# Socioeconomic Planning in Social Forestry

with particular reference to Orissa State, India.

A thesis submitted in the University of Edinburgh for the degree of Doctor of Philosophy.

By

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## Declaration

I hereby certify that this thesis, submitted in candidature for the degree of "Doctor of Philosophy" of the University of Edinburgh, is the result of my own original research, and any assistance and work of others is acknowledged overleaf. The thesis is neither already submitted in substance for any degree nor currently submitted for any other degree.

(Ram Avtar Sharma)

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## Abstract

Social forestry programmes are being implemented in India as a government land-use policy, using investment funds from Forest and Rural Development Departments. Such programmes include plantation and agroforestry components and are generally subsistence-oriented and labour intensive. Their production objective is to satisfy the villager's needs for staple food, fuelwood, fodder and small timber for construction and agricultural implements. Equally important is the social objective of providing employment for the poor and thereby generating some income with which to raise their living standards. This thesis develops an analytical planning methodology, based on both hard and soft approaches, for evaluating social forestry within the framework of the stated socioeconomic policy objectives.

The historic influence of socioeconomic factors on the management of forests is investigated mainly with respect to the planning and policies pursued. These have finally led to the implementation of a social forestry programme. The relative merits and weaknesses of existing decision-making techniques for evaluating a multi-objective land-use project such as social forestry are then examined.

A goal programming model is developed to incorporate the multiple socioeconomic objectives of social forestry into a dynamic planning framework. This achieves the desired multiple goals within the constraints of physical resources and is illustrated by a case study from the State of Orissa. In order to maximize the net socioeconomic benefits, data is generated by carrying out social cost-benefit analyses (based on modern welfare economics) for all five social forestry components (agroforestry, dense plantations of *Eucalyptus hybrid*, institutional plantations of *Acacia nilotica,* village woodlots of *Dalbergia sissoo*, and rehabilation and strip plantations of *Casuarina equisitifolia*). The socioeconomic profitability and optimum tree rotations are determined, having specified the social welfare function (incorporating consumptions of different groups of individuals) and derived the social discount rate from an intertemporal utility model.

Socioeconomic variables which influence villagers' decision-making regarding the uptake of social forestry implemented according to multiple objective planning are then identified, based on an exhaustive socioeconomic survey.

In order to investigate a broader holistic approach which is useful and manageable it is desirable to organise the data into a dynamic analytical framework, the structure being sufficiently flexible to incorporate both tangible and intangible data generated by the cost-benefit analysis, the multiple objective planning model and the survey respectively. Expert Systems are shown to have a potential role in achieving such an approach by integrating rather than replacing the hard analytical techniques such as social cost-benefit analysis and goal programming, whose role in generating a tangible knowledge base for a realistic evaluation of social forestry is demonstrably vital and cannot be ignored.

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## Glossary of Terms

| | |
|---|---|
| AAT | Average Annual Temperature |
| AI | Artificial Intelligence |
| ALR | Annualised Land Rent |
| BCR | Benefit Cost Ratio |
| CBA | Cost-Benefit Analysis |
| $C_{pl}$ | Poverty consumption level |
| CPR | Common Property Resources |
| CRI | Consumption Rate of Interest |
| DC | Developing Countries |
| $d_i$ | Inter-group consumption impact weights |
| DSM | Dasgupta, Sen and Marglin |
| EDR | Economic Discount Rate |
| $e_p^*$ | Price elasticity of demand for food |
| $e_p$ | Pure price elasticity of demand for food |
| ES | Expert Systems |
| $e_u$ | Elasticity of social marginal utility of consumption |
| EWR | Economic Wage Rate |
| $e_y$ | Income elasticity of demand for food |
| FD | Forest Department |
| FFRP | Forest Farming for Rural Poor |
| FSI | Forest Survey of India |
| FYP | Five Year Plan |
| g | Growth rate of per capita real consumption |
| GDP | Gross Domestic Product |
| GOI | Government of India |
| GNP | Gross National Product |
| GOO | Government of Orissa |
| GP | Goal Programming |
| IRR | Internal Rate of Return |
| JMP | Joint Management Plan |
| KB | Knowledge Base |
| LEV | Land Expectation Value |
| LM | Little and Mirrlees |
| LP | Linear Programming |
| $\mu$ | Marginal uility of consumption |
| m | Metre |
| M | Million |
| MAI | Mean Annual Increment |
| MC | Marginal Cost |
| $m_l$ | Marginal productivity of labour |
| MPC | Marginal propensity to consume |
| MRP | Marginal Revenue Product |
| NAS | National Account Statistics |
| NCA | National Commission on Agriculture |
| NDP | National Domestic Product |
| NGO | Non Government Organisation |
| NREP | National Rural Employment Programme |
| NRSA | National Remote Sensing Agency |
| NSB | Net Social Benefit |
| NSSO | National Sample Survey Organisation |
| NTG | Non-Traded Good |

| | |
|---|---|
| NWDB | National Wasteland Development Board |
| OC | Opportunity Cost |
| OER | Official Exchange Rate |
| OFD | Orissa Forest Department |
| ORG | Operations Research Group |
| PF | Protected Forests |
| PNW | Present Net Worth |
| PROLOG | Programming in Logic |
| PTG | Partially Traded Good |
| q | Marginal productivity of capital |
| qtl | Quintal |
| r | Discount Rate (DR) |
| RF | Reserve Forests |
| RLEGP | Rural Landless Employment Guarantee Programme |
| $r_s$ | Social discount rate (SDR) |
| Rs | Rupees (Indian) |
| Rsw | Rupees worth |
| s | Marginal propensity to save |
| SC | Scheduled Castes |
| SE | Standard Error |
| SER | Shadow Exchange Rate |
| SOC | Social Opportunity Cost |
| SQ | Site Quality |
| ST | Scheduled Tribes |
| STP | Social Time Prefrence |
| SWF | Social Welfare Function |
| SWR | Shadow Wage Rate |
| UP | Uttar Pradesh |
| v | Social value of public investment |
| VFC | Village Forest Committee |
| VWL | Village Woodlots |
| w | Agricultural wage rate |

# PART I

## Introduction and Background to the Problem

India, though still a developing economy, has come of age in the various fields of modern technology bringing the country self sufficiency in many spheres such as Agriculture, Science and Technology, etc. Yet there is still unbelievable poverty in the midst of prosperity. Though there are many causes for the poverty, the socioeconomic milieu of the country, seems to be the main inhibiting factor. Forestry in India, like many other developing countries, is a public sector venture and one of the aims of the forest management is to provide benefits to the rural people, who are mainly dependent on subsistence agriculture (more than 70% of the total population in India lives in villages practising mainly agricultural activities). Although the age old tradition of scientific management of forests based on the sustained yield principle is still in vogue, the management practices have gone through many stages of alternative developmental strategies. Despite this the forest cover has continuously shrunk and deforestation is still continuing (NRSA, 1983).

A big social forestry programme was envisaged in 1976 to provide employment and to meet the basic consumption needs of the people, mainly the rural poor, for fuel, fodder and small timber for construction and agricultural implements, (NCA, 1976). Social forestry schemes are also being implemented in more than fifty developing countries (Foley and Barnard, 1985). In India, social forestry programmes are being implemented in almost all the States, with investment made from both Forest and Rural Development Departments. The aims of the social forestry policy are the creation of sustainable forest resources for the people to meet their consumption basic needs for fuelwood, fodder and small timber for household requirements and provision for employment and income generation to the rural unemployed to improve their quality of life (OFD, 1987).

### Background

During 1985-87, I was entrusted a responsibility of preparing the Working Plans of two forest divisions in the State of Orissa. This gave me an opportunity to understand the failures of the forestry planning and the profound impact of socioeconomic factors on forest management. A purely technical and silvicultural approach of forest management, ignoring the relevant socioeconomic aspects of the environment in which forestry is practised, has not yielded the desired results. Socioeconomic criteria had not been accounted for in the forest management planning. The scarce societal resources need to be allocated, but such allocation must incorporate the views and the needs of the target groups or classes in society. If the desired socioeconomic objectives of policy are to be achieved satisfactorily, the aims and objectives of social forestry policy must be incorporated into the micro-level planning, based on a bottom-up approach.

The State of Orissa, located in eastern India, is recognised as an economically backward region (see Appendix 1 for forest economy and socioeconomic background). Eighty eight percent of its population reside in more than 50,000 villages and the economy is predominantly agrarian. Agriculture provides employment for 79% of Orissa's working population and accounts for 69% of the State's domestic product. The tribal population, who are mainly dependent on the forest economy, constitute nearly 23% of total population. Although the proportion of forests in the State is well above the national average (GOI, 1984), recent estimates based on satellite imagery indicate the disturbing trend of forest degradation, mainly due to heavy biotic pressure on the forests (CSE, 1982; 1985). The increasing scarcity of fuelwood and fodder has led to commercialisation of fuelwood collection. As a result the village forests and pastures, on which the poor villagers depend for a living, have been depleted (Sharma *et al*, 1990a).

Social forestry policies are being implemented in a number of developing countries. Each case of implementation is different as a result of the emphasis placed on the socioeconomic aspects relevant to the particular socioeconomic environment of that country. However, they basically aim at improving the rural poor's lot in relation to social forestry. In view of this fact it was felt that social forestry in Orissa could serve as a case study to formulate a generic planning framework or methodology, which after suitable modifications, can be used elsewhere. The present study was therefore carried out with following hypotheses and objectives.

**Hypotheses**

The planning methodology for implementing the social forestry policy, currently being adopted in India in general and Orissa in particular, is not the best way of planning in order to bring about a revitalisation of the rural poor, rural economy and forestry.

Specifically :

**a.** The existing decision-making methodologies/frameworks are inadequate for socioeconomic planning in social forestry.

**b.** It is possible to develop an analytical planning methodology for evaluating social forestry within the framework of its socioeconomic environment.

## Objectives

The main objectives of this study are :

1. To investigate the historic influence of socioeconomic factors on the management of forests, with respect to planning and policies pursued.

2. To examine the appropriateness of existing decision-making techniques for the evaluation of social forestry.

3. To evaluate social forestry quantitatively by assessing and incorporating its socioeconomic impacts on the target groups.

4. To identify the socioeconomic variables influencing decision-making by villagers in social forestry uptake and incorporating the results ( both qualitative and quantitative ) into an analytical planning framework which will facilitate appropriate planning for social forestry.

## Thesis Structure

**Chapter 1:** A brief account of the forest economy and socioeconomic background in which social forestry is being implemented is presented.

**Chapter 2:** The historic influence of socioeconomic factors on the management of forests is investigated with respect to planning and policies pursued.

**Chapter 3:** The appropriateness of the existing analytical techniques in the context of socioeconomic planning in social forestry is investigated.

**Chapter 4:** A financial analysis is carried out for all the five components of social forestry in Orissa.

**Chapter 5:** Based on a system approach economic pricing of inputs and outputs is carried out and optimum tree rotations determined.

**Chapters 6 & 7:** A theoretical framework of social cost-benefit analysis is presented in order to carry out the socioeconomic evaluation of social forestry in Chapter 7 by assessing its socioeconomic impacts on the groups of individuals at different consumption levels.

**Chapters 8 & 9:** A mathematical model is developed for socioeconomic planning in social forestry incorporating its multiple objectives, the use of which has been illustrated in Chapter 9 by making use of data as computed in Chapters 4 and 7.

**Chapter 10:** The socioeconomic variables influencing social forestry uptake are identified based on a field survey in Orissa.

**Chapter 11:** A dynamic planning framework based on an Expert Systems approach is presented using both tangible and intangible knowledge generated in earlier chapters.

**Chapter 12:** The main findings of the research are concluded and further improvements are suggested.

# Chapter 1

## Forest Economy and Socioeconomic Background

India, with its vast and varied territory, has an area of 3,287,782 $Km^2$ stretching from $8^04'28"$to $37^017'53"$ north latitude and from $68^07'53"$ to $97^024'47"$ east longitude. She is endowed with a variety of types of forests. However, her forests are subject to heavy biotic pressure; with less than 2% of total forest area of world, the country supports over 15% of the world's population and 14% of the cattle population. India is a union of 25 States and 7 union territories, with two-tier government at central and State levels. The country is divided into 412 districts, which are further subdivided into blocks and villages.

### 1.1 Land and resources

#### 1.1.1 Relief

The country can be divided physiographically into the regions of the Himalayas, the great plains, the central highlands, the peninsular plateaus and coastal plains.

**a.** The Himalayas can be subdivided into three sections : the greater Himalaya, the lesser Himalaya and the outer Himalaya (the Siwaliks). The region is fragile and prone to soil erosion.

**b.** The great plains extend from Ganga delta in the east to the semi-arid plains of Rajasthan in the west. These plains are bordered in the north by two narrow belts : the piedmont plain called 'bhabar' and marshy tract called 'terai'. The plains lying between the rivers Ganges and Yamuna are the most fertile and densely populated region in the country.

**c.** The central highlands, which lie between the great plains and Deccan plateaus, support the best forests and great ravine lands.

**d.** The peninsular plateau, which is the largest physiographic unit, consists of the Deccan table land, Western Ghats and Eastern Ghats.

**e.** The low lying Coastal plains surround the Deccan plateau to the west and east and are known as western and eastern coasts respectively.

#### 1.1.2. Geology

The peninsular plateau contains the early pre-Cambrian and Archean rocks with Deccan lava in the northern portion of the peninsula. These are derived from depositions of basalt from the lava eruptions in the late Cretaceous and Tertiary periods. The Western Ghats consist of gneisses, charnockites and Deccan traps while the Eastern Ghats are composed of various Archean and Purana formations, such as the Khondalites, gneisses, granites, darwarian and cuddapah rocks. The Central Himalayan zone contains both sedimentary and metamorphic rocks with large granite intrusions. The Lesser Himalayas contain units ranging in age from Pre-cambrian to Tertiary, and intrusive igneous rocks of different type. The Indo-Gangetic Plains are formed of Pleistocene and Sub-Recent alluvial river deposits.

### 1.1.3 Climate

The country belongs to the subtropical zone characterised by the prevalence of monsoons, contrasting rainfall and temperature. The highest annual rainfall, upto 4500 mm, occurs in Arunachal Pradesh and lowest around 500 mm in Rajasthan : average annual rainfall varies between 500 mm and 2000 mm. The summer monsoons (south-west monsoons) account for 90% of the total precipitation, the remainder occurring as a result of winter monsoons which occur mainly in Nov. and Dec. The northern plains get rainfall at varying intensities and times and have experienced recurrent floods and droughts in recent years, which have been exacerbated by deforestation in the upper catchments of the region.

