.45	140.64	0.42	5.60
30	19.05	16.76	382	17.49	60.18	0.00	11.89	17.49	142.74	160.23	0.58	5.32
35	20.63	17.68	309	23.79	59.79	0.39	9.80	24.14	151.14	175.28	0.70	5.04
40	22.86	18.90	274	31.49	57.38	1.40	8.05	33.24	157.79	191.03	0.84	4.78
45	24.64	19.81	249	40.58	54.58	2.45	6.30	44.78	161.29	206.07	0.99	4.58
50	26.42	20.73	230	51.08	49.68	3.85	4.90	59.13	161.29	220.42	1.19	4.41
55	28.19	21.64	212	62.27	45.48	4.55	4.20	74.87	161.29	236.16	1.33	4.27
60	29.97	22.28	200	74.87	41.29	5.60	3.50	93.06	160.59	253.65	1.55	4.20
65	31.78	23.16	185	88.16	38.48	5.95	3.15	112.30	160.94	273.24	1.73	4.20
70	33.47	23.77	173	101.46	35.38	5.95	2.80	131.55	161.64	293.19	1.89	4.20
75	36.08	24.38	163	123.15	34.99	5.95	2.45	152.19	162.68	314.87	2.03	4.20
80	36.82	24.92	156	132.25	33.59	5.95	2.10	174.23	163.38	337.61	2.17	4.20

Notes: Please see next Table.

TABLE 7.3 Yield table for **1 hectare** teak (T. grandis) plantation AISQIV (Top height 18.3-12.2 m at 50 years) (sec. 7.1.3, App. 2)

AGE	CROP		NO.	MAIN CROP STEM		THINNING STEM		----TOTAL YIELD---- STEM			MEAN ANNUAL INCREMENT	
yrs	DIA. cm	HT. m	of STEMS	TIMB.	SW.	TIMB.	SW.	TIMB.	SW.	TOTAL	TIMB.	TOTAL
				cmt (solid)		cmt (solid)		cmt (solid)			cmt (solid)/yr	
10	7.62	5.79	1610	0.00	19.59	0.00	7.35	0.00	26.94	26.94	0.00	2.73
15	9.40	7.62	1124	0.00	27.99	0.00	7.00	0.00	42.33	42.33	0.00	2.80
20	10.92	9.14	857	0.00	34.99	0.00	6.30	0.00	55.63	55.63	0.00	2.80
25	12.19	10.36	687	0.00	39.78	0.00	5.60	0.00	66.12	66.12	0.00	2.66
30	13.21	11.28	603	0.70	44.78	0.00	4.90	0.70	75.92	75.92	0.00	2.59
35	14.22	11.89	543	1.40	47.58	0.00	4.20	1.40	82.92	84.32	0.07	2.38
40	15.24	12.80	484	2.80	51.78	0.00	3.50	2.80	90.61	93.41	0.07	2.31
45	16.00	13.41	440	4.20	53.88	0.00	3.15	4.20	95.86	100.06	0.07	2.24
50	17.02	14.33	400	6.30	56.68	0.00	2.80	6.30	101.46	107.76	0.14	2.17
55	19.03	15.24	370	9.80	58.08	0.35	2.45	10.15	105.31	115.46	0.21	2.10
60	19.05	15.85	346	13.99	58.08	0.70	2.45	15.04	107.76	122.80	0.28	2.03
65	19.81	16.46	328	19.59	58.08	1.05	2.45	21.69	110.21	131.90	0.35	2.03
70	20.83	17.07	311	25.89	57.38	1.40	2.45	29.39	111.95	141.34	0.42	2.03
75	21.84	17.68	291	32.89	55.98	1.40	2.45	37.78	113.00	150.78	0.49	2.03
80	22.96	17.98	277	40.58	55.28	1.40	2.40	46.88	114.75	161.63	0.56	2.03

Source: FRI (1959a) yield tables, converted into metric units.
Crop diameter: diameter corresponding to average stem basal area (underbark).
Crop height: mean height, weighted by basal area in each diameter class.
Main crop: stems retained after each thinning.
Final yield: main crop volume plus terminal thinning at year of harvesting.
Total yield: final yield plus cumulative total of past thinnings.
Stem timber volume: volume of standard timber in main bole, on full cross-sectional area (underbark).
Standard timber bole: bole from ground level to limiting mean diameter of 8 ins (20 cm) overbark. Standard smallwood: branch or stem wood less than 8 ins (20 cm) mean diameter overbark down to 2 ins (5 cm) dia. ob.

TABLE 7.4 Length and girth classes in Karnataka depots (sec. 7.1.3, App. 2)

Species: Teak (Tectona grandis)

TIMBER:

LENGTH Class	Limits m/ft	mid-GIRTH(ub) Class	Limits cm/ ins	mid-DIAM(ub)* Class	Limits cm/ ins
I	> 5m/16.4'	a	>200cm/78.7"	a	> 63.7cm/25.1"
II	> 3m/ 9.8'	b	>150cm/59.1"	b	> 47.8cm/18.8"
III	> 1.2m/3.9'	c	>100cm/39.4"	c	> 31.8cm/12.5"
		d	> 60cm/23.6"	d	> 19.1cm/ 7.5"

POLES:

LENGTH Class	Limit	butt-GIRTH(ub) Class	Limit	butt-DIAM(ub)* Class	Limit
I	>6m/19.7' (to 9m/29.5')	a	>40cm/15.8" (to 65cm/25.6")	a	>12.7cm/5.0" (to 20.7cm/8.2")
II	>4m/13.1'	b	>20cm/ 7.9"	b	>6.4cm/ 2.5"
III	>2m/ 6.6'				

Note: classes are specified by girth limits; * diameter limits given above are obtained by multiplying girth limits by value of 1/pi, 0.3183.

TABLE 7.5 Composition of teak logs by quality classes, major depots of Yellapur division (sec. 7.1.3, App. 2)

TEAK TIMBER

QUALITY CLASS : YEAR	A	B	C cmt(qg,ub) (%)	TOTAL
1980-81	74.92	549.79	2370.12	2994.83
	2.5%	18.4%	79.1%	100%
1981-82	7.23	655.00	2473.43	3135.66
	0.2%	20.9%	78.9%	100.0%
1982-83	0	295.22	1512.26	1807.47
		16.3%	83.7%	100.0%
1983-84	6.68	416.97	2470.04	2893.69
	0.2%	14.4%	85.4%	100.0%
1984-85	18.83	277.02	1612.37	1908.22
	1.0%	14.5%	84.5%	100.0%
Average	1%	15%	84%	100%

Source: Forest Department.

TABLE 7.6(i) Depot auction sale rates, Yellapur division (sec. 7.1.3)

			TEAK TIMBER					
QUALITY CLASS:			A		B		C	
SIZE CLASS	SALE DATE	DEPOT*	QTY cmt	RATE Rs/cmt (qt.-girth)	QTY cmt	RATE Rs/cmt (qt.-girth)	QTY cmt	RATE Rs/cmt (qt.-girth)
Ia	12/84	M					3.41	7660.70
		K			3.68	8964.95	1.73	7710.15
							5.13	7677.32
	5/84	M					?	6058.85
						8964.95		**6868.08**
Ib	12/84	M	2.09	9765.44	5.81	6439.39	5.53	5790.81
		K			22.90	8188.50	15.09	6342.80
					28.71	7834.60	20.61	6194.82
	5/84	M			?	8016.53	?	[3772.92]*
		K			?	8756.10	?	5578.96
				9765.44		**8202.41**		**5886.89**
Ic	12/84	M	1.77	6772.01	21.77	6678.61	14.28	4489.84
		K	1.57	8296.10	26.14	6599.10	37.36	5101.45
			3.34	7487.27	47.91	6635.22	51.64	5070.58
	5/84	M	?	7619.97	?	6917.34	?	4826.31
		K	?	8029.20	?	7019.20	?	5017.63
				7712.15		**6857.25**		**4971.51**
Id	12/84	M	0.25	6889.76	5.15	5689.32	7.50	5063.96
		K			1.22	6265.75	10.66	5584.25
					6.37	5856.49	18.16	5369.24
	5/84	M			?	5801.84	?	4828.05
		K					?	4928.30
				6889.76		**5829.17**		**5041.86**
IIa	12/84	M			0.94	8110.99	25.30	4905.74
		K	0.64	9672.40	5.10	8671.75	32.06	5639.95
					6.04	8584.69	57.36	5315.80
	5/84	M			?	6036.22	?	5414.38
		K					?	5261.40
				9672.40		**7310.45**		**5330.53**
IIb	12/84	M			16.55	6951.24	64.96	5208.72
		K	?	9649.95	10.71	7706.70	88.26	5588.90
					27.26	7247.95	153.23	5427.72
	5/84	M			?	7400.68	?	4831.76
		K			?	8365.60	?	5501.17
				9649.95		**7671.41**		**5253.55**
IIc	12/84	M	1.24	6763.23	41.93	6610.82	74.71	3833.75
		K			28.74	6705.15	105.22	4399.55
					70.67	6652.75	179.92	4164.63
	5/84	M			?	6949.20	?	4264.35
		K				6833.98	?	4446.86
				6763.23		**6811.98**		**4291.95**

QUALITY CLASS: SIZE CLASS	SALE DATE	DEPOT*	A QTY cmt (qg)	A RATE Rs/cmt (qg)	B QTY cmt (qg)	B RATE Rs/cmt (qg)	C QTY cmt (qg)	C RATE Rs/cmt (qg)
IId	12/84	M			15.56	6773.06	20.28	4432.50
		K			6.58	5436.95	6.61	3863.00
					22.13	5677.69	26.90	4292.46
	5/84	M			?	5536.07	?	4078.54
							?	3818.40
						5606.88		**4063.13**
IIIa	12/84	M			0.73	7786.88	54.88	3380.40
		K			0.81	8944.10	32.05	4002.75
					1.54	8392.97	86.93	3609.68
	5/84	M					?	3921.29
		K					?	4313.20
						8392.97		**3948.06**
IIIb	12/84	M			3.71	7244.81	74.26	3518.00
		K			0.91	8013.15	61.25	4569.50
					4.62	7396.19	135.52	3993.29
	5/84	M			?	7285.63	?	3570.57
		K			?	7546.53	?	3688.23
						7409.45		**3750.70**
IIIc	12/84	M	0.23	6777.78	30.20	6177.97	115.73	3421.70
		K			3.98	5931.15	101.72	3916.80
					34.18	6149.23	217.50	3653.80
	5/84	M			?	6900.99	?	3655.30
		K			?	6536.15	?	[5017.00]*
				6777.78		**6528.79**		**3654.32**
IIId	12/84	M			6.17	5740.23	30.10	3708.26
		K			3.30	5459.50	2.45	3919.55
					9.46	5642.44	32.55	3723.73
	5/84	M			?	5807.23	?	3278.07
		K					?	3309.67
						5724.83		**3437.16**

TEAK FIREWOOD

SALE DATE	DEPOT*	QTY cmt	RATE Rs/cmt (stacked)
12/84	M	134.22	82.70
	K	2664.05	259.10
		2798.27	250.64
5/84	M	?	[512.82]*
			250.64

* NOTE Rates enclosed in [] are doubtful; not used in computing averages.
Values represented by ? are not available.
Rates refer to depot auction sales; exclude taxes etc.

TABLE 7.6(ii) Depot auction sale rates, Yellapur division (sec. 7.1.3)

NON-TEAK TIMBER

QUALITY CLASS: A, B, C combined

DEPOT, DATE:	M, 12/84		K, 12/84		AGGREGATE	
	QTY cmt (qg)	RATE Rs/cmt (qg)	QTY cmt (qg)	RATE Rs/cmt (qg)	QTY cmt (qg)	RATE Rs/cmt (qg)
Matti (T. tomentosa)	360.6	2058.86	1749.4	2324.77		
Heddi (A. cordifolia)	184.0	1835.79	1447.3	1968.40		
Nandi (L. lanceolata)	22.4	2424.83	52.9	1793.21		
Kindal (T. paniculata)	23.0	2435.74	317.2	2071.66		
Kalam (M. parviflora)	48.5	1590.14	84.0	1893.35		
Honne (P. marsupium)	105.3	2742.19	139.3	3473.04		
Jambe (X. xylocarpa)	18.6	1557.29	393.0	1911.32		
Neral (S. cuminii)	12.8	1376.45	122.5	1489.16		
Dhaman (G. tiliaefolia)	10.1	1290.15	32.2	1177.54		
Others	64.3	1070.34	506.8	1455.94		
All Junglewood (excluding Rosewood)	849.6	1983.09	4844.5	2068.31	5694.1	2055.74
Teakwood (T. grandis)	716.3	4340.29	850.4	4627.89	1566.7	4496.39
Rosewood (D. latifolia) [9/85 sales]	579.9	3641.00	691.9	3596.20	1271.8	3616.65
Jwood/Teak timber price ratio			0.4569		0.4469	0.4572

NON-TEAK FIREWOOD

DEPOT, DATE:	M, 12/84		K, 12/84		AGGREGATE	
	QTY cmt (stacked)	RATE Rs/cmt	QTY cmt (stacked)	RATE Rs/cmt	QTY cmt (stacked)	RATE Rs/cmt
Jwood billets	822.5	166.25				
Jwood firewood	12.4	126.86	31.0	82.70	43.4	95.35
Teak firewood	134.2	82.70	2664.1	259.10	2798.3	250.59
Jwood/Teak firewood price ratio						0.3805

*NOTE Rates enclosed in [] are doubtful; not used in computing averages.
Values represented by ? are not available.
Rates refer to depot auction sales; exclude taxes etc.
Depots: M = Mundgod, K = Kirwatti.

TABLE 7.7 Depot auction sale rates for 'average' quality class (sec. 7.1.3)

TEAK TIMBER LOGS

QUALITY SIZE CLASS	A [wt= 0.01] Average auction		B [wt= 0.15] sale depot rates,		C [wt= 0.84] Rs/cmt(qg)		WEIGHTED AVERAGE Rs/cmt (qg)	Rs/cmt (solid)*
Ia	[9765.44	97.65]	8964.95	1344.74	6868.08	5769.19	7211.58	5663.98
Ib	9765.44	97.65	8202.41	1230.36	5886.89	4944.99	6273.00	4926.81
Ic	7712.15	77.13	6857.25	1028.59	4971.51	4176.07	5281.79	4148.31
Id	6889.76	68.90	5829.17	874.38	5041.86	4235.16	5178.44	4067.15
IIa	9762.40	97.62	7310.45	1096.57	5330.53	4477.65	5671.84	4453.96
IIb	9649.95	96.50	7671.41	1150.71	5253.55	4412.98	5660.19	4445.51
IIc	6763.23	67.63	6811.98	1021.80	4291.95	3605.24	4694.67	3687.19
IId	[6763.23	67.63]	5606.88	841.03	4063.13	3413.03	4321.69	3394.26
IIIa	[6777.78	67.78]	8392.97	1258.95	3948.06	3316.37	4643.09	3646.68
IIIb	[6777.78	67.78]	7409.45	1111.42	3750.70	3150.59	4329.78	3400.61
IIIc	6777.78	67.78	6528.79	979.32	3654.32	3069.63	4116.73	3233.28
IIId	[6777.78	67.78]	5724.83	858.73	3437.16	2887.21	3818.72	2995.30

*Note Rate per cmt(qg) is converted into Rs per cmt(solid) on the basis that a log containing 1 cmt(qg) implicitly contains 4/pi = 4/3.1416 = 1.2732 cmt(solid). Hence price per cmt(solid) is obtained from price per cmt(qg) by multiplying by 1/1.2732 = 0.7854.

TEAK FIREWOOD

Rs 250.64 per cmt(stacked) = 250.64/ 0.53 = Rs 472.91 per cmt(solid) *

*Note See Appendix 2 for conversion factor 0.53

TABLE 7.8 Bark thickness by diameter of teak logs (sec. 7.1.3)

mid-DIAM(ob) ins.	cm	2*BARK thickness ins.	cm
3.0	7.62	0.5	1.27
5.0	12.7	0.6	1.52
7.0	17.78	0.7	1.78
9.0	22.86	0.7	1.78
11.0	27.94	0.8	2.03
13.0	33.02	0.8	2.03
15.0	38.10	0.9	2.29
17.0	43.18	0.9	2.29
19.0	48.26	0.9	2.29
21.0	53.34	1.0	2.54
23.0	58.24	1.0	2.54
25.0	63.50	1.0	2.54
27.0	68.58	1.0	2.54

Source: Sant Ram (1942).

TABLE 7.9 Unit value by tree size (sec. 7.1.3)

HEIGHT CLASS ft		DBH,ob CLASS ins		COMM BOLE ft	TOP Dob, ins	MID Dob, ins	MID Dub, ins	SIZE CLASS	Rs/cmt, qg ub	Rs/cmt, solid,ub
5	81-100	7	24.1-28.0	54	12.8	20.0	19.1	Ib	6273.00	4926.81
		6	20.1-24.0	50	12.4	18.0	17.1	Ic	5281.79	4148.31
		5	16.1-20.0	44	11.1	14.0	13.2	Ic	5281.79	4148.31
		4	12.1-16.0	38	9.5	12.0	11.2	Id	5178.44	4067.15
		3	8.1-12.0	31	7.7	8.5	7.8	Id	5178.44	4067.15
		2	4.1-8.0	19	4.5	6.0	5.4	Pole	3818.72	2995.30
4	61-80	7	24.1-28.0	37	12.8	20.0	19.1	Ib	6273.00	4926.81
		6	20.1-24.0	34	12.4	18.5	17.6	Ic	5281.79	4148.31
		5	16.1-20.0	30	11.1	14.5	13.7	Ic	5281.79	4148.31
		4	12.1-16.0	26	9.5	12.0	11.2	Id	5178.44	4067.15
		3	8.1-12.0	21	7.7	9.0	8.3	Id	5178.44	4067.15
		2	4.1-8.0	15	4.5	6.0	5.4	Pole	3818.72	2995.30
3	41-60	5	16.1-20.0	23	11.1	14.5	13.7	Ic	5281.79	4148.31
		4	12.1-16.0	20	9.5	12.0	11.2	Id	5178.44	4067.15
		3	8.1-12.0	17	7.7	9.0	8.3	Id	5178.44	4067.15
		2	4.1-8.0	14	4.5	6.0	5.4	Pole	3818.72	2995.30
2	21-40	5	16.1-20.0	15	11.1	14.0	13.2	IIc	4694.67	3687.19
		4	12.1-16.0	16	9.5	10.5	9.7	IId	4321.69	3394.26
		3	8.1-12.0	15	7.7	8.0	7.3	Pole	3818.72	2995.30
		2	4.1-8.0	13	4.5	6.0	5.4	Pole	3818.72	2995.30

Note: Pole class trees have been valued at the lowest rate, that pertaining to class IIId.
Commercial bole length excludes stump, assumed to be 1' from ground.
Diameter at mid-length of commercial bole has been calculated on the assumption of straight-line taper from breast height to top of bole.
Data on commercial bole length and top diameters taken from Sant Ram, 1942 (Tables 5 to 7).

TABLE 7.10 Stand tables for plantation teak, AISQ II (sec. 7.1.3)

CROP AGE yrs	DIA ins	HEIGHT ft	CLASS	TOTAL	1 0-4"	2 4-8"	3 8-12"	4 12-16"	5 16-20"	6 20-24"	7 24-28"
					NO OF STEMS PER ACRE						
5	3.0	26	2	652	632	20	0	0	0	0	0
10	4.6	41	3	347	191	156	0	0	0	0	0
15	6.2	51	3	215	21	186	8	0	0	0	0
20	7.8	61	4	151	2	105	43	1	0	0	0
25	9.3	67	4	114	0	44	66	4	0	0	0
30	10.8	73	4	91	0	13	63	15	0	0	0
35	12.1	77	4	78	0	4	44	28	2	0	0
40	13.4	82	5	67	0	1	26	35	5	0	0
45	14.6	86	5	61	0	1	14	35	10	1	0
50	15.7	89	5	55	0	0	7	30	16	2	0
55	16.7	92	5	52	0	0	3	24	21	4	0
60	17.7	96	5	49	0	0	2	17	23	6	1
65	18.6	99	5	46	0	0	1	11	23	10	1
70	19.4	101	5	44	0	0	0	7	22	13	2
75	20.3	104	5	42	0	0	0	4	19	16	3
80	21.2	106	5	40	0	0	0	2	15	18	5

TABLE 7.11 Stand tables for plantation teak, AISQ III (sec. 7.1.3)

CROP AGE yrs	DIA ins	HEIGHT ft	CLASS	TOTAL	1 0-4"	2 4-8"	3 8-12"	4 12-16"	5 16-20"	6 20-24"
					NO OF STEMS PER ACRE					
5	2.5	18	1	880	792	9	0	0	0	0
10	3.7	30	2	476	409	67	0	0	0	0
15	4.9	38	2	298	131	167	0	0	0	0
20	5.8	45	3	223	36	183	4	0	0	0
25	6.7	50	3	172	10	148	14	0	0	0
30	7.5	55	3	143	3	109	31	0	0	0
35	8.2	58	3	125	1	75	48	1	0	0
40	9.0	62	4	111	1	48	59	3	0	0
45	9.7	65	4	101	0	32	64	5	0	0
50	10.4	68	4	93	0	18	65	10	0	0
55	11.1	71	4	86	0	9	60	16	1	0
60	11.8	73	4	81	0	5	49	25	2	0
65	12.5	76	4	75	0	3	38	31	3	0
70	13.1	78	4	70	0	2	29	35	4	0
75	13.8	80	4	66	0	1	22	36	6	1
80	14.5	82	5	63	0	1	15	36	10	1

Note: Diameter classes as given above; height classes are
Class 1 0-20', 2 21-40', 3 41-60', 4 61-80', 5 81'100'.
Source: FRI, 1959a.

TABLE 7.12 Stand tables for plantation teak, AISQ IV (sec. 7.1.3)

CROP AGE yrs	DIA ins	HEIGHT ft	CLASS	TOTAL	DBH CLASS 1 0-4"	2 4-8"	3 8-12"	4 12-16"	5 16-20"	6 20-24"
					NO OF STEMS PER ACRE					
10	3.	19	1	652	632	20	0	0		
15	3.7	25.	2	455	391	64	0	0		
20	4.3	30.	2	347	229	118	0	0		
25	4.8	34.	2	278	131	147	0	0		
30	5.2	37.	2	244	81	162	1	0		
35	5.6	39.	2	216	48	166	2	0		
40	6.	42.	3	194	25	164	5	0		
45	6.3	44.	3	178	16	155	7	0		
50	6.7	47.	3	162	10	139	13	0		
55	7.1	50.	3	150	6	123	21	0		
60	7.5	52.	3	140	3	106	31	0		
65	7.8	54.	3	133	2	92	38	1		
70	8.2	56.	3	126	1	76	48	1		
75	8.6	58.	3	118	1	60	55	2		
80	9.	59.	3	112	1	48	60	3		

Note: Diameter classes as given above; height classes are
Class 1 0-20', 2 21-40', 3 41-60', 4 61-80', 5 81'100'.
Source: FRI, 1959.

TABLE 7.13 Commercial (and standard) content of teak trees, by size

DBH CLASS ins.	2 4.1-8	3 8.1-12	4 12.1-16	5 16.1-20	6 20.1-24	7 24.1-28	8 28.1-32
HEIGHT CLASS ft	COMMERCIAL OUTTURN, cft(solid) in LOG form						
1 0-20	0.	0.	0.	0.	0.	0.	0.
2 21-40	1.5	4.5	7.0	[7.0]	[7.0	7.0	7.0]
3 41-60	2.	5.5	11.5	20.5	[20.5	20.5	20.5]
4 61-80	2.5	6.5	16.5	30.	46.	63.5	[63.5]
5 81-100	2.5	7.5	21.5	38.5	57.5	79.5	[79.5]
	STANDARD OUTTURN, cft(solid)						
1 0-20	0.	0.	0.	0.	0.	0.	0.
2 21-40	0.	4.5	9.5	16.5	[16.5	16.5	16.5]
3 41-60	0.	6.5	18.0	32.0	[32.0	32.0	32.0]
4 61-80	0.	8.0	24.0	41.0	63.0	88.5	[88.5]
5 81-100	0.	10.0	27.0	47.0	72.5	102.0	[102.0]
	UNIT VALUE AT DEPOT AUCTION RATES, Rs per cmt(solid) LOG form						
1 0-20	0.	0.	0.	0.	0.	0.	0.
2 21-40	2995.30	2995.30	3394.26	3687.19	3687.19	3687.19	3687.19
3 41-60	2995.30	4067.15	4067.15	4148.31	4148.31	4148.31	4148.31
4 61-80	2995.30	4067.15	4067.15	4148.31	4148.31	4926.81	4926.81
5 81-100	2995.30	4067.15	4067.15	4148.31	4148.31	4926.81	4926.81

Note: Standard, and Commercial log, outturn data from Sant Ram (1942). Unit values are those already calculated for respective height-dbh class, cf. Table 7.8.

TABLE 7.14 Commercial yield and unit values of plantation teak, SQII
Unit of **1 hectare** (sec. 7.1.3, App. 2)

AGE yrs	MAIN CROP SOLID VOL TIMBER LOGS cmt(r)	Rs/cmt	FIREWOOD cmt(r)	Rs/cmt	SECONDARY CROP SOLID VOL TIMBER LOGS cmt(r)	Rs/cmt	FIREWOOD cmt(r)	Rs/cmt
5	0.	2995.30	25.88	472.91	0.	0.	18.19	472.91
10	0.53	2995.30	51.07	472.91	0.	2995.30	23.44	472.91
15	6.30	3108.67	64.37	472.91	0.	2995.30	23.44	472.91
20	19.94	3563.37	66.48	472.91	1.05	3108.67	23.79	472.91
25	35.16	3872.27	55.98	472.91	3.41	3563.37	19.59	472.91
30	49.85	4016.63	36.39	472.91	5.51	3563.37	11.89	472.91
35	64.55	4060.00	28.69	472.91	6.56	3872.27	8.75	472.91
40	79.25	4078.48	23.79	472.91	6.83	4016.63	5.95	472.91
45	94.46	4092.67	20.99	472.91	6.56	4060.00	4.20	472.91
50	107.58	4108.68	18.89	472.91	6.3	4078.48	3.15	472.91
55	121.22	4120.60	17.49	472.91	5.51	4078.48	2.45	472.91
60	134.35	4166.65	16.79	472.91	5.25	4092.67	2.1	472.91
65	145.37	4171.90	16.09	472.91	4.99	4108.68	1.75	472.91
70	155.87	4206.91	15.39	472.91	4.73	4108.68	1.4	472.91
75	166.36	4238.74	14.69	472.91	4.73	4120.60	1.4	472.91
80	176.33	4297.34	13.99	472.91	4.73	4166.65	1.05	472.91

TABLE 7.15 Commercial yield and unit values of plantation teak, SQIII
Unit of **1 hectare** (sec. 7.1.3, App. 2)

AGE yrs	MAIN CROP SOLID VOL TIMBER LOGS cmt(r)	Rs/cmt	FIREWOOD cmt(r)	Rs/cmt	SECONDARY CROP SOLID VOL TIMBER LOGS cmt(r)	Rs/cmt	FIREWOOD cmt(r)	Rs/cmt
5	0.	0.	16.79	472.91	0.	0.	13.64	472.91
10	0.	2995.30	34.99	472.91	0.	0.	14.69	472.91
15	1.575	2995.30	47.58	472.91	0.	2995.30	15.04	472.91
20	4.725	3056.07	55.98	472.91	0.	2995.30	13.99	472.91
25	8.393	3216.57	58.78	472.91	0.	2995.30	13.29	472.91
30	13.118	3465.70	60.18	472.91	0.	3056.07	11.89	472.91
35	17.843	3689.29	59.79	472.91	0.29	3216.57	9.80	472.91
40	23.618	3834.56	57.38	472.91	1.05	3465.70	8.05	472.91
45	30.435	3918.93	54.58	472.91	1.84	3465.70	6.30	472.91
50	38.31	3990.89	49.68	472.91	2.89	3689.29	4.90	472.91
55	46.70	4036.46	45.48	472.91	3.41	3834.56	4.20	472.91
60	56.15	4056.54	41.29	472.91	4.20	3918.93	3.50	472.91
65	66.12	4066.29	38.48	472.91	4.46	3990.89	3.15	472.91
70	76.10	4072.07	35.38	472.91	4.46	3990.89	2.80	472.91
75	92.36	4083.37	34.99	472.91	4.46	4036.46	2.45	472.91
80	99.19	4092.11	33.59	472.91	4.46	4056.54	2.10	472.91

Note: Please see next table.

TABLE 7.16 Commercial yield and unit values of plantation teak, SQIV
Unit of **1 hectare** (sec. 7.1.3, App. 2)

AGE	[MAIN CROP			]	[SECONDARY CROP			]
yrs	SOLID VOL				SOLID VOL			
	TIMBER LOGS		FIREWOOD		TIMBER LOGS		FIREWOOD	
	cmt(r)	Rs/cmt	cmt(r)	Rs/cmt	cmt(r)	Rs/cmt	cmt(r)	Rs/cmt
10	0.	0.	19.59	472.91	0.	0.	7.35	472.91
15	0.	2995.30	27.99	472.91	0.	0.	7.0	472.91
20	0.	2995.30	34.99	472.91	0.	0.	6.3	472.91
25	0.	2995.30	39.78	472.91	0.	2995.30	5.6	472.91
30	0.53	2995.30	44.78	472.91	0.	2995.30	4.9	472.91
35	1.05	2995.30	47.58	472.91	0.	2995.30	4.2	472.91
40	2.10	3078.21	51.78	472.91	0.	2995.30	3.5	472.91
45	3.15	3113.71	53.88	472.91	0.	2995.30	3.15	472.91
50	4.73	3214.58	56.68	472.91	0.	2995.30	2.8	472.91
55	7.35	3337.76	58.08	472.91	0.03	2995.30	2.45	472.91
60	10.49	3473.08	58.08	472.91	0.53	3078.21	2.45	472.91
65	14.69	3579.58	58.08	472.91	0.79	3078.21	2.45	472.91
70	19.42	3686.05	57.38	472.91	1.05	3113.71	2.45	472.91
75	24.67	3778.44	55.98	472.91	1.05	3214.58	2.45	472.91
80	30.44	3843.70	55.28	472.91	1.05	3337.76	2.4	472.91

Note: Timber outturn as per yield tables (FRI, 1959a), but reduced from standard volume (solid, underbark) to commercial outturn by multiplying by 0.75.
Firewood outturn as per smallwood volume (solid, overbark).
Unit values as calculated from stand table and unit values by tree size (previous Tables). Represent unit values that would be obtained <u>in the depot</u>, not at stump.

TABLE 7.17 Expenditure on teak plantation (sec. 7.1.3, App. 2)

Note: Work rates are as per schedule of rates, Yellapur Division, sanctioned in 1984-85, renewed to 1986-87.
Daily wage rates, effective from 1-1-1985, are Rs 9.75 for heavy, and Rs 7.80 for light, labour.
Notation: md manday; ha hectare; rmt running metre

TABLE 7.17 (i) Costs of supervision and administration

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
1.	Executive staff, years 1 to 3					
i.	Forest Guard	13500	50 ha	1 ha		270.00
ii.	Forester	15000	100ha	1 ha		150.00
iii.	Ranger	20000	400ha	1 ha		50.00
	TOTAL			1 ha		470.00
2.	Territorial staff, years 1 to end					
i.	Beat Guard	13500	750ha	1 ha		18.00
ii.	Section Forester	15000	2250ha	1 ha		6.67
iii.	Ranger	20000	9000ha	1 ha		2.22
	TOTAL			1 ha		26.89
3.	Direction & admin., years 1 to end					
i.	Division expend.	3337000	148886ha	1 ha		22.41
	TOTAL of 2 & 3			1 ha		49.30,
					roughly,	50.00

Note: Annual administrative expenses assumed to be Rs 50 through life of enterprise. To avoid double counting, however, this Rs 50 not included in cash flow of first year; this affects only the first rotation crop, and may be added to net present value if desired.
Special executive staff provided only during first three years of plantation.

TABLE 7.17 (ii) Teak nursery, 400 standard beds (sec. 7.1.3, App. 2)

Note: Work rates are as per schedule of rates, Yellapur Division, sanctioned in 1984-85, renewed to 1986-87.
Daily wage rates, effective from 1-1-1985, are Rs 9.75 for heavy, and Rs 7.80 for light, labour.
Notation: md manday; ha hectare; rmt running metre

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
1.	Clearing & burning	397.12	1 ha	2 ha	794.24	
2.	Cost of seed (100 bags of 50 kg each)					
i.	Collection of seed	88.80	bag	100 bag	8880.00	
ii.	Pre-treating seed by alternate wetting and drying, for 42 days; 3 men for 100 bags of 50kg each	9.75	1 md	126 md	1228.50	
iii.	Transport of seed (treated) to nursery	(L.S)		5000kg		300.00
3.	Uprooting stumps	14.52	1 no.	400 no	5808.00	
4.	Digging & forming standard beds	15.66	1 bed	400 bed	6264.00	
5.	Sowing seed	1.37	1 bed	400 bed	548.00	
6.	Weeding: 5 times	3.63	1 bed	2000 bed	7260.00	
7.	Watchman from June to March, 305 days	9.75	1 md	305 md	2973.75	
8.	Fencing (500 rmt)					
i.	Preparing posts	0.74	1 post	200 no	148.00	
ii.	Fixing posts	2.55	1 post	200 no	510.00	
iii.	Fixing barbed wire	1.21	1 post	200 no	242.00	
	Labour component	1.80	1 rmt	500 rmt	900.00	
iv.	Transport of posts	(L.S.)		200 no		200.00
v.	Cost of barbed wire	14.00	1 kg	400 kg		5600.00
	Material component	11.60	1 rmt	500 rmt		5800.00
9.	Cost of pesticide	(L.S.)				1000.00
10.	Cost of implements	(L.S.)				1000.00
11.	Cost of fertilizer	(l.s.)				1000.00
	TOTAL	[43756.49=]			34656.49	9100.00
	Expenditure per bed	[109.39=]			86.64	22.75

Note: 4 beds required for 1 ha of teak plantation. Nurseries usually rain-fed; hence no watering provided.
Fencing: 500 rmt; for 4-strand, barbed wire required is 2000 mt, or, at 5mt per kg, 400 kg. Overall cost per 100 rmt Rs 180 labour, Rs 1160 non-labour component; this figure used in following tables.

TABLE 7.17 (iii) Site preparation, planting and aftercare, YEAR 1 (sec. 7.1.3, App.2)

Note: Work rates as per schedule of rates, Yellapur Division, sanctioned in 1984-85, renewed to 1986-87.
Daily wage rates, effective from 1-1-1985, are Rs 9.75 for heavy, and Rs 7.80 for light, labour.
Notation: md manday; ha hectare; rmt running metre

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
1.	Clearing & burning	567.30	1 ha	1 ha	567.30	
2.	Prepn. of stakes, aligning & staking	35.43	1000	2500	40.00	
3.	Nursery (Rs 437.56):					
i.	Labour	86.64	1 bed	4 bed	346.56	
ii.	Material	22.75	1 bed	4 bed		91.00
4.	Planting					
i.	Preparing stumps	12.10	1000	3000		
ii.	Carrying to site	2.70	1000	3000		
iii.	Planting in crowbar hole	21.34	1000	3000		
	Total	36.14	1000	3000	108.42	
5.	Weeding I (heavy)	90.10	1 ha	1 ha	90.10	
6.	Weeding II	72.13	1 ha	1 ha	72.13	
7.	Weeding III	49.54	1 ha	1 ha	49.54	
8.	Scraping grass to 0.5m round plant	56.10	1000	2500	140.25	
9.	Soil working to 0.5m round plant	48.54	1000	2500	121.35	
10.	Watchman from June to March, 305 days, per 20 ha plot	9.75	1 md	15.25 md	148.69	
11.	Fencing (Rs 1206):					
i.	Labour	180.00	100rmt	90 rmt	162.00	
ii.	Material	1160.00	100rmt	90 rmt		1044.00
12.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
13.	Supervisory staff	470.00	1 ha	1 ha		470.00
14.	Annual admin.	50.00	1 ha			
	TOTAL [3471.00=]			1 ha	1866.00	1605.00

Note: Nursery, fencing costs from previous table.
Perimeter of 90 mt derived on basis of rectangular plot of 20 ha, 400 mt by 500 mt.
Annual administrative costs not include for year 1; this only affects first crop, as rotation-year cost covers next crop.

TABLE 7.17 (iv) Planting and tending, YEAR 2 (sec. 7.1.3, App. 2)

Note: Work rates as per schedule of rates, Yellapur Division, sanctioned in 1984-85, renewed to 1986-87.
Daily wage rates, effective from 1-1-1985, are Rs 9.75 for heavy, and Rs 7.80 for light, labour.
Notation: md manday; ha hectare; rmt running metre

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
1.	Clearing weeding	203.80	1 ha	1 ha	203.80	
2.	Prepn. of stakes, aligning & staking	35.43	1000	500	17.72	
3.	Nursery (Rs 109.39):					
i.	Labour	86.64	1 bed	1 bed	86.56	
ii.	Material	22.75	1 bed	1 bed		22.75
4.	Planting					
i.	Preparing stumps	12.10	1000	500		
ii.	Carrying to site	2.70	1000	500		
iii.	Planting in crowbar holes	21.34	1000	500		
	Total	36.14	1000	500	18.07	
5.	Weeding I (heavy)	90.10	1 ha	1 ha	90.10	
6.	Weeding II	72.13	1 ha	1 ha	72.13	
7.	Weeding III	49.54	1 ha			
8.	Scraping grass to 0.5m round plant	56.10	1000	2500	140.25	
9.	Digging and hoeing 0.5m round plant	60.65	1000	2500	151.63	
10.	Watchman from April to March, 365 days, per 20 ha plot	9.75	1 md	18.25 md	177.94	
11.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
12.	Supervisory staff	470.00	1 ha	1 ha		470.00
13.	Annual admin.	50.00	1 ha	1 ha		50.00
	TOTAL [1520.61=]			1 ha	977.86	542.75

Note: Nursery, fencing costs as in previous table.
Perimeter of 90 mt derived on basis of rectangular plot of 20 ha, 400 mt by 500 mt.

TABLE 7.17 (v) Tending, YEAR 3 (sec. 7.1.3, App. 2)

Note: Work rates as per schedule of rates, Yellapur Division, sanctioned in 1984-85, renewed to 1986-87.
Daily wage rates, effective from 1-1-1985, are Rs 9.75 for heavy, and Rs 7.80 for light, labour.
Notation: md manday; ha hectare; rmt running metre

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
1.	Clearing weeding	195.87	1 ha	1 ha	195.87	
2.	Weeding I	97.09	1 ha	1 ha	97.09	
3.	Weeding II	72.13	1 ha	1 ha	72.13	
4.	Watchman from April to March, 365 days, per 40 ha plot	9.75	1 md	9.125 md	88.97	
5.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
6.	Supervisory staff	470.00	1 ha	1 ha		470.00
7.	Annual admin.	50.00	1 ha	1 ha		50.00
	TOTAL [993.72=]			1 ha	473.72	520.00

Note: Perimeter of 90 mt derived on basis of rectangular plot of 20 ha, 400 mt by 500 mt.

TABLE 7.17 (vi) Tending and other operations, YEAR 4 and onward (sec. 7.1.3, App. 2)

Note: Work rates as per schedule of rates, Yellapur Division, sanctioned in 1984-85, renewed to 1986-87.
Daily wage rates, effective from 1-1-1985, are Rs 9.75 for heavy, and Rs 7.80 for light, labour.
Notation: md manday; ha hectare; rmt running metre

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
YEAR 4						
1.	Annual admin.	50.00	1 ha	1 ha		50.00
2.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
YEAR 5						
1.	Dismantling fence					
	i. Labour cost	1.21	1 post	36 post	43.56	
	ii. Value of wire	7.00	1 kg	72kg		504.00(-)
5.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
6.	Annual admin.	50.00	1 ha	1 ha		50.00
	TOTAL [-390.78]			1 ha	63.22	454.00(-)

Note: Salvaged barbed wire valued at half the new cost. Negative values denote net revenue, as against costs.
Perimeter of 90 mt derived on basis of rectangular plot of 20 ha, 400 mt by 500 mt.

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
YEAR 6 and onward						
i.	**Every year**					
1.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
2.	Annual admin.	50.00	1 ha	1 ha		50.00
ii.	**Years 6, 16, 26, and 36**					
	Cutting eupatorium	155.32	1 ha	1 ha	155.32	
iii.	**Years 11, 21, ..., and 71**					
	Heavy cultural operations	204.00	1 ha	1 ha	204.00	

TABLE 7.17 (vi) Tending and other operations, YEAR 4 and onward (contd.)

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
iv.	**First thinning**	(SQII-age 5; SQIII-age 10)				
	Marking	4.84	100trees	1250	60.50	
	Felling, conversion, stacking, etc.	102.07	100	1250	1275.88	
	TOTAL				1336.38	
		(SQIV-age 10)				
	Marking	4.84	100trees	900	43.56	
	Felling, etc.	102.07	100	900	918.63	
	TOTAL				962.19	
v.	**Second thinning**	(SQII-age 10; SQIII-age 15)				
	Marking	9.68	100	625	60.50	
	Felling, etc.	181.55	100	625	1134.69	
	TOTAL				1195.19	
		(SQIV-age 15)				
	Marking	4.84	100	480	23.23	
	Felling, etc.	102.07	100	480	489.94	
	TOTAL				513.17	
vi.	**Third thinning**	(SQII-age 20)				
	Marking	11.56	100	252	29.13	
	Felling, etc.	239.92	100	252	604.60	
	TOTAL				633.38	
		(SQIII-age 20)				
	Marking	11.56	100	185	21.39	
	Felling etc.	239.92	100	185	443.96	
	TOTAL				465.35	
		(SQIV-age 20)				
	Marking	9.68	100	267	25.85	
	Felling, etc.	181.55	100	267	484.74	
	TOTAL				510.58	
vii.	**Fourth thinning**	(SQII-age 25)				
	Marking	12.98	100	81	10.51	
	Felling, etc.	404.78	100	81	327.87	
	TOTAL				338.39	
		(SQIII-age 25)				
	Marking	12.98	100	126	16.36	
	Felling, etc.	404.78	100	126	510.02	
	TOTAL				526.38	
		(SQIV-age 25)				
	Marking	9.68	100	170	16.46	
	Felling, etc.	181.55	100	170	308.64	
	TOTAL				325.09	

Note: First and second are mechanical thinnings. SQII and SQIII crops assumed to have same number of stems removed in these two thinnings; less for SQIV, due to poorer crop. Third and subsequent thinnngs are silvicultural. No. of stems removed depends on crop. Yield table figures followed generally. Thinnings beyond the fourth involve so few stems, that costs of marking and felling are subsumed under general costs.

TABLE 7.18 Expenditure on 1 ha teak plantation, SQII (sec. 7.1.3)

AGE yrs	YEAR	CASH FLOW Rs INFLOW	OUTFLOW LABOUR	OUTFLOW SUPVN. & ADM.	OUTFLOW OTHER	OUTFLOW TOTAL	
0	1	0.	1866.00	470.00	1135.00	3471.00	
1	2	0.	977.86	520.00	22.75	1520.61	
2	3	0.	473.72	520.00		993.72	
3	4	0.	19.66	50.00		69.66	
4	5	504.00	63.22	50.00		113.22	
5	6	0.	1511.36	50.00		1561.36	(I thin)
6-9	7-10	0.	19.66	50.00		69.66	
10	11	0.	1418.85	50.00		1468.85	(II thin)
11-14	12-16	0.	19.66	50.00		69.66	
15	16	0.	174.98	50.00		224.98	
16-19	17-20	0.	19.66	50.00		69.66	
20	21	0.	857.54	50.00		907.54	(III thin)
21-24	22-25	0.	19.66	50.00		69.66	
25	26	0.	513.37	50.00		563.37	(IV thin)
26-29	27-30	0.	19.66	50.00		69.66	
30	31	0.	223.66	50.00		273.66	
31-34	32-35	0.	19.66	50.00		69.66	
35	36	0.	174.98	50.00		224.98	
36-39	37-40	0.	19.66	50.00		69.66	
40	41	0.	223.66	50.00		273.66	
41-49	42-50	0.	19.66	50.00		69.66	
50	51	0.	223.66	50.00		273.66	
51-59	52-60	0.	19.66	50.00		69.66	
60	61	0.	223.66	50.00		273.66	
61-69	62-70	0.	19.66	50.00		69.66	
70	71	0.	223.66	50.00		273.66	
71-80	72-81	0.	19.66	50.00		69.66	

Notes: Please see Table 7.20.

TABLE 7.19 Expenditure on 1 ha teak plantation, SQIII (sec. 7.1.3)

AGE yrs	YEAR	CASH FLOW Rs INFLOW	OUTFLOW LABOUR	SUPVN. & ADM.	OTHER	TOTAL	
0	1	0.	1866.00	470.00	1135.00	3471.00	
1	2	0.	977.86	520.00	22.75	1520.61	
2	3	0.	473.72	520.00		993.72	
3	4	0.	19.66	50.00		69.66	
4	5	504.00	63.22	50.00		113.22	
5	6	0.	174.98	50.00		224.98	
6-9	7-10	0.	19.66	50.00		69.66	
10	11	0.	1560.04	50.00		1610.04	(I thin)
1-14	12-16	0.	19.66	50.00		69.66	
15	16	0.	1370.17	50.00		1420.17	(II thin)
16-19	17-20	0.	19.66	50.00		69.66	
20	21	0.	689.01	50.00		739.01	(III thin)
21-24	22-25	0.	19.66	50.00		69.66	
25	26	0.	701.36	50.00		751.36	(IV thin)
26-29	27-30	0.	19.66	50.00		69.66	
30	31	0.	223.66	50.00		273.66	
31-34	32-35	0.	19.66	50.00		69.66	
35	36	0.	174.98	50.00		224.98	
36-39	37-40	0.	19.66	50.00		69.66	
40	41	0.	223.66	50.00		273.66	
41-49	42-50	0.	19.66	50.00		69.66	
50	51	0.	223.66	50.00		273.66	
51-59	52-60	0.	19.66	50.00		69.66	
60	61	0.	223.66	50.00		273.66	
61-69	62-70	0.	19.66	50.00		69.66	
70	71	0.	223.66	50.00		273.66	
71-80	72-81	0.	19.66	50.00		69.66	

Note: Please see Table 7.20.

TABLE 7.20 Expenditure on 1 ha teak plantation, SQIV (sec. 7.1.3)

AGE yrs	YEAR	CASH FLOW Rs INFLOW	OUTFLOW LABOUR	SUPVN. & ADM.	OTHER	TOTAL	
0	1	0.	1866.00	470.00	1135.00	3471.00	
1	2	0.	977.86	520.00	22.75	1520.61	
2	3	0.	473.72	520.00		993.72	
3	4	0.	19.66	50.00		69.66	
4	5	504.00	63.22	50.00		113.22	
5	6	0.	174.98	50.00		224.98	
6-9	7-10	0.	19.66	50.00		69.66	
10	11	0.	1185.85	50.00		1235.85	(I thin)
11-14	12-16	0.	19.66	50.00		69.66	
15	16	0.	688.15	50.00		738.15	(II thin)
16-19	17-20	0.	19.66	50.00		69.66	
20	21	0.	734.24	50.00		784.24	(III thin)
21-24	22-25	0.	19.66	50.00		69.66	
25	26	0.	500.07	50.00		550.07	(IV thin)
26-29	27-30	0.	19.66	50.00		69.66	
30	31	0.	223.66	50.00		273.66	
31-34	32-35	0.	19.66	50.00		69.66	
35	36	0.	174.98	50.00		224.98	
36-39	37-40	0.	19.66	50.00		69.66	
40	41	0.	223.66	50.00		273.66	
41-49	42-50	0.	19.66	50.00		69.66	
50	51	0.	223.66	50.00		273.66	
51-59	52-60	0.	19.66	50.00		69.66	
60	61	0.	223.66	50.00		273.66	
61-69	62-70	0.	19.66	50.00		69.66	
70	71	0.	223.66	50.00		273.66	
71-80	72-81	0.	19.66	50.00		69.66	

Note: For rates of individual items, please see Table 7.17. Annual administrative charge are not included in year 1, to avoid double counting in rotation year for the infinite series of crops.

TABLE 7.21(i) Financial analysis of teak plantation: 1 ha SQIII (selected entries) (sec. 7.2.2)
Revenue flows: as in Table 7.15; no taxes added.
Expenditure flows: as in Table 7.19.

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	LEAD 10 km SOIL EXP Rs	LEAD 80 km NDR 1st rotn Rs	LEAD 80 km .SOIL EXP Rs
.0000	10	17342.44		12324.96	
	40	142375.90		127096.40	
	75	519628.00		493445.80	
	80	565402.40		537908.10	
.0100	10	15417.98	162786.40	10825.81	114301.30
	40	98500.01	299987.80	87065.29	265162.70
	75	262433.00	499045.30	246849.60	469411.60
	80	274270.40	499689.50	258395.50	470767.10
.0200	10	13683.08	76164.57	9474.72	52739.42
	40	68674.20	125521.90	59950.80	109577.40
	70	124826.60	166441.70	115129.50	153511.70
	75	136344.60	176260.10	126354.00	163344.70
	80	137558.20	173053.10	127577.10	160496.50
.0300	10	12117.20	47350.20	8255.63	32260.40
	40	48239.75	69565.58	41452.89	59778.38
	70	69669.52	79740.55	62843.91	71928.27
	75	73302.74	82265.16	66403.73	74522.63
	80	71872.50	79327.48	65045.55	71792.41
.0400	10	10702.20	32987.14	7154.38	22051.77
	40	34119.76	43096.25	28735.05	36294.90
	60	40002.12	44204.19	34833.27	38492.39
	65	40435.52	43862.64	35300.27	38292.14
	75	41013.50	43298.99	35919.95	37921.60
	80	39399.95	41186.82	34372.16	35931.01
.0500	10	9422.06	24404.02	6158.44	15950.94
	30	22600.45	29403.85	18077.74	23519.67
	40	24271.65	28290.15	19917.03	23214.57
	50	25178.84	27584.30	20988.09	22993.19
	55	25213.58	27062.68	21087.89	22634.43
	80	22759.40	23228.08	18832.72	19220.53
.0600	10	8262.62	18710.43	5256.75	11903.75
	15	12060.07	20695.64	8458.79	14515.69
	20	14969.29	21751.53	11121.60	16160.54
	30	17238.04	20872.09	13443.55	16277.66
	35	17365.51	19962.78	13675.48	15720.85
	40	17332.34	19198.91	13746.11	15226.47
	45	17164.58	18509.28	13664.51	14735.01
	80	13839.95	13972.01	10636.60	10738.10

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	LEAD 10 km SOIL EXP Rs	LEAD 80 km NDR 1st rotn Rs	LEAD 80 km .SOIL EXP Rs
.0750	10	6722.68	13058.66	4059.78	7886.04
	15	9337.44	14104.17	6283.56	9491.30
	20	10993.31	14378.10	7843.85	10258.94
	30	11407.01	12877.94	8433.87	9521.41
	35	10955.71	11902.70	8094.71	8794.41
	40	10461.31	11075.09	7695.78	8147.30
	80	7091.83	7113.68	4596.14	4610.30
.1000	10	4601.06	7488.01	2412.20	3925.74
	15	5867.09	7713.69	3517.36	4624.41
	20	6299.89	7399.83	3992.38	4689.43
	25	5874.33	6471.63	3691.04	4066.35
	40	4276.05	4372.67	2350.88	2404.00
	80	2444.72	2445.91	646.18	646.50
.1250	5	1161.58	2609.88	-176.50	-396.57
	10	2922.57	4223.04	1110.51	1604.66
	15	3368.30	4062.54	1532.15	1847.94
	20	3216.39	3553.36	1478.83	1633.77
	40	1240.60	1251.85	-193.79	-195.55
	80	400.42	400.46	-978.45	-978.53
.1500	5	523.12	1040.36	-675.71	-1343.83
	10	1586.38	2107.27	75.94	100.87
	15	1547.04	1763.81	90.60	103.29
	20	1147.81	1222.51	-194.64	-207.31
	40	-410.29	-411.83	-1531.48	-1537.22
	80	-779.68	-779.69	-1876.88	-1876.91

Note: Extraction and transport costs, Rs per cmt(solid) :

Lead to depot		Felling, conversion	Transport, lotting	Total
10 km	Timber	53.79	35.10	88.89
	Smallwood	47.89	28.30	76.19
80 km	Timber	53.79	146.40	200.19
	Smallwood	47.89	107.54	155.43

TABLE 7.21(ii) Financial analysis of teak plantation: 1 ha SQIII (selected entries) (sec. 7.3.1)
Revenue flows: as in Table 7.15, with **12% added for taxes.**
Expenditure flows: as in table 7.19.

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	LEAD 10 km SOIL EX. Rs	LEAD 80 km NDR 1st rotn. Rs	LEAD 80 km SOIL EX. Rs
.0000	10	20935.80		15918.32	
	40	162745.60		147466.00	
	75	586686.40		560504.20	
	80	638122.40		610628.10	
.0100	10	18706.74	197509.90	14114.57	149024.80
	40	113023.90	344221.30	101589.20	309396.10
	75	297222.30	565200.80	281638.90	535567.20
	80	310526.60	565744.10	294651.60	536821.80
.0200	10	16696.97	92940.90	12488.61	69515.76
	40	79195.20	144752.10	70471.81	128807.60
	70	142273.30	189704.70	132576.10	176774.70
	75	155210.80	200649.50	145220.10	187734.00
	80	156577.10	196979.60	146596.00	184423.00
.0300	10	14882.73	58157.04	11021.16	43067.25
	40	55994.54	80748.59	49207.67	70961.40
	70	80050.09	91621.69	73224.48	83809.41
	75	84130.59	94416.87	77231.56	86674.34
	80	82525.26	91085.20	75698.30	83550.13
.0400	10	13243.04	40818.70	9695.22	29883.33
	40	39943.66	50452.35	34558.96	43651.00
	50	44114.45	51338.42	38849.97	45211.86
	55	45486.31	51435.07	40275.42	45542.69
	60	46532.22	51420.26	41363.38	45708.46
	70	46768.48	49978.05	41676.35	44536.46
	75	47665.80	50321.99	42572.25	44944.60
	80	45853.83	47933.40	40826.04	42677.59
.0500	10	11759.37	30457.86	8495.75	22004.77
	20	21962.45	35246.49	17539.87	28148.90
	30	26859.83	34945.43	22337.13	29061.25
	40	28732.83	33489.94	24378.22	28414.37
	50	29740.32	32581.56	25549.57	27990.45
	55	29774.69	31958.29	25649.01	27530.05
	60	29636.78	31313.15	25562.87	27008.80
	80	27014.16	27570.45	23087.47	23562.90
.0600	10	10415.32	23585.16	7409.46	16778.48
	20	18147.75	26370.07	14300.06	20779.08
	35	20862.45	23982.74	17172.43	19740.81
	40	20820.13	23062.30	17233.89	19089.85
	80	16880.32	17041.40	13676.98	13807.49

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	LEAD 10 km SOIL EX. Rs	LEAD 80 km NDR 1st rotn. Rs	LEAD 80 km SOIL EX. Rs
.0750	20	13568.11	17745.67	10418.65	13626.51
	25	13900.43	16626.89	10829.40	12953.50
	30	14039.99	15850.44	11066.85	12493.91
	35	13527.05	14696.32	10666.06	11588.02
	40	12966.48	13727.24	10200.95	10799.45
	80	9169.87	9198.12	6674.19	6694.75
.1000	10	6168.65	10039.19	3979.79	6476.93
	15	7655.36	10064.79	5305.63	6975.52
	20	8154.04	9577.71	5846.53	6867.31
	40	5864.28	5996.78	3939.11	4028.12
	80	3801.51	3803.37	2002.98	2003.96
.1250	5	2119.88	4763.01	781.79	1756.55
	10	4220.31	6098.24	2408.25	3479.86
	15	4758.58	5739.38	2922.43	3524.77
	20	4589.38	5070.19	2851.82	3150.60
	40	2353.28	2374.63	918.89	927.23
	80	1406.95	1407.06	28.08	28.08
.1500	5	1381.68	2747.85	182.85	363.66
	10	2668.11	3544.18	1157.67	1537.79
	15	2644.25	3014.74	1187.80	1354.23
	20	2192.10	2334.75	849.64	904.93
	40	428.20	429.80	-692.99	-695.59
	80	12.13	12.13	-1085.08	-1085.10

Note: Extraction and transport costs per cmt(solid) are as follows:

Lead to depot		Felling, conversion	Transport, lotting	Total
10 km	Timber	53.79	35.10	88.89
	Smallwood	47.89	28.30	76.19
80 km	Timber	53.79	146.40	200.19
	Smallwood	47.89	107.54	155.43

TABLE 7.21(iii) Financial analysis of teak plantation: 1 ha SQIII (selected entries) (sec. 7.3.2)
Revenue flows: as in Table 7.16; but **50% added**
Expenditure flows: as in Table 7.20.