On the basis of the average annual temperature (AAT) the country can be divided into five well defined temperature regions :

**a.** the tropical south eastern coast with AAT of 27.5$^0$C and above.

**b.** the region bounded by the 25.0$^0$C and 27.5$^0$C isotherms, which covers the largest part of the country and has a large variability in rainfall.

**c.** the region with an AAT between 22.5$^0$C and 25.0$^0$C in central India around Tropic of Cancer.

**d.** the areas between the foothills of western and eastern Himalaya with an AAT between 20.0$^0$C and 22.5$^0$C where mean temperatures are largely determined by altitude.

**e.** the region with an AAT of 20.0$^0$C and below, which corresponds to altitudes of 1500 metres (m) and above in the western and eastern Himalaya.

### 1.1.4 Soils

The distribution of soils follows geographical regions and the following descriptions are based on soil map prepared by FAO (1974). Chromic Luvisols are predominant in the

Peninsula and Eastern Ghats while Nitosols, Fluvisols and Regosols are represented in Western Ghats. Nitosols, Vertisols, Luvisols and Cambisols are found in the States of Maharashtra, Madhya Pradesh, Uttar Pradesh, Bihar and Himalayan range. The predominant soils of Rajasthan, Gujarat, Punjab and Haryana are Cambric Arenosols, Xerosoles, Chromic Vertisols, Orthic Luvisols and Gleyic Solonchaks. In Eastern India including Orissa and West Bengal major soil types are Luvisols (Orthic and Ferric), Nitosols (Dystric and Eutric) and Chromic Vertisols.

## 1.2 Social background

### 1.2.1 Cultural background

The Indus valley civilisation, which flourished from 2500 BC to 1500 BC, vanished about 1000 years later (Spears, 1961) due mainly to invasions by Aryans. The Aryans, with their large flocks, settled in small villages to practise agriculture, and these villages have remained intact until now. Indian culture was influenced by a sequence of invaders and rulers, assimilating many aspects, the most important being the economic thoughts of western culture. The economy was essentially a subsistence one made up of self-sufficient villages whose socioeconomic structure was mainly based on caste, religion and occupation.

### 1.2.2 Demography

Physical conditions such as the soil and fertility, topography and climate, and morphology have resulted in a peculiarly uneven distribution of population, with the highest concentration in the Indo-Gangetic and Coastal plains. Nearly 80% of India's population lives in 575,936 villages with an average density of 18 villages per 100 $Km^2$. Rural settlement has been greatly influenced by agricultural developments : since the rural population is mainly dependent on agriculture, the high population density areas logically coincide with predominantly agrarian tracts such as northern plains, coastal plains and intervening valleys.

### 1.2.3 Population growth

The increase in population (Table 1.1) has been spectacular, especially after 1920's, being 25% and 24.8% during the decades 1961-71 and 1971-81 respectively. An important aspect of this is the reduction in proportion of rural population from 80% in 1971 to 77% in 1981. This is due mainly to the migration of rural population to urban centres in search of employment. Table 1.2 shows the population projections for the period 1981-2001, indicating that the annual addition to the population is likely to be of the order of 15.7, 15.8 and 15.2 millions (M) respectively in 1986-91, 1991-96 and 1996-2001. So the population pressure is likely to ease only by 1996. The increase in tribal population, who are mainly dependent on forest economy, rose from 6.8% in 1971 to 7.8% in 1981. The literacy rate has increased from 29% in 1971 to 36% in 1981.

## 1.3 Economic background

### 1.3.1 Occupational pattern

More than 50% of the workers in rural areas are cultivators, followed by nearly 30% of agricultural labourers. In sharp contrast to this, more than 82% of the workers in urban areas are in the category of 'other workers' and only 5 to 6% are cultivators or agricultural labourers (Table 1.3).

### 1.3.2 Land-use

Agriculture, which is the backbone of the Indian economy, occupies the largest share of land resources (47% of the total land area, Table 1.4). Table 1.5 gives the trend in land use pattern over the period 1950 to 1979, indicating a continuous increase in the land area under cultivation.

### 1.3.3 Socioeconomics of development planning

After independence the Indian planners, in their quest for measures to benefit the rural poor, adopted the model of planned economic development. Central planning through Five Year Plans (FYP) promised the solution of economic problems of the country. The Planning Commission, established as an autonomous body, was entrusted with the task of taking decisions about the basic objectives of plans with respect to size of investment and its allocation among various sectors of the economy.

The Gandhian philosophy envisaged the improvement of the rural poor through the development of self-sustained villages, with an equitable distribution of work obligations and opportunities. This can be achieved when production is localised, in other words distribution should be accompanied with decentralised production. Equitable distribution should be provided at the production level and not at the consumption end : otherwise, an accumulation of factors of production will generate disparities. This means that distribution must be simultaneously associated with growth and not considered later after growth has first been attained. But instead, the early development planning in India adopted a growth-oriented approach of economic development. As a result the distributional aspects of socioeconomic development, although echoed in the plans as the objectives of social justice, could not be translated into practice and socioeconomic issues such as poverty alleviation and equitable income distribution were treated as secondary. This was due to the unrealistic assumption that rapid economic development will ensure poverty mitigation through 'trickle-down effects'.

Later decades of planning, however, saw the gradual shift from a commodity-oriented approach to a beneficiary-based approach of economic development due mainly to learnings from the experiences of earlier planning strategy and increased poverty. Social development was integrated with economic development to tackle directly the chronic poverty and disparities in income distribution. In retrospect, Indian experience of development planning is a mixture of spectacular success and dismal failure. The following brief review of various FYPs illustrates the arguments made above.

The first FYP (1951-56) was based on a simple capital-output ratio of the Harrod-Domar type of economic growth model (GOI, 1951). An important feature of this plan was the comparatively large amount of investment (10.2% of total outlay) in agriculture (Table 1.6). This increased investment along with good monsoons resulted in increased food production and employment for the rural poor.

The second FYP (1956-61), prepared on the basis of a four sector model of the economy, placed strong emphasis on rapid growth. This was to be achieved through industrialisation and reduction of over population in agriculture sector by the creation of more employment opportunities in the industrial sector. Consequently a large share of total outlay was allotted to heavy industries, while the outlay for agriculture was comparatively less (7.1% of total outlay). This strategy of rapid industrialisation was also continued in the third FYP (1961-66), which was mainly an extension of second. These two plans, which resulted in creation of a large industrial infrastructure, attracted bitter criticism for their strong urban bias and neglect of agriculture (Hanson, 1966; Lipton, 1968).

The fourth FYP (1969-74) was based on an inter-sectoral and inter-temporal consistency model and the economy was classified into 77 sectors. In this plan, the importance of agriculture was restated by increasing the share to 16.9% of the total outlay. The strategy to achieve self-sufficiancy in food production was based on a high technology package approach of inputs (i.e. fertilizers, irrigation and high yielding crop variety seeds). This shows that in the first four FYPs development strategy was based on capital accumulation, diversification of the unproductive rural labour force to industries and attaining self-sufficiency in food grain production. However, given the high population density, rate of population growth and incidence of poverty, the strategy should have been based on technological improvements which are labour-intensive and land and capital saving. Since no specific measures were taken to break the vicious cycle of poverty, distributional aspects received inadequate considerations. Even in the area of industrial policies and trade, the planning fell into the trap of excessively detailed, physical target-oriented planning. As a result, improvements in economic policies designed to accelerate the planned development did not emerge (Bhagawati and Desai, 1972).

By this time, however, the urge to reduce disparities in income distribution and poverty was getting stronger. It was realised that economic growth cannot be measured only in terms of Gross National Product (GNP), leaving aside the distributional aspects. So the fifth FYP (1974-79), called 'plan for growth with redistribution' included specific measures for poverty alleviation. A beneficiary centred approach of planning was adopted as it was realised that poverty can only be eradicated by incorporating direct measures to benefit the target groups. In general, the plan contemplated raising the consumption level of the three poorest decile groups by making provision for employment and commodities for basic consumption.

The sixth FYP (1980-85) incorporated massive integrated rural development programmes such as National Rural Employment Programme (NREP) and the Rural Landless Employment Guarantee Programme (RLEGP). Their main aims were to improve productivity by creating rural assets and providing employment to the target groups.

The development schemes during the seventh FYP (1985-90, drawn up as part of longer term plans for 1985-2000), aim for the eradication of poverty, the provision of full employment and satisfaction of basic needs for the rural poor. Nearly 120 million persons joining the labour force during the 15 year period are to be provided gainful employment by creating productive job opportunities in the rural areas. This is to be achieved by the development of agriculture, social forestry and rural infrastructure and the promotion of village and cottage industries.

### 1.3.4 Agricultural growth

Since agriculture is the largest contributor to GNP its development can help the economy in three ways : by increasing GNP, by supplying food and raw materials to other sectors of the economy, and by providing economic surplus within a region. The contribution of agriculture to GNP has fluctuated from nearly 50% in the fifties to 40% in the eighties. However, the area under cultivation has continuously increased over the period (Table 1.5).

An increase in agricultural production can come in four main ways : larger investment, more intensive use of traditional techniques, introduction of improved techniques, and increase in area under cultivation. During the first two decades of planning the strategy was mainly to increase the investment and to bring more and more areas under cultivation. But new strategy of agricultural development in the seventies was based on technological modernisation, involving a shift from major to minor irrigation works, credit facilities to farmers, and use of high inputs such as fertilizers and high yielding variety seeds. Due to its high input nature this technology suited the already rich farmers and comparatively developed regions which were well endowed with necessary infrastructure such as irrigation facilities (Table 1.7). However, the value added in agriculture grew at the rate of 2.4% and 2.2% during the periods 1950-51 to 1964-65 and 1967-68 to 1981-82 respectively (Bardhan, 1984). So during the later period, associated with the 'Green Revolution' the country did not witness acceleration in overall rate of agricultural growth. The explanation of this lies in the fact that in the first period, the growth of agriculture was due to area expansion, which in most cases was released from forests, during the second period the growth was due to increased productivity (Sharma *et al*, 1990a). The use of high input oriented technology resulted in increased dependence of agriculture on industry and two way agriculture-industry linkages (Table 1.8). This meant inappropriate use of surplus factors of production such as labour. Table 1.9 presents the sectoral composition and Table 1.10 shows the long term trend of use of factors of production in the agricultural sector.

### 1.3.5 Growth of national income

Basically there are three approaches to measuring the economic activity of a nation, based on production, income, or expenditure. India follows the product approach in as many sectors of the economy as possible, the income approach being followed for the remaining sectors. The annual growth rates of Gross Domestic Product (GDP, $Y_1$) and per capita GDP ($Y_2$) in real terms for the period 1950 to 1985 were 4% and 1.9% as shown by following semi-loglinear models :

$$\log_e Y_1 = -73.1 + 0.04\,T \qquad R^2 = 99.3\%$$

and

$$\log_e Y_2 = -30.4 + 0.019\,T \qquad R^2 = 97.2\%$$

where T refers to year.

The marginal propensity to save during the periods 1960 to 1985 and 1970 to 1985 estimated from the national account statistics were 22.4% and 25% respectively. This shows that the economy has grown mature in the later years of the planning period. The percentage of gross domestic saving to GDP (at current prices) increased from 9.5 in 1950-51 to 22.9 in 1978-79 (Table 1.11).

The long term pattern of investments and the sectoral growth rates in the important sectors of the economy have fluctuated as shown in Tables 1.12, 1.13 and 1.14. Investment in primary sectors, and their share in the total GDP have decreased steadily, while the share of manufacturing sector has increased. This shows a disturbing trend in view of the country's land-labour situation. The solution of this problem lies in increasing productivity in the primary sector, which will continue to support a majority of rural people for earning their livelihood. Since the manufacturing sector has limited employment capacity, especially to non-wage workers, the bulk of gainful employment opportunities should be created in the primary sector mainly through technological innovations such as social forestry.

### 1.3.6 Income distribution and poverty

Income inequality at first increases during the process of development then diminishes once a certain level has been reached (Kuznets, 1966). However, in many developing economies including India, growth has not resulted in reducing the income inequalities and poverty (Tables 1.15 and 1.16). This is due mainly to high population growth and unemployment, higher dependency on primary sector and limited access to capital and land resources. So there is a need for direct measures to redistribute productive assets and capital formation towards poverty groups (Chenery *et al*, 1976). This can be achieved either through equitable distribution of factors of production or redistributing the fruits of higher economic growth among the poor. However, this later option is not practically feasible in a democratic country such as India. So the strategy should be provision of employment at a minimum wage for all those who do not have the means of production and creation of productive assets through application of an appropriate technology.

### 1.3.7 Unemployment

Unemployment in India takes one of two forms : firstly there are persons who are full time unemployed, and secondly there are unemployed workers who find seasonal employment as agricultural labourers. The first type of employment can be measured in terms of persons wholly unemployed (for example in 1973, there were 4 M persons unemployed). But it is difficult to measure underemployment, which is common in developing economies where the basic unit of production is the household dependent on family labour and not a firm as in developed economies. Due to increasing displacement of traditional village and cottage industries by competitive modern industry, underemployment is widespread in rural areas (Table 1.17). Thus in addition to full time jobs it is also necessary to create additional employment opportunities compatible with location, skills and idle time of the rural unemployed.

## 1.4 Forest economy

### 1.4.1 Spatial distribution

The spatial distribution of forests in the country is uneven (Table 1.18). A comparison of figures in this table with the population density of the respective States (Population census, 1981), shows that the thickly populated States have a much lower percentage of forest area in comparison to thinly populated States. In addition, those States which are comparatively more developed economically (e.g. Haryana and Punjab) have less forest area than the undeveloped States (e.g. Orissa, Assam and Madhya Pradesh). Two main conclusions can be drawn from these statistics. Firstly, that decreased forest cover is linked with increased industrialisation and prosperity of the State. Secondly, that there is a large potential for developing forests in poorer States.

### 1.4.2 Forest types

According to species composition the forests can be classified into coniferous (6%) and broad leaved (94%). The percentage of forest area under various forest types, as classified by Champion and Seth (1968), is presented in Table 1.19. Of the sixteen major types, the tropical and montane subtropical forests are widely found and are economically important. Among these the tropical dry deciduous and moist deciduous forests are most common.