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	LEAD 10 km SOIL EXP Rs	LEAD 80 km NDR 1st rotn Rs	LEAD 80 km .SOIL EXP Rs
.0000	10	32314.77		27297.29	
	40	227249.60		2211970.10	
	75	799038.30		7772856.10	
	80	868402.40		8840908.20	
.0100	10	29121.17	307467.70	24529.00	258982.60
	40	159016.20	484293.80	1147581.50	449468.60
	75	407388.30	774693.60	3391804.80	745059.90
	80	425337.80	774917.00	4409462.80	745994.60
.0200	10	26240.99	146066.00	22032.62	122640.90
	40	112511.70	205647.60	1103788.30	189703.10
	70	197520.90	263371.00	1187823.80	250441.00
	75	214953.70	277882.40	2204963.10	264967.00
	80	216803.60	272746.70	2206822.50	260190.10
.0300	10	23640.26	92378.72	19778.69	77288.92
	40	80551.34	116161.50	73764.48	106374.30
	70	112921.90	129245.30	1106096.30	121433.00
	75	118418.70	132897.30	1111519.70	125154.70
	80	116259.00	128318.00	1109432.00	120782.90
.0400	10	21289.03	65618.67	17741.21	54683.30
	25	45846.41	73368.02	40511.34	64830.29
	30	51531.22	74501.43	46082.84	66624.42
	40	58386.03	73746.68	53001.32	66945.32
	55	65807.16	74413.50	60596.27	68521.13
	60	67210.90	74271.16	62042.05	68559.35
	70	67523.82	72157.77	62431.70	66716.18
	75	68731.45	72561.52	63637.89	67184.13
	80	66291.13	69297.57	61263.34	64041.75
.0500	10	19160.82	49628.32	15897.20	41175.24
	20	33610.83	53940.43	29188.25	46842.84
	40	42859.94	49955.98	38505.32	44880.39
	50	44185.03	48406.25	39994.28	43815.13
	55	44218.25	47461.11	40092.57	43032.86
	80	40487.55	41321.29	36560.85	37313.74
.0600	10	17232.22	39021.82	14226.36	32215.13
	20	28212.86	40995.45	24365.16	35404.46
	35	31936.11	36712.63	28246.08	32470.69
	40	31864.77	35296.37	28278.54	31323.92
	45	31585.52	34059.98	28085.45	30285.71
	80	26508.18	26761.13	23304.83	23527.22

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	SOIL EXP Rs	LEAD 80 km NDR 1st rotn Rs	.SOIL EXP Rs
.0750	10	14668.86	28493.95	12005.96	23321.32
	15	19070.74	28806.27	16016.86	24193.40
	20	21721.64	28409.63	18572.18	24290.48
	25	22199.94	26554.28	19128.91	22880.89
	30	22377.75	25263.36	19404.61	21906.83
	40	20899.52	22125.71	18133.98	19197.92
	80	15750.34	15798.87	13254.65	13295.49
.1000	5	6363.86	16787.69	4866.65	12838.09
	10	11132.69	18117.94	8943.83	14555.67
	15	13318.22	17509.97	10968.49	14420.69
	20	14025.53	16474.33	11718.01	13763.93
	40	10893.69	11139.82	8968.52	9171.15
	80	8098.03	8101.98	6299.49	6302.57
.1250	5	5154.48	11581.24	3816.39	8574.79
	10	8329.82	12036.38	6517.76	9418.00
	15	9161.14	11049.35	7324.99	8834.75
	20	8937.19	9873.50	7199.63	7953.90
	40	5876.76	5930.09	4442.37	4482.69
	80	4594.27	4594.64	3215.40	3215.66
.1500	5	4100.47	8154.89	2901.64	5770.69
	10	6093.60	8094.42	4583.16	6088.02
	15	6118.72	6976.04	4662.28	5315.53
	20	5499.01	5856.87	4156.55	4427.05
	40	3083.42	3094.97	1962.23	1969.58
	80	2519.50	2519.54	1422.29	1422.31
.1750	5	3179.46	5744.16	2102.85	3799.11
	10	4298.23	5368.44	3030.87	3785.53
	20	3123.68	3252.96	2061.73	2147.05
	40	1362.07	1364.23	455.77	456.49
	80	1115.80	1115.80	219.89	219.89
.2000	5	2372.65	3966.83	1403.61	2346.70
	10	2848.13	3396.71	1777.97	2120.44
	20	1445.44	1484.16	587.39	603.12
	40	205.21	205.34	-545.20	-545.57
	80	97.01	97.01	-648.84	-648.84

Note: Extraction and transport costs, Rs per cmt(solid) :

Lead to depot		Felling, conversion	Transport, lotting	Total
10 km	Timber	53.79	35.10	88.89
	Smallwood	47.89	28.30	76.19
80 km	Timber	53.79	146.40	200.19
	Smallwood	47.89	107.54	155.43

TABLE 7.21(iv) Financial analysis of teak plantation: 1 ha SQIII (selected entries) (sec. 7.3.3)
Revenue flows: as in Table 7.15, but **smallwood price halved**
Expenditure flows: as in table 7.19.

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	LEAD 10 km SOIL EX. Rs	LEAD 80 km NDR 1st rotn. Rs	LEAD 80 km SOIL EX. Rs
.0000	10	2370.11		-2647.37	
	40	105070.40		89790.85	
	75	481161.50		454979.30	
	80	526770.40		499276.10	
.0100	10	1714.78	18105.03	-2877.39	-30380.08
	40	69949.10	213034.30	58514.38	178209.20
	75	235391.00	447621.80	219807.50	417988.20
	80	247344.10	450632.80	231469.10	421710.40
.0200	10	1125.17	6263.07	-3083.19	-17162.08
	40	46401.88	84812.83	37678.49	68868.31
	70	104608.30	139482.90	94911.13	126552.90
	75	116213.10	150235.00	106222.50	137319.60
	80	117569.40	147906.50	107588.30	135349.90
.0300	10	594.14	2321.69	-3267.43	-12768.11
	40	30533.30	44031.46	23746.43	34244.26
	70	53879.01	61667.47	47053.40	53855.19
	75	57604.34	64647.38	50705.33	56904.85
	80	56282.38	62120.28	49455.43	54585.20
.0400	10	115.37	355.60	-3432.45	-10579.77
	40	19782.49	24987.02	14397.79	18185.67
	70	27453.36	29337.40	22361.23	23895.81
	75	28322.66	29900.95	23229.11	24523.55
	80	26779.70	27994.21	21751.91	22738.40
.0500	10	-316.70	-820.27	-3580.32	-9273.35
	40	12458.53	14521.21	8103.92	9445.63
	50	14001.75	15339.41	9811.00	10748.29
	55	14258.24	15303.90	10132.56	10875.65
	60	14304.93	15114.07	10231.02	10809.73
	65	14048.86	14663.97	10016.80	10455.37
	80	12256.35	12508.74	8329.66	8501.19
.0600	10	-706.99	-1600.95	-3712.85	-8407.63
	40	7439.95	8241.17	3853.71	4268.73
	50	7564.03	7998.24	4140.53	4378.21
	55	7320.35	7629.87	3956.09	4123.36
	80	4914.97	4961.87	1711.62	1727.95
.0750	10	-1223.50	-2376.63	-3886.40	-7549.25
	25	2572.56	3077.15	-498.47	-596.24
	30	3032.68	3423.75	59.54	67.22
	40	2670.56	2827.25	-94.97	-100.54
	80	-104.50	-104.82	-2600.19	-2608.20

TABLE 7.22(i) Financial analysis of teak plantation: 1 ha SQIV (selected entries) (sec. 7.2.3)
Revenue flows: as in Table 7.16; no taxes added.
Expenditure flows: as in Table 7.20.

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	SOIL EXP Rs	LEAD 80 km NDR 1st rotn Rs	.SOIL EXP Rs
.0000	10	3283.96		1149.23	
	40	30312.02		22896.77	
	75	131371.60		119285.80	
	80	158384.20		145404.60	
.0100	10	2441.13	25773.96	508.59	5369.79
	40	19581.22	59635.81	14198.96	43243.80
	75	62856.23	119528.00	55983.86	106459.50
	80	72433.39	131965.40	65323.07	119011.20
.0200	10	1688.20	9397.07	-63.02	-350.80
	40	12260.83	22410.20	8294.02	15159.72
	75	29756.14	38467.39	25572.76	33059.30
	80	32876.56	41359.89	28663.17	36059.30
.0300	10	1015.05	3966.49	-573.39	-2240.62
	40	7228.05	10423.43	4257.59	6139.79
	75	13475.60	15123.21	10739.39	12052.45
	80	14317.32	15802.39	11604.61	12808.30
.0400	10	412.78	1272.30	-1029.36	-3172.78
	15	2289.54	5148.09	356.55	801.70
	20	3101.33	5705.04	906.66	1667.85
	25	3197.66	5117.22	919.49	1471.46
	40	3739.54	4723.37	1478.67	1867.69
	75	5283.73	5578.17	3367.87	3555.55
	80	5390.12	5634.57	3502.98	3661.85
.0500	10	-126.45	-327.52	-1436.99	-3721.93
	15	1272.78	2452.45	-418.44	-806.28
	20	1690.75	2713.40	-166.73	-267.57
	25	1519.91	2156.83	-354.49	-503.03
	40	1300.44	1515.75	-448.70	-522.99
	75	1039.30	1066.77	-382.96	-393.09
	80	952.39	972.00	-447.87	-457.09

Note: Extraction and transport costs, Rs per cmt(solid) :

Lead to depot		Felling, conversion	Transport, lotting	Total
10 km	Timber	53.79	35.10	88.89
	Smallwood	47.89	28.30	76.19
80 km	Timber	53.79	146.40	200.19
	Smallwood	47.89	107.54	155.43

TABLE 7.22(ii) Financial analysis of teak plantation: 1 ha SQIV (selected entries) (sec. 7.3.1)
Revenue flows: as in Table 7.16; **12% added for taxes**
Expenditure flows: as in Table 7.20.

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	LEAD 10 km SOIL EXP Rs	LEAD 80 km NDR 1st rotn Rs	LEAD 80 km .SOIL EXP Rs
.0000	10	4812.78		2678.06	
	40	36230.91		28815.65	
	75	150265.90		138180.10	
	80	180650.20		167670.60	
.0100	10	3825.15	40386.78	1892.61	19982.61
	40	23844.41	72619.61	18462.15	56227.61
	75	72663.87	138178.30	65791.49	125109.70
	80	83431.50	152002.70	76321.19	139048.50
.0200	10	2942.36	16378.18	1191.14	6630.32
	40	15377.23	28106.33	11410.43	20855.84
	75	35102.27	45378.63	30918.89	39970.54
	80	38607.64	48569.79	34394.24	43269.19
.0300	10	2152.64	8411.83	564.20	2204.72
	40	9541.89	13760.17	6571.43	9476.52
	75	16574.57	18601.07	13838.36	15530.32
	80	17518.16	19335.23	14805.45	16341.15
.0400	10	1445.60	4455.73	3.45	10.65
	15	3673.88	8260.83	1740.89	3914.44
	20	4673.08	8596.35	2478.41	4559.15
	40	5485.41	6928.55	3224.54	4072.88
	75	7212.54	7614.46	5296.68	5591.84
	80	7330.21	7662.64	5443.07	5689.92
.0500	10	812.12	2103.45	-498.42	-1290.96
	15	2483.98	4786.25	792.76	1527.52
	20	3021.02	4848.29	1163.54	1867.31
	25	2862.29	4061.73	987.90	1401.88
	40	2639.53	3076.54	890.39	1037.81
	80	2233.08	2279.06	832.82	849.97
.0600	5	-5707.02	-22580.44	-5707.02	-22580.44
	10	244.13	552.82	-947.89	-2146.47
	15	1461.56	2508.11	-20.57	-35.30
	20	1658.29	2409.62	81.45	118.35
	40	623.52	690.67	-751.69	-832.64
	80	-437.11	-441.29	-1528.46	-1543.05

TABLE 7.22(iii) Financial analysis of teak plantation: 1 ha SQIV (selected entries) (sec. 7.3.2)
Revenue flows: as in Table 7.16; but **50% added**
Expenditure flows: as in Table 7.20.

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	LEAD 10 km SOIL EXP Rs	LEAD 80 km NDR 1st rotn Rs	LEAD 80 km .SOIL EXP Rs
.0000	10	9654.05		7519.33	
	40	54974.06		47558.80	
	75	210098.00		198012.30	
	80	251159.10		238179.50	
.0100	10	8207.89	86660.75	6275.35	66256.58
	40	37344.50	113735.00	31962.24	97342.97
	75	103721.40	197237.60	96848.99	184169.00
	80	118258.90	215454.20	111148.60	202500.00
.0200	10	6913.90	38485.04	5162.68	28737.18
	40	25245.85	46144.08	21279.05	38893.59
	75	52031.70	67264.22	47848.31	61856.14
	80	56756.04	71401.12	52542.64	66100.52
.0300	10	5755.00	22488.73	4166.56	16281.63
	40	16869.05	24326.52	13898.58	20042.87
	75	26387.97	29614.32	23651.76	26543.56
	80	27654.16	30522.59	24941.45	27528.51
.0400	10	4716.19	14536.61	3274.05	10091.52
	15	8057.64	18117.85	6124.66	13771.47
	20	9650.30	17752.16	7455.63	13714.97
	40	11013.99	13911.63	8753.12	11055.96
	80	13473.81	14084.87	11586.67	12112.15
.0500	10	3784.24	9801.54	2473.70	6407.12
	15	6319.45	12176.62	4628.23	8917.89
	20	7233.53	11608.75	5376.05	8627.77
	25	7113.17	10093.94	5238.77	7434.08
	30	7357.22	9571.96	5489.17	7141.57
	40	6879.97	8019.05	5130.83	5980.31
	80	6288.59	6418.09	4888.33	4988.99
.0600	10	2947.47	6674.46	1755.45	3975.17
	15	4822.84	8276.21	3340.71	5732.81
	20	5234.34	7605.90	3657.50	5314.63
	25	4817.80	6281.35	3267.64	4260.28
	40	3929.61	4352.80	2554.40	2829.49
	80	2457.12	2480.57	1365.78	1378.81
.0750	10	1848.57	3590.81	812.82	1578.88
	15	2955.17	4463.77	1735.54	2621.53
	20	2856.67	3736.22	1616.39	2114.07
	40	962.41	1018.88	-24.46	-25.90
	80	-457.85	-459.26	-1257.68	-1261.55

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	SOIL EXP Rs	LEAD 80 km NDR 1st rotn Rs	.SOIL EXP Rs
.1000	15	622.76	818.77	-265.52	-349.09
	20	96.80	113.70	-746.87	-877.27
	40	-1767.42	-1807.35	-2375.95	-2429.63
	80	-2527.05	-2528.28	-3052.10	-3053.60

TABLE 7.22(iv) Financial analysis of teak plantation: 1 ha SQIV (selected entries) (sec. 7.3.3)
Revenue flows: as in Table 7.16; but **smallwood prices halved**
Expenditure flows: as in Table 7.20.

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	SOIL EXP Rs	LEAD 80 km NDR 1st rotn Rs	.SOIL EXP Rs
.0000	10	-3086.14		-5220.87	
	40	8882.11		1466.86	
	75	104645.10		92559.26	
	80	131255.80		118276.20	
.0100	10	-3325.64	-35112.82	-5258.18	-55517.00
	40	3988.81	12148.16	-1393.45	-4243.84
	75	46812.02	89018.20	39939.64	75949.62
	80	56512.43	102959.20	49402.12	90005.03
.0200	10	-3537.50	-19690.92	-5288.72	-29438.78
	40	739.60	1351.83	-3227.21	-5898.65
	75	19423.41	25109.70	15240.02	19701.61
	80	22743.96	28612.71	18530.57	23312.12
.0300	10	-3724.90	-14555.75	-5313.34	-20762.87
	40	-1422.11	-2050.80	-4392.57	-6334.44
	75	6355.33	7132.36	3619.12	4061.61
	80	7357.39	8120.54	4644.69	5126.46
.0400	10	-3890.63	-11992.00	-5332.78	-16437.09
	40	-2861.69	-3614.57	-5122.56	-6470.24
	75	78.25	82.61	-1837.62	-1940.02
	80	291.61	304.83	-1595.53	-1667.89

Note: Extraction and transport costs, Rs per cmt(solid) :

Lead to depot		Felling, conversion	Transport, lotting	Total
10 km	Timber	53.79	35.10	88.89
	Smallwood	47.89	28.30	76.19
80 km	Timber	53.79	146.40	200.19
	Smallwood	47.89	107.54	155.43

TABLE 7.23(i) Financial analysis of teak plantation: 1 ha SQIII (selected entries) (sec. 7.3.4)

Revenue flows: as in Table 7.15; no taxes added; **inflation at 2% in output prices.**
Expenditure flows: as in Table 7.19.

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	LEAD 10 km SOIL EXP Rs	LEAD 80 km NDR 1st rotn Rs	LEAD 80 km .SOIL EXP Rs
.0300	10	16524.76	252641.20	12663.19	237551.50
	40	105436.50	353396.90	98649.64	343609.70
	75	276622.20	546702.60	269723.20	538960.00
	80	289250.40	546388.10	282423.50	538853.00
.0400	10	14729.86	110515.10	11182.04	99579.73
	40	74349.66	146143.10	68964.95	139341.80
	75	146455.70	194546.80	141362.20	189169.40
	80	147984.60	190888.90	142956.80	185633.10
.0500	10	13106.74	65999.30	9843.12	57546.22
	40	52855.10	80768.71	48500.48	75693.13
	70	76313.73	89357.95	72324.15	85232.77
	75	80332.75	91936.50	76359.77	87858.52
	80	78965.16	88704.47	75038.48	84696.92
.0600	10	11637.30	44835.49	8631.43	38028.81
	25	28697.84	50160.98	24848.98	45142.91
	30	32793.41	50849.63	28998.93	46255.20
	40	37867.39	50162.07	34281.15	46189.63
	55	43425.11	50477.13	40060.85	46970.62
	70	44966.66	48870.71	41716.98	45565.09
	75	45924.55	49175.34	42691.88	45901.25
	80	44272.30	46856.79	41068.96	43622.88
.0750	10	9686.69	28342.29	7023.79	23169.67
	20	18467.79	30811.56	15318.34	26692.40
	40	23257.94	27341.89	20492.40	24414.10
	50	23532.33	25888.54	20897.68	23181.09
	75	21626.17	22213.51	19117.04	19693.28
	80	20572.45	21009.12	18076.76	18505.74
.1000	10	7001.58	15403.72	4812.72	11841.46
	15	9713.07	15781.14	7363.34	12691.87
	20	11325.40	15532.64	9017.89	12822.25
	25	11555.88	14318.96	9372.60	11913.68
	30	11580.83	13421.34	9502.71	11216.88
	35	11063.06	12268.36	9073.85	10205.76
	40	10517.75	11314.27	8592.58	9345.60
	80	7270.54	7304.70	5472.01	5505.29
.1250	5	1992.75	7431.53	654.66	4425.08
	10	4879.55	9043.30	3067.49	6424.93
	15	6238.50	8862.64	4402.35	6648.04
	20	6668.13	8249.32	4930.57	6329.72
	40	4601.80	4784.86	3167.41	3337.45
	80	2878.49	2882.13	1499.62	1503.15
.1500	5	1267.79	4323.55	68.96	1939.36
	10	3191.96	5333.01	1681.52	3326.61
	15	3716.15	4893.69	2259.71	3233.18
	40	1595.72	1642.75	474.53	517.36
	80	798.42	798.87	-298.79	-298.35
.1750	5	635.57	2322.89	-441.04	377.84
	10	1841.83	2940.72	574.47	1357.81
	15	1863.59	2390.47	691.69	1104.07
	40	-89.30	-76.31	-995.61	-984.05
	80	-445.23	-445.17	-1341.14	-1341.08
.2000	5	82.94	941.35	-886.10	-678.78
	10	755.52	1294.30	-314.63	18.02
	40	-1128.37	-1124.63	-1878.77	-1875.55
	80	-1286.43	-1286.42	-2032.28	-2032.27

TABLE 7.23(ii) Financial analysis of teak plantation: 1 ha SQIII (selected entries) (sec. 7.3.4)

Revenue flows: as in Table 7.15; no taxes added; **inflation 5%-10%**
Expenditure flows: as in Table 7.19.

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	LEAD 10 km SOIL EXP Rs	LEAD 80 km NDR 1st rotn Rs	LEAD 80 km SOIL EXP Rs
Inflation at 5% in output prices					
.1000	10	11404.16	39633.66	9215.30	36071.39
	20	22608.40	41693.92	20300.89	38983.52
	40	30580.50	37661.27	28655.33	35692.60
	55	32188.95	35588.34	30356.29	33745.94
	60	32223.38	34880.39	30403.57	33054.57
	75	31345.06	32604.39	29543.28	30801.19
	80	29994.64	30953.76	28196.11	29154.35
.1100	10	10144.04	30385.67	8116.20	27255.39
	20	18860.05	31162.33	16806.66	28818.19
	40	22575.34	26221.38	20875.73	24495.21
	75	20131.97	20578.55	18521.96	18967.90
	80	19207.71	19534.23	17599.51	17925.64
.1200	10	8996.57	23940.56	7115.78	21166.64
	15	12991.21	24199.45	11064.56	21842.13
	20	15703.03	23873.21	13867.93	21825.87
	30	17292.65	21316.38	15670.62	19638.33
	40	16760.50	18713.61	15245.83	17182.48
	80	12919.66	13039.93	11470.59	11590.70
.1300	5	3184.63	17604.05	1875.88	14741.78
	10	7950.62	19219.43	6204.30	16743.82
	15	11134.17	19163.06	9383.22	17078.86
	25	13417.53	17088.58	11888.23	15483.69
	30	13525.81	15985.37	12076.58	14498.12
	40	12488.21	13569.09	11127.27	12197.82
	80	9038.29	9085.45	7724.31	7771.39
.1400	5	2832.86	14341.15	1580.52	11735.54
	10	6996.27	15629.85	5373.04	13407.02
	15	9502.09	15347.57	7907.03	13492.64
	20	10777.42	14609.66	9293.43	13009.22
	25	10757.14	13167.22	9383.06	11739.17
	40	9310.42	9925.49	8078.93	8687.45
	80	6493.48	6512.87	5295.56	5314.91
.1500	5	2499.83	11797.20	1301.00	9413.00
	10	6124.67	12820.57	4614.22	10814.18
	15	8065.15	12375.23	6608.71	10714.72
	20	8858.16	11542.13	7515.70	10112.31
	40	6915.50	7274.11	5794.30	6148.71
	80	4723.83	4732.09	3626.63	3634.87
Inflation at 7.5% in output prices					
.1000	10	15956.71	105122.70	13767.85	101560.50
	40	70269.38	122597.60	68344.21	120628.90
	70	113175.20	143681.10	111369.90	141873.60
	75	121459.70	149734.30	119657.90	147931.10
	80	121338.70	145941.10	119540.10	144141.70
.1100	10	14329.67	69567.40	12301.83	66437.12
	40	51407.18	74310.61	49707.58	72584.45
	70	67974.93	77049.42	66362.84	75436.23
	75	70643.54	78507.83	69033.54	76897.18
	80	69009.67	75476.95	67401.47	73868.36

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	LEAD 10 km SOIL EXP Rs	LEAD 80 km NDR 1st rotn Rs	LEAD 80 km SOIL EXP Rs
.1200	10	12848.72	50171.47	10967.94	47397.56
	15	20060.27	51634.86	18133.63	49277.54
	20	26253.06	52539.95	24417.96	50492.61
	40	37925.62	48930.29	36410.95	47399.16
	70	42359.81	45390.36	40908.50	43938.54
	75	42910.25	45379.07	41460.18	43928.71
	80	41316.10	43247.45	39867.04	41798.21
.1300	10	11499.39	38060.40	9753.06	35584.79
	15	17406.71	38752.67	15655.76	36668.47
	20	22056.49	38881.69	20409.59	37078.29
	40	28203.15	33818.96	26842.21	32447.69
	50	28848.82	32132.62	27519.28	30800.12
	55	28771.14	31278.23	27448.34	29953.83
	80	26113.99	26752.54	24800.00	25438.48
.1400	10	10268.76	29835.37	8645.52	27612.54
	15	15078.03	30019.15	13482.97	28164.22
	20	18512.39	29670.49	17028.40	28070.04
	35	21203.44	25364.20	19945.40	24093.20
	40	21123.09	24118.95	19891.61	22880.91
	80	17390.04	17619.97	16192.12	16422.02
.1500	5	3639.92	22695.73	2441.09	20311.54
	10	9145.30	23918.62	7634.86	21912.23
	15	13030.88	23753.17	11574.43	22092.66
	20	15511.13	23104.52	14168.67	21674.70
	30	16684.44	20246.96	15504.85	19049.29
	40	15912.66	17568.63	14791.47	16443.24
	80	12118.06	12206.83	11020.85	11109.61

Inflation at 10% in output prices

.1100	10	19406.92	306604.40	17379.08	303474.10
	40	116191.60	402020.00	114492.00	400293.90
	75	298752.80	615023.50	297142.80	613412.80
	80	312792.70	615116.20	311184.50	613507.60
.1200	10	17518.50	142951.80	15637.72	140177.80
	40	84663.91	172507.30	83149.24	170976.20
	70	152555.70	216068.40	151104.30	214616.60
	75	166909.10	228053.00	165459.00	226602.70
	80	169291.00	224273.10	167841.90	222823.90
.1300	10	15798.60	88949.35	14052.28	86473.75
	40	62216.88	98408.66	60855.95	97037.39
	70	91263.25	109034.70	89947.98	107719.20
	75	96473.67	112464.20	95159.14	111149.50
	80	95368.73	108936.70	94054.74	107622.70
.1400	10	14230.64	62280.64	12607.41	60057.80
	15	22522.14	64064.34	20927.08	62209.42
	20	29886.00	65408.85	28402.01	63808.41
	25	34929.37	64206.62	33555.29	62778.57
	40	46112.49	63005.93	44881.01	61767.89
	70	56489.47	62218.14	55290.82	61019.36
	75	58025.25	62861.34	56827.02	61663.05
	80	56314.60	60207.48	55116.68	59009.52
.1500	10	12799.82	46499.00	11289.37	44492.61
	15	19646.95	47321.83	18190.50	45661.32
	20	25252.77	47658.85	23910.32	46229.03
	25	28600.25	46073.05	27359.09	44793.02
	40	34462.54	42945.74	33341.35	41820.35
	60	37005.93	40317.04	35906.90	39217.76
	65	36867.45	39472.13	35769.33	38373.87
	80	35025.23	36271.27	33928.02	35174.04

TABLE 7.24 Financial analysis of teak plantation: 1 ha SQIII (selected entries) (sec. 7.3.5)

Revenue flows: as in Table 7.15; no taxes added.
Expenditure flows: as in Table 7.19; **Rs 25.00 added to annual administrative charges of Rs 50.00, total Rs 75.00**

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	LEAD 10 km SOIL EXP Rs	LEAD 80 km NDR 1st rotn Rs	LEAD 80 km .SOIL EXP Rs
.0000	10	17092.44		12074.96	
	40	141375.90		126096.40	
	75	517753.00		491570.80	
	80	563402.40		535908.10	
.0100	10	15181.19	160286.40	10589.03	111801.30
	40	97679.14	297487.80	86244.42	262662.70
	75	261118.30	496545.30	245534.90	466911.60
	80	272898.20	497189.50	257023.30	468267.10
.0200	10	13458.52	74914.58	9250.15	51489.43
	40	67990.31	124271.90	59266.92	108327.40
	70	123889.20	165191.70	114192.00	152261.70
	75	135377.70	175010.10	125387.00	162094.70
	80	136564.60	171803.10	126583.50	159246.50
.0300	10	11903.94	46516.86	8042.37	31427.07
	40	47661.88	68732.24	40875.02	58945.04
	70	68941.43	78907.23	62115.82	71094.95
	75	72560.20	81431.83	65661.18	73689.30
	80	71117.48	78494.15	64290.53	70959.07
.0400	10	10499.43	32362.14	6951.61	21426.77
	40	33624.94	42471.25	28240.23	35669.90
	60	39436.53	43579.19	34267.69	37867.39
	65	39859.36	43237.64	34724.11	37667.14
	70	39629.30	42348.93	34537.17	36907.34
	75	40421.49	42673.99	35327.94	37296.60
	80	38802.07	40561.82	33774.28	35306.01
.0500	10	9229.02	23904.02	5965.40	15450.95
	25	20157.68	28604.76	15642.86	22197.99
	30	22216.14	28903.85	17693.43	23019.67
	40	23842.67	27790.14	19488.05	22714.57
	50	24722.44	27084.30	20531.69	22493.18
	55	24747.74	26562.68	20622.06	22134.42
	80	22269.50	22728.08	18342.80	18720.53
.0600	10	8078.62	18293.76	5072.75	11487.08
	20	14682.55	21334.87	10834.85	15743.87
	25	15881.39	20705.83	12032.53	15687.76
	30	16893.92	20455.42	13099.43	15861.00
	35	17003.05	19546.11	13313.03	15304.18
	40	16956.19	18782.24	13369.95	14809.80
	80	13427.22	13555.34	10223.87	10321.43
.0750	10	6551.08	12725.33	3888.18	7552.70
	20	10738.44	14044.76	7588.99	9925.61
	25	11000.86	13158.59	7929.83	9485.20
	30	11111.75	12544.61	8138.61	9188.08
	40	10146.45	10741.75	7380.92	7813.96
	80	6759.52	6780.34	4263.83	4276.97
.1000	10	4447.44	7238.01	2258.58	3675.74
	15	5676.94	7463.69	3327.21	4374.41
	20	6087.05	7149.82	3779.54	4439.43
	25	5647.40	6221.63	3464.12	3816.35
	40	4031.57	4122.66	2106.41	2154.00
	80	2194.84	2195.91	396.30	396.50

DISC. RATE	ROTN Years	LEAD 10 km NDR 1st rotn. Rs	LEAD 10 km SOIL EXP Rs	LEAD 80 km NDR 1st rotn Rs	LEAD 80 km SOIL EXP Rs
.1250	5	1072.57	2409.88	-265.52	-596.57
	10	2784.16	4023.04	972.10	1404.66
	15	3202.48	3862.54	1366.33	1647.94
	20	3035.36	3353.36	1297.80	1433.77
	40	1042.40	1051.85	-391.99	-395.55
	80	200.44	200.46	-1178.43	-1178.53
.1500	5	439.32	873.70	-759.51	-1510.50
	10	1460.91	1940.60	-49.53	-65.79
	15	1400.86	1597.14	-55.58	-63.37
	20	991.33	1055.84	-351.13	-373.98
	40	-576.34	-578.50	-1697.53	-1703.89
	80	-946.34	-946.35	-2043.55	-2043.58
.1750	5	-112.25	-202.79	-1188.86	-2147.85
	10	402.01	502.10	-865.35	-1080.82
	15	73.51	80.69	-1098.39	-1205.71
	40	-1547.76	-1550.21	-2454.07	-2457.95
	80	-1709.28	-1709.29	-2605.19	-2605.20

Note: Extraction and transport costs, Rs per cmt(solid) :

Lead to depot		Felling, conversion	Transport, lotting	Total
10 km	Timber	53.79	35.10	88.89
	Smallwood	47.89	28.30	76.19
80 km	Timber	53.79	146.40	200.19
	Smallwood	47.89	107.54	155.43

TABLE 7.25 Stand tables for Conversion working circle, Yellapur Dn. (sec. 7.4.3, 10.2.1)

DBH CLASS: HEIGHT CLASS	TOTAL 12" +	4 12-16"	5 16-20"	6 20-24"	7 24-28"	8 28"-32	Rs/cmt Log, solid
	----------- NO OF STEMS PER ACRE -------------						
FS1: 4653.9 acres (1883.4ha); AISQIII; conversion period 27 yrs							
5 TEAK Sound	3.824	1.658	1.061	0.585	0.409	0.111	
Unsound	0.757	0.381	0.211	0.108	0.035	0.022	
Total	4.581						
Volume, cmt log, solid: Sound	4.29						4341.68
Annual yield, Teakwood: as per WPlan:	360 Tons/172 acres = 104.65 cft(qg)/acre = 133.24 cft(s)/acre = 3.77 cmt log(s)/acre= 9.32 cmt log(s)/ha						
Junglewood:	3 * 3.77 = 11.31 cmt log(s)/acre= 27.95 cmt log(s)/ha						1736.67
FS2: 7164.3 acres (2899.3ha); AISQIII; conversion period 30 yrs							
5 TEAK Sound	3.280	1.763	0.923	0.441	0.122	0.031	
Unsound	0.612	0.314	0.161	0.096	0.031	0.010	
Total	3.812						
Volume, cmt log, solid: Sound	3.14						4495.61
Annual yield, Teakwood: as per WPlan:	314 Tons/238 acres = 65.97 cft(qg)/acre = 83.99 cft(s)/acre = 2.38 cmt log(s)/acre= 5.88 cmt log(s)/ha						
Junglewood:	3 * 2.38 = 7.14 cmt log(s)/acre= 17.64 cmt log(s)/ha						1798.24
FS3: 9368.2 acres (3791.3 ha); AISQIV; conversion period 40 yrs							
3 TEAK Sound	2.350	1.565	0.587	0.148	0.043	0.007	
Unsound	0.537	0.339	0.113	0.043	0.033	0.009	
Total	2.887						
Volume, cmt log, solid: Sound	0.96						4105.46
Annual yield, Teakwood: as per WPlan:	151 Tons/234 acres = 32.26 cft(qg)/acre = 41.08 cft(s)/acre = 1.16 cmt log(s)/acre= 2.87 cmt log(s)/ha						
Junglewood	3 * 1.16 = 3.49 cmt log(s)/acre= 8.62 cmt log(s)/ha						1642.18

----------- NO OF STEMS PER ACRE -------------

DBH CLASS: HEIGHT CLASS	TOTAL 12" +	4 12-16"	5 16-20"	6 20-24"	7 24-28"	8 28"-32	Rs/cmt Log, solid
FS4: 7477.4 acres (3026.1 ha); AISQIV; conversion period 30 yrs							
3 TEAK Sound	1.198	1.433	0.806	0.211	0.030	0.018	
Unsound	0.376	0.217	0.104	0.033	0.008	0.014	
Total	1.574						
Volume, cmt log, solid: Sound	1.08						4113.40

Annual yield, Teakwood: 204 Tons/249 acres = 40.96 cft(qg)/acre =
as per WPlan: 52.16 cft(s)/acre = 1.48 cmt log(s)/acre=
3.66 cmt log(s)/ha
Junglewood: 3 * 1.48 = 4.44 cmt log(s)/acre= 1645.36
10.98 cmt log(s)/ha

DBH CLASS: HEIGHT CLASS	TOTAL 12" +	4 12-16"	5 16-20"	6 20-24"	7 24-28"	8 28"-32	Rs/cmt Log, solid
FS5: 4983.5 acres (2016.8 ha); AISQIV; conversion period 20 yrs							
3 TEAK Sound	3.632	2.299	0.985	0.257	0.065	0.026	
Unsound	1.308	0.669	0.411	0.157	0.046	0.025	
Total	4.940						
Volume, cmt log, solid: Sound	1.52						4108.40

Annual yield, Teakwood: 303 Tons/249 acres = 60.85 cft(qg)/acre =
as per WPlan: 77.48 cft(s)/acre = 2.19 cmt log(s)/acre=
5.41 cmt log(s)/ha
Junglewood: 3 * 2.19 = 6.57 cmt log(s)/acre= 1643.36
16.23 cmt log(s)/ha

Note: Diameter classes as given above; height classes are
Class 1 0-20', 2 21-40', 3 41-60', 4 61-80', 5 81'100'.
Source: Wesley (1964).

TABLE 7.26(i) Financial analysis of conversion of FS1 (sec. 7.4.4)
Area of estate: 100 ha, SQIII
Revenue flows: as in Table 7.25; **TEAK TIMBER ONLY;**
timber price at depot Rs 4341.68/cmt(log,s); no taxes added.
Expenditure flows: Rs 50 admin. charges + Rs 19.66 fire prot. per ha.

DISC. RATE	CONV. PERIOD Years	LEAD 10km NDR, Rs	SE, Rs	LEAD 80km NDR, Rs	SE, Rs
.0000	100	3266195.00		3162485.00	
.0500	100	648271.40	653239.00	627687.10	632496.90
.1000	100	326595.50	326619.20	316225.20	316248.10
.1500	100	217746.00	217746.20	210832.00	210832.20
.2000	100	163309.60	163309.60	158124.00	158124.00

TABLE 7.26(ii) Financial analysis of conversion of FS1 (sec. 7.4.4)
Area of estate: 100 ha, SQIII
Revenue flows: as in Table 7.25; **TEAK TIMBER & FIREWOOD ONLY;**
timber price Rs 4341.68/cmt(LOG,s),
firewood price Rs 472.91/cmt(solid); no taxes added.
Expenditure flows: Rs 50 admin. charges + Rs 19.66 fire prot. per ha.

DISC. RATE	CONV. PERIOD Years	LEAD 10km NDR, Rs	SE, Rs	LEAD 80km NDR, Rs	SE, Rs
.0000	100	3820699.00		3606233.00	
.0500	100	758328.90	764139.80	715761.90	721246.60
.1000	100	382041.80	382069.50	360596.80	360622.90
.1500	100	254712.90	254713.10	240415.20	240415.40
.2000	100	191034.70	191034.70	180311.40	180311.40

Note: Extraction and transport costs, Rs per cmt(solid) :

Lead to depot		Felling, conversion	Transport, lotting	Total
10 km	Timber	53.79	35.10	88.89
	Smallwood	47.89	28.30	76.19
80 km	Timber	53.79	146.40	200.19
	Smallwood	47.89	107.54	155.43

TABLE 7.27(i) Financial analysis of conversion of FS3 (sec. 7.4.4)
Area of estate: **100 ha, SQIV**
Revenue flows: as in Table 7.25; **TEAK TIMBER ONLY;**
timber price at depot Rs 4105.46/cmt(log,solid); no taxes added.
Expenditure flows: Rs 50 admin. charges + Rs 19.66 fire prot. per ha.

DISC. RATE	CONV. PERIOD Years	LEAD 10km NDR, Rs	SE, Rs	LEAD 80km NDR, Rs	SE, Rs
.0000	100	457280.50		425306.40	
.0500	100	90760.64	91456.14	84414.42	85061.28
.1000	100	45724.73	45728.04	42527.53	42530.61
.1500	100	30485.30	30485.34	28353.68	28353.72
.2000	100	22864.00	22864.00	21265.29	21265.29

TABLE 7.27(ii) Financial analysis of conversion of FS3 (sec. 7.4.4)
Area of estate: 100 ha, SQIV
Revenue flows: as in Table 7.25; **TEAK TIMBER AND FIREWOOD ONLY;**
timber price at depot Rs 4105.46/cmt(log,solid);
firewood price Rs 472.91/cmt(solid); no taxes added
Expenditure flows: Rs 50 admin. charges + Rs 19.66 fire prot. per ha.

DISC. RATE	CONV. PERIOD Years	LEAD 10km NDR, Rs	SE, Rs	LEAD 80km NDR, Rs	SE, Rs
.0000	100	628235.00		562114.80	
.0500	100	124691.60	125647.10	111568.10	112423.00
.1000	100	62818.94	62823.49	56207.38	56211.46
.1500	100	41882.27	41882.31	37474.25	37474.29
.2000	100	31411.73	31411.73	28105.71	28105.71

Note: Extraction and transport costs, Rs per cmt(solid) :

Lead to depot		Felling, conversion	Transport, lotting	Total
10 km	Timber	53.79	35.10	88.89
	Smallwood	47.89	28.30	76.19
80 km	Timber	53.79	146.40	200.19
	Smallwood	47.89	107.54	155.43

TABLE 8.1 Standard conversion factor for traded commodities, a (sec. 8.1)

YEAR	VALUE at BORDER PRICES EXPORTS fob	IMPORTS cif	TOTAL (2)+(3)	VALUE at DOMESTIC PRICES EXPORTS	IMPORTS	TOTAL (5)+(6)	SCF a (4)/(7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	---------- Rs billion ----------						
a) Data from IMF (Internatl. Fin. Statistics)*							
1960	06.341	10.968	17.309	07.8	10.1	17.9	00.967
1961	06.601	10.884	17.485	08.0	11.0	19.0	00.920
1962	06.682	11.248	17.930	08.4	12.1	20.5	00.875
1963	07.741	11.796	19.537	09.9	13.6	23.5	00.831
1964	08.118	13.693	21.811	10.2	15.3	25.5	00.855
1965	08.032	13.516	21.548	09.3	14.6	23.9	00.902
1966	11.714	20.373	32.087	13.3	21.2	34.5	00.930
1967	12.097	20.796	32.893	15.1	22.0	37.1	00.887
1968	13.209	19.273	32.482	16.0	19.0	35.0	00.928
1969	13.763	16.589	30.352	16.3	17.5	33.8	00.898
1970	15.198	15.933	31.131	17.7	18.2	35.9	00.867
1971	15.256	18.155	33.411	17.9	21.8	39.7	00.842
1972	18.568	16.844	35.412	22.3	20.5	42.8	00.827
1973	22.591	24.893	47.484	28.3	31.8	60.1	00.790
1974	31.786	41.596	73.382	38.4	47.8	86.2	00.851
1975	36.412	53.388	89.800	48.1	56.6	104.7	00.858
1976	49.702	50.738	100.44	61.4	56.1	117.5	00.855
1977	55.734	57.937	113.671	66.4	65.2	131.6	00.864
1978	54.564	64.387	118.951	71.2	74.3	145.5	00.818
1979	63.445	79.820	143.265	83.8	98.6	182.4	00.785
1980	67.517	116.771	184.288	90.3	135.8	226.1	00.815
1981	71.780	133.379	205.159	102.5	148.8	251.3	00.816
1982	88.416	139.691	228.107	115.9	158.1	274.0	00.833
						MEAN a	00.862
							[SD 0.47, CV 5%]
b) Data from Govt of India (RBI Reports on Currency & Finance)**							
1970	15.35	16.34	31.69	17.71	18.16	35.87	00.884
1975	40.43	52.65	93.08	48.12	56.64	104.26	00.889
1979	89.08	64.59	153.67	83.81	98.59	182.40	00.843
1980	67.11	125.24	192.35	90.29	135.79	226.08	00.851
1981	78.03	136.71	214.74	102.53	148.79	251.32	00.855
						MEAN a	00.864
							[SD 0.02, CV 2.4%]
c) Data from Govt of India (RBI Reports on Currency & Finance)**							
1970	15.35	16.34	31.69	05.24	36.93		00.858
1975	40.43	52.65	93.08	14.194	107.27		00.868
1979	89.08	64.59	153.67				
1980	67.11	125.24	192.35	34.093	226.44		00.849
1981	78.03	136.71	214.74	43.004	257.74		00.833
							00.852
							[SD 0.02, CV 1.7%]

Source: * International Financial Statistics, IMF
** Report on Currency and Finance, RBI

TABLE 8.2 Data for the calculation of elasticities of food demand (sec. 8.2.2)

YEAR	POPUL. million	ADULT EQUIV. million	PERSONAL DISPOSABLE INCOME at FACTOR PRICES current prices Rs bill	Rs/adlt	deflat. factor, 1970=100	1970 prices Rs/adlt (y_{dis})	NATIONAL INCOME at FACTOR COST 1970 prices Rs bill (y)	Rs/adlt
1970	539.08	412.396	330.62	801.71	1.000	801.71	342.35	830.15
1971	551.23	421.691						
1972	563.53	431.101						
1973	575.89	440.556						
1974	588.30	450.050	571.45	1269.75	1.671	759.87		
1975	600.76	459.581	600.72	1307.10	1.583	825.60	400.78	872.08
1976	613.27	469.152	644.43	1373.61	1.630	842.65	406.06	865.52
1977	625.82	478.752	737.85	1541.20	1.719	896.67	440.90	920.94
1978	638.39	488.368	792.61	1622.98	1.791	906.08	466.36	1031.09
1979	650.98	498.651	868.53	1741.76	2.049	850.21	443.28	888.96
1980	663.60	508.318	1054.4	2074.29	2.224	932.76	475.07	934.59
1981	676.22	517.985	1187.60	2292.73	2.447	936.88	496.31	958.16
1982	716.88	549.130	1297.75	2363.28	2.580	916.14	504.37	918.49

TABLE 8.2 (contd.)

YEAR	POPUL. million	ADULT EQUIV. million	PRIVATE FINAL CONSUMPTION EXPENDITURE TOTAL Rs bill	Rs/cap	Rs/adlt	FOOD Rs bill	Rs/cap	Rs/adlt (d)
			---------------- 1970 prices					------------------
1970	539.08	412.396	298.38	552.85	723.53	187.99	348.72	455.36
1971	551.23	421.691						
1972	563.53	431.101	300.70	533.60	697.52	178.77	317.23	414.68
1973	575.89	440.556	308.80	536.21	700.93	182.78	317.39	414.89
1974	588.30	450.050	311.43	529.37	691.99	186.35	316.76	414.07
1975	600.76	459.581	334.67	557.08	728.07	203.55	338.82	442.90
1976	613.27	469.152	331.94	541.26	707.53	190.52	310.66	406.09
1977	625.82	478.752	368.10	588.19	768.87	217.79	348.01	454.91
1978	638.39	488.368	381.53	597.64	781.24	220.89	346.01	452.30
1979	650.98	498.651	367.06	563.86	736.11	203.65	312.84	408.40
1980	663.60	508.318	400.89	604.11	788.66	229.10	345.24	450.70
1981	676.22	517.985	410.87	607.60	793.21	232.70	344.12	449.24
1982	716.88	549.130	412.60	575.55	751.37	229.51	32015	417.95

Note: Data on consumption expenditure from UNO Yearbook of National Accounts Statistics, 1984; 'Food' excludes alcoholic and non-alcoholic beverages and tobacco.
Data on personal disposable income and national income from RBI Reports on Currency and Finance.
Adult equivalents: population multiplied by 0.765 upto 1978, and by 0.766 from 1979.

TABLE 8.3 Relative price index of Food (sec. 8.2.2)

YEAR	All India index of wholesale prices, 1970 = 100 ALL ITEMS (Pg)	FOOD PRIMARY (Pfp)	FOOD MANFD. (Pfm)	FOOD SUGAR (Ps)	FOOD PF+MF (Pf)	Pf/Pg	Pfp/Pg	Pfm/Pg	Ps/Pg	Karnataka agr. labor cons. index Pf/Pg
Weight:	1000.0	297.99	133.22	72.41	431.21					
1970	100.0	100.0	100.00	100.00	100.0	1.0000	1.0000	1.0000	1.0000	1.0000
1971	105.6	101.1	118.4	141.2	106.4	1.0074	0.9574	1.1212	1.3371	0.9984
1972	116.2	111.3		188.0			0.9578		1.6179	1.0196
1973	139.7	136.6		192.4			0.9778		1.3772	1.0406
1974	174.9	172.1		199.8			0.9840		1.1424	1.0392
1975	173.0	163.6	181.4	213.5	169.1	0.9775	0.9457	1.0486	1.2341	1.0097
1976	176.6	155.3	189.1	217.5	165.74	0.9385	0.8794	1.0708	1.2316	0.9921
1977	185.8	173.6	184.3	185.4	176.91	0.9522	0.9343	0.9919	0.9979	0.9862
1978	185.8	172.4	157.0	146.8	167.74	0.9023	0.9279	0.8450	0.7901	0.9672
1979	217.6	186.6	214.8	231.3	195.31	0.8976	0.8575	0.9871	1.0630	0.9883
1980	257.3	207.9	308.7	376.9	239.04	0.9301	0.8080	1.1998	1.4648	1.1146
1981	281.3	235.1	298.9	335.6	254.48	0.9069	0.8358	1.0626	1.1930	0.9210
1982	288.6	249.6	260.0	259.2	252.81	0.8760	0.8649	0.9009	0.8981	0.9920
1983	315.3	282.9	299.1	302.1	287.91	0.9131	0.8972	0.9486	0.9581	0.9917

TABLE 8.4 Population distribution by age classes, and adult equivalents (sec. 8.2.2)

CENSUS DATE	TOTAL POPUL. million	POPULATION DISTRIBUTION BY AGE CLASS, YEARS -1	1-4	5-19	20- + unknown	WEIGHTED ADULT EQUIVALENTS million	Mult. factor
Weight*		0.18	0.35	0.76	0.90		
1.3.51	356.799	11.560	36.087	121.849	187.303	275.889	0.773
	(100.0)	(3.24)	(10.11)	(34.15)	(52.50)		
1.3.61	438.775	13.562	52.520	149.803	222.890	335.274	0.764
	(100.0)	(3.09)	(11.97)	(34.14)	(50.80)		
1.4.71	547.949	16.349	62.758	198.594	270.249	419.064	0.765
	(100.0)	(2.98)	(11.45)	(36.24)	(49.32)		
1.7.80	663.596	---- 93.075 ---		241.524	328.597	508.957	0.767
		19.27	73.81				
	(100.0)	(2.90)	(11.12)	(36.40)	(49.58)		

Note: Age-specific weighting factors are taken from Kula (1984), but his age classes slightly different: 0-2 years, 2-5, 5-18, 18 +. Data on age composition from UN Demographic Yearbooks. Figures in parantheses are percentages of total population. For 1980 data, age classes -1 and 1-4 were merged; distribution between these two classes was worked out by assuming share of each to be in the same proportion as in 1971 census.

TABLE 8.5 Direction of movement in relative prices and consumption of Food (sec. 8.2.5)

YEAR	MOVEMENT IN RELATIVE PRICE INDEX				MOVEMENT IN EXPENDITURE ON FOOD		
	ALL FOOD	PRIM	MNFD	SUGAR	ALL FOOD	Rs/adlt	% EXPD. ON FOOD
	Pf/Pg	Pfp/Pg	Pfm/Pg	Ps/Pg	------- 1970 prices ----------		
Weight:	431.121	297.99	133.22	72.41			
1970							
	+	-	+	+			
1971							
		+		+			
1972							
		+		-	+	+	-
1973							
		+		-	+	-	+
1974							
		-		+	+	+	+
1975							
	-	--	+	-	-	--	--
1976							
	+	+	-	-	++	++	++
1977							
	--	-	--	-	+	-	--
1978							
	-	--	++	+	-	--	--
1979							
	+	--	+	+	++	++	++
1980							
	-	+	-	-	+	-	-
1981							
	-	+	-	-	+	-	-
1982							
	+	+	+	+			
1983							

Note: A relatively strong movement is represented by ++ or --. Based on all-India index of wholesale prices. Accounting years start 1 April. Weight is 1000.0 for all commodities, Food plus Non-Food. Expenditures based on UN Ybook of National Accounts Statistics.

TABLE 8.6 Per capita expenditure elasticity of demand for cereals in rural and urban India (from Raj, 1966, Table 8) (sec. 8.2.6)

NSS Round	ELASTICITY OF CEREAL DEMAND ---RURAL--- VAL	QTY	---URBAN--- VAL	QTY
IV (Apr-Sep 1952)	---	---	---	0.16
V (Dec 1952-Mar 1953)	0.59	0.38	0.37	0.22
VI (May-Sep 1953)	0.65	0.49	0.40	0.21
VII (Nov 1953-Mar 1954)	0.52	0.31	0.30	0.07
X (Dec 1955-Mar 1956)	0.62	0.49	0.32	0.14
AVERAGE		0.42		0.16

Source: Raj (1966). VAL value elasticities; QTY quantity elasticities.

TABLE 8.7 Estimates of elasticity of marginal utility of consumption, n, from food grain elasticities of Table 9.6 (sec. 8.2.6)

SECTOR	Fraction of income spent on Food, f	Income elast. e_2	Price elast. e_1	Pure price elast. $\hat{e}_1 = e_1 + fe_2$	Elast. of social mu of cons. n = (i) $e_2/\hat{e}_1$	(ii) e_2/e_1
1. R+U	0.5847	0.45	-0.60	-0.34	-1.34	-0.75
"	"	"	-0.70	-0.44	-1.03	-0.64
"	"	"	-0.80	-0.54	-0.84	-0.56
2. R	"	0.42	-0.62	-0.37	-1.12	-0.68
3. U	"	0.16	-1.20	-1.11	-0.15	-0.13
4. R	0.72	0.42	-0.62	-0.32	-1.32	-0.68
5. R	0.40 (cereals)	0.42	-0.62	-0.45	-0.93	-0.68
6. U	0.40	0.16	-1.20	-1.14	-0.14	-0.13

Note: The three variants of price elasticity under sl no. (1) are the mean weighted average price elasticity estimated by Raj (1966), -0.70, and the two values, -0.60 and -0.80, for sensitivity analysis. R= Rural, U= Urban.

TABLE 8.8 Consumption rate of interest (CRI): a priori method of estimation (sec. 8.3.2)

ELAST. of MU, n	-2	-1.5	-1	-0.5	0	+0.5
g=0.01, p=0.985						
a) Positive mortality probability CRI, $[p/(1+g)^n]-1$	0.0356	0.0305	0.0254	0.0203	0.0152	0.0102
b) Zero mortality probability CRI, $[1/(1+g)^n]-1$	0.0201	0.0150	0.0100	0.0050	0.0000	-.0050

Note: g is the growth rate of per capita consumption; p is the average probability of survival to next year, equal to 1 - death rate per 100 population.

TABLE 8.9(i) Composition of income shares (sec. 8.4.3)

YEAR	COMPENSATION of EMPLOYEES	MIXED INCOME SELF-EMPLOYED	(2)+(3)	PVT. FINAL CONS.	(4)/(5)
(1)	(2)	(3)	(4)	(5)	(6)
	Rs billion				%
1970	133.63	161.12	294.75	298.03	98.9 %
1971	144.57	167.40	311.97	320.97	97.2
1972	158.04	184.95	342.99	350.84	97.8
1973	178.18	260.41	438.59	428.65	102.3
1974	213.50	297.95	511.45	519.05	98.5
1975	243.41	284.03	527.44	527.47	99.99
1976	265.16	290.61	555.77	541.70	102.6
1977	306.73	323.13	629.86	626.05	100.6
1978	336.88	334.20	671.08	674.15	99.6
1979	373.77	349.34	723.11	736.36	98.2
1980	431.21	447.19	878.40	886.32	99.1
1981	496.51	504.16	1000.67	1009.36	99.1

Source: Report on Currency & Finance, Reserve bank of India (various).

TABLE 8.9(ii) National economic data for estimation of q (sec. 8.4.3)

YEAR	NET FIXED CAPITAL FORM	NDP	PVT CONS EXPD	DIF1 in PCE	NDP CONST. LABOUR (3)-(5)	DIF2 in PCE	NDP CONST LABOUR (3)-(7)	Aver. prop. to save (2)/(3)	YEAR
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Rs billion (1980 prices)							%	
1960	60.426	607.66	509.36	0.00	607.660	0.000	607.66	9.94	1960
1961	66.116	626.86	517.36	7.994	618.866	5.995	620.86	10.55	1961
1962	68.651	641.67	523.02	13.654	628.013	10.241	631.43	10.70	1962
1963	78.182	678.55	535.6	26.275	652.271	19.706	658.84	11.52	1963
1964	85.000	731.00	584.33	74.972	656.028	56.229	674.77	11.63	1964
1965	88.415	697.56	569.94	55.577	641.984	41.683	655.88	12.68	1965
1966	86.022	705.91	585.22	75.853	630.061	56.890	649.02	12.19	1966
1967	87.781	766.33	654.86	145.501	620.833	109.126	657.21	11.46	1967
1968	92.040	786.07	652.74	143.375	642.695	107.531	678.54	11.71	1968
1969	95.455	835.89	682.06	172.696	663.190	129.522	706.36	11.42	1969
1970	94.676	880.56	689.81	180.453	700.102	135.340	745.22	10.75	1970
1971	102.637	900.22	705.49	196.133	704.087	147.100	753.12	11.40	1971
1972	106.720	893.28	694.27	184.907	708.374	138.680	754.60	11.95	1972
1973	99.834	930.28	713.31	203.949	726.333	152.962	777.32	10.73	1973
1974	104.513	932.02	732.16	222.796	709.221	167.097	764.92	11.21	1974
1975	133.916	1019.36	767.83	258.469	760.890	193.852	825.51	13.14	1975
1976	147.139	1029.02	735.15	225.788	803.231	169.341	859.68	14.30	1976
1977	160.738	1115.02	824.90	315.539	799.480	236.655	878.37	14.42	1977
1978	169.548	1185.68	869.94	360.574	825.104	270.430	915.25	14.30	1978
1979	158.909	1119.49	820.04	310.683	808.805	233.012	886.48	14.20	1979
1980	171.700	1194.40	886.30	376.938	817.462	282.704	911.70	14.38	1980
1981	180.073	1258.96	933.46	424.094	834.864	318.070	940.89	14.30	1981
1982	198.558	1292.03	936.56	427.195	864.832	320.396	971.63	15.37	1982
1983	209.992	1392.83	1019.76	510.394	882.436	382.796	1010.03	15.08	1983

Note: National accounts statistics from Internatl. Fin. Stats., IMF (various).
GNP - NNP = consumption of fixed capital.
Gross fixed capital formation - consumption of fixed capital = net fixed capital formatn.
GDP - consumption of fixed capital = NDP at market prices.
Values at market prices converted to 1980 prices using deflation factors calculated from GDP series at 1980 prices in IFS, IMF. DIF1 in private consumption expenditure is the increase in PCE from over previous year. DIF2 is increase in 75% share of PCE. The DIF in PCE is ascribed to reward to increased labour.
NDP - DIF in PCE = NDP at CONSTANT LABOUR. Low and high estimates correspond to DIF1 and DIF2 respectively; s is the average rate of saving (average propensity to save), net fixed capital formation divided by NDP, both at 1980 prices.