### 1.4.3 Management of forests

Various silvicultural systems have been adopted depending on species characteristics and management objectives. According to mode of regeneration these can be grouped into uniform, selection, clearfelling and coppice systems. On hilly forests the selection system is adopted, while those Sal (*Shorea robusta*) forests which regenerate freely are managed under the uniform system. A coppice system is adopted in dry deciduous forests because they have species which can coppice and are situated near villages. In areas under artificial regeneration, the clearfelling system is practised (Table 1.20). It is evident from the table that the area under artificial regeneration is much less than that of natural regeneration, showing that management of forests relies heavily on natural regeneration.

### 1.4.4 Status of forests

According to official records, the total forest area is nearly 75 M hectare (ha), or nearly 23% of the total geographical area. Of this 40 M ha is reserved forests (RF), 22 M ha is protected forests (PF) and the remaining 13 M ha is unclassified. However, recent estimates put the forest area at approximately 64 M ha, or nearly 20% of the total geographical area.

### 1.4.5 Long term trends in forest area

A time series of indices for forest area is compiled from the annual Returns of Statistics and Statistical Abstracts relating to British India (1901 to 1947). A multiple regression analysis of these statistics gave the following best fit equation :

$$I_f = 70.6 + 1.09\,A - 0.789\,P \qquad R^2 = 99\%$$

where, $I_f$ is the index of forest area adjusted for population, A is the forest area index and P is the index for mid year estimates of population. The negative regression coefficient of P (significant at the 1% level) shows the significant negative impact of population growth on per capita forest area. After this period, the forests under ex-Zamindars (landlords) and princely states were amalgated into government forests. So the area under forests increased substantially (Table 1.21) and long term comparison is not possible.

### 1.4.6 Productivity trends

The Forest Survey of India (FSI) has estimated the total growing stock over 31 M ha as

2664 M cubic metre ($m^3$) with a projected figure of 1924 M $m^3$ for rest of forest area, giving a national total of 4588 M $m^3$ or 71 $m^3$ per ha. The annual production of timber, fuelwood and charcoal over the last ten years (Table 1.22) is compiled from FAO (1986) production statistics yearbook. This gives an average annual production of 41 M $m^3$, which can be taken as equal to overall annual increment (as the forests are managed on sustained yield principle). This figure is very close to the estimate of 33 M $m^3$ published by government (GOI, 1968). The difference is due to the fact that charcoal has been included, whereas government estimates do not include charcoal. The overall annual increment is therefore even less than 1% of the total growing stock and the average annual production of wood of 0.64 $m^3$ per ha is much less than the world average of 2 $m^3$ per ha.

There is a great variability in density of forests, ranging from very dense evergreen forests in Western Ghats to very sparse scrub forests in Rajasthan and Gujarat (Table 1.23). FSI has estimated the actual potential productivity in various regions (Table 1.24) and this shows that the productivity of forests could be increased to a much higher level.

### 1.4.7 Loss in forest cover

Estimates of the National Remote Sensing Agency (NRSA, 1983) of the extent of forest cover for the two periods 1972-75 and 1980-82 suggest a reduction in forest cover of 91710 $Km^2$. This is nearly 2.8% of the total geographical area. Although these estimates are not particularly precise due mainly to limitations of remote sensing technology (Sharma, 1986) it is now widely agreed that forests are being lost rapidly (Table 1.25).

Conflict over land-use has resulted in the regular encroachment of forests by agriculture (Table 1.26) in an attempt to feed the rapidly increasing population and nearly 700,000 ha of forests are currently under active encroachment (Table 1.23). There is a shortage of accurate information on the extent, location and number of people practising shifting cultivation. An estimate put the area at 4.35 M ha, practised by 622,000 families in 13 States (Table 1.27). In Orissa alone nearly 9% of total forest area is affected by shifting cultivation.

### 1.4.8 Tribal dependence on forests

The dependence of tribals on forests is not only economic, but also social and cultural.

Nearly 250 tribal communities with a total population of 52 M live in and around forests and depend directly or indirectly on them for their sustenance. The symbiotic relationship between the forests and tribals has recently changed to one of exploitation. It is estimated that nearly 12% of the total tribal population are involved in shifting cultivation and 5% of them have encroached onto forest lands to earn their livelihood (GOI, 1987). Though the degree of dependence of tribals on forests varies from 15 to 84% of the total annual income depending on location, the overall estimate is that 33% of their livelihood is earned from forest based employments and forest produce, the major share of their income coming from the sale of minor forest produce (Table, 1.28). However, government's emphasis on revenue-oriented forestry and consequent restrictions on tribal's use of forests has alienated them and in Orissa and Bihar the resentment has resulted in violent clashes with the Forest Department. The confidence of tribals has not been reinstated by the forest schemes which are of direct benefit to them.

### 1.4.9 Fuelwood demand

The percentage share of fuelwood in per capita energy consumption in 1975-76 was 68.5% in rural areas and 45.5% in urban areas, with a total fuelwood consumption of 133 M tonnes (GOI, 1979). But the recorded production of fuelwood from forests was only 19 M tonnes (FAO, 1984). The National Sample Survey Organisation (NSSO) based on a survey found that in 1977-78 nearly 30 M tonnes of fuelwood was obtained from private lands, gardens and trees around houses. This still leaves nearly 84 M tonnes unaccounted for, which must have been met through illicit removal from the forests. Thus, forests are being exploited beyond their productive capacity, a fact also observed by Trivedi (1986). This phenomenon is not recent but seems to have increased since the early fifties (Table, 1.29) such that FAO (1983) has classified India in a fuelwood deficit zone.

The annual per capita consumption of fuelwood in rural areas varies from 0.15 tonnes in Punjab to 0.8 tonnes in Andhra Pradesh (AP); in urban areas these figures are 0.1 tonnes in Haryana and o.8 tonnes in AP (FSI, 1987). On the basis of these figures, the total fuelwood consumption during 1987 is estimated to be 134 M tonnes in rural India and 23 M tonnes in urban areas. With a potential production estimated at 28 M tonnes (ibid, 1987), the gap of 129 M tonnes remains a major problem. The seventh FYP has assumed that the amount of non-commercial energy as a percentage of total energy used in the country will go down (Table, 1.30). But its actual magnitude has increased with the growing population (GOI, 1985).

This widening gap between supply and demand of fuelwood (Table, 1.31) has also been emphasised by the National Commission on Agriculture (NCA). Fuelwood scarcity also leads to 7.3 M tonnes of cattle dung being burnt each year (Barnard and Kristferson, 1984) which would normally have been used on agricultural fields as manure, thereby decreasing crop production substantially (Sagreiya, 1962, 1964; Chaturvedi, 1979; Pant, 1979). A large number of cattle which are otherwise unproductive are kept only for dung production. The energy crisis has been highlighted by many such as Varmah (1980), Tiwari (1983), Kaul and Gurumurti (1981), Oka (1981) and Revelle (1981).

### 1.4.10 Fodder demand

Approximately 12.5 M ha of land is under pasture and grazing for communal use. These lands, which are not managed under any management plan, have become almost devoid of vegetation due mainly to overgrazing, brought about by an increase in cattle population from 292 M in 1951 to 369 M in 1977. The number of animals grazed in forests has risen from 35 M in 1958 to 60 M in 1974, and 90 M in recent years.

### 1.4.11 Timber demand

The Ministry of Agriculture has estimated that the annual demand for timber in 1987 is over 27 M $m^3$, compared with the current silviculturally permissible annual cut of only 12 M $m^3$ (FSI, 1987). Although the consumption of timber for industrial uses is comparatively low, due mainly to low productivity of forests, projections for the future suggest an increasing industrial use of timber.

### 1.4.12 Nistar demand

The requirements of forest produce for domestic bonafide needs of villagers, but not for sale, gifts or barter, have been defined as 'Nistar'. Their supply is made obligatory on agencies working with the harvesting of forest produce, and in some regions supply is made through local cooperatives and councils. At the time of forest consolidation when these rights and concessions to supply Nistar were fixed, the forests were adequate to cover these demands. This is no longer the case. For example, in hilly regions of Uttar Pradesh nearly 16% of total production from forests was supplied as Nistar (Gupta, 1979).

## 1.5 Social Forestry

### 1.5.1 Origin of social forestry

The scarcity and consequent need for provision of fuelwood and small timber to villagers was realised as early as in 1892, when Voelcker (1893) recommended to Government of India the creation of fuelwood and fodder reserves. This was again restated in 1928 when Royal Commission on Agriculture suggested the creation of village forests and minor forest divisions for provision of fuelwood and grazing. The National Forest Policy (1952) envisaged farm forestry for afforestation of communal lands and government unused lands. Farm forestry was to be implemented by the Rural Development Department, but this scheme did not get off the ground due mainly to lack of interest among the staff (Wilson, 1986).

In 1958 concrete steps were formulated for implementing farm forestry in an All India seminar (GOI, 1958). However, little tangible progress was achieved until 1961 when a farm forestry scheme was initiated during the third FYP, and although the outlay for this scheme was comparatively small it became successful in States such as Tamil Nadu. The scheme envisaged that the villagers would take up the responsibility of raising and protecting these plantations.

However, the involvement of villagers could not be assured, so the plantations were raised and protected by the Forest Department and only a part of harvest was distributed to villagers. The real impetus to social forestry came from an interim report on social forestry submitted by the National Commission on Agriculture (NCA, 1973) which recommended a wider scope of farm forestry (see Appendix 1.1). Social forestry was included as a component of economic development programmes. Separate funds were allotted for social forestry from both the Forest and Rural Development Departments. The need of social forestry in economic development was also restated in the final report of the National Commission on Agriculture (NCA, 1976). A National Wasteland Development Board (NWDB) was set up in 1985 to supervise and monitor the progress of social forestry being implemented in various States.

The role of forestry in community development was also realised by international funding agencies. For example the World Bank (1978) forest sector policy paper stated, "A major part of forest degradation today is caused by poor farmers seeking a livelihood through low production agriculture. ---- destruction of forests can be slowed only as governments pursue greatly expanded rural development programmes to help the rural poor. ---- The challenge is to bring about, in the policies of developing countries, a change that will result in a larger share of resources being allocated to rural afforestation programmes that have a wide impact on the income of small farmer." A similar concern was voiced by FAO (1978), "----the objective is to raise the standard of living of the rural dweller to involve him in the decision-making process which affects his very existence--. The physical goals which will be set are really means towards achieving the objective of enhancing the lives of human beings."

### 1.5.2 Objectives of social forestry

Westoby (1968) for the first time defined social forestry as that "which aims at producing a flow of protection and recreational benefits for the community". However NCA (1976) adopted a wider perspective : the objective of social forestry, being related to the basic and economic needs of the community, should aim at improving :

**a.** fulwood supply to the rural areas and replacement of cowdung,

**b.** supply of small timber,

**c.** supply of fodder and

**d.** protection of agricultural fields against wind.

Depending on local conditions some variations are noticed in the emphasis on various objectives of social forestry in different States. The Orissa social forestry paper (OFD, 1987) mentions :

**i.** Social forestry is the creation of sustainable forest resources for the villagers, with government support.

**ii.** Social forestry programme implementation implies full involvement of the villagers as individuals and as members of local communities,

**iii.** Social forestry creates resources primarily to meet the needs of the villagers for products of importance in the local economy such as fuelwood, small timber, fodder and wood for constructions, agricultural implements, small scale village industries and handicrafts.

**iv.** Social forestry provides employment to rural unemployed and underemployed to generate income to meet their basic consumption needs.

The above objectives can be broadly classified into production and rural development objectives. However, an implicit objective of establishing tree cover can be classified as an ecological objective.

### 1.5.3 Components of social forestry

The major components of social forestry in Orissa are as follows :

i. Village woodlots (VWL): The main concept of the VWL is that the Forest Department will support villagers to carry out a community-oriented tree plantation on community lands and government unused lands for the benefit of the villagers.

ii. Reforestation of degraded forests: This component aims at reforesting those degraded and depleted forest areas which are in the vicinity of villages and over which villagers have Nistar rights.

iii. Institutional plantations : These are similar to VWL except that institutions such as community centres and schools are encouraged to participate in the programme. A related component is strip plantations, in which plantations are raised in strips along sea coasts, roads etc. instead of blocks.

iv. Farm forestry for rural poor (FFRP) : This component has similar objectives to the Economic Rehabilitation of Rural Poor (ERRP). ERRP is an important part of rural development schemes and is currently being implemented in almost all the States, mainly to raise the income and consequently consumption level of the landless rural poor. The objective of FFRP is to enable landless rural households to practise intensive forest farming or agroforestry, whichever is feasible, on government wastelands in and around the villages. The beneficiaries are selected on the basis of guidelines framed for the ERRP programme. Each beneficiary is allotted 0.5 ha of unused government land with usufruct rights to the agricultural and forest produce. With technical and financial support from the Forest Department, plantations of quick growing biomass species such as Eucalyptus are established. From the nursery stage until the harvest of first agricultural crop, the beneficiary is closely associated with all the activities and nearly 250 to 300 worker days are generated over a 0.5 ha area (Pattanaik, 1988). This wage earning along with annual income from agricultural crops for the initial three years contributes a substantial income for an otherwise comparatively longer gestation forestry enterprise.

### 1.5.4 Management of social forestry

In traditional production forestry compartment is the unit of management; in extension forestry it is the farm. In social forestry, management should be based on the entire village or a group of villages sharing the communal or government lands on which social forests are to be established. Since social forestry is largely funded by government for the greater benefits of the society, its management must be based on the mutual interests of the villagers and government. This should result in the creation of sustainable resources satisfying their common interests. Conflicts should be resolved amicably in the general interests of society.

There can be two possible ways of managing social forests : management can either be handed over to existing Panchayats (village level councils of elected representatives) in villages or to the joint control of the Forest Department and the villagers. The first option, although preferable, was tried in some States such as Tamil Nadu, but it failed due mainly to conflict of interests within the heterogeneous villages. This means that a joint management system implemented through a village level forest committee consisting of representatives from the villagers and Forest Department needs to be adopted. Orissa social forestry has adopted this model of management .

### 1.5.5 Factors of production in social forestry

Natural resources such as forests have a potential role in the economic development of a developing economy (Westoby, 1962, 1978; Gane, 1969; Muthoo, 1971). This is particularly important in those countries which lack capital. In India the person-land ratio is high and this means that a proper utilisation of scarce land and surplus labour resources is of critical importance for the prospects of socioeconomic development .

#### 1.5.5.1 Land resources

Although the present area under cultivation is comparatively large, there is no possibility of converting agricultural land to social forestry because of increasing population. The per capita availibility of cultivable land has continuously declined from 0.48 ha in 1951 to 0.26 ha in 1981, despite an increase in total area under agriculture during the same period. This shows that potential land area for social forestry will mainly come from non-agricultural lands.