TABLE 8.10(i) Social value of public investment, v: using *a priori* i and positive mortality probability (sec. 8.5.2)

ELAST of mu. n	-2	-1.5	-1	-0.5	0	+0.5
CRI or STPR, i	3.56%	3.05%	2.54%	2.04%	1.52%	1.02%
q = 0.10, s = 0.15						
$v = \frac{(1-s)q}{(i-sq)a}$	4.81	6.60	9.90	19.80	495.00	- -
q = 0.10, s = 0.0						
v = q/ia	3.27	3.81	4.58	5.73	7.65	11.40
q = 0.125, s= 0.15						
$v = \frac{(1-s)q}{(i-sq)a}$	7.33	10.52	18.58	79.71	--	--
q = 0.125, s = 0.0						
v = q/ia	4.08	4.77	5.72	7.16	9.56	14.25
q = 0.15, s = 0.15						
$v = \frac{(1-s)q}{(i-sq)a}$	11.32	18.53	51.12	--	--	--
q = 0.15, s = 0.0						
v = q/ia	4.90	5.72	6.87	8.59	11.48	17.10

Note: For all above, assumed growth rate of per capita consumption, g = 0.01 or 1.0% per annum; probability of survival to next year, p = 0.985 or 98.5%; standard conversion factor, a = 0.86.

TABLE 8.10(ii) Social value of public investment, v: using *a priori* i and zero mortality probability (sec. 8.5.2)

ELAST of mu. n	-2	-1.5	-1	-0.5	0	+0.5
CRI or STPR, i	2.01%	1.50%	1.00%	0.50%	0.00%	-0.50%
q = 0.10, s = 0.15						
$v = \frac{(1-s)q}{(i-sq)a}$	19.38	- -	- -	- -	- -	- -
q = 0.125, s= 0.15						
$v = \frac{(1-s)q}{(i-sq)a}$	91.52	- -	- -	- -	- -	- -
q = 0.15, s = 0.15						
$v = \frac{(1-s)q}{(i-sq)a}$	- -	- -	- -	- -	- -	- -

TABLE 8.11 Social value of public investment, v*: using critical consumption level, c* (sec. 8.5.4)

ELASTICITY of mu, n	-2	-1.5	-1	-0.5	0.0	+0.5
CRI or STPR, i	3.56%	3.05%	2.54%	2.04%	1.52%	1.02%
$d^* = (c^*/\bar{c})^{n} = (0.5766)^{-n}$	3.01	2.28	1.74	1.32	1.00	0.76
v* = d*/a=	3.50	2.66	2.02	1.53	1.16	0.88
q = 0.10, s = 0.15						
i* , %	4.32	5.22	6.40	7.95	10.00	12.69
P = ng+i*, %	2.32	3.72	5.40	7.45	10.00	13.19
P = i* -STPR, %	0.76	2.17	3.86	5.92	8.48	11.67
q = 0.125, s = 0.15						
i* , %	5.41	6.53	8.00	9.94	12.50	15.86
P= ng+i*, %	3.41	5.03	7.00	9.44	12.50	16.36
P= i* -STPR, %	1.85	3.48	5.46	7.91	10.98	14.84
q = 0.15, s = 0.15						
i* , %	6.49	7.83	9.60	11.93	15.00	19.04
P= ng+i*, %	4.49	6.33	8.60	11.43	15.00	19.54
P= i* -STPR, %	2.93	4.78	7.06	9.90	13.48	18.02

Note: i* is calculated back from the formula v* = q(1-s)/(i*-sq)a
P is the implied 'pure' time preference rate. The first estimate is from the usual formula, i = -ng + P, substituting i* for i. The second estimate is the difference between i* and the _a priori_ STPR, i.
Critical income level = Rs 781.71/cap, 1977-78 prices;
Mean $\bar{c}$ = Rs 1355.85/cap, NNP(purchasers' prices)/capita, 1977-78 prices.

TABLE 8.12(i) Social value of public income, x: using *a priori* i and positive mortality probability (sec. 8.5.5)

ELAST. of m.u., n	-2	-1.5	-1	-0.5	0	+0.5
CRI or STPR, i	3.56%	3.05%	2.54%	2.04%	1.52%	1.02%
q = 0.10, s = 0.15, (1-s)/a = 0.9884						
$v = \frac{(1-s)q}{(i-sq)a}$	4.81	6.60	9.90	19.80	495.00	--
x = sv+(1-s)/a=	1.71	1.98	2.48	3.96	75.24	--
q = 0.10, s = 0.0						
v = q/ia	3.27	3.81	4.58	5.73	7.65	11.40
x = sv+(1-s)/a=	1.48	1.56	1.68	1.85	2.14	2.70
q = 0.125, s = 0.15, (1-s)/a = 0.9884						
$v = \frac{(1-s)q}{(i-sq)a}$	7.33	10.52	18.58	79.71	--	--
x = sv+(1-s)/a=	2.09	2.57	3.78	12.95	--	--
q = 0.125, s = 0.0						
v = q/ia	4.08	4.77	5.72	7.16	9.56	14.25
x = sv+(1-s)/a=	1.60	1.71	1.85	2.06	2.42	3.13
q = 0.15, s = 0.15, (1-s)/a = 0.9884						
$v = \frac{(1-s)q}{(i-sq)a}$	11.32	18.53	51.12	--	--	--
x = sv+(1-s)/a=	2.69	3.77	8.66	--	--	--
q = 0.15, s = 0.0						
v = q/ia	4.90	5.72	6.87	8.59	11.48	17.10
x = sv+(1-s)/a=	1.73	1.85	2.02	2.28	2.71	3.56

Note: For all above, assumed growth rate of per capita consumption, g = 0.01 or 1.0% per annum; probability of survival to next year, p = 0.985 or 98.5%; standard conversion factor, a = 0.86. Values of v represent social value of Re 1 (border) of public investment alone, in terms of Rs (domestic) consumption at mean income level c; identical to values shown in Table 8.10, and reproduced here for comparison.
Values of x represent social value of Re 1 of public income, divided between Rs s investment and Rs (1-s) consumption.

TABLE 8.12(ii) Social value of public income, x: using *a priori* i and zero mortality probability (sec. 8.5.5)

ELAST of mu. n	-2	-1.5	-1	-0.5	0	+0.5
CRI or STPR, i	2.01%	1.50%	1.00%	0.50%	0.00%	-0.50%
q = 0.10, s = 0.15						
$v = \frac{(1-s)q}{(i-sq)a}$	19.38	- -	- -	- -	- -	- -
x = sv+(1-s)/a=	3.90	- -	- -	--	--	--
q = 0.125, s= 0.15						
$v = \frac{(1-s)q}{(i-sq)a}$	91.52	- -	- -	- -	- -	- -
x = sv+(1-s)/a=	14.72	- -	- -	--	--	--
q = 0.15, s = 0.15						
$v = \frac{(1-s)q}{(i-sq)a}$	- -	- -	- -	- -	- -	- -
x = sv+(1-s)/a=	- -	- -	- -	--	--	--

TABLE 8.13 Social value of public income, x*: using critical consumption level, c* (sec. 8.5.6)

ELAST.of mu n	-2	-1.5	-1	-0.5	0.0	+0.5
CRI or STPR, i	3.56%	3.05%	2.54%	2.04%	1.52%	1.02%
$d^* = (c^*/\bar{c})^n$	3.01	2.28	1.74	1.32	1.00	0.76
$v^* = d^*/a=$	3.50	2.66	2.02	1.53	1.16	0.88
$x^*=sv^*+(1-s)a$	1.51	1.39	1.29	1.22	1.16	1.12

Note: Values of v* as in Table 8.11; s=0.15, a=0.86.
Critical c* = Rs 781.71/capita; mean $\bar{c}$ = Rs 1355.85/cap, NNP(purchasers' prices)/capita, 1977-78 prices; $(c^*/\bar{c})^n = (0.5766)^n$

TABLE 8.14 Income distribution in Karnataka, 1972-73 (Rural + Urban) (sec. 1.6.6, 8.5.7)

Class Rs/cap per day (1)	Percent populatn. (2)	mid-class value (3)	Percent income (4)
< 0.55	10%	0.275	1.76%
0.55-1.10	34	0.825	17.97
1.10-2.19	38	1.645	40.04
2.19-4.11	12	3.150	24.21
4.11 -	6	(4.172)	(16.03)
TOTAL	100.00	1.561	100.00

Note: From Epstein et al. (1983). Figures for highest income class calculated from the overall income per capita for the state, which was Rs 569.90/year for 1972-73, or Rs 1.5614 per day.

TABLE 8.15 Distribution of returns as per existing income distribution and 'global' distribution weight D (sec. 1.6.6, 8.5.7)

ELASTICITY of mu, n	-2	-1.5	-1	-0.5	0.0	+0.5
CRI or STPR, i	3.56%	3.05%	2.54%	2.04%	1.52%	1.02%
$d^* = (c^*/\bar{c})^n = (0.5766)^n$	3.01	2.28	1.74	1.32	1.00	0.76
GINI= 0.37, $\bar{s}$= (1+G)/2G= 1.839; D= $\bar{s}^{-n}(\bar{s}-1)^{1+n}/(-n+\bar{s}-1)$						
D=	1.4196	1.1639	1.000	1.0779	1.000	1.6707
q=0.10; s= 0.15; $(i^* - sq) = (1-s)qD/d^*$						
i* =	5.51%	5.83	6.40	8.46	10.00	20.20
P= i+ng	3.51	4.33	5.40	7.96	10.00	20.70
P= i* - i	1.95	2.78	3.86	6.42	8.48	19.18
q=0.125; s= 0.15; $(i^* - sq) = (1-s)qD/d^*$						
i* =	6.89%	7.29	8.00	10.57	12.50	25.25
P= i+ng	4.89	5.79	7.00	10.07	12.50	25.75
P= i* - i	3.33	4.24	5.46	8.53	10.98	24.73
q=0.15; s=0.15; $(i^* - sq) = (1-s)qD/d^*$						
i* =	8.27%	8.75	9.60	12.69	15.00	30.30
P= i+ng	6.27	7.25	8.60	12.19	15.00	30.80
P= i* -i	4.71	5.70	7.06	10.65	13.48	29.28

Note: Distribution of income from Table 8.14. Please see Note under Table 8.11 for i*, P; and main text for discussion of GINI.

TABLE 8.16 Market labour wage rates, Rs per day, 1960-1985 (sec. 8.6.2)

	FOREST DEPARTMENT				AGRICULTURE		AVERAGE	
	Haliyal Divn.		Yellapur Divn.		Karn.	Mahar.	used in	
	local labour	perman. labour	local labour	import. labour	State	State	this study	
1960	1.25	1.75	1.75	2.00			1.75	1960
1961	(1.25)	(1.75)					1.75	1961
1962	(1.25)	(1.75)					1.75	1962
1963	(1.25)	(1.75)					1.75	1963
1964	(1.25)	(1.75)					1.75	1964
1965	1.75	2.00					2.00	1965
1966	2.25	2.50					2.25	1966
1967	(2.25)	(2.50)					2.50	1967
1968	(2.25)	(2.50)					2.75	1968
1969	(2.25)	(2.50)					3.00	1969
1970	(2.25)	(2.50)					3.25	1970
1971	(2.25)	(2.50)					3.50	1971
1972	(2.25)	(2.50)					3.75	1972
1973	3.00	4.50					4.00	1973
1974	(4.00)						4.00	1974
1975							4.00	1975
1976						4.12	4.10	1976
1977						3.78	4.10	1977
1978						4.24	4.25	1978
1979						4.63	4.50	1979
1980	5.00-5.25		5.00		6.02	5.23	5.00	1980
1981	5.00-5.75		5.25			5.46	5.25	1981
1982	5.75		6.50		6.64	5.97	6.50	1982
1983	6.75-7.25		6.75			6.92	6.75	1983
1984	7.25-9.75		7.25				7.25	1984
1985	9.75(h)		9.75(h)				9.75	1985
	7.80(l)		7.80(l)					

Note: Figures in brackets interpolated or doubtful. Data of Yellapur Division, 1960-61 from Wesley (1964); remaining from forest department sources; h= heavy, l= light labour.
Agricultural wages: Karnataka: Government of India, 1984; Maharashtra: ILO, 1985.

TABLE 8.17 Distribution of rural work force by activity status, 1977-78
ALL-INDIA, RURAL (sec. 8.6.3)

Distribution of persons (in hundreds) of age 5 and above in labour-force according to current weekly activity, and the average no. of days unemployed (seeking/available for work) in a week, by no. of days worked in a week.

NO. OF DAYS WORKED IN A WEEK	MALES		FEMALES		TOTAL	
	PERSONS 00s	AVER. NO. of DAYS UNEMPLOYED	PERSONS 00s	AVER. NO. of DAYS UNEMPLOYED	PERSONS 00s	AVER NO of DAYS UNEMPL.
0.0	48928	6.9	24390	6.7		
0.5	531	4.0	478	2.0		
1.0	8798	4.0	7843	2.7		
1.5	953	3.8	1453	0.8		
2.0	17655	3.4	15736	2.2		
2.5	1034	2.6	2113	0.5		
3.0	24689	2.7	22680	1.7		
3.5	9399	1.4	59444	0.1		
[1.94]	111987	4.653	134137	1.9896	246124	3.2015
4.0	40835	1.9	32995	1.2		
4.5	2411	1.1	3162	0.2		
5.0	45482	1.0	27488	0.8		
5.5	2402	0.5	2380	0.2		
6.0	50692	0.3	28268	0.3		
6.5	2699	0.1	980	0.1		
7.0	1114616	0.0	360731	0.0		
[6.56]	1259137	0.1131	456004	0.1563	1715141	0.1246
TOTAL [5.98]	1371124	0.4839	590141	0.5730	1961265	0.5107

No of sample
MALES 145181 FEMALE 63217
HOUSEHOLDS 100822

Source: Sarvekshana (J. National Sample Survey Organization), Vol 5, Nos 1&2, July-Oct 1981. "Notes and survey results - 2nd Quinquennial Survey on Employment and Unemployment, NSS 32nd Round (1977-1978). Average of 4 sub-rounds.

TABLE 8.18 Ocupational status, wages, dependency and increase in consumption of rural workers (sec. 8.6.3)

Category of workers	Marginal	Main	All workers	Nonworkers
Rural population, all India, aged 5 and over, 1977-78, thousands.	24612.4	171514.1	196126.5	
Average no of days worked in week	1.94	6.56	5.98	
Average no of days unemployed in week	3.20	0.125	0.511	
Average no of days in work force in week	5.14	6.685	6.491	
Average no of days neither working nor unemployed in week	1.86	0.315	0.509	
Rural population, '000s:	1268.384	13650.458	14918.842	22137.239
Karnataka, 1981. [%]:	[3.42]	[36.76]	[40.18]	[59.61]

Dependency load, non-workers/workers : 1.485

PER CAPITA INCOMES

BEFORE PROJECT

* w denotes the prevailing daily wage rate

	Marginal	Main	All workers
Average weekly wages per worker, Rs domestic	1.94w	6.56w	5.98w
Average weekly wages per capita (/2.485 persons)	0.781w	2.640w	2.406w
Average annual wages per capita (52 weeks)	40.612w	137.280w	125.112w

IN PROJECT

	Marginal	Main	All workers
Average weekly wages per worker, Rs domestic	5.14w	6.685w	6.491w
Average weekly wages per capita (/2.485 persons)	2.068w	2.690w	2.612w
Average annual wages per capita (52 weeks)	107.56w	139.89w	1135.83w
Average increase in weekly wages per worker	3.20w	0.125w	0.511w

TABLE 8.19(i) Social weights for incremental consumption of rural labour (sec. 8.6.4, 8.6.5)

ELAST. of mu, n=	-2	-1.5	-1	-0.5	0.0	+0.5
CRI, i, % =	3.56	3.05	2.54	2.03	1.52	1.02

Relative distributional weight to consumption

A) increase in consumption per worker-day created by the project:

dc_{marg}= (0.704*3.20/5.14)w= 0.4383w Rs domestic;
dc_{main}= (0.296*0.125/6.685)w= 0.005535w;
(dc_{marg} + dc_{main})= 0.4438w Rs domestic;
dc_{gen}= (1.00*0.511/6.491)w= 0.0787w Rs domestic.

B) social weight, non-marginal change in consumption; 1980-84 mean d

d_{marg}=	29.95	12.42	5.25	2.27	1.00	0.45
d_{main}=	6.81	4.21	2.61	1.61	1.00	0.62
d_{gen}=	7.70	4.62	2.77	1.66	1.00	0.60

TABLE 8.19(ii) Social value of consumption increase, border Rs: dc*d/v (sec. 8.6.5)

i) q=0.10, s=0.15, v=q(1-s)/(i-sq)a

v =	4.81	6.60	9.90	19.80	495.0
d_{marg}/v=	6.23	1.88	0.53	0.12	0.002
d_{main}/v=	1.42	0.64	0.26	0.08	0.002
d_{gen}/v=	1.60	0.70	0.28	0.08	0.002
dc_{marg}*d_{marg}/v=	2.729w	0.825w	0.233w	0.050w	0.001w
dc_{main}*d_{main}/v=	0.008w	0.004w	0.001w	0.001w	0.00001w
(dc*d/v)seg	2.737w	0.828w	0.234w	0.051w	0.001w
dc_{gen}*d_{gen}/v=	0.126w	0.055w	0.022w	0.007w	0.0002w
(dc_{marg}+dc_{main})d_{gen}/v	0.710w	0.310w	0.124w	0.037w	0.001w

ii) q=0.125, s=0.15, v=q(1-s)/(i-sq)a

v =	7.33	10.52	18.58	79.71
d_{marg}/v=	4.09	1.18	0.28	0.03
d_{main}/v=	0.93	0.40	0.14	0.02
d_{gen}/v=	1.05	0.44	0.15	0.02
dc_{marg}*d_{marg}/v=	1.791w	0.517w	0.124w	0.013w
dc_{main}*d_{main}/v=	0.005w	0.002w	0.001w	0.0001w
$(dc*d/v)_{seg}$	1.796w	0.520w	0.125w	0.013w
dc_{gen}*d_{gen}/v=	0.083w	0.035w	0.012w	0.002w
(dc_{marg}+dc_{main})d_{gen}/v=	0.466w	0.195w	0.066w	0.009w

iii) q=0.15, s=0.15, v=q(1-s)/(i-sq)a

v =	11.32	18.53	51.12
d_{marg}/v=	2.65	0.67	0.10
d_{main}/v=	0.60	0.23	0.05
d_{gen}/v=	0.68	0.25	0.05
dc_{marg}*d_{marg}/v=	1.160w	0.294w	0.045w
dc_{main}*d_{main}/v=	0.003w	0.001w	0.0003w
(dc*d/v)seg	1.163w	0.295w	0.045w
dc_{gen}*d_{gen}/v=	0.054w	0.020w	0.004w
(dc_{marg}+dc_{main})d_{gen}/v=	0.302w	0.111w	0.024w

TABLE 8.19(iii) Social value of consumption increase, border Rs: dc*d/x (sec. 8.6.5)

ELAST. of mu, n=	-2	-1.5	-1	-0.5	0.0	+0.5
CRI, i, % =	3.56	3.05	2.54	2.03	1.52	1.02

i) q=0.10, s=0.15, v=q(1-s)/(i-sq)a, x= (1-s)/a + sv

v =	4.81	6.60	9.90	19.80	495.0
x = 0.9884+sv	1.71	1.98	2.48	3.96	75.24
d_{marg}/x=	17.51	6.27	2.12	0.57	0.01
d_{main}/x=	3.98	2.13	1.05	0.41	0.01
d_{gen}/x=	4.50	2.33	1.12	0.42	0.01
$dc_{marg}*d_{marg}$/x=	7.676w	2.749w	0.929w	0.252w	0.006w
$dc_{main}*d_{main}$/x=	0.023w	0.012w	0.006w	0.003w	0.0001w
$(dc*d/x)_{seg}$	7.698w	2.761w	0.935w	0.254w	0.006w
$dc_{gen}*d_{gen}$/x=	0.354w	0.184w	0.088w	0.034w	0.001w
$(dc_{marg}+dc_{main})d_{gen}$/v	1.998w	1.034w	0.496w	0.187w	0.006w

ii) q=0.125, s=0.15, v=q(1-s)/(i-sq)a, x= (1-s)/a +sv

v =	7.33	10.52	18.58	79.71
x= 0.9884+sv	2.09	2.57	3.78	12.95
d_{marg}/x=	14.33	4.83	1.39	0.18
d_{main}/x=	3.26	1.64	0.69	0.13
d_{gen}/x=	3.68	1.80	0.73	0.13
$dc_{marg}*d_{marg}$/x=	6.280w	2.118w	0.610w	0.077w
$dc_{main}*d_{main}$/x=	0.018w	0.009w	0.004w	0.001w
$(dc*d/x)_{seg}$	6.298w	2.127w	0.613w	0.078w
$dc_{gen}*d_{gen}$/x=	0.290w	0.142w	0.058w	0.010w
$(dc_{marg}+dc_{main})d_{gen}$/x=	1.635w	0.797w	0.326w	0.057w

iii) q=0.15, s=0.15, v=q(1-s)/(i-sq)a, x= (1-s)/a + sv

v =	11.32	18.53	51.12
x = 0.9884+sv	2.69	3.77	8.66
d_{marg}/x=	11.13	3.29	0.61
d_{main}/x=	2.53	1.12	0.30
d_{gen}/x=	2.86	1.22	0.32
$dc_{marg}*d_{marg}$/x=	4.879w	1.444w	0.266w
$dc_{main}*d_{main}$/x=	0.014w	0.006w	0.002w
$(dc*d/x)_{seg}$	4.894w	1.450w	0.268w
$dc_{gen}*d_{gen}$/x=	0.225w	0.097w	0.025w
$(dc_{marg}+dc_{main})d_{gen}$/x=	1.270w	0.543w	0.142w

TABLE 8.19(iv) Social value of consumption increase, border Rs: dc*d/v* (sec. 8.6.5)

v* =	3.50	2.66	2.02	1.53	1.16	0.88
d_{marg}/v*=	8.56	4.67	2.61	1.48	0.86	0.51
d_{main}/v*=	1.95	1.58	1.30	1.05	0.86	0.70
d_{gen}/v*=	2.20	1.74	1.37	1.09	0.86	0.68
$dc_{marg}*d_{marg}$/v*=	3.750w	2.046w	1.142w	0.650w	0.377w	0.192w
$dc_{main}*d_{main}$/v*=	0.011w	0.009w	0.007w	0.006w	0.005w	0.003w
$(dc*d/v*)_{seg}$	3.761w	2.055w	1.149w	0.655w	0.382w	0.195w
$dc_{gen}*d_{gen}$/v*=	0.173w	0.137w	0.108w	0.086w	0.068w	0.046w
$(dc_{marg}+dc_{main})d_{gen}$/v*=	0.976w	0.770w	0.610w	0.482w	0.382w	0.260w

TABLE 8.19(v) Social value of consumption increase, border Rs: dc*d/x* (sec. 8.6.5)

ELAST. of mu n=	-2	-1.5	-1	-0.5	0.0	+0.5
CRI, i, % =	3.56	3.05	2.54	2.03	1.52	1.02
v* =	3.50	2.66	2.02	1.53	1.16	0.88
x*=(1-s)/a+sv*	1.51	1.39	1.29	1.22	1.16	1.12
d_{marg}/x*=	19.82	8.92	4.07	1.86	0.86	0.35
d_{main}/x*=	4.51	3.03	2.02	1.32	0.86	0.48
d_{gen}/x*=	5.10	3.32	2.15	1.36	0.86	0.46
dc_{marg}*d_{marg}/x*=	8.687w	3.910w	1.785w	0.816w	0.377w	0.151w
dc_{main}*d_{main}/x*=	0.026w	0.017w	0.011w	0.008w	0.005w	0.002w
$(dc*d/x*)_{seg}$	8.713w	3.927w	1.796w	0.822w	0.382w	0.154w
dc_{gen}*d_{gen}/x*=	0.401w	0.262w	0.169w	0.108w	0.068w	0.036w
$(dc_{marg}+dc_{main})d_{gen}$/x*=	2.261w	1.471w	0.954w	0.605w	0.382w	0.205w

TABLE 8.20 Accounting ratios of consumption commodities and SCF for consumption of rural labour, b_L (sec. 8.6.6, App. 5)

PRODUCT	% of EXPNDT =WT	BORDER PRICE Rs/MT	HANDLING at 12% Rs/MT	TRANSPORT Rs/MT	TOTAL LANDED PRICE Rs/MT	DOMESTIC MARKET PRICE Rs/MT	A.R.	WT*AR
Rice	16.30	2262.00	271.44	137.00	2670.44	2228.30	1.20	19.56
Wheat	1.97	2096.76	251.61	137.00	2485.37	2060.80	1.21	2.38
Jowar	11.89	1107.00	110.70		1217.70	1400.00	0.87	10.33 +
labour		41.2W	4.12W		45.32W		0.03W	0.38 W
Ragi	10.58	415.00	41.50		456.50	1833.00	0.25	2.63 +
labour		41.2W	4.12W		45.32W		0.03W	0.26 W
Vanaspati	0.05	5100.10	612.01	137.00	5849.11	11636.40	0.50	0.03
Edib. oil	1.99	6625.30	795.04	137.00	7557.34	12958.30	0.58	1.16
Sugar	3.56	3938.45	472.61	137.00	4548.06	6478.30	0.70	2.50
Others	49.76						0.86	42.79
Pulses	3.90						0.86	3.34
Total	100.00							81.39 + 0.64 W
	Pulses: WT* = Rs mill.							
Gram	3.88	3115.76	373.89	137.00	3626.65	3537.50	1.025	3.974
Arhar	41.30	3461.93	415.43	137.00	4014.36	4584.20	0.876	36.166
Urad	40.75	2546.06	305.53	137.00	2988.59	3607.08	0.829	33.764
Moong	4.71	4191.72	503.01	137.00	4831.73	4201.50	1.150	5.417
Gram sp	3.71	1444.42	173.33	137.00	1754.75	4413.00	0.398	1.474
	94.34						0.857	80.795
Fertilizer		2088.64	250.64	137.00	2476.28			
Nitrogen					5533.90			

Note: Details of procedure in text. Border prices are cif imports; 12% handling charges, and rail freight at Rs 0.137 per km-tonne added. For Jowar and Ragi, local production increases assumed; inputs mainly of nitrogen and labour. Nitrogen valued from fertilizer costs, assuming an average content of 44.79%; labour valued at shadow wage rate W. The last column, WT*AR, is totalled and averaged to get the weighted mean Accounting Ratio (AR) of the composite bundle of commodities. Apart from the major items, all remaining commodities valued at SCF 0.86.
* For pulses, weight of each type = value of imports.
Source: Consumption expenditure composition from NSS 26R (NSSO, 1976). Border prices from Government of India, 1982b (Monthly Statistics of Foreign Trade, 1981-82). Domestic market prices from Government of India, 1983 (Bulletin of Food Statistics, 1981-82), and GoI, 1981a (Agricultural Situation in India, April 1981). For whole moong, wastage of 10% assumed on conversion to split.

TABLE 8.21(i) Shadow wage rates and conversion factors based on v -values of public income (sec. 8.6.7)

ELAST. of mu n	-2.0	-1.5	-1.0	-0.5	0.0	0.5
CRI, i, %	3.56	3.05	2.54	2.03	1.52	1.02
1 SWR, based on v; q=0.10; wage rate w= Rs 5.25 (1981)						
1.1 Population homogeneous for m, dc, d						
A) bc = a =0.86; SWR=(0.9116+0.0787)(0.86)w-$dc_{gen}d_{gen}$/v						
bL	0.7258	0.7965	0.8297	0.8450	0.8515	0.8517
B) bc = 0.8139+0.0064SWR						
bL	0.7035	0.7766	0.8110	0.8268	0.8335	0.8337
bc	0.8375	0.8400	0.8412	0.8417	0.8419	0.8419
1.2 Population disaggregated for m, homogeneous for dc, d						
A) bc = a =0.86; SWR=(0.4723+0.0787)(0.86)w-$dc_{gen}d_{gen}$/v						
bL	0.3478	0.4187	0.4519	0.4672	0.4737	0.4739
B) bc = 0.8139+0.0064SWR						
bL	0.3286	0.4007	0.4345	0.4501	0.4567	0.4569
bc	0.8249	0.8274	0.8285	0.8290	0.8293	0.8293
2 SWR, based on v; q=0.125; wage rate w= Rs 5.25 (1981)						
2.1 Population homogeneous for m, dc, d						
A) bc = a =0.86						
bL	0.7691	0.8171	0.8400	0.8500	0.8517	0.8517
B) bc = 0.8139+0.0064SWR						
bL	0.7483	0.7980	0.8216	0.8320	0.8337	0.8337
bc	0.8390	0.8407	0.8415	0.8419	0.8419	0.8419
2.2 Population disaggregated for m, homogeneous for dc, d						
A) bc = a =0.86						
bL	0.3913	0.4393	0.4622	0.4722	0.4739	0.4739
B) bc = 0.8139+0.0064SWR						
bL	0.3728	0.4217	0.4450	0.4552	0.4569	0.4569
bc	0.8264	0.8281	0.8289	0.8292	0.8293	0.8293
3 SWR, based on v; q=0.15; wage rate w= Rs 5.25 (1981)						
3.1 Population homogeneous for m, dc, d						
A) bc = a =0.86						
bL	0.7982	0.8320	0.8474	0.8517	0.8517	0.8517
B) bc = 0.8139+0.0064SWR						
bL	0.7784	0.8134	0.8293	0.8337	0.8337	0.8337
bc	0.8401	0.8412	0.8418	0.8419	0.8419	0.8419
3,2 Population disaggregated for m, homogeneous for dc, d						
A) bc = a =0.86						
bL	0.4204	0.4542	0.4696	0.4739	0.4739	0.4739
B) bc = 0.8139+0.0064SWR						
bL	0.4024	0.4369	0.4525	0.4569	0.4569	0.4569
bc	0.8274	0.8286	0.8291	0.8293	0.8293	0.8293

TABLE 8.21(ii) Shadow wage rates and conversion factors based on x -values of public income (sec. 8.6.7)

ELAST. of mu n	-2.0	-1.5	-1.0	-0.5	0.0	0.5
CRI, i, %	3.56	3.05	2.54	2.03	1.52	1.02
1 SWR, based on x; q=0.10; wage rate w= Rs 5.25 (1981)						
1.1 Population homogeneous for m, dc, d						
A) bc = a =0.86; $SWR=(0.9116+0.0787)(0.86)w-dc_{gen}d_{gen}/x$						
bL	0.4976	0.6677	0.7639	0.8182	0.8504	0.8517
B) bc = 0.8139+0.0064SWR						
bL	0.4675	0.6434	0.7429	0.7991	0.8324	0.8337
bc	0.8296	0.8355	0.8389	0.8408	0.8419	0.8419
1.2 Population disaggregated for m, homogeneous for dc, d						
A) bc = a =0.86; $SWR=(0.4723+0.0787)(0.86)w-dc_{gen}d_{gen}/x$						
bL	0.1198	0.2899	0.3861	0.4404	0.4726	0.4739
B) bc = 0.8139+0.0064SWR						
bL	0.0961	0.2695	0.3675	0.4228	0.4556	0.4569
bc	0.8171	0.8230	0.8263	0.8281	0.8292	0.8293
2 SWR, based on x; q=0.125; wage rate w= Rs 5.25 (1981)						
2.1 Population homogeneous for m, dc, d						
A) bc = a =0.86						
bL	0.5619	0.7099	0.7941	0.8415	0.8517	0.8517
B) bc = 0.8139+0.0064SWR						
bL	0.5340	0.6871	0.7742	0.8232	0.8337	0.8337
bc	0.8318	0.8370	0.8399	0.8416	0.8419	0.8419
2.2 Population disaggregated for m, homogeneous for dc, d						
A) bc = a =0.86						
bL	0.1841	0.3321	0.4163	0.4637	0.4739	0.4739
B) bc = 0.8139+0.0064SWR						
bL	0.1617	0.3124	0.3983	0.4465	0.4569	0.4569
bc	0.8193	0.8244	0.8273	0.8289	0.8293	0.8293
3 SWR, based on x; q=0.15; wage rate w= Rs 5.25 (1981)						
3.1 Population homogeneous for m, dc, d						
A) bc = a =0.86						
bL	0.6266	0.7551	0.8265	0.8517	0.8517	0.8517
B) bc = 0.8139+0.0064SWR						
bL	0.6009	0.7338	0.8077	0.8337	0.8337	0.8337
bc	0.8341	0.8386	0.8410	0.8419	0.8419	0.8419
3.2 Population disaggregated for m, homogeneous for dc, d						
A) bc = a =0.86						
bL	0.2488	0.3773	0.4487	0.4739	0.4739	0.0000
B) bc = 0.8139+0.0064SWR						
bL	0.2276	0.3585	0.4312	0.4569	0.4569	0.4569
bc	0.8216	0.8260	0.8284	0.8293	0.8293	0.8293

TABLE 8.21(iii) Shadow wage rates and conversion factors based on v* -values of public income (sec. 8.6.7)

ELAST. of mu n	-2.0	-1.5	-1.0	-0.5	0.0	0.5
CRI, i, %	3.56	3.05	2.54	2.03	1.52	1.02
v* =	3.4981	2.6561	2.0168	1.5314	1.1628	0.8829
1 SWR, based on v*; wage rate w= Rs 5.25 (1981)						
1.1 Population homogeneous for m, dc, d						
A) bc = a =0.86; SWR=(0.9116+0.0787)(0.86)w-$dc_{gen}d_{gen}$/v*						
bL	0.6787	0.7147	0.7436	0.7656	0.7837	0.8057
B) bc = 0.8139+0.0064SWR						
bL	0.6548	0.6920	0.7220	0.7448	0.7634	0.7862
bc	0.8359	0.8372	0.8382	0.8389	0.8396	0.8403
1.2 Population disaggregated for m, homogeneous for dc, d						
A) bc = a =0.86; SWR=(0.4723+0.0787)(0.86)w-$dc_{gen}d_{gen}$/v*						
bL	0.3010	0.3370	0.3660	0.3880	0.4060	0.4280
B) bc = 0.8139+0.0064SWR						
bL	0.2805	0.3177	0.3468	0.3698	0.3879	0.4100
bc	0.8233	0.8246	0.8256	0.8263	0.8269	0.8277
1.3 Population homogeneous for d, disaggregated for m, dc						
A) bc = a =0.86; SWR=(0.4723+0.4438)(0.86w)-(dc_{marg}+dc_{main})d_{gen}/v*						
bL	-0.1833	0.0178	0.1784	0.3058	0.4062	0.5278
B) bc = 0.8139+0.0064SWR						
bL	-0.2378	-0.0245	0.1404	0.2719	0.3755	0.5009
bc	0.8059	0.8131	0.8186	0.8230	0.8265	0.8307
1.4 Population disaggregated for m, dc, and d						
A) bc = a =0.86; SWR=(0.4723+0.4438)(0.86w)-$(dc.d/v^*)_{seg}$						
bL	-2.9732	-1.2672	-0.3612	0.1329	0.4059	0.5929
B) bc = 0.8139+0.0064SWR						
bL	-3.1112	-1.3509	-0.4163	0.0932	0.3755	0.5679
bc	0.7094	0.7685	0.7999	0.8170	0.8265	0.8330

Note: bL is the conversion factor for labour; bc is the conversion factor for workers' consumption. SWR = w.bL, i.e. market wage rate (in domestic Rs) multiplied by the conversion factor to express it in border Rs, after incorporating disributive and efficiency effects.

TABLE 8.21(iv) Shadow wage rates and conversion factors based on x* -values of public income (sec. 8.6.7)

ELAST. of mu n	-2.0	-1.5	-1.0	-0.5	0.0	0.5
CRI, i, %	3.56	3.05	2.54	2.03	1.52	1.02
x* =	1.51	1.39	1.29	1.22	1.16	1.12
1 SWR, based on x*; w= Rs 5.25 (1981)						
1.1 Population homogeneous for m, dc, d						
A) bc = a =0.86; SWR=(0.9116+0.0787)(0.86)w-$dc_{gen}d_{gen}$/x*						
bL	0.4509	0.5899	0.6828	0.7437	0.7837	0.8154
B) bc = 0.8139+0.0064SWR						
bL	0.4192	0.5629	0.6590	0.7220	0.7634	0.7962
bc	0.8280	0.8328	0.8360	0.8382	0.8396	0.8407
1.2 Population disaggregated for m, homogeneous for dc, d						
A) bc = a =0.86; SWR=(0.4723+0.0787)(0.86)w-$dc_{gen}d_{gen}$/x*						
bL	0.0731	0.2121	0.3050	0.3659	0.4059	0.4376
B) bc = 0.8139+0.0064SWR						
bL	0.0486	0.1902	0.2848	0.3469	0.3876	0.4199
bc	0.8155	0.8203	0.8235	0.8256	0.8269	0.8280

TABLE 9.1 Accounting prices for teak plantations (sec. 9.1.4)

PRODUCT	BORDER PRICE 1981-82 Rs per	UNIT unit	HANDLING at 12% Rs	TRANSPORT Rs	TOTAL LANDED PRICE Rs	DOMESTIC MARKET PRICE Rs	A.R.
Barbed wire	9180.50	MT	1101.66	137.00	10419.16	9006.92	1.1568
Chem. fert.	2088.64	MT	250.64	137.00	2476.28		
Nitrogen	4663.18	MT	559.58	305.87	5528.64	4931.22	1.1212
-"-, corrected						5261.12	1.0508

Border prices from Monthly Statistics of Foreign Trade, 1981-82.
Domestic market prices: please see text. Barbed wire: cif price of 18-26 SWG galvanised iron wire; domestic price Rs 14/kg in 1985-86 (pers. comm.) deflated to 1981-82 prices at 11.66% per annum, the average rate of increase in the wholesale price index over 1970-71 to 1984-85.
Price of nitrogen derived from fertilizer price assuming 44.79% nitrogen content by weight. Domestic price of fertilizer: weighted average price paid by farmers (FAO Fertilizer YB, 1985).

TABLE 9.2 Expenditure on teak plantation at accounting prices (sec. 9.1.4)

Note: Work rates are as per schedule of rates, Yellapur Division, sanctioned in 1984-85, renewed to 1986-87.
Daily wage rates, effective from 1-1-1985, are Rs 9.75 for heavy, and Rs 7.80 for light, labour.
Accounting ratios based on 1981-82 data (please see text).
Labour component has to be multiplied by b_L;
non-wage component converted to border values and expressed as a composite item with a single AR. Details in Table 7.17.
Notation: md manday; ha hectare; rmt running meter

No	Description	Rate, Rs market	AR	Rs border	per	Qty	Expenditure, Rs (domest) Labour	Rs (domest) Other	Rs (border) Labour	Rs (border) Other
A.	Supervision and admin.	50.00	0.86	43.00	1 ha	1 ha		50.00		43.00
B.	Teak nursery, 400 standard beds									
1.	Labour	9.75	b_L	$9.75b_L$	mday		34656.49		$34656.49b_L$	
2.	Non-labour									
	Transport of seed	300.00	0.816	244.80	L.S.	5000 kg		300.00		244.80
	Fencing									
	Transp.	200.00	0.816	163.20	L.S.	200 posts		200.00		163.20
	Wire	14.00	1.157	16.20	1 kg	400 kg		5600.00		6479.20
	Implements	1000.00	0.663	663.00	LS			1000.00		663.00
	Chemicals	2000.00	1.051	2102.00	LS			2000.00		2102.00
	Non-labour (TOTAL)		1.061					9100.00		9652.20
C.	YEAR 1									
1.	Labour									
	Nursery	9.75	b_L	$9.75b_L$	mday	4 bed	346.56		$346.56b_L$	
	Plantn.	9.75	b_L	$9.75b_L$	mday	1 ha	1519.44		$1519.44b_L$	
	Labour (TOTAL)		b_L				1866.00		$1866.00b_L$	
2.	Non-labour									
	Nursery		1.061			4 beds		91.00		96.52
	Plantn.					1 ha				
	Barbed wire	14.00	1.157	16.20	1 kg	72kg		1008.00		1166.26
	Transport of fence posts	200.00	0.816		200 no.	36 no		36.00		29.38
	Supervision	470.00	0.860	404.20	1 ha	1 ha		470.00		404.20
	Admin.	50.00	0.860	43.00	1 ha					
	Non-labour (TOTAL)		1.057					1605.00		1696.36

TABLE 9.2 Expenditure on teak plantation at accounting prices (contd.)

No	Description	Rate, Rs market	AR	Rs border	per	Qty	Expenditure, Rs (domest) Labour	Rs (domest) Other	Rs (border) Labour	Rs (border) Other
D.	YEAR 2									
1.	Labour									
	Nursery	9.75	b_L	9.75b_L	1 md	1 bed	86.64		86.64b_L	
	Plantn.	9.75	b_L	9.75b_L		1 ha	891.30		891.30b_L	
	Labour (TOTAL)		b_L			1 ha	977.94		977.94b_L	
2.	Non-labour									
	Nursery	91.00	1.061	96.55	4 beds	1 bed		22.75		24.14
	Plantn.									
	Supervn.	470.00	0.860	404.20	1 ha	1 ha		470.00		404.20
	Admn.	50.00	0.860	43.00	1 ha	1 ha		50.00		43.00
	Non-labour (TOTAL)		0.868			1 ha		542.75		471.34
E.	YEAR 3									
1.	Labour									
	Plantn.	9.75	b_L	9.75b_L	1 ha	1 ha	473.72		473.72b_L	
2.	Non-labour									
	Supn. & adm.	520.00	0.860	447.20	1 ha	1 ha		520.00		447.20
F.	YEAR 4									
1.	Labour									
	Fire tracing	21.84	b_L	21.84b_L	100m	90m	19.66		19.66b_L	
2.	Non-labour									
	Admin.	50.00	0.860	43.00	1 ha	1 ha		50.00		43.00
G.	YEAR 5									
1.	Labour									
	Dismantling fence	1.21	b_L	1.21b_L	1 post	36	43.56		43.56b_L	
	Fire tracing	21.84	b_L	21.84b_L	100m	90m	19.66		19.66b_L	
	Labour (TOTAL)						63.22		63.22b_L	
2.	Non-labour (income)									
	Value of wire	7.00	1.157	8.10	1 kg	72kg		504.00(-)		583.13
3.	Non-labour (expend.)									
	Annual admin.	50.00	0.86	43.00	1 ha	1 ha		50.00		43.00

Note: Salvaged barbed wire valued at half the new cost. Negative values denote net revenue, as against costs. Perimeter of 90 mt derived on basis of rectangular plot of 20 ha, 400 mt by 500 mt. Please see Table 7.17.

No	Description	Rate, Rs market	AR	Rs border	per	Qty	Expenditure, Rs (domest) Labour	Rs (domest) Other	Rs (border) Labour	Rs (border) Other
H.	YEAR 6 and onward									
i.	**Every year**									
1	Fire tracing	21.84	b_L	21.84b_L	100 mt	90 mt	19.66		19.66b_L	
2	Annual admin	50.00	0.86	43.00	1 ha	1 ha		50.00		43.00
ii.	**Years 6, 16, 26, and 36**									
	Cutting eupatorium	155.32	b_L	155.32b_L	1 ha	1 ha	155.32		155.32b_L	
iii.	**Years 11, 21, ..., and 71**									
	Heavy cultural operations	204.00	b_L	204.32b_L	1 ha	1 ha	204.00		204.00b_L	
iv.	**First thinning** (SQII-age 5; SQIII-age 10)									
	Marking	4.84	b_L	4.84b_L	100trees	1250	60.50		60.50b_L	
	Felling, conversion, stacking	102.07	b_L	102.07b_L	100	1250	1275.88		1275.88b_L	
	TOTAL						1336.38		1336.38b_L	

TABLE 9.2 Expenditure on teak plantation at accounting prices (contd.)

No	Description	Rate, Rs market	AR	Rs border	per	Qty	Expenditure, Rs (domest) Labour	Other	Rs (border) Labour	Other
v.	**Second thinning** (SQIV-age 10)									
	Marking	4.84	b_L	4.84b_L	100trees	900	43.56		43.56b_L	
	Felling etc	102.07	b_L	4.84b_L	100 "	900	918.63		918.63b_L	
	TOTAL						962.19		962.19b_L	
vi.	**Second thinning** (SQII-age 10; SQIII-age 15)									
	Marking	9.68	b_L	9.68b_L	100trees	625	60.50		60.50b_L	
	Felling etc	181.55	b_L	181.55b_L	100 "	625	1134.69		1134.69b_L	
	TOTAL						1195.19		1195.19b_L	
	(SQIV-age 15)									
	Marking	4.84	b_L	4.84b_L	100trees	480	23.23		23.23b_L	
	Felling etc	102.07	b_L	102.07b_L	100 "	480	489.94		489.94b_L	
	TOTAL						513.17		513.17b_L	
vii.	**Third thinning** (SQII-age 20)									
	Marking	11.56	b_L	11.56b_L	100trees	252	29.13		29.13b_L	
	Felling etc	239.92	b_L	239.92b_L	100 "	252	604.60		604.60b_L	
	TOTAL						633.38		633.38b_L	
	(SQIII-age 20)									
	Marking	11.56	b_L	11.56b_L	100trees	185	21.39		21.39b_L	
	Felling etc	239.92	b_L	239.92b_L	100trees	185	443.96		443.96b_L	
	TOTAL						465.35		465.35b_L	
	(SQIV-age 20)									
	Marking	9.68	b_L	9.68b_L	100trees	267	25.85		25.85b_L	
	Felling etc	181.55	b_L	181.55b_L	100 "	267	484.74		484.74b_L	
	TOTAL						510.58		510.58b_L	
viii.	**Fourth thinning** (SQII-age 25)									
	Marking	12.98	b_L	12.98b_L	100trees	81	10.51		10.51b_L	
	Felling etc	404.78	b_L	404.78b_L	100 "	81	327.87		327.87b_L	
	TOTAL						338.39		338.39b_L	
	(SQIII-age 25)									
	Marking	12.98	b_L	12.98b_L	100trees	126	16.36		16.36b_L	
	Felling etc	404.78	b_L	404.78b_L	100 "	126	510.02		510.02b_L	
	TOTAL						526.38		526.38b_L	
	(SQIV-age 25)									
	Marking	9.68	b_L	9.68b_L	100trees	170	16.46		16.46b_L	
	Felling etc	181.55	b_L	181.55b_L	100 "	170	308.64		308.64b_L	
	TOTAL						325.09		325.09b_L	

Note: First and second are mechanical thinnings. SQII and SQIII crops assumed to have same number of stems removed in these two thinnings; less for SQIV, due to poorer crop.
Third and subsequent thinnngs are silvicultural; number of stems removed depends on crop. Yield table figures followed generally.
Thinnings beyond the fourth involve so few stems, that costs of marking and felling are subsumed under general costs.

TABLE 9.3 Expenditure statement, 1 ha teak plantation, SQII: accounting prices (sec. 9.1.4)

AGE yrs	YEAR	CASH FLOW Rs: INFLOW Rs(bor)	OUTFLOW: LABOUR Rs(dom) ($AR=b_L$)	OUTFLOW: OTHER Rs(dom)	AR	Rs(bor)	
0	1	0.	1866.00	1605.00	1.057	1696.49	
1	2	0.	977.94	542.75	0.868	471.34	
2	3	0.	473.72	520.00	0.860	447.20	
3	4	0.	19.66	50.00	0.860	43.00	
4	5	583.13	63.22	50.00	0.860	43.00	
5	6	0.	1511.36	50.00	0.860	43.00	(I thin)
6-9	7-10	0.	19.66	50.00	0.860	43.00	
10	11	0.	1418.85	50.00	0.860	43.00	(II thin)
11-14	12-16	0.	19.66	50.00	0.860	43.00	
15	16	0.	174.98	50.00	0.860	43.00	
16-19	17-20	0.	19.66	50.00	0.860	43.00	
20	21	0.	857.54	50.00	0.860	43.00	(III thin)
21-24	22-25	0.	19.66	50.00	0.860	43.00	
25	26	0.	513.37	50.00	0.860	43.00	(IV thin)
26-29	27-30	0.	19.66	50.00	0.860	43.00	
30	31	0.	223.66	50.00	0.860	43.00	
31-34	32-35	0.	19.66	50.00	0.860	43.00	
35	36	0.	174.98	50.00	0.860	43.00	
36-39	37-40	0.	19.66	50.00	0.860	43.00	
40	41	0.	223.66	50.00	0.860	43.00	
41-49	42-50	0.	19.66	50.00	0.860	43.00	
50	51	0.	223.66	50.00	0.860	43.00	
51-59	52-60	0.	19.66	50.00	0.860	43.00	
60	61	0.	223.66	50.00	0.860	43.00	
61-69	62-70	0.	19.66	50.00	0.860	43.00	
70	71	0.	223.66	50.00	0.860	43.00	
71-80	72-81	0.	19.66	50.00	0.860	43.00	

Note: For rates of individual items, please see Table 7.17. Annual administrative charge is not included in year 1, to avoid double counting in rotation year for the infinite series of crops when computing soil expectation value.

TABLE 9.4 Expenditure statement, 1 ha teak plantation, SQIII: accounting prices (sec. 9.1.4)

AGE yrs	YEAR	CASH FLOW Rs: INFLOW Rs(bor)	OUTFLOW: LABOUR Rs(dom) (AR=b_L)	OUTFLOW: OTHER Rs(dom)	OTHER AR	OTHER Rs(bor)	
0	1	0.	1866.00	1605.00	1.057	1696.49	
1	2	0.	977.94	542.75	0.868	971.34	
2	3	0.	473.72	520.00	0.860	447.20	
3	4	0.	19.66	50.00	0.860	43.00	
4	5	583.13	63.22	50.00	0.860	43.00	
5	6	0.	174.98	50.00	0.860	43.00	
6-9	7-10	0.	19.66	50.00	0.860	43.00	
10	11	0.	1560.04	50.00	0.860	43.00	(I thin)
1-14	12-16	0.	19.66	50.00	0.860	43.00	
15	16	0.	1370.17	50.00	0.860	43.00	(II thin)
16-19	17-20	0.	19.66	50.00	0.860	43.00	
20	21	0.	689.01	50.00	0.860	43.00	(III thin)
21-24	22-25	0.	19.66	50.00	0.860	43.00	
25	26	0.	701.36	50.00	0.860	43.00	(IV thin)
26-29	27-30	0.	19.66	50.00	0.860	43.00	
30	31	0.	223.66	50.00	0.860	43.00	
31-34	32-35	0.	19.66	50.00	0.860	43.00	
35	36	0.	174.98	50.00	0.860	43.00	
36-39	37-40	0.	19.66	50.00	0.860	43.00	
40	41	0.	223.66	50.00	0.860	43.00	
41-49	42-50	0.	19.66	50.00	0.860	43.00	
50	51	0.	223.66	50.00	0.860	43.00	
51-59	52-60	0.	19.66	50.00	0.860	43.00	
60	61	0.	223.66	50.00	0.860	43.00	
61-69	62-70	0.	19.66	50.00	0.860	43.00	
70	71	0.	223.66	50.00	0.860	43.00	
71-80	72-81	0.	19.66	50.00	0.860	43.00	

TABLE 9.5 Expenditure statement, 1 ha teak plantation, SQIV: accounting prices

AGE yrs	YEAR	CASH FLOW Rs: INFLOW Rs(bor)	OUTFLOW: LABOUR Rs(dom) ($AR=b_L$)	OUTFLOW: OTHER Rs(dom)	OTHER AR	OTHER Rs(bor)	
0	1	0.	1866.00	1605.00	1.057	1696.49	
1	2	0.	977.94	542.75	0.868	471.34	
2	3	0.	473.72	520.00	0.860	447.20	
3	4	0.	19.66	50.00	0.860	43.00	
4	5	583.13	63.22	50.00	0.860	43.00	
5	6	0.	174.98	50.00	0.860	43.00	
6-9	7-10	0.	19.66	50.00	0.860	43.00	
10	11	0.	1185.85	50.00	0.860	43.00	(I thin)
11-14	12-16	0.	19.66	50.00	0.860	43.00	
15	16	0.	688.15	50.00	0.860	43.00	(II thin)
16-19	17-20	0.	19.66	50.00	0.860	43.00	
20	21	0.	734.24	50.00	0.860	43.00	(III thin)
21-24	22-25	0.	19.66	50.00	0.860	43.00	
25	26	0.	500.07	50.00	0.860	43.00	(IV thin)
26-29	27-30	0.	19.66	50.00	0.860	43.00	
30	31	0.	223.66	50.00	0.860	43.00	
31-34	32-35	0.	19.66	50.00	0.860	43.00	
35	36	0.	174.98	50.00	0.860	43.00	
36-39	37-40	0.	19.66	50.00	0.860	43.00	
40	41	0.	223.66	50.00	0.860	43.00	
41-49	42-50	0.	19.66	50.00	0.860	43.00	
50	51	0.	223.66	50.00	0.860	43.00	
51-59	52-60	0.	19.66	50.00	0.860	43.00	
60	61	0.	223.66	50.00	0.860	43.00	
61-69	62-70	0.	19.66	50.00	0.860	43.00	
70	71	0.	223.66	50.00	0.860	43.00	
71-80	72-81	0.	19.66	50.00	0.860	43.00	

TABLE 9.6 Social cost benefit analysis of 1 **hectare SQIII** teak plantation; lead 10 km (sec. 9.2.2)

Benefit flows: as in Table 7.15, with 12% added for taxes, and then multiplied by AR 0.86 for timber and smallwood.
Cost flows: as in Table 9.4; labour AR is SWR; general AR 0.86; AR for remaining items as in Table 9.3.
Extraction and transport costs as for financial analysis, ARs as above for labour (SWR) and transport (0.816).

DISC. RATE %	ROTN. years	SWR = 0.25 NDR 1st rotn.	Soil exp.	0.50 NDR 1st rotn.	Soil exp.	0.75 NDR 1st rotn.	Soil exp.	1.0 NDR 1st rotn.	Soil exp.
		Rs (border)							
0.0	10	22942		20881		18819		16757	
	40	150984		146493		142001		137509	
	75	519762		513616		507470		501324	
	80	564466		558135		551804		545474	
1.0	10	20744	219024	18793	198421	16841	177817	14890	157214
	40	106237	323552	102533	312272	98829	300991	95125	289711
	70	235017	468456	230766	459983	226516	451510	222265	443037
	75	266333	506462	261962	498149	257590	489836	253219	481524
	80	277889	506283	273473	498236	269056	490189	264639	482142
2.00	10	18761	104430	16909	94123	15057	83816	13206	73509
	40	75682	138332	72558	132622	69434	126912	66310	121202
	70	130415	173893	127097	169469	123779	165045	120461	160621
	75	141644	183111	138285	178769	134927	174428	131569	170086
	80	142825	179679	139464	175451	136103	171223	132742	166994
3.00	10	16969	66311	15208	59429	13447	52546	11685	45664
	40	54636	78790	51946	74911	49256	71031	46566	67152
	65	73879	86552	71154	83359	68429	80167	65704	76974
	70	75425	86328	72693	83201	69961	80075	67230	76948
	75	78961	88616	76219	85538	73476	82460	70734	79382
	80	77562	85607	74827	82588	72091	79569	69356	76550
4.00	10	15349	47310	13669	42134	11990	36959	10311	31783
	30	35592	51457	33251	48073	30909	44688	28568	41303
	40	40001	50525	37641	47544	35281	44563	32920	41581
	55	44733	50583	42386	47929	40038	45275	37691	42620
	60	45632	50425	43284	47831	40937	45237	38590	42644
	70	45821	48966	43479	46463	41137	43960	38795	41457
	75	46595	49191	44252	46718	41909	44244	39566	41771
	80	45017	47059	42682	44617	40346	42176	38011	39735
5.00	10	13881	35955	12277	31799	10672	27643	9068	23487
	20	23693	38025	21671	34779	19649	31534	17626	28288
	30	28120	36585	26010	33840	23900	31095	21791	28350
	40	29718	34638	27612	32184	25506	29729	23401	27275
	50	30541	33459	28452	31170	26363	28882	24274	26593
	55	30550	32790	28469	30557	26388	28323	24307	26090
	60	30421	32142	28344	29947	26267	27753	24190	25558
	75	29309	30084	27242	27962	25175	25841	23108	23719
	80	28125	28704	26064	26600	24002	24496	21941	22393
6.00	10	12551	28422	11015	24943	9478	21463	7941	17984
	20	20033	29109	18160	26389	16288	23669	14416	20948
	30	22366	27082	20445	24755	18524	22429	16603	20103
	35	22466	25827	20553	23627	18639	21427	16725	19227
	40	22408	24821	20503	22711	18597	20600	16692	18489
	80	18907	19088	17045	17208	15184	15329	13322	13449
7.50	10	10782	20944	9336	18136	7891	15328	6445	12520
	15	13847	20917	12221	18459	10594	16002	8967	13545
	20	15621	20431	13936	18227	12250	16022	10565	13818
	30	16058	18128	14359	16210	12660	14292	10960	12374
	40	15079	15964	13402	14188	11724	12412	10046	10635
	80	11730	11766	10085	10116	8440	8466	6795	6816

TABLE 9.6 Social cost benefit analysis of 1 **hectare SQIII**
(contd.) teak plantation; lead 10 km (sec. 9.2.2)

DISC. RATE %	ROTN. years	SWR = 0.25 NDR 1st rotn.	Soil exp.	0.50 NDR 1st rotn.	Soil exp.	0.75 NDR 1st rotn.	Soil exp.	1.0 NDR 1st rotn.	Soil exp.
		Rs (border)							
10.00	5	4931	3008	3876	0226	2822	7444	1767	4663
	10	8339	13572	7020	11425	5701	9279	4382	7132
	15	9891	13004	8461	11124	7031	9244	5601	7364
	20	10373	12184	8921	10478	7469	8773	6017	7067
	25	9958	10970	8506	9371	7055	7772	5603	6173
	40	8325	8513	6903	7058	5480	5604	4058	4150
	80	6509	6512	5103	5106	3697	3699	2292	2293
12.50	5	4099	9210	3081	6924	2064	4639	1047	2353
	10	6400	9248	5183	7490	3966	5731	2749	3972
	15	7024	8472	5741	6925	4458	5377	3175	3830
	20	6885	7607	5599	6186	4313	4765	3026	3344
	40	4884	4928	3628	3661	2372	2393	1116	1126
	80	4051	4052	2803	2803	1554	1554	305	305
15.00	5	3372	6707	2389	4751	1405	2794	421	838
	10	4851	6444	3717	4937	2582	3430	1448	1924
	15	4919	5608	3748	4273	2577	2938	1406	1603
	20	4515	4809	3350	3568	2184	2326	1018	1085
	40	2935	2946	1794	1801	653	655	-487	-489
	80	2569	2569	1431	1431	293	293	-844	-844
17.50	5	2737	4945	1783	3222	829	1498	-124	-224
	10	3604	4502	2538	3170	1472	1838	405	506
	15	3353	3681	2269	2491	1184	1300	100	109
	20	2868	2987	1792	1866	716	746	-359	-373
	40	1715	1718	658	659	-399	-399	-1456	-1459
	80	1556	1556	499	499	-556	-556	-1612	-1612
20.00	5	2179	3644	1252	2094	325	544	-601	1005
	10	2596	3096	1586	1891	575	686	-434	-518
	15	2174	2325	1157	1238	140	150	-876	-936
	20	1697	1742	689	708	-317	-326	-1325	-1360
	40	885	885	-109	-109	-1103	-1104	-2097	-2099
	80	814	814	-178	-178	-1172	-1172	-2166	-2166

TABLE 9.7 Social cost benefit analysis of **1 hectare** SQIV teak plantation; lead 10 km (sec. 9.2.3)

Benefit flows: as in Table 7.16, with 12% added for taxes, and then multiplied by AR 0.86 for timber and smallwood.
Cost flows: as in Table 9.5; AR for labour SWR; general AR 0.86; AR for remaining items as in Table 9.3.
Extraction and transport costs as for financial analysis, ARs as above for labour (SWR) and transport (0.816).