However, there are currently nearly 175 M ha of wastelands, which remain either unutilised or underutilised and which can be available for social forestry (Table, 1.32). The poor depended on these lands for their sustenance (GOI, 1986) : most was classified as common property resources (CPR) such as village forests and grazing lands. But in the absence of any rational government land-use policy or investment these have become 'no man's lands', to be exploited by whosoever gets it first, promoting resource deterioration (Romm, 1981a, 1981b). However, Governement of India has recognised this nexus between rural poverty and land degradation.

The Land-Use Policy (GOI, 1986) states, " in planning efficient resource allocations, we should not forget the problems of rural communities, the tribals and others below the poverty level in whose hands these resources have to be efficiently utilised and whose minimum needs the efficient use of such resources is meant to provide. Resource use in the hands of such persons cannot be optimal unless the policy framework facilitates such optimal use by making the prescribed use relevant and profitable to the user by providing the necessary supporting package of technology, input, supply, credit, social infrastructure and marketing support".

#### 1.5.5.2 Labour resources

Social forestry is well suited for absorbing surplus labour resources by providing them gainful employment and creating productive and disposable assets. Due to its labour-intensive nature, the employment potential of forestry is quite substantial (Shah, 1978; Pant, 1978, 1979; Sharma, 1979). This can solve the problem of unemployment and underemployment in rural areas to a considerable extent. Also many forestry operations are flexible in timing and requirement of skill. So a wide range of non-skilled and semi-skilled workers can get employment at different times of the year.

#### 1.5.5.3 Capital resources

Investment funds for social forestry are made available by the Forest and Rural Development Departments. Taking all rural development schemes together at least 25% of the total outlay is invested in social forestry. Many social forestry schemes are also being funded by international agencies such as World Bank, Swedish Internatioanl Development Agency, Overseas Development Administration, etc.

### 1.5.6 Socioeconomic linkages of social forestry

Socioeconomic functions of social forestry in an agrarian economy such as India are significant and diverse, notwithstanding the protective and ameliorating effect on the environment. To achieve these functions a wider perspective should be adopted rather than meeting a single need with a technological solution. An appropriate technology has to address these issues for individuals and communities.

Social forestry has strong backward and forward linkages with the local rural economy : Chetty (1985) has identified nearly 90 small scale, cottage and village industries which are dependent on forests for raw materials. If promoted, these forest-based rural industries will reduce dependence of the rural labour force on cultivated lands, promote self-employment especially for village artisans, generate healthy competition in rural markets and encourage technological transfer to rural areas.

In addition, other primary sectors such as agriculture, dairy and animal husbandry depend on forests for raw materials while tribals and other communities living in the vicinity of forests collect, sell and eat many edible fruits and other materials from forests. Despite this important role of forests in rural economy, their potential has not been achieved due mainly to inappropriate planning framework adopted which is reviewed in the next chapter.

**Summary :** A brief account of the forest economy and socio-economic background in which social forestry is being implemented has been presented in this chapter.

# Chapter 2

## Socioeconomics of Forest Planning

Forest planning in India has been closely linked with the socioeconomic environment at three main levels, namely Forest policy, sectoral Five Year Plans and Working Plans. Forest policy provides broad guidelines for strategic planning, a sectoral plan provides the strategies and means to achieve the broad policy objectives, while Working Plans are operational planning documents at forest division level which detail annual work programmes.

## 2.1 Socioeconomics of the Forest Policy

### 2.1.1 Ancient period

The history of forest planning is not well documented as there is very little literature which throws light on the management of forests before British control. However some remarks are found in ancient holy books of Indian culture about the respect Indian people had for trees and forests. There is evidence that the 'ashram system' was practised as early as 4000 BC. These ashrams were sylvan centres, the abode of thinkers, philosophers, poets and writers who practised human social values and veneration of trees and forests. The ancient holy books such as Rigveda, Manusamhita, Mahabharata etc. mention the thick forests around which the ancient Indian culture flourished (Sen, 1966).

Lord Buddha preached, "the forest is a peculiar organism of unlimited kindness and benevolence that makes no demands for its sustenance and extends generously the products of its life activity, it affords protection to all beings offering shade to even axeman who destroys it". But there was no systematic forest planning until 300 BC when a Superintendent of forests assisted by staff was appointed to manage the forests of one region. There is evidence that the first forest policy which specified guidelines for managing forests was implemented during this time (Mobbs, 1941). For example, at the time of king Ashoka (300 BC) permission of the palace was required if living trees were to be felled. But after this forests were left unmanaged and successive waves of invasion and immigration contributed to the devastation of forests.

Aryans, who immigrated along with their large herds, gradually settled in small village communities, by clearing forests for agricultural settlements. A variety of ways of earning livelihood such as settled agriculturists, shifting cultivators, pastoral nomads and food gatherers have prevailed (some of them are practised till to date) due mainly to large variations in climate and environment.

People were encouraged by the rulers to clear forests for practising agriculture in order to increase revenue by extracting tax on agricultural production. Labour resources must have been crucial at this time because land resources were surplus. This possibly explains the practice of shifting cultivation in a subsistence agriculture characterised by a land-surplus and labour-scarce economy in which the villagers maximised the yield per unit labour rather than the absolute yield per ha.

### 2.1.2 Medieval period

The Mohammedan invaders and rulers were not interested in the conservation and management of forests, except raising some aesthetic roadside plantations. The indirect effect of the invasions was the further devastation of forests at the hands of local inhabitants. The forests were cleared for making roads, burning, grazing, lopping and cultivation. The Muslim rulers were keen to extend the cultivated region, whenever sufficient number of humans were available, with the objective of increasing their tax-base and thence their revenue (Lal, 1988). This meant that the land-use policy was based on exploitation of land resources rather than their development because no attempt was made to reinvest the extracted rural surplus. However, a larger proportion of the rural population enjoyed an unrestricted supply of forest produce and the people were therefore better off because there was more forest and less cultivation (Moreland, 1920).

After the downfall of the Mughal empire, small kingdoms and principalities emerged, and these groups often fought amongst each other. Although on paper forests belonged to the rulers of these kingdoms, in practice there was no control on their management. According to an official handbook of the Forest Department, under the oriental governments that preceded British rule anyone was accustomed without let or hindrance to get what he wanted from the forests, to graze his cattle where he liked and to clear forests for cultivation wherever he liked (Tiwari, 1985). A small attempt at control was made in some forests rich in wildlife to protect these as game reserves for kings. In later years, certain valuable tree species were specified as royal trees and royalties were collected for their extraction.

### 2.1.3 British period

The early British rule was associated with further exploitation of forests. The East India Company made no attempts at planning forests for sustained yield. Ribbentrop (1900) wrote, "our early administrators, occupied with the building up of an empire, probably never thought of the important part that forests have played, play now and will forever play in the household of nature, or the immense influence they exercise on the physical well being of a country, while as a necessity for the people and as a revenue yielding property, they were considered insignificant. ........ No apprehenson was felt that the supply of forest produce should ever fall short of demand and forests were considered as an obstruction to agriculture rather than otherwise. ..... It was the watchword of the time to bring more extensive forest areas under cultivation and the whole policy tended in that direction".

The British followed the policy of earlier native rulers, of reservation of certain valuable timber species such as teak (*Tectona grandis*). It appears that at this time the British government otherwise occupied with the expansion of its territory, did not want to interfere with the local traditions, customs and practices of the inhabitants and thus alienate them.

The first concern for forests arose due to demand for shipbuilding: the government wanted to know the extent to which teak timber could be supplied and appointed a Forestry Commission in 1800 to make regulations prohibiting the felling of young teak in Malabar forests (Stebbing, 1921). On the basis of the report submitted by a forest committee set up to enquire into the capacity and status of proprietary rights in forests, unauthorised felling was stopped and royalty rights over teak trees were established.

In 1806, a Police Officer was appointed as the first Conservator of Forests, for arranging exploitation of forests for supply of timber for the Navy. The Conservator had wide powers to interfere with the established rights of local people and largely eliminated these private rights, giving rise to discontent among the natives who had used the forests from time immemorial to fulfil their needs. The East India Company, eager to maintain cordial relations with the inhabitants, abolished the post of the first

Conservator of Forests in 1823, leading to further damage from local people. Thus the policy swung from one extreme of strict control to the other of no control. This first attempt at forest management was a dismal failure, an act of injustice which cannot be condemned too severely : originally started in order to secure a permanent supply it degenerated into an attempt to establish, without regards to private rights, a government monopoly (Brandis, 1897). However, demand for the supply of teak timber for the Navy was restated and the post of Conservator of Forests was revived in 1847.

In 1854, another report suggesting restrictions on the unchecked exploitation of forests by private parties was submitted to government. This formed the basis of the first major policy document issued in 1855, known as "the Charter of Indian Forestry". This policy paper laid down the rules and principles of management of state forests and contemplated that the timber standing in the state forests was state property and people had no rights or claims on the trees.

The trees of exploitable size were to be removed according to the silvicultural requirements of the species, for the proper conservation of forests and were not to be exploited for the benefits of timber merchants as earlier. The earlier policy of reservation of certain type of trees was thus extended to land, with forested lands being reserved instead of trees. Although the charter was a step forward it was not given effect until the Forest Department was created in 1864 when Dr Dietrich Brandis was appointed as the first Inspector General of Forests to implement it. Despite mention of the population pressure on forests the charter did not recommend any specific measures to meet the bonafide demands of local people dependent on them.

Prior to Brandis assuming office the extent and status of forests were unknown. On arrival he carried out work leading to demarcation and reservation of forest lands so that the nation's proprietary rights could be exercised. To achieve monopoly rights the first Indian Forest Act was enacted in 1865, subsequently replaced by the more comprehensive Indian Forest Act of 1878, which had provisions for the demarcation of valuable tracts of forests and the constitution of Reserved Forests (RF), Protected Forests (PF) and the Village Forests (GOI, 1878). The ownership of the government was absolute in RFs with only very few rights and concessions to local people which were recorded. Apart from these all felling, grazing, etc. was strictly prohibited and punishable under the provisions of the Act. PFs were also government property but there were rights and concessions given to local people in order to meet their bonafide demands for fuelwood, fodder and small timber. Thus in RFs the rights were settled once and for all but in PFs the rights were only recorded, and not settled.

Village forests were the property of local communities, the government only having rights over certain kinds of trees. The Indian Forest Act 1878 states "the local government may from time to time assign any village community the rights of government to or over any land which has been constituted as a RF and may cancel such assignment - all forests so assigned shall be called village forests". The state's proprietary rights and obligations in the form of privileges and concessions to the local people were thus exercised at the mercy of local rulers representing two important though conflicting features of the policy. Possibly the policy makers did not want to annoy the Indian peasantry, but it gave rise to discontent and unrest when people were confronted with an alien situation, especially in tribal areas, where the notion of private property was quite unknown.

The development of forest policy in Europe was also the result of a growing population pressure. As the extension of cultivation led to a decrease in forest areas the latter came under systematic management. The forest policy of India was greatly influenced by the German concepts of land management in which the state was given proprietary rights to manage the forests in perpetuity for the welfare of present and future generations.

During this period reservation and demarcation of forests and settlement of rights were the only policy measures implemented. The first important shift in forest land-use policy came mainly from socioeconomic and political considerations. The great famine of 1876-78 emphasised the need for extending areas under agriculture to combat starvation and hunger. The strict forest administration coupled with a policy of settlement and demarcation had alienated the people, so the British attempted to maintain peace by a policy which would not cause unrest among the local people. Dr Voelcker, a chemist of the Royal Agricultural Society, was invited by GOI to advise on the improvement of agriculture and submitted a detailed report in 1893. This report recommended,

(i) the creation of fuel and fodder reserves,

(ii) the increase of plantations along canal banks and railway lines,

(iii) the encouragement of arboriculture,

(iv) the setting up of an enquiry to determine the needs of different districts for forest produce, and

(v) the annual use of some Forest Department revenue for the extension of reserves to meet agricultural requirements (Voelcker, 1893).

Although these recommendations were never fully implemented they formed the basis of the first Indian Forest Policy, produced in 1894, in which forestry was rather made subservient to agricultural interests. A quotations (GOI, 1894) will serve to illustrate this point: "it should be remembered that subject to certain conditions, the claims of cultivation are stronger than the claims of preservation....... and so whenever an effective demand for cultivable land exists and can only be supplied from forest areas, the land should ordinarily be relinquished without hesitation".

The consequent widespread release of forest lands for agriculture led Brandis to comment that "....... the release of forests recommended in forest policy document would be detrimental to agriculture, since tree cover in these areas was required to meet the basic needs of agriculture itself (Shyam Sunder *et al,* 1987). However, the policy took the people's point of view, ".... considerations of income (i.e. revenue accruing to government) should be made secondary to the full satisfaction of local needs........., no restrictions should be placed upon reasonable local demands, merely in order to increase the state revenues".

Despite the fact that the latter concept was of far reaching importance and remains valid even today, the recommendations were not put into practice because of the emphasis on revenue earning. Indeed, since the forest policy was only applicable to lands under Forest Department control, large forest areas under Revenue Department control suffered heavily due to lack of management.

Introduction of the land tenure systems and the consequent agrarian structure also affected forests adversely (Sharma, *et al* 1990a). Since settlements such as the Permanent and Pringle's were marked by considerable overassessments, which majority of cultivators were unable to pay, they were either driven into debts and dispossession or found their lands directly sold up for revenue arrears (Charlesworth, 1982). The investment in agriculture by cultivators was negligible due mainly to their poverty. Similarly the government investment in agriculture was also marginal, although a greater part of revenue was derived from it by means of indirect taxes and land revenue.

Deindustrialisation of the indigeneous small scale, cottage and village industries served to increase pressure on forest lands because more and more lands were brought under plough for earning livelihood (Sharma, *et al* 1990a). The problem was further compounded by the lack of investment (particularly in developing irrigation and rural extansion facilities), which along with a shift of paddy cultivation to marginal lands resulted in declining agricultural productivity.

On the other hand, the agriculture was commercialised through improvements in communication and investment in growing large scale plantations of cash crops such as rubber, coffee and tea due mainly to their demands in world markets. As a result forests were cleared for raising commercial plantations as reported by Cleghorn (1861), "the successful cultivation of coffee plants is extending remarkably, and the applications for clearing forest lands pour in upon the revenue authorities." This means that the economic environment characterised by the policy of free trade and *laissez faire* had adverse affects on forests.