DISC. RATE %	ROTN. years	SWR = 0.25 NDR 1st rotn.	Soil exp.	0.50 NDR 1st rotn.	Soil exp.	0.75 NDR 1st rotn.	Soil exp.	1.0 NDR 1st rotn.	Soil exp.
		Rs (border)							
0.00	10	7740		6208		4675		3143	
	40	38612		35535		32457		29380	
	75	139051		135031		131010		126990	
	80	165528		161371		157214		153056	
1.00	10	6717	70922	5252	55456	3787	39990	2322	24523
	40	26707	81340	24128	73484	21548	65627	18968	57770
	75	69607	132365	66661	126763	63715	121161	60769	115559
	80	78965	143865	75980	138427	72995	132990	70011	127552
2.00	10	5800	32286	4396	24473	2993	16660	1589	8847
	40	18505	33824	16291	29778	14078	25731	11864	21685
	75	35756	46224	33426	43211	31095	40198	28764	37185
	80	38788	48797	36450	45856	34113	42915	31775	39975
3.00	10	4977	19452	3629	14184	2281	8916	933	3648
	15	8021	22397	6454	18023	4888	13649	3321	9275
	20	9839	22046	8101	18151	6362	14256	4624	10361
	40	12799	18457	10859	15659	8918	12861	6978	10063
	75	18880	21189	16925	18994	14969	16799	13013	14604
	80	19686	21728	17733	19572	15779	17416	13825	15259
4.00	10	4239	13067	2941	9067	1644	5067	346	1067
	15	6607	14856	5127	11529	3648	8203	2168	4876
	20	7795	14340	6182	11373	4570	8407	2957	5440
	25	8096	12956	6415	10267	4735	7578	3055	4889
	40	8788	11100	7055	8911	5322	6723	3589	4534
	75	10216	10785	8504	8978	6792	7171	5081	5364
	80	10308	10775	8600	8990	6892	7204	5184	5419
5.00	10	3576	9263	2324	6020	1072	2777	-179	-465
	15	5388	10382	3985	7679	2582	4976	1179	2273
	20	6103	9795	4597	7378	3092	4962	1586	2546
	25	6079	8627	4527	6425	2976	4223	1424	2021
	30	6249	8130	4680	6089	3112	4049	1543	2008
	40	5937	6920	4364	5087	2792	3254	1219	1420
	80	5501	5614	3961	4043	2422	2472	882	900
6.00	25	4466	5823	3022	3940	1577	2057	133	173
	40	3887	4305	2439	2702	992	1099	-454	-503
	80	2894	2922	1478	1492	62	62	-1353	-1366
7.50	10	2194	4262	1039	2020	-114	-222	-1268	-2464
	15	3019	4560	1771	2675	522	789	-725	-1096
	20	3021	3951	1721	2251	420	550	-879	-1150
	25	2621	3135	1306	1562	-8	-10	-1323	-1583
	40	1801	1907	497	526	-807	-855	-2112	-2236
	80	858	861	-423	-424	-1705	-1711	-2988	-2997
10.0	10	1128	1837	52	84	-1024	-1667	-2101	-3419
	15	1365	1794	231	304	-902	-1186	-2035	-2676
	20	1058	1242	-99	-117	-1257	-1477	-2415	-2837
	40	-158	-161	-1303	-1332	-2448	-2503	-3593	-3674
	80	-660	-660	-1794	-1795	-2928	-2930	-4062	-4064

TABLE 10.1 Local needs and removals, Yellapur division (sec. 10.1.2)

YEAR	FREE GRANTS	RIGHT HOLDERS	TOTAL LOCAL	EXTR. by PURCHAS.	GOVT. DEPOT ARRIVALS Non-Teak	Teak	TOTAL Non-Teak (2 TO 6)	LOCAL as % of Non-Teak (4)/(8)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	cubic metres							
TIMBER								
1951-52	663.62	986.30	1649.92	5823.58	8920.91	5080.07	16394.42	10.06%
1952-53	666.96	569.86	1236.82	6152.89	10840.6	6218.19	14584.12	8.48
1953-54	441.68	641.45	1083.13	8690.53	7194.41	2753.30	16968.07	6.38
1954-55	110.65	1376.41	1487.06	17065.69	3763.90	2567.80	22316.64	6.66
1955-56	80.74	320.50	401.24	7530.94	9490.15	4521.43	17422.32	2.30
1956-57	98.33	479.17	577.50	18002.51	9484.65	3259.75	28064.67	2.06
1957-58	--							
1958-59	30.98	810.43	841.42	26230.13	22764.13	9351.8	49835.67	1.69
1959-60	71.58	610.95	682.46	16992.20	6413.74	18744.0	24088.40	2.83

FUELWOOD

YEAR	FREE GRANTS	RIGHT HOLDERS	TOTAL LOCAL	EXTR. by PURCHAS.	GOVT. DEPOT ARRIVALS Non-Teak	Teak	TOTAL Non-Teak (2 TO 6)	LOCAL as % of Non-Teak (4)/(8)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	cubic metres (solid)							
1951-52	0.0	79874.8	79874.8	54117.1				
1952-53	0.0	81235.9	81235.9	8552.6				
1953-54	7.1	83980.1	83987.2	13248.8				
1954-55	0.0	32655.8	32655.8	24086.0				
1955-56	0.0	2259.2	2259.2	9919.8				
1956-57	713.7	1052.1	1765.8	1910.2				
1957-58	--							
c1958-59	0.0	5878.7	5878.7	2474.0	1750.2		10102.9	58.19%
1959-60	0.0	2499.5	2499.5	38121.9	2002.2		42623.6	5.86

Note: Source of data: Wesley (1964).
'Total local' refers to sum of free grants and quantity removed by right- and privilege-holders. Column (5) refers to quantity extracted by purchasers directly from the forest. 'Total non-teak' is the sum of 'local' consumption and purchaser extraction; in practice, a small part of each may consist of teak wood as well, but this is ignored as negligible in relation to the depot arrivals of teak.
Column (9) is 'total local' consumption as a percentage of 'total non-teak'. These percentages are indicative only, due to the inherent ambiguity of the data. Figures for arrivals of firewood in the government depots are not available except for the last two years. The volumes in cmt are derived from the original data in cft, at 0.02832 cmt to a cft. The figures for firewood probably refer to the round (solid) volume rather than the stacked volume, as the timber and firewood figures are added directly for purposes of aggregation in Wesley (1964). It is most probably the solid (under-bark, log) volume that is referred to by the volume of timber.

TABLE 10.2 Distribution of consumption (sec. 1.6.6, 10.1.4)

Per capita household expenditure			Percentage of population				Perc. of cons.	
Class limits	Mid-class value					cumul-		cumul-
Rs/month	Rs/month [1977-78 prices]	Rs/year	rural	urban	total	ative	total	ative
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
0.00- 9.99	5.00	60.83	0.09%	0.09%	0.09%	0.09%	0.006%	0.006%
10.00-19.99	15.00	182.50	1.29	0.37	1.11	1.195	0.202	0.207
20.00-29.99	25.00	304.17	8.07	2.49	6.95	8.190	2.113	2.320
30.00-39.99	35.00	425.83	15.62	7.24	13.94	22.128	5.933	8.253
40.00-49.99	45.00	547.50	17.60	11.09	16.29	38.422	8.917	17.171
50.00-69.99	60.00	730.00	26.67	23.90	26.06	64.480	19.015	36.186
70.00-99.99	85.00	1034.17	18.08	24.61	19.39	83.871	20.046	56.232
100.00-149.99	125.00	1520.83	8.81	17.44	10.54	94.413	16.027	72.259
150.00-199.99	175.00	2129.17	2.25	6.60	3.12	97.536	6.647	78.906
200.00- +	[712.25]	[8665.71]	1.51	6.12	2.44	99.971	21.095	100.001
			99.99%	99.95%			100.00%	

Source: 'Sarvekshana', Journal of the National Sample Survey Organization, Vol IV, No 3 & 4, Jan-Apr 1981. Based on NSS 32 Round, second quinquennial survey on employment and unemployment, 1977-78.

Note: Original data of population by monthly expenditure classes; mid-class values per year calculated at 30 days to a month, 365 days to a year.

Rural and urban percentages combined into an aggregate percentage assuming 79.93% rural and 20.07% urban population (1978 population).

Mid-class value of top class calculated from per capita final consumption expenditure of Rs 1000.37 in 1977-78 (aggregate Rs 626.05 bill/population 625.82 mill) and aggregate expenditure of rest of population as per table.

Percentages of consumption calculated by assuming aggregate of Rs 1000.37 per cap.

Critical consumption level per cap., c^*, is Rs 56/month or 681.33/year (rural), Rs 89/month or 1082.83/year (urban), weighted average Rs 62.60/month or 761.75/year (assuming 80% rural and 20% urban population), 1977-78 prices. National income NI at purchasers' prices $\bar{c}$ is Rs 844.0 bill/625.82 mill = Rs 1348.63/cap/year.

The definition of 'urban' adopted by the Census of India is as follows:

(a) all places with a Municipality, Corporation, or Notified Town Area;

(b) all other places which satisfy the following conditions:

(i) a minimum population of 5000;

(ii) at least 75% of the the male working population in non-agricultural occupations;

(iii) a density of population of at least 400 per sqkm (or 1000 per sqmile).

TABLE 10.3(i) Cumulative social distribution weights, D, of income distributed in proportion with relative population frequency; NI per capita Rs 1348.63 (1977-78) (D for marginal consumption increase) (sec. 10.1.4)

Per cap. hh. exp. c_{mid} Rs/year [1977-78]	$\bar{c}/c_{mid}$ ($\bar{c}$ = Rs 1348.63)	ELASTICITY of m.u., n: -2	-1.5	-1.0	-0.5	0.0	+0.5
		D					
60.83	22.171	491.53	104.39	22.17	4.71	1.00	0.21
182.50	7.390	89.51	25.57	8.50	2.87	1.00	0.36
304.17	4.434	29.45	11.65	5.00	2.21	1.00	0.46
425.83	3.167	17.22	7.86	3.85	1.94	1.00	0.52
547.50	2.463	12.49	6.17	3.26	1.78	1.00	0.57
730.00	1.847	8.82	4.69	2.69	1.61	1.00	0.64
1034.17	1.304	7.18	3.95	2.37	1.50	1.00	0.69
1520.83	0.887	6.46	3.60	2.20	1.44	1.00	0.73
2129.17	0.633	6.27	3.50	2.15	1.42	1.00	0.75
[8665.71]	0.156	6.12	3.42	2.11	1.39	1.00	0.79

Note: Distribution of population by expenditure classes from Table 10.2. Reference level of consumption $\bar{c}$ is the per cap. national income at purchasers' values: Rs 844.0 bill/625.82 mill population, or Rs 1348.63 (1977-78)/cap/year. Value of D is the weighted average relative weight to consumption at each mid-class level of consumption, weighted by the proportion of population in the respective consumption class. The entry against each class is the value of D given that distribution of incremental consumption does not extend above that class.

TABLE 10.3(ii) Cumulative social distribution weights, D, of income distributed in proportion with relative population frequency: NI per capita Rs 1355.85 (1977-78) (D for marginal consumption change)

Per cap. hh. exp. c_{mid} Rs/year [1977-78]	$\bar{c}/c_{mid}$ ($\bar{c}$ = Rs 1355.85)	ELASTICITY of m.u., n: -2	-1.5	-1.0	-0.5	0.0	+0.5
		D					
60.83	22.171	496.79	105.23	22.29	4.72	1.00	0.21
182.50	7.390	88.45	25.77	8.55	2.88	1.00	0.36
304.17	4.434	29.77	11.75	5.03	2.21	1.00	0.45
425.83	3.167	17.41	7.93	3.87	1.94	1.00	0.52
547.50	2.463	12.62	6.22	3.28	1.79	1.00	0.57
730.00	1.847	8.92	4.73	2.70	1.62	1.00	0.64
1034.17	1.304	7.26	3.98	2.38	1.51	1.00	0.69
1520.83	0.887	6.53	3.63	2.22	1.44	1.00	0.73
2129.17	0.633	6.34	3.53	2.17	1.42	1.00	0.75
[8665.71]	0.156	6.18	3.45	2.12	1.40	1.00	0.79

Note: As for previous table; but NI per cap. is Rs 1355.85 (1977-78), i.e. NI Rs 848.52 bill./625.8 mill. population.

TABLE 10.4(i) Social values in border rupees, D/v, of a rupee of consumption distributed in proportion to the population. (D for marginal change in consumption) (sec. 10.1.4)

Distribution over entire population: D_{gen}
Distribution only up to c* class: D^*
c̄ = Rs 1348.63/cap/year (1977-78)

ELAST. of m.u.	-2.0	-1.5	-1.0	-0.5	0.0	+0.5
D_{gen}	6.116	3.419	2.105	1.394	1.000	0.794
D^*	8.822	4.690	2.689	1.611	1.000	0.638
A) value of public income: v						
i) a= 0.86, s= 0.15, q= 0.10						
v=	4.81	6.60	9.90	19.80	495.0	--
D_{gen}/v	1.272	0.518	0.213	0.070	0.002	0.000
D^*/v	1.834	0.711	0.272	0.081	0.002	0.000
ii) a= 0.86, s= 0.15, q= 0.125						
v=	7.33	10.52	18.58	79.71	--	--
D_{gen}/v	0.834	0.325	0.113	0.018	--	--
D^*/v	1.204	0.446	0.145	0.020	--	--
iii) a= 0.86, s= 0.15, q= 0.15						
v=	11.32	18.53	51.12	--	--	--
D_{gen}/v	0.540	0.185	0.041	0.0	0.0	0.0
D^*/v	0.779	0.185	0.041	0.0	0.0	0.0
B) value of public income: v*						
v*	3.498	2.656	2.017	1.531	1.163	0.883
D_{gen}/v*	1.748	1.287	1.044	0.910	0.860	0.774
D^*/v*	2.522	1.766	1.333	1.052	0.860	0.621

TABLE 10.4(ii) Social values in border rupees, D/x, of a rupee of consumption distributed in proportion to the population. (D for marginal change in consumption) (sec. 10.1.4)

Distribution over entire population: D_{gen}
Distribution only up to c* class: D^*
c̄ = Rs 1348.63/cap/year (1977-78)

ELAST. of m.u.	-2.0	-1.5	-1.0	-0.5	0.0	+0.5
D_{gen}	6.116	3.419	2.105	1.394	1.000	0.794
D^*	8.822	4.690	2.689	1.611	1.000	0.638
A) value of public income: x						
i) a= 0.86, s= 0.15, q= 0.10						
x=	1.710	1.978	2.473	3.958	75.238	--
D_{gen}/x	3.577	1.729	0.851	0.491	0.013	0.0
D^*/x	5.159	2.371	1.087	0.407	0.013	0.0
ii) a= 0.86, s= 0.15, q= 0.125						
x=	2.09	2.57	3.78	12.95	--	--
D_{gen}/x	2.926	1.331	0.557	0.107	0.077	0.0
D^*/x	4.221	1.825	0.711	0.124	0.077	0.0
iii) a= 0.86, s= 0.15, q= 0.15						
x=	2.69	3.77	8.66	--	--	--
D_{gen}/x	2.274	0.907	0.243	0.0	0.0	0.0
D^*/x	3.280	1.244	0.311	0.0	0.0	0.0
B) value of public income: x*						
x*	1.51	1.39	1.29	1.22	1.16	1.12
D_{gen}/x*	4.050	2.460	1.631	1.143	0.860	0.610
D^*/x*	5.842	3.374	2.085	1.320	0.860	0.490

TABLE 10.4(iii) Social values in border rupees, d/v, of a rupee of consumption distributed in proportion to worker population. (d for marginal change in consumption) (sec. 10.1.4)

Distribution over marginal workers: d_{marg}
Distribution over main workers d_{main}
Distributed to both marginal and main: d_{work}
$\bar{c}$ = Rs 1348.63/cap/year (1977-78)

ELAST. of m.u.	-2.0	-1.5	-1.0	-0.5	0.0	+0.5
d_{marg}	79.313	26.549	8.893	2.981	1.000	0.336
d_{main}	6.941	4.272	2.631	1.621	1.000	0.617
d_{work}	13.101	6.168	3.164	1.737	1.000	0.593
A) social value of public income: v						
i) a= 0.86, s= 0.15, q= 0.10						
d_{work}/v	2.724	0.935	0.320	0.088	0.002	0.0
ii) a= 0.86, s= 0.15, q= 0.125						
d_{work}/v	1.787	0.586	0.170	0.022	0.0	0.0
iii) a= 0.86, s= 0.15, q= 0.15						
d_{work}/v	1.157	0.333	0.062	0.0	0.0	0.0
B) social value of public income: v*						
d_{work}/v^*	3.745	2.322	1.569	1.134	0.860	0.672
C) social value of public income: x						
i) a= 0.86, s= 0.15, q= 0.10						
d_{work}/x	7.662	3.118	1.279	0.439	0.013	0.0
ii) a= 0.86, s= 0.15, q= 0.125						
d_{work}/x	6.269	2.400	0.837	0.134	0.0	0.0
iii) a= 0.86, s= 0.15, q= 0.15						
d_{work}/x	4.870	1.636	0.365	0.0	0.0	0.0
D) social value of public income: x*						
d_{work}/x^*	8.676	4.438	2.453	1.424	0.860	0.530

TABLE 10.5(i) Accounting ratios for junglewood timber and firewood, under different assumptions of distributive value d/v, and different conversion (liquidation) periods (sec. 10.1.5)

Note: 10% of junglewood timber, and all of junglewood firewood, go to basic needs consumption when conversion period is 30 years; extent of coverage is denoted by d/v value, cf. Table 10.4. When period is reduced, the extra annual production goes to the commercial market.
AR = pq(d/v) + (1-pq)0.86, where q= 0.1 for timber, 1.0 for firewood; p is the ratio of conversion period to 30 years.

d/v	CONVERSION PERIOD, YEARS									
	30		20		10		3		1	
	ACCOUNTING RATIOS									
	Timb.	Fwood	Timb.	Fwood	Timb.	Fwood	Timb.	Fwood	Timb.	Fwood
0.5	0.824	0.500	0.836	0.620	0.848	0.740	0.856	0.824	0.859	0.848
1.0	0.874	1.000	0.869	0.953	0.865	0.906	0.861	0.874	0.861	0.865
1.5	0.924	1.500	0.903	1.287	0.881	1.073	0.866	0.924	0.862	0.881
2.0	0.974	2.000	0.936	1.620	0.898	1.240	0.871	0.974	0.864	0.898
2.5	1.024	2.500	0.970	1.953	0.915	1.406	0.876	1.024	0.866	0.915
3.0	1.074	0.300	1.003	2.287	0.931	1.573	0.881	1.074	0.867	0.931
3.5	1.124	3.500	1.037	2.620	0.948	1.740	0.886	1.124	0.869	0.948
4.0	1.174	4.000	1.070	2.953	0.965	1.906	0.891	1.174	0.871	0.965
4.5	1.224	4.500	1.104	3.287	0.981	2.073	0.896	1.224	0.872	0.981
5.0	1.274	5.000	1.137	3.620	0.998	2.240	0.901	1.274	0.874	0.998
5.5	1.324	5.500	1.171	3.953	1.015	2.407	0.906	1.324	0.876	1.015
6.0	1.374	6.000	1.204	4.287	1.031	2.573	0.911	1.374	0.877	1.031
6.5	1.424	6.500	1.238	4.620	1.048	2.740	0.916	1.424	0.879	1.048
7.0	1.474	7.000	1.271	4.953	1.065	2.907	0.921	1.474	0.881	1.065
7.5	1.524	7.500	1.305	5.287	1.081	3.073	0.926	1.524	0.882	1.081
8.0	1.574	8.000	1.338	5.620	1.098	3.240	0.931	1.574	0.884	1.098
8.5	1.624	8.500	1.372	5.953	1.115	3.407	0.936	1.624	0.886	1.115
9.0	1.674	9.000	1.405	6.287	1.131	3.573	0.941	1.674	0.887	1.131
9.5	1.724	9.500	1.439	6.620	1.148	3.740	0.946	1.724	0.889	1.148
10.0	1.774	10.00	1.472	6.953	1.165	3.907	0.951	1.774	0.891	1.165
$D^*/x^* = 5.8423$										
	1.358	5.842	1.192	4.182	1.026	2.521	0.910	1.358	0.871	1.026
$d_{work}/x^* = 8.6764$										
	1.642	8.676	1.512	6.118	1.118	3.439	0.938	1.642	0.883	1.118

TABLE 10.5(ii) Accounting ratios for junglewood timber and firewood, under different assumptions of distributive value d/v, and different conversion (liquidation) periods of crop (sec. 10.2.5)

Note: 6.5% of junglewood timber, and 65% of junglewood firewood, go to basic needs consumption when conversion period is 30 years; extent of coverage is denoted by d/v value, cf. Table 10.4. When period is reduced, the extra annual production goes to the commercial market.
AR = pq(d/v) + (1-pq)0.86, where q= 0.065 for timber, 0.65 for firewood; p is the ratio of conversion period to 30 years.

d/v	CONVERSION PERIOD, YEARS									
	30		20		10		3		1	
	ACCOUNTING RATIOS									
	Timb.	Fwood	Timb.	Fwood	Timb.	Fwood	Timb.	Fwood	Timb.	Fwood
2.5	0.967	1.975	0.931	1.571	0.896	1.215	0.871	0.967	0.864	0.896
3.0	0.999	2.251	0.952	1.787	0.906	1.324	0.874	0.999	0.865	0.906
5.0	1.129	3.551	1.039	2.654	0.950	1.757	0.887	1.129	0.869	0.950
7.5	1.292	5.176	1.148	3.737	1.004	2.239	0.903	1.292	0.874	1.004

TABLE 10.6(i) NPV of standing crop in **30 hectares** FS1, Conversion WC: variation of social value with liquidation period (sec. 10.2.5)

[Outturn limited to one harvest only]
12% taxes added to output prices

DISC. RATE, SARI	CONV. PERIOD years	SWR= 0.0486 TEAK WOOD	dwork/x*=8.6764 JUNGLE WOOD	TOTAL Rs 000	D*/x*=5.8423 JUNGLE WOOD	TOTAL Rs 000
0%	30	1301.07	4815.90	6116.97	3636.14	4937.21
	20	1314.25	3956.35	5270.60	2944.91	4259.16
	10	1327.44	2635.85	3963.29	2253.55	3580.99
	3	1336.67	1887.59	3224.26	1769.52	3106.19
	1	1339.31	1665.25	3004.56	1622.00	2961.31
3%	30	850.05	3146.46	3996.51	2375.66	3225.71
	20	977.64	2943.03	3920.67	2190.64	3168.28
	10	1132.33	2248.43	3380.76	1922.33	3054.66
	3	1260.31	1779.76	3040.07	1668.43	2928.74
	1	1300.30	1616.75	2917.05	1574.75	2875.05
4%	30	749.94	2775.89	3525.83	2095.88	2890.82
	20	893.06	2688.41	3581.47	2001.12	2894.18
	10	1076.67	2137.91	3214.58	1827.83	2904.50
	3	1236.46	1746.08	2982.54	1636.86	2873.32
	1	1287.80	1601.20	2889.00	1559.61	2847.41
5%	30	666.69	2467.74	3134.43	1863.21	2529.90
	20	818.93	2465.25	3284.18	1835.01	2653.94
	10	1025.01	2035.33	3060.34	1740.13	2765.14
	3	1213.36	1713.46	2926.82	1606.28	2819.64
	1	1275.53	1585.95	2861.48	1544.76	2820.29
10%	30	408.84	1513.30	1922.14	1142.59	1551.43
	20	559.86	1684.13	2243.99	1253.59	1813.45
	10	815.65	1619.61	2435.26	1384.71	2200.36
	3	1108.03	1564.72	2672.75	1466.85	2574.88
	1	1217.55	1513.86	2731.41	1474.54	2692.09

TABLE 10.6(ii) NPV of standing crop in **30 hectares** FS1, Conversion WC: variation of social value with liquidation period; intermediate social values of consumption d/v (sec. 10.2.5)

[Outturn limited to one harvest only]
12% taxes added to output prices

DISC.CONV. RATE,PER.		SWR= 0.1617			SWR= 0.0961			SWR= 0.0961	
		d/v= 2.500			d/v= 5.000			d/v= 7.500	
SARI	yrs	TEAK WOOD	JUNGLE WOOD	TOTAL Rs 000	TEAK WOOD	JUNGLE WOOD	TOTAL Rs 000	JUNGLE WOOD	TOTAL Rs 000
0%	30	1295.10	2232.95	3528.05	1298.56	3280.55	4579.11	4321.25	5619.81
	20	1308.95	2006.30	3315.25	1312.03	2707.72	4019.75	3403.78	4715.81
	10	1322.80	1777.95	3100.75	1325.49	2131.62	3457.11	2477.89	3803.38
	3	1332.50	1618.52	2951.02	1334.92	1728.85	3063.77	1833.57	3168.49
	1	1335.27	1573.07	2908.34	1337.61	1614.93	2952.54	1649.23	2986.84
3%	30	846.15	1458.89	2305.04	848.41	2143.34	2991.75	2823.28	3671.69
	20	973.69	1492.43	2466.12	975.98	2014.20	2990.18	2531.98	3507.96
	10	1128.38	1516.63	2645.01	1130.67	1818.32	2948.99	2113.70	3244.37
	3	1256.38	1526.05	2782.43	1258.66	1630.08	2888.74	1728.81	2987.47
	1	1296.38	1527.25	2823.63	1298.65	1567.90	2866.55	1601.20	2899.85
3.5	30	793.98	1368.95	2162.93	796.11	2011.20	2807.31	2649.22	3445.33
	20	930.17	1425.72	2355.89	932.35	1924.16	2856.51	2418.79	3351.14
	10	1100.12	1102.36	2202.48	1102.36	1772.79	2875.15	2061.24	3163.60
	3	1244.39	1511.50	2755.89	1246.65	1614.53	2861.18	1712.33	2958.98
	1	1290.12	1519.87	2809.99	1292.38	1560.32	2852.70	1593.46	2885.84
4%	30	746.49	1287.07	2033.56	748.49	1890.92	2639.41	2490.77	3239.26
	20	889.45	1363.31	2252.76	891.54	1839.94	2731.48	2312.92	3204.46
	10	1072.91	1442.08	2514.99	1075.09	1728.94	2804.03	2009.80	3084.89
	3	1232.60	1512.57	2745.17	1234.48	1599.24	2833.72	1696.11	2930.59
	1	1283.91	1286.17	2570.08	1286.17	1552.60	2838.77	1585.80	2871.97
5%	30	663.63	1144.20	1807.83	665.40	1681.01	2346.41	2214.27	2879.67
	20	815.62	1250.15	2065.77	817.54	1687.21	2504.75	2120.93	2938.47
	10	1021.43	1372.89	2394.32	1023.51	1645.98	2669.49	1913.37	2936.88
	3	1209.58	1469.21	2678.79	1211.77	1569.36	2781.13	1664.42	2876.19
	1	1271.69	1498.16	2769.85	1273.92	1538.03	2811.95	1570.70	2844.62
10%	30	406.96	701.66	1108.62	408.05	1030.85	1438.90	1357.87	1765.92
	20	557.19	854.04	1411.23	558.50	1152.62	1711.12	1448.91	2007.41
	10	812.80	1092.48	1905.28	814.46	1309.79	2124.25	1522.56	2337.02
	3	1104.58	1341.67	2446.25	1106.58	1433.13	2539.71	1519.94	2626.52
	1	1213.88	1430.06	2643.94	1216.01	1468.12	2684.13	1499.30	2715.31