A further policy shift occurred in 1921, when the management of forests became vested in provincial governments. This was consolidated in Government of India (GOI) Act of 1935, with the GOI ceasing to have direct control. Thus the role of forests in the socioeconomic development of provinces rather than the country as whole became the main aim. This remained the case until 1976 when forestry was transferred to the concurrent list to enable GOI to exercise control in case of conflicts between the national and regional objectives.

### 2.1.4 Post Independence period

In the period after independence it was necessary to revise the 1894 Forest Policy because of changes in the socioeconomic environment of the country. The two World Wars had a major adverse impact on the forests and in addition it was realised that they were not an inexhaustible resource. The former princely and feudatory states merged with the union, bringing together large forest areas which had been either not managed or poorly managed. These deteriorating forests (Rai, 1954,1955) were to be covered under the new policy. The rights and concessional claims of local inhabitants in forest areas were to be rationalised so as to be compatible with national interests. The new National Forest Policy (GOI, 1952) recognised forests as a distinct, balanced and complementary land-use, not a mere handmaid of agriculture but an indispensable ally or foster mother, essential to maintain and increase the productivity of agricultural land.

The policy proposed the classification of forests on the following functional basis :

(I) protection forests

(II) national forests

(III) village forests, and

(Iv) remaining tree lands.

Provisions were made to exercise control over the private forests and ex-princely forests. The policy of releasing forest lands to agriculture was to be discouraged and foresters were instructed to assimilate, integrate and educate the people by establishing village forests and tree lands for increasing the supply of fuelwood, fodder and small timber. The policy also laid down that the practice of shifting cultivation should be discouraged and slowly eradicated by providing those practising it with employment. The management of village forests was entrusted to Panchyats in order to meet both present and future needs of the local people. However, the policy was at odds with the earlier strong emphasis on the fulfilment of basic needs of people dependent on forests: it is now widely recognised that national forest policies. especially in poor countries, have tended to place too much emphasis on long term industrial (urban) objectives and too little on satisfying short term needs of the people living in and near forests (Maaren, 1984).

The management of forests was largely under the jurisdiction of provinces which were not under any obligation to strictly follow the national policy. As a result the laud objectives of the policy remained unimplemented. The functional classification of forests as suggested in the policy, has so far not been done, which often leads to conflicts between societal and national goals.

In 1976, keeping in view the future demands on forests, the National Commission on Agriculture again recommended that all forest lands should be classified into Protection, Production and Social forests. Forests occupying hill slopes, watersheds, riverbanks and other areas vulnerable to erosion and degradation should be classified as Protection forests, where no felling would normally be permitted. Production forests are essentially commercial forests, comprising valuable timber-bearing stands and occurring in ecologically stable regions. Social forests were to include all government forest lands which were being used to meet the requirement of local population for fuelwood, fodder and small timber. Social forests were also to include wasteland, village common lands and lands on the side of roads, canals and railway lines which may be brought under tree cover.

The creation of social forests was mostly neglected until social forestry was launched in a number of States in the late 1970's and early 1980's. The passing of the Forest Conservation Act (1980) resulted in the GOI intervening in the trend for forest areas to be diverted to non-forestry purposes (Tables 3.1 and 3.2). The policy would have been more effective, had it been passed in the provincial legislatures. This policy, like the previous one, did not cover forests under the Revenue Department. Also, the abolition of private ownership of forests without simultaneous legislation to take them over resulted in large scale destruction of these forests at the hands of owners (Sagreiya, 1982; Tucker, 1982).

Forestry practices which were initially meant to supply forest produce for local needs gradually shifted away from the communities possibly under the influence of market demand, industrialisation and technological change. The rural population was thus either bypassed by forest planning or received meagre attention in the form of a limited supply of forest produce, namely Nistar. This gave rise to dualism between local people and management staff with respect to customary rights and concessions (in the form of Nistar), modern forest law and planning. Although villagers had rights and concessions they had no influence or say in the management of the forests to which they apply. The Forest Department did not have adequate resources to augment the forests and enhance their productivity to cope with the increased demands of growing population.

With the increasing emphasis on rural development the role of forestry in creating rural assets by absorbing surplus resources such as land and labour has to be given a place in policy documents. FAO (1980) has suggested that national forest policies should add social objectives to the usual productive and protective objectives since social forestry provides a link between forests and people, and between forests and agriculture. In arriving at decisions when formulating and executing a forest policy one must consider the social and cultural acceptability of the decisions (FAO, 1987).

The revised National Forest Policy (GOI, 1988) has taken account of some of the aspects discussed above. Besides its strong emphasis on conservation and protection, the policy document noted the supply of fuelwood, fodder and small timber for rural populace as one of its basic objectives, of greater importance than direct economic benefits and revenue earning. The potential role of social forestry in rural development and the symbiotic relationship between tribals and forests have been strongly stated. The provision of rights and concessions to rural populations, although linked with the carrying capacity of forests, has been incorporated in the document so that forests can no more be managed in isolation from society, and indeed are the means to achieve social welfare. The policy document affirms this point by emphasising the increased involvement of people and the sharing of costs and benefits accruing from forests.

## 2.2 Socioeconomics in sectoral planning

At national and State levels forest planning is achieved through forest sectoral plans (contained within Five Year Plans) which are developed within the broad framework of the National Forest Policy in order to meet the desired national objectives. With the changing priorities over the period since independence, the thrust of planning in forestry sector has also changed accordingly.

### 2.2.1 First Five Year Plan (1951-56)

The main focus in this plan was to consolidate and integrate approximately 20 M acres of degraded forests taken over from ex-Zamindars and princely states. The forestry sector outlay was only 0.39% of the total (4.1% of outlay in the agriculture sector) and emphasis was laid on raising commercial plantations over 3000 acres per year (GOI, 1958).

### 2.2.2 Second Five Year Plan (1956-61)

The outlay in forestry sector was raised to 0.46% of the total. Commercial plantations were raised over 0.164 M ha and nearly 0.147 M ha of degraded forests were rehabilitated through reforestation and soil conservation works. Survey, demarcation and settlement rights over 5.9 M ha of forests were undertaken. The financial and physical targets achieved are shown in Tables 2.3 and 2.4. This suggests that during the first two FYPs the emphasis was on consolidation of forests and no efforts were made to create social forests.

### 2.2.3 Third Five Year Plan (1961-66)

In this plan, forestry as a subsector of agriculture was recognised but the emphasis was again laid on raising large scale commercial plantations to meet the long term requirements for industrial purposes. As a result the forestry sector outlay was increased to 0.53% of the total and States were encouraged to establish plantations of quick growing species with central aid.

However, the increasing population pressure on forests and the need to extend tree cover outside traditional forest areas was realised. The scheme of raising economic plantations outside the forests namely 'Extension Forestry' was initiated. Another centrally sponsored scheme named ' Farm Forestry' was also initiated, though with only a small outlay of Rs. 10.95 M, to extend tree planting on the lands not fit for agriculture including village commons and wastelands. The main purpose of this scheme was to reduce pressure on traditional forests by creating fuelwood and fodder reserves near villages deficient in forest resources. During the period 1966-69 FYPs were not prepared. The tempo of raising pulpwood plantations was, however, continued and an attempt was made to modernise harvesting and plantation techniques.

### 2.2.4 Fourth Five Year Plan (1969-74)

The guiding principles for forestry in this plan were to maintain adequate forest cover and to meet the requirements of wood for industrial purposes. The main objective was to achieve self-sufficiency in the forest produce required by forest-based industries through intensive management of existing forests, although the forestry sector outlay was only 0.54% of the total. The specific objectives of this plan were as follows :

(i) consolidation and scientific management of all hitherto unorganised forests,

(ii) strict protection against unregulated cutting,

(iii) the establishment of a permanent organisation to carry out an inventory of forest resources, with a view to assessing the country's supply of raw material for industry and domestic consumption,

(iv) replacement of forests having slow rates of growth by plantations of fast-growing species of industrial value,

(v) afforestation of barren lands and the formation of manageable units to ensure protection and improvement of productivity,

(vi) introduction of improved methods of harvesting, and extension of communications to facilitate the exploitation of inaccessible forests,

(vii) multiple use of natural resources for recreation and wildlife conservation.

Approximately 23% of the forest sector expenditure in the first three FYPs was spent on economic and industrial plantations, followed by a similar percentage in the fourth

FYP. Establishment of fuelwood plantations started as late as the third FYP and only accounted for 2.2% and 4.1% of total expenditure in the third and fourth FYPs respectively. This indicates the low priority attached to meeting fuelwood needs.

### 2.2.5 Fifth Five Year Plan (1974-79)

As this plan emphasised the removal of poverty and employment generation, an emphasis was laid on the potential of forestry in rural development. Three important links for the forestry sector were identified in this plan; forest and wood, forest and food, and forest and people. In the forest and food link forestry and farming were considered as the same form of activity, i.e both producing maximum output from land as one of the factors of production. It was stated that forestry activities are labour intensive and so have potential for absorbing a large surplus labour, especially in undeveloped rural areas. The plan aimed at afforestation of barren lands and wastelands to protect the environment and meet people's demands for forest produce.

In the forest and people link, multiple-use and awareness of the need for forest conservation were emphasised. However, the main thrust of the plan was still on the third link i.e. forest and wood, to achieve self-sufficiency in industrial wood production. Forest Development Corporations were established in many States, mainly to convert low productive mixed forests into large-scale commercial plantations with the help of institutional finance. Though these corporations raised some successful plantations this resulted in the conversion of mixed forests of multiple-use into monocrops, which attracted criticisms on social and ecological grounds. The forestry sector outlay was reduced slightly to 0.51% of the total.

### 2.2.6 Sixth Five Year Plan (1980-85)

The theme in this plan was 'development without destruction' and so the conversion of mixed forests into monocrops was stopped. The forestry sector outlay was increased to 0.71% of the total, mainly to implement development schemes such as social forestry. Beside this, social forestry schemes received funds from other sectors such as rural development. In many forest deficient regions as much as 25% of the total outlay of the rural development schemes was earmarked for social forestry programmes. The main thrust was on saving natural forests from further depletion and the creation of fuel and fodder reserves.

### 2.2.7 Seventh Five Year Plan (1985-90)

The theme in this plan is " forest for survival". Some of the main objectives of this plan are as follows :

(I) to meet the basic needs for fuelwood, fodder and small timber,

(II) to enhance the productivity of forests,

(III) to mobilise people's involvement in afforestation and increasing vegetal cover, and

(Iv) to preserve biological diversity.

The forest sector outlay has been increased substantially to 1.03% of the total. It is anticipated that social forestry schemes will create forest resources and employment opportunities for small and marginal farmers, and landless labourers. The plan envisages the reclamation of wastelands and communal lands by afforestation and also the meeting of non-commercial energy needs by providing fuelwood to rural households.

Table 2.5 gives the forestry sector outlay for each of the FYPs which shows that the forestry sector has not been allocated enough funds over the period and one reason for this seems to be inappropriate planning. The production and supply of forest produce for specific end uses have remained unbalanced because management has not given sufficient importance to this aspect (Prasad, 1976). The contribution of forestry sector to GDP (1980-81 prices) was only 0.98% as compared to 37.4% from agriculture, although the area under forests is almost half of that under agriculture. In the year 1971, the agriculture and ancillary sectors provided employment to over 7% of the rural work force, while forestry and logging accounted for only 0.2% (Gupta, 1978).

## 2.3 Socioeconomic aspects in Working Plans

### 2.3.1 Contents in a Working Plan

At the micro-level of the forest division, planning is given effect through a written plan of management called a Working Plan (WP). Such a plan is usually prepared for a 10 year period and conforms to long term objectives as stated in forest policy and sectoral plans. The WP regulates the management of forests, according to time and locality, aiming at continuity of policy and actions. It incorporates quantitative aspects of planning compatible with the silvicultural aspects. A WP consists of two parts : Part I is descriptive providing details of the growing stock, socioeconomic aspects affecting the management, administrative subdivisions of each forest and a review of the results of past management, for example. Part II deals with prescriptions for future management. For planning purposes, estimates are made of the annual increment and yield, with detailed plans for restocking the felled stands. At present nearly 78.5% of total forests are covered by WPs (Table, 3.6) but even now nearly 1.4 M ha of forest lands are undemarcated and under no management. The situation is acute in comparatively undeveloped States such as Orissa, Sikkim, Himachal Pradesh and Madhya Pradesh.

### 2.3.2 Principles of Working Plans

The general principles of management have been issued in various government circulars. To maintain uniformity in compilation of WPs guidelines were framed in a Working Plan Code as early as 1891 (D'Arcy, 1891) which was subsequently revised in 1952 with only minor changes. The principles of management were adopted from a German model of sustained yield as early as 1856, when Brandis prepared a formal WP on the following basis : in any forest to be worked, as many first class trees (i.e. trees above a certain diameter) could and should be felled in one year as would be replaced during that year by second class trees (Schlich, 1911). He estimated the growing stock by a technique called ' Linear Valuation Survey' and annual yield was fixed by the number of exploitable trees. This concept was an important part of European forest management planning in the nineteenth century. It was developed in response to prevailing economic conditions such as the scarcity of timber, a need for perpetual physical supply of wood, expansive transport facilities and high bulk/value ratio (Thirgood, 1968; Eckmullner and Madas, 1984).

The WPs aim to regulate yield on a sustained basis to obtain regular production in perpetuity. This is ensured by establishing the maximum sustained yield of particular forest area and then planning the harvesting from annual coupes. A natural corollary of sustained yield is the attainment of a 'normal forest', an ideal state characterised by a normal growing stock (an even distribution of age classes upto rotation age in even-aged forests). The emphasis of the sustained yield model is on the establishment of subsequent crops. The normal yield is considered as the quantity of produce available as a result of restocking within a reasonable time and attaining a normal forest (Trevor and Smythies, 1923; Schlich, 1911).

Although theoretically possible, normality is difficult to achieve in practice, due mainly to the socioeconomic interactions to which forests are subject. In fact there is no normal forest in India (Mishra, 1982), despite forest planning for the last two hundred years. The sustained yield principle can be restated in economic terms as the harvesting of interest (increment) earned by the capital (i.e the growing stock), leaving the latter intact. The harvesting is regulated either by area, using a rotation of maximum physical production, or by volume, estimating increment and hence the annual cut (which is supposed to be constant over time). Working circles which are units of management with different objects of management are created in order to be worked separately.

### 2.3.3 Socioeconomic environment

Working Plans recognise the socioeconomic role of forests by including the meeting of local needs as an objective of management. It should be emphasised that agricultural traditions, customs and needs of people have an important bearing on forest management planning; in fact, a whole chapter in each WP is devoted to deal with this subject.

In many cases silvicultural systems have been chosen on the basis of socioeconomic aspects. In labour surplus areas, for example, agri-silviculture or taungya systems have been encouraged and the coppice system has been adopted in those areas where local people require small timber and fuelwood. The sustained yield model served its purpose well upto nearly 1950, because the forest resource was able to meet the demands of people. However, with significant increases in population, the demands on forests increased to a point where they could not be met. Although the WPs still mentioned the needs of local people, no attempt was made to assess these and alter operational planning accordingly for different forest areas.

With more emphasis on revenue earning the people's needs have been relegated to the background and the net effect of this is seen in rampant pilferage from the forests by local inhabitants. As a result many areas managed under age-old coppice system (usually situated near villages) have become deforested (Sharma, 1987) due mainly to inadequate regeneration. In forests which are still worked for the supply of forest produce to local people, the distribution of forest produce to poor is ineffective because of high rates for forest produce fixed by harvesting and marketing organisations such as forest corporations. There is a growing concern that foresters and forest planning are unidirectional, indifferent to the needs of people and concerned only with the biological aspects of forestry. The significance of wider socioeconomic aspects has been neglected in forest planning (Chowdhry, 1977; Gupta, 1978; Mishra, 1982; Murdia, 1982; Shiva *et al*, 1985 ).

The WPs cover mainly Reserved Forests and occasionally Protected Forests. This means that Village Forests and tree lands remained unmanaged. It was thought that village forests would act as buffer zones for RFs and PFs by meeting the needs of villagers. However, due to lack of any management and over exploitation, these forests have become almost barren, requiring to be reforested now under social forestry schemes.

### 2.3.4 Socioeconomic view of sustained yield

The proponents of sustained yield argue that it is essential for stability of communities, industry and forest externalities (Holt, 1968; Moss, 1970). Due to their peculiarities such as long period to maturity, intangible benefits and the fact that growing stock constitutes both production plant and product, for example, forests need to be treated differently from a business firm. Ecologists argue that the earth's environmental system should not be treated as other capital goods (Rees, 1985), and so economic principles have limited applicability.

On the other hand economic criticism of the sustained yield model rests on the following arguments :

(i) the cost of sustaining the yield is generally ignored,

(ii) the forest is treated as a closed biological entity producing timber in inelastic physical quantities unaffected by the market mechanism (Smith, 1969),

(iii) yield is estimated on the basis of maximum mean annual volume increment (which results in longer tree rotations) rather than economic criteria and

(iv) the time value of money and opportunity cost of land are ignored.

At one extreme, it may be argued that sustained yield primarily takes into consideration the interests of future generations by handing over the forest resources so that each generation receives a forest heritage. On the other extreme, injunctions such as 'choose programmes so as to maximise the number of future options' may disregard the social costs that would be associated with such plans (Dasgupta, 1982). A balanced approach based on socioeconomic aspects considering both the present and future generations need to be adopted because well being of present generation, who struggle hard to make ends meet and depend on forests for their livelihood, is equally desirable.

The sustained yield principle presupposes the renewability of forest resources so that the yield can be sustained in perpetuity. The concept of resource renewability of forest resources is socioeconomic as well as biological in nature (Kimmins, 1973) and there are many forests being harvested today, or scheduled for harvesting on the basis of sustained yield which cannot legitimately be considered as renewable resources (Kimmins, 1974). In almost 85% of the forests in India, the natural regeneration is inadequate (Table, 3.7) which is a basic requirement for the successful application of sustained yield principle. There are various reasons for this but socioeconomic factors are largely responsible. Forests are still being worked to get the sustained yield and thence revenue though the very renewability of forests is in danger of conflicting with the basic assumption of the sustained yield model.

## Summary

A brief critical review of forest planning has been presented which forms a basis for designing an appropriate planning methodology for social forestry evaluation. Next chapter explores the appropriateness of the existing analytical techniques in the context of the socioeconomic planning in social forestry.

PART

# II

# QUANTITATIVE FRAMEWORK

# Chapter 3

## Analytical Techniques for Social Forestry Evaluation : A Review

Planning can be looked upon as an important form of applied welfare economics, which provides the basis for assessing the relative desirability of different forms of government control in achieving socioeconomic objectives which are not subserved by an unfettered market mechanism (Lal, 1980). The main goal of the planning process is the allocation of resources according to some form of conflict resolution between value holding groups in society. This value conflict is mainly concerned with matters of distributional equity and is a dominant element in social forestry policy. The process of policy analysis is at least as important as the result itself (Tribe, 1976).

### 3.1 Social forestry policy analysis

The analysis of a complex policy such as social forestry will by necessity involve its subdivision into its constituent elements and then the application of analytical techniques in order to assist decision-making. This process can be termed modelling. A model is defined as an abstraction from reality that is intended to order and simplify our view of that reality while still capturing its essential characteristics (Foreese and Richer, 1973). The process of rational decision-making in social forestry can be organised according to following steps :

**a.** Classification and organisation of the goals, values, aims and objectives;

**b.** Listing of an exhaustive set of feasible alternative management options;

**c.** Prediction of the main consequences of each management option; and

**d.** Selection of those management options which achieve the best results in meeting identified goals and objectives, on the basis of chosen criteria.

Policy analysis was defined for the first time by Dror (1968) in terms of the following main elements :

**(i)** A broad conception of decision-making;

**(ii)** Attention to the political aspects of decision-making;

**(iii)** Extensive reliance on qualitative methods;

**(iv)** A major emphasis on creativity and the search for new policy alternatives;

**(v)** A systematic approach which would recognise the complex interdependence of means and ends, the multiplicity of relevant criteria for decision-making, and the partial and tentative nature of every analysis.

(vi) Future prediction about the alternative policy scenarios.

Dror (1971) further refined his definition as an approach and methodology for identifying and designing preferable management options in respect to complex policy issues. However, Wildvosky (1969) argued that policy analysis is a process of deciding on the objectives of an organisation, on changes in these objectives, and on the resources used to attain these objectives.

A simpler definition is given by Ukeles (1977) who states that policy analysis is the systematic investigation of alternative management options and the gathering and display of evidence for and against each option, i.e. predicting consequences of alternative courses of action based on knowledge. This suggests that decision-making should not only use heuristics but also be based on a holistic approach, incorporating disciplines such as behavioral sciences and systems analysis. Coleman (1972) advocated the view that in policy analysis partial information available at the time an action must be taken is better than complete information after that time. This is important because social forestry exists in a larger system consisting of a complex socioeconomic reality. Included in this larger system are the value judgments of villagers and planners.

In this context, Rokeach (1973) defined a 'value' as a standard that guides and determines action, attitudes towards objects and situations, ideology, presentation of self to others, evaluations, judgments, justifications and attempts to influence others. All persons possess a number of values or a value set, arranged in a hierarchical manner. Such a value set is less complicated than the real world and this is a great virtue since a few standards apply in a multiplicity of situations (Fowles, 1977). This means that the value set is like a model which attempts to simplify reality. A value judgment is an application of these value sets. Value judgment or ideology within analytical techniques is inevitable and value neutrality impossible (Clifford, 1978).

There can be two types of value judgments in an analysis of social forestry. Endogenous value judgments are an integral part of the analysis, whereas exogenous value judgments may be fed into the analysis in terms of policy and problem definition, knowledge gathered from villagers and planners, and the selection of a particular technique. The results of social forestry analysis are more relevant when value judgments are applied, and this means that social forestry policy should not only be evaluated in terms of hard objective data but also be complemented by soft subjective data. In addition, an investigation is required about what values and whose values matter : the social units that participate in public policy-making constitute the structural framework of a policy (Panandiker, 1989) such as social forestry.

Some economists argue that the value judgments should not be part of an analysis and be left to the decision maker (Mishan, 1974), but since the judgments have direct effects on analytical results they cannot be ignored. However, most value judgments are not amenable to hard analysis and have often been ignored because the measurement of qualities is difficult in comparison to measurement of quantities. Such divergence between the model and socioeconomic reality makes the former inadequate as an aid to practical decision-making in social forestry. The problem is not due to the social forestry environment but the inadequacy of hard analytical techniques.

Cost-benefit analysis (to be discussed below) is able to incorporate some value judgments of society by integrating preferences derived from an objective assessment of weights. Similarly, sensitivity and post-optimal analyses enable the investigation and determination of lower and upper bounds of impacts. Despite their limitations these techniques can be of value if integrated into any dynamic analytical framework capable of handling value judgments and soft aspects such as distributional equity, and expectations and motivations of social forestry policy and the villagers associated with it respectively. This will not only overcome the problems of socioeconomic realism, adequate theoretical base, measurement, valuation, aggregation, public participation and dynamic framework but also enable the incorporation of both hard (objective) and soft (subjective) data. The following main techniques are reviewed with the view of pursuing a balanced perspective on the role of analytical techniques in evaluating social forestry.

### 3.2 Input-output model

An input-output (I-O) model can be regarded as a large collection of data relating to a socioeconomic system or as an analytical technique for explaining and predicting outcomes from a socioeconomic system. A static I-O analysis gradually involves all purchases of each sector from the remaining sectors of the economy, and similarly all sales of each sector to all others. In an I-O table each sector of the economy is represented by one row and one column, showing the outputs (sales) and inputs (purchases) of that sector to all other sectors considered in the analysis. The total sales of any one sector including sales to households, governments, exports, etc. form the final output of that particular sector. Forestry, agriculture and other industrial sectors are called intermediate sectors as their demand for products arises from their own decisions to produce. Households, governments and export trade form autonomous sectors. Demand of these sectors is due to consumer preferences, population changes or political pressure.

The size of an I-O table depends on the number of sectors identified for the economy to be studied. Suppose an economy has been defined in terms of n sectors and each sector of these produces just enough of its own product to satisfy the requirements of all other sectors, then a simple I-O model is described by the following n linear equations :

$$X_i = \sum_{i,\ j=1}^{n} X_{ij} + F_i \quad ; \qquad i, j = 1, 2, \ldots\ldots\ldots, n \qquad (3.1)$$

where $X_i$ is the output of any intermediate sector and represents sales to other intermediate sectors ($X_{ij}$) and autonomous sectors ($F_i$). In other words, $X_i$ is the quantity of good i produced by sector i, and sector j required $X_{ij}$ units of good i to produce one unit of its own product, good j. Equations (3.1) can also be expressed as a table or transaction matrix, which will show the value of flows from the producing sectors to the consuming sectors of the economy. Information from this transaction matrix can be used in knowing the relationships between the inputs to any one sector from other sectors and by the net output of that sector.

At this point in the development of I-0 models, Leontief (1966), who originally put forward this theoretical concept, made an assumption of fixed proportions of factor inputs i.e. the quantity of good i required by sector j is directly proportional to the total amount of good j produced. So

$$X_{ij} = a_{ij} X_j \qquad (3.2)$$

where $a_{ij}$ (a constant of proportionality) is the production coefficient of sector j in respect of sector i. So every $a_{ij}$ gives a monetary units worth of the produce of sector i required by sector j per unit value of output of sector j. The following expression is obtained by substituting the value of $X_{ij}$ from equation (3.2) to (3.1),

$$X_i - \sum_{i,j=1}^{n} X_{ij} = F_i \qquad (3.3)$$

These n linear equations represent the functional relationships between the autonomous sectors ($F_i$) and the net output ($X_i$) and the relationships between intermediate sectors ($a_{ij}$) in the economy. Matrix Algebra enables the solution of these equations which can be represented as,

$$(I - A)(X) = (F)$$

where (A), (X), (F) and (I) are the n x n, n x 1, n x 1 and identity matrix respectively. The inverse matrix $(I - A)^{-1}$ gives the value of interdependence coefficients, providing an estimate of direct and indirect effects, which can be used in intersectoral analysis. The use of the I-O technique in forestry is illustrated by Parasnis (1976) and Schuster (1980).

The technique has theoretical weaknesses due to its assumptions, and practical limitations. It is a clumsy tool because of the large amount of data required (Mutch, 1971; 1988) and so its use at regional level poses practical problems, especially in forestry sector having weak data base : Saluja's (1968) intersectoral-intertemporal consistency model having a total of 77 sectors in Indian economy could not disaggregate the forestry sector adequately (only three subsectors i.e. timber, wood products and other forestry products were included).

However, as a low cost alternative, the GRIT (Generating a Regional Input-output Table) method involving 15 steps can be employed in preparing regional I-O tables from national I-O tables and readily available secondary data. This means that the results are less accurate, although they may embody the main characteristics of the regional economy. The aim of the GRIT method is to reduce (based on the relative intensities of regional employment) the national inter-industry coefficients to a level where they more closely represent the transactions at the regional level.

The model assumes that each sector has only one input structure and produces only one good. This may not always be the case depending on the level of dissaggregation that has taken place. Also, in the case of inputs with high backward linkages, dissaggregation will be extremely difficult. What happens in practice is that many sectors are aggregated together which results in a loss of specifity. The average coefficients resulting from this aggregation also may not be truely representative of activities.

Leonteiff's basic assumption of fixed proportionality of factor inputs conflicts with the traditional production theory which is basically based on the non-linear relationship between inputs and outputs. The input coefficients derived from a single set of observations may not be valid because it assumes that not marginal inputs but total inputs are proportional to outputs.

As I-O tables are usually prepared at producer's prices and give intersectoral flows in terms of monetary values, information about physical quantities of inputs and outputs cannot be derived. Also, since it is assumed in the model that the total effect of production by a number of sectors is equal to the sum of their individual effects ignoring the response of changes in prices of products, the use of I-O model for forecasting purposes is limited. Additionally, the assumption that any changes in sales outside the region do not affect economic flows within the region, is not realistic. It is generally agreed that so far as economic theory is concerned the Leontief model is an oversimplified presentation of reality based on assumptions which are not acceptable in any rigorous sense (Ghosh, 1968).

The above limitations combined with the approach's emphasis on treating households as profit-maximising firms restrict its applicability for evaluating social forestry. The technique, although useful in macro-level planning based on a top-down approach, is not useful for micro-level planning based on a bottom-up approach; the purpose of this study.

Another technique known as optimum output model consists of, within a given budget constraint, a combination of transformation and indifference curves. Gregory (1955) applied this technique considering two production possibilities, i.e. timber and forage. However, the construction of transformation curves of changing taste and the incorporation of the time variable in practice result in the sacrifice of reality for any real world system.