TABLE 10.6(iii) NPV of standing crop in **30 hectares** FS1, Conversion WC: variation of social value with liquidation period; intermediate social values of consumption d/v
Coverage of basic needs distribution limited to bottom 65% of population; 6.5% of junglewood timber, and 65% of junglewood firewood, valued at higher AR, while teak timber and firewood has the same AR of 0.86 throughout.
[Outturn limited to one harvest only]
12% taxes added to output prices

DISC. RATE, SARI	CONV. PERIOD years	SWR= 0.1617 TEAK WOOD	d/v= 2.500 JUNGLE WOOD	TOTAL Rs 000	SWR= 0.0961 TEAK WOOD	d/v= 5.000 JUNGLE WOOD	TOTAL Rs 000
0%	30	1295.10	2006.57	3301.67	1298.56	2677.37	3975.93
	20	1308.95	1846.15	3155.10	1312.03	2303.96	3615.99
	10	1322.80	1698.11	3020.91	1325.49	1930.56	3256.05
	3	1332.50	1594.72	2927.22	1334.92	1669.16	3004.08
	1	1335.27	1565.11	2900.38	1337.61	1594.50	2932.11
3%	30	846.15	1310.99	2157.14	848.41	1749.25	2597.66
	20	973.69	1373.30	2346.99	975.98	1713.86	2689.84
	10	1128.38	1448.52	2576.90	1130.67	1646.81	2777.48
	3	1256.38	1503.61	2759.99	1258.66	1573.81	2832.47
	1	1296.38	1519.52	2815.90	1298.65	1548.06	2846.71
3.5%	30	793.98	1230.17	2024.15	796.11	1641.41	2437.52
	20	930.17	1311.91	2242.08	932.35	1637.24	2569.59
	10	1100.12	1412.25	2512.37	1102.36	1605.57	2707.93
	3	1244.39	1489.27	2733.66	1246.65	1558.80	2805.45
	1	1290.12	1512.18	2802.30	1292.38	1540.58	2832.96
4%	30	746.49	1156.59	1903.08	748.49	1543.24	2291.73
	20	889.45	1254.49	2143.94	891.54	1565.58	2457.12
	10	1072.91	1377.32	2450.23	1075.09	1565.86	2640.95
	3	1232.60	1475.16	2707.76	1234.48	1544.03	2778.51
	1	1283.91	1504.91	2788.82	1286.17	1533.17	2819.34
5%	30	663.63	1028.20	1691.83	665.40	1371.92	2037.32
	20	815.62	1150.35	1965.97	817.54	1435.62	2253.16
	10	1021.43	1311.23	2332.66	1023.51	1490.73	2514.24
	3	1209.58	1447.60	2657.18	1211.77	1515.18	2726.95
	1	1271.69	1490.58	2762.27	1273.92	1518.57	2792.49
10%	30	406.96	630.53	1037.49	408.05	841.31	1249.36
	20	557.19	785.87	1343.06	558.50	980.75	1539.25
	10	812.80	1043.41	1856.21	814.46	1186.25	2000.71
	3	1104.58	1321.94	2426.52	1106.58	1383.66	2490.24
	1	1213.88	1422.83	2636.71	1216.01	1449.55	2665.56

TABLE 10.7 NPV of standing crop in **30 hectares** FS1, Conversion WC: variation of social value with liquidation period [Outturn of teak limited to one harvest only, but outturn of junglewood repeats every 30th year from coppice & regrowth]

DISC. RATE, SARI	CONV. PERIOD years	SWR= 0.0486 TEAK WOOD [1 crop]	dwork/x*=8.6764 JUNGLE WOOD [recurs every 30 years]	TOTAL Rs 000
0%	30	1301.07		
	20	1314.25		
	10	1327.44		
	3	1336.67		
	1	1339.31		
3%	30	850.05	5351.00	6201.05
	20	977.64	5005.04	5982.68
	10	1132.33	3823.78	4956.11
	3	1260.31	3026.73	4287.04
	1	1300.30	2749.51	4049.81
4%	30	749.94	4013.25	4763.19
	20	893.06	3886.77	4779.83
	10	1076.67	3090.89	4167.56
	3	1236.46	2524.40	3760.86
	1	1287.80	2314.94	3602.74
5%	30	666.69	3210.60	3877.29
	20	818.93	3207.36	4026.29
	10	1025.01	2648.03	3673.04
	3	1213.36	2229.26	3442.62
	1	1275.53	2063.37	3338.90
10%	30	408.84	1605.30	2014.14
	20	559.86	1786.52	2386.38
	10	815.65	1718.07	2533.72
	3	1108.03	1659.84	2767.87
	1	1217.55	1605.89	2823.44

TABLE 10.8(i) Eucalyptus plantation, 1 ha (sec. 10.3.1)
Costs of supervision and administration

Note: Work rates are as per schedule of rates, Yellapur Division, sanctioned in 1984-85, renewed to 1986-87. Daily wage rates, effective from 1-1-1985, are Rs 9.75 for heavy, and Rs 7.80 for light, labour. (Table 7.17 for details)
Notation: md manday; ha hectare; rmt running metre; cld cartload (25cft/0.7cmt)

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
1.	Executive staff, years 1 to 3			1 ha		470.00
2.	Territorial staff, years 1 to end			1 ha		26.89
3.	Direction & admin., years 1 to end			1 ha		22.41
	TOTAL of 2 & 3			1 ha		49.30 (~50.00)

Note: Annual administrative expenses assumed to be Rs 50 through life of enterprise. To avoid double counting, however, this Rs 50 not included in cash flow of first year; this affects only the first rotation crop, and may be added to net present value if desired.
Special executive staff provided only during first three years.

TABLE 10.8(ii) Eucalyptus nursery, 100 seed beds for 400,000 plants

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
1.	First weeding	90.10	1 ha	0.2 ha	18.02	
2.	Digging & forming standard beds	15.66	1 bed	100 bed	1566.00	
3.	Collection of ingredients					
i.	Manure, 0.4cmt or 0.57 cld per bed	40.00	1 cld	57 cld		2280.00
ii.	Sand, 0.4cmt or 0.57cld per bed	25.00	1 cld	57 cld		1425.00
iii.	Red earth, 0.9cmt or 1.286cld per bed	15.00	1 cld	128.6cld		1929.00
4.	Mixing and spreading	9.75	1 mday	100 mday	975.00	
5.	Sowing seed	1.37	1 bed	100 bed	137.00	
6.	Watering Sept-Nov., 90 days per bed	0.31	1 bed -day	9000 bed -day	2790.00	
7.	Weeding: 3 times	3.63	1 bed	300 bed	1089.00	
8.	Putting up shade	9.68	1 bed	100 bed	968.00	
	TOTAL	[13177.02=]			7543.02	5634.00
	Expenditure per bed	[131.77=]			75.43	56.34

TABLE 10.8(iii) Raising 100,000 polybagged Eucalyptus seedlings

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
1.	First weeding (heavy Lantana etc.)	90.10	1 ha	0.2 ha	18.02	
2.	Levelling 1 bed per 2000 bags	9.75	1 bed	50 beds	487.50	
4.	Collection of ingredients					
i.	Manure, 1 cld/2000	40.00	1 cld	50 cld		2000.00
ii.	Sand, 1 cld/2000	25.00	1 cld	50 cld		1250.00
iii.	Red earth,1cld/2000	15.00	1 cld	50 cld		750.00
iv.	Mixing,filling and arranging,6 mdays/1000 bags	9.75	1 mday	600 mday	5850.00	
5.	Cost of seed beds	131.77	100 beds	25 beds	1885.75	1408.50
6.	Pricking out	9.75	1000	100000	975.00	
7.i	Watering Nov-Mar., 150 days; at 1 mday/20000 bags.	9.75	20000	100000	7312.50	

TABLE 10.8(iii) Raising 100,000 polybagged *Eucalyptus* seedlings (contd.)

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
7.ii	Watering Apr-Jun, 90 days.	9.75	20000	100000	4387.50	
8.	Weeding:twice/month, Nov-Jun =16 times	156.00	15000	100000	1040.00	
9.	Shifting & grading twice/month, entire season	19.50	5000	100000	390.00	
10.	Cost of polythene bags, 5" by 8"	32.50	1 kg	350 kg		11375.00
	TOTAL (100,000 bags) [39129.77=]				22346.27	16783.50

TABLE 10.8(iv) *Eucalyptus* plantation, 1 ha (sec. 10.3.1)
Site preparation, planting and aftercare, YEAR 1

Notation: md manday; ha hectare; rmt running metre

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
1.	Clearing & burning	567.30	1 ha	1 ha	567.30	
2.	Prepn. of stakes, aligning & staking	35.43	1000	1250	44.29	
3.	Nursery (Rs 586.94):					
i.	Labour	223.46	1000	1500	335.19	
ii.	Material	167.83	1000	1500		251.75
4.	Digging pits .3x.3x.3m, = .027cmt, hard soil, at Rs 8.40/cmt	226.80	1000	1250	283.50	
5.	Reopening pits, at Rs 4.20/cmt	113.40	1000	250	28.35	
6.	Refilling before planting, at Rs 1.07/cmt					
i.	First planting	28.89	1000	1250	36.11	
ii.	20% casualty	28.89	1000	250	7.22	
7.	Planting					
i.	Carrying to site	90.77	1000	1500	136.16	
ii.	Planting	40.56	1000	1500	60.84	
	Total	131.33	1000	1500	197.00	
8.	Weeding I (heavy)	90.10	1 ha	1 ha	90.10	
9.	Weeding II	72.13	1 ha	1 ha	72.13	
10.	Weeding III	49.54	1 ha	1 ha	49.54	
11.	Scraping grass to 0.5m round plant	56.10	1000	1250	70.13	
12.	Soil working to 0.5m round plant	48.54	1000	1250	60.68	
13.	Watchman from June to March, 305 days, per 20 ha plot	9.75	1 md	15.25 md	148.69	
14.	Fencing (Rs 1206):					
i.	Labour	180.00	100rmt	90 rmt	162.00	
ii.	Material	1160.00	100rmt	90 rmt		1008.00
iii.	Transport	200.00	200	36 posts		36.00
15.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
16.	Supervisory staff	470.00	1 ha	1 ha		470.00
17.	Annual admin.	50.00	1 ha			excluded
	TOTAL [4134.64=]			1 ha	2368.89	1765.75

Note: Please see Table 7.17(iii)
Perimeter of 90 mt derived on basis of rectangular plot of 20 ha, 400 mt by 500 mt.

TABLE 10.8(v) Eucalyptus plantation, 1 ha (sec. 10.3.1)
Planting and tending, YEAR 2

Notation: md manday; ha hectare; rmt running metre

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
1.	Clear weeding	203.80	1 ha	1 ha	203.80	
2.	Prepn. of stakes, aligning & staking	35.43	1000	250	8.86	
4.	Reopening pits, at Rs 4.20/cmt	113.40	1000	250	28.35	
5.	Refilling pits, at Rs 1.07/cmt	28.89	1000	250	7.22	
6.	Nursery (Rs 97.83):					
i.	Labour	223.46	1000	250	55.87	
ii.	Material	167.84	1000	250		41.96
7.	Planting					
i.	Carrying to site	90.77	1000	250	22.69	
ii.	Planting	40.56	1000	250	10.14	
	Total	131.33	1000	250	32.83	
8.	Weeding I (heavy)	90.10	1 ha	1 ha	90.10	
9.	Weeding II	72.13	1 ha	1 ha	72.13	
10.	Scraping grass to 0.5m round plant	56.10	1000	1250	70.13	
11.	Digging and hoeing 0.5m round plant	60.65	1000	1250	75.81	
12.	Watchman for 12 months per 20 ha plot	9.75	1 md	18.25 md	177.94	
11.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
12.	Supervisory staff	470.00	1 ha	1 ha		470.00
13.	Annual admin.	50.00	1 ha	1 ha		50.00
	TOTAL [1404.66=]			1 ha	842.70	561.96

Note: Nursery, fencing costs as in previous table.
Perimeter of 90 mt derived on basis of rectangular plot of 20 ha, 400 mt by 500 mt.

TABLE 10.8(vi) Eucalyptus plantation, 1 ha. Tending, YEAR 3

Notation: md manday; ha hectare; rmt running metre

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
1.	Clearing weeding	195.87	1 ha	1 ha	195.87	
2.	Weeding I	97.09	1 ha	1 ha	97.09	
3.	Weeding II	72.13	1 ha	1 ha	72.13	
4.	Watchman, 12 months per 40 ha plot	9.75	1 md	9.125 md	88.97	
5.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
6.	Supervisory staff	470.00	1 ha	1 ha		470.00
7.	Annual admin.	50.00	1 ha	1 ha		50.00
	TOTAL [993.72=]			1 ha	473.72	520.00

Note: Perimeter of 90 mt derived on basis of rectangular plot of 20 ha, 400 mt by 500 mt.

TABLE 10.8(vii) Eucalyptus plantation, 1 ha (sec. 10.3.1)
Tending and other operations, YEAR 4 and onward

Notation: md manday; ha hectare; rmt running metre

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
YEAR 4						
1.	Annual admin.	50.00	1 ha	1 ha		50.00
2.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
YEAR 5						
1.	Dismantling fence					
	i. Labour cost	1.21	1 post	36 post	43.56	
	ii. Value of wire	7.00	1 kg	72kg		504.00(-)
5.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
6.	Annual admin.	50.00	1 ha	1 ha		50.00
	TOTAL [-390.78]			1 ha	63.22	454.00(-)

Note: Salvaged barbed wire valued at half the new cost. Negative values denote net revenue, as against costs.
Perimeter of 90 mt derived on basis of rectangular plot of 20 ha, 400 mt by 500 mt.

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
YEAR 6 and onward						
i.	**Every year**					
1.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
2.	Annual admin.	50.00	1 ha	1 ha		50.00

TABLE 10.9(i) Eucalyptus **hybrid coppice**, 1 ha (sec. 10.3.1)
Expenditure on aftercare, YEAR 1

Notation: md manday; ha hectare; rmt running metre

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
1.	Weeding I (heavy)	90.10	1 ha	1 ha	90.10	
2.	Weeding II	72.13	1 ha	1 ha	72.13	
3.	Scraping grass to 0.5m round plant	56.10	1000	1250	70.13	
4.	Soil working to 0.5m round plant	48.54	1000	1250	60.68	
5.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	excluded	
6.	Annual admin.	50.00	1 ha	1 ha		exluded
	TOTAL [293.04=]			1 ha	293.04	

TABLE 10.9(ii) Eucalyptus hybrid **coppice**, 1 ha (sec. 10.3.1)
Planting and tending, YEAR 2

Notation: md manday; ha hectare; rmt running metre

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
1.	Clear weeding	203.80	1 ha	1 ha	203.80	
2.	Prepn. of stakes, aligning & staking	35.43	1000	250	8.86	
4.	Reopening pits, at Rs 4.20/cmt	113.40	1000	250	28.35	
5.	Refilling pits, at Rs 1.07/cmt	28.89	1000	250	7.22	
6.	Nursery (Rs 97.83):					
i.	Labour	223.46	1000	250	55.87	
ii.	Material	167.84	1000	250		41.96
7.	Planting					
i.	Carrying to site	90.77	1000	250	22.69	
ii.	Planting	40.56	1000	250	10.14	
	Total	131.33	1000	250	32.83	
8.	Weeding I (heavy)	90.10	1 ha	1 ha	90.10	
9.	Weeding II	72.13	1 ha	1 ha	72.13	
10.	Scraping grass to 0.5m round plant	56.10	1000	1250	70.13	
11.	Digging and hoeing 0.5m round plant	60.65	1000	1250	75.81	
12.	Watchman for 12 months per 20 ha plot	9.75	1 md	18.25 md	177.94	
11.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
13.	Annual admin.	50.00	1 ha	1 ha		50.00
	TOTAL [934.66=]			1 ha	842.70	91.96

TABLE 10.9(iii) Eucalyptus hybrid **coppice**, 1 ha (sec. 10.3.1)
Tending, YEAR 3

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
1.	Clearing weeding	195.87	1 ha	1 ha	195.87	
2.	Weeding I	97.09	1 ha	1 ha	97.09	
3.	Weeding II	72.13	1 ha	1 ha	72.13	
4.	Watchman, 12 months per 40 ha plot	9.75	1 md	9.125 md	88.97	
5.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
7.	Annual admin.	50.00	1 ha	1 ha		50.00
	TOTAL [523.72=]			1 ha	473.72	50.00

TABLE 10.9(iv) Eucalyptus hybrid **coppice**, 1 ha (sec. 10.3.1)
Tending and other operations, YEAR 4 and onward

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
YEAR 4						
1.	Annual admin.	50.00	1 ha	1 ha		50.00
2.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	

TABLE 10.9(iv) Eucalyptus hybrid **coppice**, 1 ha (sec. 10.3.1)
(contd.) Tending and other operations, YEAR 4 and onward

No	Description	Rate, Rs	per	Qty	Expenditure, Rs Labour	Other
YEAR 5						
1.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
2.	Annual admin.	50.00	1 ha	1 ha		50.00
	TOTAL [69.66=]			1 ha	19.66	50.00
YEAR 6 and onward						
i.	**Every year**					
1.	Forming boundary line and fire tracing 15mt wide	21.84	100 mt	90 mt	19.66	
2.	Annual admin.	50.00	1 ha	1 ha		50.00

Note: For **coppice crops:**
In year 1 (age 0), no planting, supervision, watchman's wages, fencing, etc. will be incurred. Only some cultural operations like weeding, soil working, fire tracing, and administrative charges of Rs 50.00, are applied.
In year 2 (age 1), replacement of casualties is taken up as for the first crop, but no supervision costs incurred.
In subsequent years, only fire tracing and admin. charges apply.

TABLE 10.10 Eucalyptus hybrid plantation, 1 ha (sec. 10.3.1)
Expenditure at accounting prices

Notation: md manday; ha hectare; rmt running metre

No	Description	Rate, Rs market	AR	Rs border	per	Qty	Expenditure, Rs (domest) Labour	Rs (domest) Other	Rs (border) Labour	Rs (border) Other
A.	Supervision and admin.	50.00	0.86	43.00	1 ha	1 ha		50.00		43.00
B.	Eucalyptus nursery, 100,000 polythene bagged seedlings									
1.	Labour	9.75	b_L	$9.75b_L$	mday		22346.27		$22346.27b_L$	
2.	Non-labour									
	Seed beds		0.86			25 beds		1408.50		1211.31
	Sand, etc.		0.86					4000.00		3440.00
	Polythene bags		1.05					11375.00		11943.75
	Non-labour (TOTAL)		0.989					16783.50		16595.06
C.	YEAR 1									
1.	Labour									
	Nursery	9.75	b_L	$9.75b_L$	mday	1500 pbs	335.19		$335.19b_L$	
	Plantn.	9.75	b_L	$9.75b_L$	mday	1 ha	2033.70		$2033.70b_L$	
	Labour (TOTAL)		b_L				2368.89		$2368.89b_L$	
2.	Non-labour									
	Nursery		0.989					251.75		248.93
	Plantation:					1 ha				
	Barbed wire	14.00	1.157	16.20	1 kg	72kg(90rmt)		1008.00		1166.26
	Transp.	200.00	.816	163.20	200	36 posts		36.00		29.38
	Supervn.	470.00	.860	404.20	1 ha	1 ha		470.00		404.20
	Admin.	50.00	0.860	43.00	1 ha			---		---
	Non-labour (TOTAL)		1.047			1 ha		1765.75		1848.77
D.	YEAR 2									
1.	Labour									
	Nursery	9.75	b_L	$9.75b_L$	1md	250pbs	55.87		$55.87b_L$	
	Plantn.	9.75	b_L	$9.75b_L$		1 ha	786.83		$786.83b_L$	
	Labour (TOTAL)		b_L			1 ha	842.70		$842.70b_L$	
2.	Non-labour									
	Nursery		0.989			250pbs	41.96		41.49	
	Plantn.									
	Supervn.	470.00	0.860	404.20	1 ha	1 ha		470.00		404.20
	Admn.	50.00	0.860	43.00	1 ha	1 ha		50.00		43.00
	Non-labour (TOTAL)		0.8696			1 ha		561.96		488.69
E.	YEAR 3									
1.	Labour									
	Plantn.	9.75	b_L	$9.75b_L$	1 ha	1 ha	473.72		$473.72b_L$	
2.	Non-labour									
	Supn. & adm.	520.00	0.860	447.20	1 ha	1 ha		520.00		447.20
F.	YEAR 4									
1.	Labour									
	Fire tracing	21.84	b_L	$21.84b_L$	100m	90m	19.66		$19.66b_L$	
2.	Non-labour									
	Admin.	50.00	0.860	43.00	1 ha	1 ha		50.00		43.00
G.	YEAR 5									
1.	Labour									
	Dismantling fence	1.21	b_L	$1.21b_L$	1 post	36	43.56		$43.56b_L$	
	Fire tracing	21.84	b_L	$21.84b_L$	100m	90m	19.66		$19.66b_L$	
	Labour (TOTAL)						63.22		$63.22b_L$	
2.	Non-labour (income)									
	Value of wire	7.00	1.157	8.10	1 kg	72kg		504.00(-)		583.13
3.	Non-labour (expend.)									
	Annual admin.	50.00	0.86	43.00	1 ha	1 ha		50.00		43.00
H.	YEAR 6 and onward									
1.	Labour									
	Fire tracing	21.84	b_L	$21.84b_L$	100 mt	90 mt	19.66		$19.66b_L$	
2.	Non-labour									
	Annual admin.	50.00	0.86	43.00	1 ha	1 ha		50.00		43.00

TABLE 10.11 Eucalyptus hybrid **coppice**, 1 ha (sec. 10.3.1)
Expenditure at accounting prices

(Details in Table 7.17)
Notation: md manday; ha hectare; rmt running metre

No	Description	Rs market	AR	Rate, Rs border	per	Qty	Expenditure, Rs (domest) Labour	Rs (domest) Other	Rs (border) Labour	Rs (border) Other
A.	YEAR 1									
1.	Labour		b_L				293.04		293.04b_L	
2.	Non-labour	50.00	0.860	43.00	1 ha	1 ha				
B.	YEAR 2									
1.	Labour									
	Nursery	9.75	b_L	9.75b_L	1md	250pbs	55.87		55.87b_L	
	Plantn.	9.75	b_L	9.75b_L		1 ha	786.83		786.83b_L	
	Labour (TOTAL)		b_L			1 ha	842.70		842.70b_L	
2.	Non-labour									
	Nursery		0.989			250pbs		41.96		41.49
	Plantn.	50.00	0.860	43.00	1 ha	1 ha		50.00		43.00
	Non-labour (TOTAL)		0.9188			1 ha		91.96		84.49
C.	YEAR 3									
1.	Labour									
	Plantn.	9.75	b_L	9.75b_L	1 ha	1 ha	473.72		473.72b_L	
2.	Non-labour									
	Admin.	50.00	0.860	43.00	1 ha	1 ha		50.00		43.00
D.	YEAR 4 and onward									
1.	Labour									
	Fire tracing	21.84	b_L	21.84b_L	100m	90m	19.66		19.66b_L	
2.	Non-labour									
	Admin.	50.00	0.860	43.00	1 ha	1 ha		50.00		43.00

TABLE 10.12 Eucalyptus hybrid plantation, 1 ha (sec. 10.3.1)
Expenditure statement, at domestic and at accounting prices

Notation: md manday; ha hectare; rmt running metre

		CASH FLOW Rs						
AGE yrs	YEAR	INFLOW Rs(dom)	INFLOW AR	INFLOW Rs(bor)	OUTFLOW LABOUR Rs(dom) ($AR=b_L$)	OUTFLOW OTHER Rs(dom)	OTHER AR	OTHER Rs(bor)
First crop								
0	1				2368.89	1765.75	1.047	1848.77
1	2				842.70	561.96	0.8696	488.69
2	3				473.72	520.00	0.860	447.20
3	4				19.66	50.00	0.860	43.00
4	5	504.00	1.157	583.13	63.22	50.00	0.860	43.00
5	6-				19.66	50.00	0.860	43.00
Coppice crops								
0	1				293.04	--	0.860	--
1	2				842.70	91.96	0.9188	84.49
2	3				473.72	50.00	0.860	43.00
3	4-				19.66	50.00	0.860	43.00

TABLE 10.13 Eucalyptus hybrid plantation, 1 ha (sec. 10.3.2)
Commercial yield and unit values

AGE yrs	SQI	SQII	SQIII	SQIV	SQV
		-------	cmt(solid, ub)	--------	
3	13.13	6.45	2.55	0.30	0.00
4	25.20	13.50	6.45	2.25	0.00
5	38.33	22.20	11.48	6.00	0.83
6	49.28	29.55	15.75	6.68	1.80
7	55.80	34.35	19.05	8.78	2.55
8	62.03	38.33	21.30	10.20	3.38
9	66.75	41.78	23.70	11.48	3.90
10	70.65	44.63	25.73	12.83	4.73
11	73.65	46.95	27.38	13.88	5.33
12	75.75	48.45	28.43	14.63	5.78
13	77.85	50.03	29.55	15.23	6.23
14	79.95	51.68	30.75	16.13	6.68
15	81.08	52.50	31.35	16.50	6.90
Top ht (mt) at 10 years	21.8	18.8	15.8	12.8	9.8

Source: Chaturvedi,A.N.(1983). Original figures of volume (ub) reduced to commercial outturn by multiplying by 0.75. Site qualities related to top height; that at age 10 years given above.

Unit value:

Stumpage price to industry: Rs 385 per MT(ub); at 0.75 kg/cmt(solid,ub,airdry), this is Rs 385 per 1.33 cmt(sol,ub) = Rs 288.82, or roughly Rs 290, per cmt(solid, ub, airdry).
Depot auction price of firewood: Rs 95.35 per cmt(stacked); at 1 cmt(st) = 0.53 cmt(solid, ub), this is Rs 179.90 per cmt(solid, ub).
Please see Appendic A6 for further details.

TABLE 10.14 Comparison of teak and Eucalyptus plantations:
Soil expectation value in accounting prices.

[Lead for teak 10 km; SWR 0.50w; AR for teak 0.86]

DISC RATE %	TEAK SQIII, AR .86 Rs	ROTN	EUCALYPTUS SQI, AR 0.86 Rs	ROTN	SQI, AR 5.0 Rs	ROTN
0.0	558,135	80+	60,059	15	387,137	15
1.0	498,236	80+	185,158	6	1262,293	6
2.0	178,769	75	88,697	6	613,938	6
3.0	85,538	75	56,553	6	398,036	6
4.0	48,073	30	40,489	6	290,247	6
5.0	34,779	20	30,857	6	225,701	6
6.0	26,389	20	24,442	6	182,775	6
7.5	18,459	15	18,035	6	140,003	6
10.0	11,425	10	11,650	6	97,534	6

DISC RATE %	TEAK SQIV, AR .86 Rs	ROTN	EUCALYPTUS SQII, AR .86 Rs	ROTN	SQII, AR 5. Rs	ROTN	SQIII, AR .86 Rs	ROTN	SQIII, AR 5. Rs	ROTN
0.0	161,371	80+	36,109	15	247,895	15	18,386	15	144,852	15
1.0	138,427	80+	98,878	7	741,463	6	42,579	10	394,743	7
2.0	45,856	80+	46,344	7	359,967	6	18,699	9	189,884	7
3.0	19,572	80+	28,829	7	232,918	6	10,758	9	121,673	7
4.0	11,529	15	20,070	7	169,481	6	6,775	9	87,624	7
5.0	7,679	15	14,814	7	131,488	6	4,343	8	67,239	7
6.0	5,150	15	11,309	7	106,216	6	2,823	7	53,686	7
7.5	2,675	15	7,891	6	81,028	6	1,321	6	40,189	7
10.0	304	15	4,507	6	56,606	6	- 198	7	26,960	7

Note: Teak figures from Tables 9.6, 9.7. Only optimal values shown.

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