### 3.3 Multiplier analysis

This technique originated in the field of urban economic relationships (Hoyt, 1937; Meyer, 1963) and consists of estimating the first round income multiplier and subsequent multiplier for a region; the following statements are derived from Greig (1971). The first round income multiplier may be stated as follows:

$$K_a = 1 + V + [\{(E_d + \Delta V / I)\ \beta\ W_p\}/E_d\ W_d]$$

where, $K_a$ = the first round income multiplier,

$E_d$ = the direct employment in the activity examined,

$W_d$ = the average income of direct employees,

$W_p$ = the average income of public service employees,

I = the increase in local value added required to create one extra job in the service trades,

ß = the ratio of public service employees to other employees,

V = the proportion of an increase in income which is local value added; $V = (1-s-t)(1-m)$, where s is the average propensity to save, t is the average tax rate, and m is the average propensity to import from other regions,

$\Delta V$ = the increase in local value added created by direct employees i.e $\Delta V = E_d W_d V$.

Second and subsequent multiplier effects are given by,

$$K_b = 1/\{1 - ¢ - c^* (1 - t^* - u)(1 - m)\}$$

where, ¢ = the income of the public service employees expressed as a proportion of total income,

$c^*$ = the marginal propensity to consume,

$t^*$ = the marginal propensity to direct tax rate,

m = the average propensity to import,

u = the ratio of unemployment benefit to income.

This shows that the technique takes into account income multiplier effects and so is an improvement upon the evaluation techniques discussed so far. It also considers indirect effects such as unemployment but to be operative this technique requires the estimation of certain regional parameters for which substantial regional statistics are necessary. Although multiplier analysis provides estimates of the income generating ability of a given activity, it ignores the associated changes in other activities in the local economy. If a number of options are to be evaluated, their analysis requires estimation of income multipliers for each activity; this requires a lot of data and time and the estimation procedure is cumbersome. Finally, if the objective is to optimise social welfare - as indeed is the case with socioeconomic planning in social forestry - the technique does not provide a criterion for measuring the change in social welfare due to social forestry. Although the technique is useful for indicating the multiplier effects to corporate firms and service sectors such as tourism, its applicability for the present study is restricted.

## 3.4 Operations Research (OR)

Mathematical programming as a part of OR is a general term for a group of analytical techniques involving optimisation of objectives subject to specific constraints on resources associated with a range of alternative activities. OR techniques are a specific method of providing executive departments with a quantitative basis for decisions regarding the operations under their control (Morse and Kimball, 1951). Given a meaningful mathematical function of one or more variables, the value(s) of variable that, within certain allowable limits, will make the function take on its maximum or minimum value is calculated, this general process of maximising or minimising being referred to as optimisation (Cooper and Steinberg, 1970). The needs for methods of optimisation occurs because of the mathematical complexity needed to describe real life systems.

A mathematical model may be used for analysing the behaviour of a system for the purposes of improving its performance and also to define the ideal structure of a system, including the functional relationships among its components. In other words, optimisation methods can be used to explore the local region of operation and predict the way that system parameters should be adjusted. The importance of optimisation lies not in trying to find out everything about a system but in finding out, with the least possible effort, the best way to adjust the system so as to function in a desired way (Adby and Dempster, 1974). However, the reliability and validity of the solution obtained from the model depends on the extent to which the model represents the real system as the resulting solution applies to this representation. Any discrepancies between the real and the assumed real solutions depend directly on how accurately the model describes the behaviour of the original system.

Simulation is yet another approach to optimisation and can be defined as the action of performing experiments on a model of a given system for determination of the best possible policy among several feasible alternatives (Schmidt and Taylor, 1970). A simulation model is a digital representation which imitates the behaviour of a system by accumulating the statistics describing various measures of its performance as the simulation advances on the computer.

While simulation procedures are often used to develop a range of alternatives without specifying a single most desirable solution to the modelling problem, optimisation techniques are designed to identify a particular "optimal solution" that satisfies a set of predetermined output criteria. The advantage of simulation modelling lies in its capacity of being more flexible and so capable of representing complex systems which are otherwise difficult to formulate mathematically. As simulation is not an optimisation technique it has the disadvantage of not yielding precise and general solutions like those obtained from successful optimisation models.

The objective and constraint functions of a mathematical model depend directly on the systems they represent and can be linear or non-linear. Similarly, the decision variables may be continuous or discrete and the parameters describing the system may be deterministic or stochastic. Accordingly various optimisation techniques for problem solving have been developed, including linear programming (LP), non-linear programming (NLP), goal programming (GP), integer programming (IP), dynamic programming (DP) and stochastic programming (SP). LP is used to analyse models with linear objective and constraint functions, while NLP deals with models containing non-linear functions. GP deals with models having multiple goals to be attained or satisfied simultaneously. IP applies to models having integer (discrete) variables and DP deals with models where the complete problem can be subdivided into smaller and simpler subproblems. Finally, SP applies to models in which the system's parameters are described by probability distributions.

A common feature of all the above techniques is that the optimal solution to a problem is obtained in an iterative manner with each new iteration yielding an improved solution. The optimal decision process consists of mainly three stages : knowing accurately and quantitatively how the system is constructed and how the system variables interact, deciding a quantitative measure of effectiveness, such as an economic index, and finally using a solution algorithm to find out an optimal value for the measure of effectiveness.

Although mathematical programming techniques are potentially useful in socioeconomic planning in social forestry, especially in achieving constrained optimum solutions, OR has tended to work with measurements - often financial - that are wholly quantifiable. However, having completed measurement and evaluation of socioeconomic benefits and costs to the beneficiaries accruing from social forestry, mathematical programming can be used in allocating the scarce resources to the alternative management options, thereby ensuring maximum net socioeconomic returns. So before developing a mathematical model (in Chapter 8), it is necessary to discuss about the applicability of an important technique, i.e cost-benefit analysis, which enables an understanding of the complex issues involved and the trade off among benefits, and costs accruing to the beneficiaries.

## 3.5 Cost-Benefit Analysis (CBA)

CBA is especially useful in public policy analysis as the government's overall aim is to ensure that social welfare is maximised, subject to those constraints over which it has no control, such as tastes, technology and resource endowments (Layard, 1972). In the Indian economy this objective requires some government intervention, in this case the implementation of social forestry. This is due to the failure of free markets to deal with the efficiency aspects, externalities, economies of scale, inadequate market opportunities and distributional equity aspects arising due to inequalities present in society.

CBA is a way of setting out the factors which need to be taken into account when making certain economic choices (Prest and Turvey, 1972). It permits decentralised decision-making such as found in the bottom-up approach of planning. However, this decentralised decision-making , if based on the market prices, may not result in the social optimum. To deal with this problem of distorted prices, shadow prices reflecting the social values of inputs and outputs are used in the analysis. CBA, therefore, involves two separate stages : first to evaluate in money units the advantages and disadvantages accruing to each individual or groups of individuals and secondly to combine these into a single measure of changes in social welfare. It is at this second stage that CBA criterion can be termed 'applied Welfare Economics'. This enables the assessment of socioeconomic impacts accruing to various target groups or beneficiaries at different levels of consumption. CBA, therefore, is a potential straight on candidate analytical technique, although appropriate modifications need to be made in order to be suitable for the present study.

Many relevant socioeconomic aspects of the social forestry system are however, not amenable to quantitative analysis. To incorporate these qualitative aspects along with some quantitative aspects into a dynamic analytical framework the possibility of using Expert Systems (ES) should be explored. This brings us to a review of ES which as branch of Artificial Intelligence (AI), is being increasingly adopted in several disciplines.

## 3.6 Expert Systems

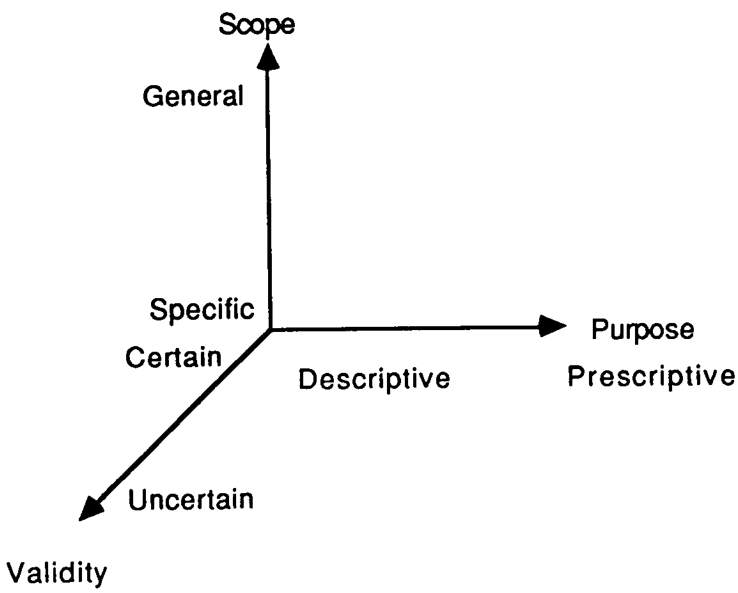
An ES has been defined by Weiss and Kulikowski (1984) as that "handles real world complex problems requiring an expert's interpretation" and that "solves these problems using a computer model of expert human reasoning, reaching the same conclusions that the human expert would reach if faced with a comparable problem". It can also be described as a computer program capable of intelligent problem solving by making use of AI techniques.

AI is a way of making a computer act intelligently, by studying how people think while making decisions and solving problems. The thought process is broken down into basic steps and a computer program is designed to stimulate this process. AI thus enables a structured and simple approach to designing complex decision-making programs. AI imitates the human learning process by which new information is absorbed and made available for future reference.

A special characteristic of ES is their ability to draw intelligent conclusions by manipulating and exploring their symbolically expressed knowledge bases (KBs) which are comprised of large bodies of domain-specific knowledge. An assumption behind ES is that specific knowledge of the task and general problem-solving knowledge will eventuate in expert level analysis. In other words the capacity of ES for intelligent problem solving is due to their ability of separating task-specifc knowledge from the procedures that manipulate it. This gives flexibility as the task specific knowledge (i.e KB) can be treated as any other data structure. Thus ES derive their expertise from knowledge about domain specific information and algorithims for solving domain-specific problems.

The knowledge can be obtained both from public sources such as reports, books, journals and theories and also private sources such as experience, intuition and heuristics. Hayes-Roth (1984) represent the knowledge in three dimensions as follows :

**Figure 3.1 Representation of knowledge**




Another way of encoding knowledge, as also used by humans, could be :

**a.** Empirical associations, which may actually be used as procedures.

**b.** Heuristics, used to solve problems efficiently and also to deal with uncertain or erroneous data.

**c.** Causal diagrams of the system.

### 3.6.1 Suitability of ES in social forestry

ES may have some of the following characteristic features which are useful in evaluation of social forestry :

**1.** Accurate and quick solutions to complex problems such as decision-making in social forestry systems.

**2.** The ability to address problems in specilized domains using speciliazed techniques.

**3.** The capacity of using both hard and soft data, the latter usually in the form of heuristics or 'rules of thumb'.

**4.** ES avoid blind search and permit reasoning with both formal and judgmental knowledge. This is particularly useful in case of social systems, which are usually characterised by a lack of quantitative knowledge although judgmental knowledge and theories have been generated sufficiently. ES can help evaluate social forestry even with available symbolic knowledge and influence statements.

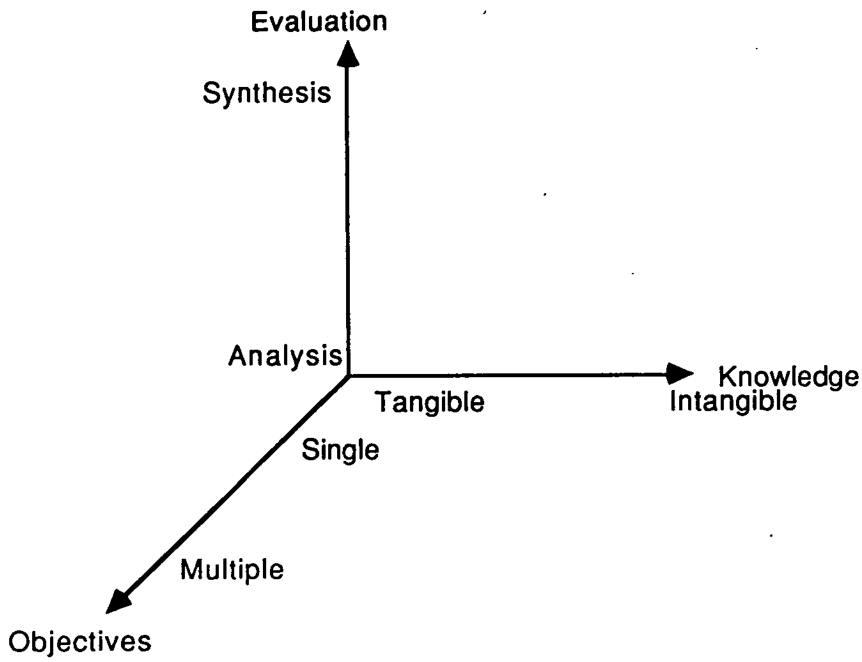
5. ES are transparent i.e they can provide justifications and explanations for the answers arrived, through user interactive interface.

6. ES have the ability to take problem stated in some arbitrary initial form and convert it into a form appropriate for processing by expert rules. This flexibility can be used in reformulating the systems' parameters according to the problem at hand. This is in contrast to mathematical models which are rigid, often necessitating an adjustment of the problem. Many social systems including social forestry are characterised by their fuzzy structure and complex interactions. This means that the systems' parameters need to be changed as understanding of the problem increases and interactions become known. A good reformulation system is one which knows its limits and does not force the problem into models which are unsuited to it.

7. ES can function even with erroneous, uncertain and incomplete data. Since social forestry is a comparatively new policy, inadequate empirical data is available. Using ES, knowledge can be utilised as and when available during social forestry implementation.

8. The KB for evaluation of social forestry consists of two components . The tangible knowledge can be structured and represented in a mathematical model but intangible knowledge can only be represented in a natural language. This is due to the fact that a natural language is the only means of communication and passing information among villagers, which is an important component of social forestry systems. It is this intangible knowledge which ought to be utilised, along with hard data, in the evaluation of social forestry but the studies to date have usually treated it as a residual or a black box and have only analysed the hard data. This amounts to ignoring the true socioeconomic environment of social forestry. An appropriate system for socioeconomic planning in social forestry therefore must be based on a conceptual structure which captures a KB enabling a satisfactory representation. ES not only enable analysis such as diagnosis and interpretation but can also help in synthesis such as design and planning. The following diagram illustrates these arguments (Sharma *et al*, 1990e) :

**Figure 3.2 Decision-making in social forestry**

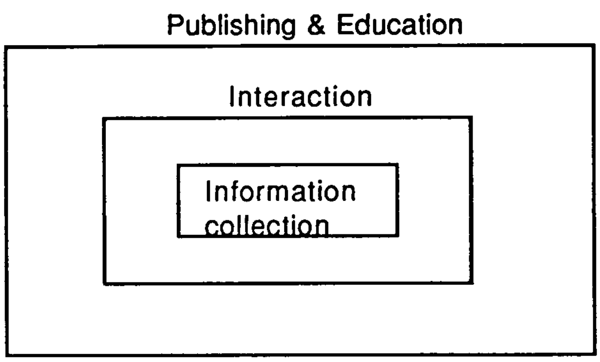



**9.** ES can capture intangible knowledge by involving decision-makers and experts (in this study, the villagers and staff themselves) in the modelling and solution finding process. This is important as normally optimal decision-making process is doomed to fail if the human problem-solving capacity is not granted its proper place in the decision-making process (Rinnooy Kan, 1984). In this aspect ES have some similarity with GP where decision-maker and problem solver interact closely. In fact ES utilise reasoning based on forward and backward chaining (discussed in Chapter 11), which are similar to the concepts used in LP and GP respectively.

**10.** Theoretically it is possible to collect all of the data required for the evaluation of social forestry. In most cases it is not feasible or impossible to collect all the required data. The enormous difficulties faced in such data collection have been realised by many social scientists and to overcome these problems Chambers (1985) suggests short cut techniques such as Rapid Rural Appraisal (which though inexact, enable quick data collection). ES are particularly suited for utilising data derived in this way because they can use villagers' judgment and experiences as a proxy for hard data which are either unavailable or difficult to derive.

11. Hard objective data takes on meaning when value judgements are applied to it by experts (Carley, 1980). In the case of social forestry evaluation the preferences of the villagers need to be considered: these indirectly-measured socio-psychological variables such as expectations, motivations, needs and feelings help determine whether uptake of the policy is as desired and help assess the priority and sensitivity of particular aspects of the policy in relation to whole. By increasing villagers' participation, and the interaction between them and the planners responsible for developing social forestry policy, these variables can be identified and information gathered. Hampton's (1977) model of public participation includes three activities which are conceptually contained in three boxes:

**Figure 3.3 Public participation model**




The centre box, collection of information, can only be accessed by involvement in the outer boxes - publicising and interaction. The participation of villagers will not only provide expert knowledge which, as a complement to the objective data, can be synthesised by the decision-maker, but also increase the psychological incentives for better cooperation and appreciation of the social forestry planning process.

12. ES can help integrate the various relevant aspects of social forestry policy by a cross-disciplinary perspective, theoretically, methodologically and practically. This can be done by a linkage of levels between practical experiences and theoretical developments (Jenkins, 1978) resulting in clear and consistent evaluation of social forestry.

## Summary

This critical review of the main analytical tools suggests that hard techniques need to be complemented by soft techniques to achieve a holistic and balanced perspective for social forestry evaluation. Economics is essential to dealing with the implications of resource allocation and scarcity, but the techniques of economic analysis are often developed with too narrow a focus. Hence there is a gap, which this study attempts to fill up by shifting the focus to consider the relevant socioeconomic aspects.

The successive chapters are devoted to developing a planning methodology or framework by adopting an integrated approach. To achieve this a case study is taken from Orissa State in India, where social forestry has been implemented from early 1980's.

Part II of the thesis deals with the application of hard analytical techniques for the socioeconomic evaluation while Part III complements the analysis by making use of an ES approach in socioeconomic evaluation of social forestry uptake.

# Chapter 4

## Financial Evaluation of Social Forestry

Any decision-making requires an assessment and comparison of alternative options which may fulfil the desired objective function. Analytical techniques can be used to aid such decision-making, presenting the analysis of alternative options in ways the decision-maker would find useful. This is more necessary in social forestry where there are numerous alternative management options which can fulfil the objectives.

Financial evaluation of an enterprise or project achieves effcient allocation of resources by maximising the net benefits accruing to the owner. Costs and benefits accruing from the project are valued at market prices in a competitive market. The financial model derives its validity from a classical economic model which treats efficiency as the basic criterion of acceptability in a world of relative economic scarcity. The logical framework for the evaluation of alternatives is one which maximises the net benefits over time, leading to increased productivity. The market prices estimated for various promising alternatives reflect the values placed on them by individuals, providing a measure of the ratio of rates of substitution among the alternatives. The appropriate measures or criteria are then estimated to help arrive at the optimum alternative option. A number of decision criteria and models will now be examined.

### 4.1 Decision criteria

Decision criteria involve both non-discounting and discounting types of decision algorithms (Gittinger, 1984). Of the two main discounting criteria, Present Net Worth (PNW) and Internal Rate of Return (IRR), the former has been found suitable for analysing subsistence-oriented social forestry systems, the main reasons being (for a detailed review, see Sharma, 1988a):

**a.** the IRR criterion may select projetcs or management alternatives leading to faster depletion of resources which is not desirable in social forestry systems which are inherently long-term in nature: the IRR criterion will lead to heavier discounting of distant future benefits (final felling as compared to thinnings, for example), thus preferring short-term options of an exploitative nature.

**b.** the IRR criterion implicitly assumes that all intermediate revenues are reinvested and that they yield a return equal to IRR until the terminal date. But alternatives may exist, such as harvesting of plantations maturing at different points in time, where capital is scarce while land as a factor of production is available. This is not true in all situations. Indeed, the reverse is true in India where capital is available for social forestry from various agencies due mainly to the current emphasis while land could not be physically available because of socio-political and tenurial considerations.

PNW expresses the difference between the discounted benefits and costs, while their ratio gives the Benefit Cost Ratio (BCR):

$$PNW = \sum_{t=0}^{n} (B_t - C_t) / (1 + r)^t \qquad (4.1)$$

and

$$BCR = [\sum_{t=0}^{n} B_t / (1 + r)^t] / [\sum_{t=o}^{n} C_t / (1 + r)^t] \qquad (4.2)$$

where, $B_t$ and $C_t$ are the benefits and costs in year t, n is the rotation of tree species and r is the discount rate (DR). Being a ratio, BCR does not give any idea about the extent or value of net benefits and is indeed sensitive to the classification of the effects of a project: all benefits might be considered as positive and all costs as negative. In addition, BCR would be comparatively higher for projects with lower investments, i.e. with a lower denominator in expression (4.2), although the returns in real terms may be small.

The main advantage of BCR is that it can be used in those cases where the benefits and costs, although quantifiable in numerical terms, cannot be measured in monetary values (Newton, 1972). However, BCR is linearly related to PNW: suppose an initial investment of C' returns a stream of benefits over the total period (n years) of a social forestry project, with no intermittent costs, then

$$PNW = \sum_{t=0}^{n} B_t / (1 + r)^t - C' \qquad (4.3)$$

$$BCR = \sum_{t=0}^{n} [ B_t / (1 + r)^t ] / C' \qquad (4.4)$$

Combining equations (4.3) and (4.4) the following expression is obtained which shows a linear relationship between BCR and PNW.

$$PNW = (BCR - 1).C'$$

Therefore, PNW per unit land area is chosen for the purposes of this study.

### 4.1.1 Biological model

According to a biological model rotation length should be chosen to correspond with the maximum mean annual increment (MAI) per unit area of forest stand. If q(t) is the volume (per unit area) of timber at the rotation age t then,

$$(MAI)_{max} = q(t) / t$$

Since the model is not price-responsive and does not take account of (assuming no intermediate yields) opportunity costs of the investment or land, it is not suitable in social forestry analysis.

### 4.1.2 Economic models for forest land valuation

The PNW criterion, unlike IRR, implicitly assumes that land and not capital is a limiting factor of production. The PNW per unit land area will therefore provide an approximate measure of the returns from the land in a single rotation, if no opportunity cost of land is included in its computation. Since PNW does not account for differing rotations it cannot be used to determine the optimum choice between two alternative management options with different rotations. Logically, however, the option with a shorter rotation will be preferred to the longer rotation alternative. In addition PNW, like IRR, is sensitive to land value.

The forest land valuation model developed by Faustman as early as 1849, which is based on capital theory and asset replacement, overcomes these shortcomings. The rationale of this model rests on the fact that the value of the forest land (land expectation value, LEV) is an attribute of the use to which it is put and must therefore be calculated from the value of forestry crops which can be grown on it in perpetuity. This can be calculated by discounting all future net benefits during each rotation for an infinite number of rotations. The net revenue, calculated for each rotation by compounding them up to the rotation age (T), is capitalised as if it was the first payment in an infinitely long series of identical periodical payments. So if PNW is the present net worth for a single rotation, then LEV is given by,

$$LEV = PNW + PNW / (1 + r)^T + PNW / (1 + r)^{2T} + \dots\dots\dots + \infty$$

which is an infinite convergent series. The following expression for LEV is obtained by multiplying both sides by a factor, $1 / (1 + r)^T$ and subtracting the resulting equation from the above:

$$LEV = [ PNW . (1 + r)^T ] / [ (1 + r)^T - 1 ] \qquad (4.5)$$

By substituting the expression for PNW from equation (4.1), we have

$$\text{LEV} = (1 + r)^T \left[ \sum_{t=0}^{T} (B_t - C_t) / (1 + r)^t \right] / \left[ (1 + r)^T - 1 \right]$$

$$= \left[ \sum_{t=0}^{T} (B_t - C_t) \; (1 + r)^{T-t} \right] / \left[ (1 + r)^T - 1 \right]$$

which is the required expression for computation of LEV, giving the capital value of an infinite number of returns each received T years apart.

Another measure for the forest land value is called annualised land rent (ALR) or soil rent, which gives the rate of annual returns from the forest land in addition to 100r% annual returns from the capital. This is given by the following expression:

$$\text{ALR} = r\,\text{LEV} = r\left[ \sum_{t=0}^{T} (B_t - C_t) \; (1 + r)^{T-t} \right] / \left[ (1 + r)^T - 1 \right] \qquad (4.6)$$

### 4.1.3 Optimality conditions

Samuelson (1976), while arguing that capital theory requires that the objective of managing forest land should be to maximise the PNW of an infinite sequence of harvests which can be obtained from that land, proves the identical optimality conditions in annual rental and perpetual timber production models based on two different approaches. Chang (1984) also, analysing the relationships among different models, concludes, " the LEV model provides the correct model of rotation age determination and other models are special cases of the LEV model with biological model being the most restrictive".

For example, suppose that a stumpage value $B_t$ is received at year t for 1 ha of social forestry plantations, established at an initial cost $C_0$ with no intermittent costs and benefits, where t is variable assuming values for various rotations. Then, by definition:

$$\text{PNW} = B_t / (1 + r)^t - C_0$$

and, $$\text{LEV} = -C_0 + (B_t - C_0) \left[ 1 / (1 + r)^t + 1 / (1 + r)^{2t} + \ldots\ldots + \infty \right]$$

$$= -C_0 + (B_t - C_0) \,.\, \left[ 1 / (1 + r)^t - 1 \right]$$

and, $$\text{ALR} = r\,\text{LEV}$$

where, $B_t$ = p(t) q(t) is the stumpage value of the forest stand (with $B_t' > 0$ and $B_t'' < 0$),

p(t) is the base year current price (or real stumpage price),

q(t) is the volume of 1 ha forest stand at the rotation age t,

and r is real interest rate.

If discounting is done continuously the above expressions can be rewritten as :

$$PNW = B_t / e^{rt} - C_0 \quad (4.7)$$

$$LEV = [ (B_t - C_0) / (e^{rt} - 1) ] - C_0 \quad (4.8)$$

and

$$ALR = r\, LEV = r \; [ \{ (B_t - C_0) / (e^{rt} - 1) \} - C_0 ] \quad (4.9)$$

Since ALR is a product of the discount rate (DR) and LEV, maximisation of LEV at a particular DR will correspond to maximisation of ALR, and vice versa. The following expression is obtained by differentiating (4.8) with respect to t :

$$\partial(LEV)/\partial t = [ \; B_t' \; (e^{rt} - 1) - r\, e^{rt} \; (B_t - C_0) ] / [ \; (e^{rt} - 1)^2 ]$$

For maxima , $\partial(LEV)/\partial t = 0$ and $\partial^2(LEV)/\partial^2 t < 0$, and so :

$$B_t' = [ \; r\, e^{rt} \; (B_t - C_0) ] / (e^{rt} - 1) ] \quad (4.10)$$

and

$$Bt'' \; (e^{rt} - 1) - r^2 \, e^{rt} \, (B_t - C_0) ] < 0$$

From equation (4.10), $B_t'$ = marginal revenue product (MRP)

$$= [ \; r\, e^{rt} \; (B_t - C_0) ] / (e^{rt} - 1) ]$$

$$= r\, B_t + r [ \{ (B_t - C_0) / (e^{rt} - 1) \} - C0 ]$$

$$= r\, B_t + r\, LEV$$

$$= r\, B_t + ALR \quad (4.11)$$

Since at the optimal rotation the MRP should be equal to the marginal cost (MC), expression (4.11) represents the MC of waiting out the rotation. The first term, $r\,B_t$ represents the cost of holding the growing stock, i.e. the interest payable to a forest land owner if the forest stand is sold at year t and the money invested at interest r for one year. The second term is the cost of holding the forest land since the forest owner should charge himself for waiting one more year. The decision rule would therefore be: if $B_t' > r\,B_t + ALR$ (i.e. MRP > MC) then let the forest stand grow one more year; if not, harvest it.

## 4.2 Social forestry case study

The species selected for the components of social forestry i.e. agroforestry, dense plantations, institutional planatations, village woodlots, and rehabilitation of degraded forests and strip plantations are *Eucalyptus hybrid (Eucalyptus tereticornis), Acacia nilotica, Dalbergia sissoo* and *Casuarina equisitifolia*, respectively, which are not only fast growing and suitable for fuelwood, poles and small timber, and timber (Acacia and Dalbergia are good fodder species as well) but are also preferred by the villagers (see Appendix 4.1 for silvicultural note about these species). Yield models and tables developed by the Indian Forest Research Institute (based on data from sample plots located in various States such as Uttar Pradesh, Orissa, Rajasthan, Haryana, Bihar, Karnataka, West Bengal and Tamil Nadu) have been used for the estimation of yields for these species, in cases where sample plot data in Orissa were not available, it is plausible to assume the applicability of the models based on the sample plots in the neighbouring States, given the almost similar climatic and topographic conditions.

Stumpage prices for different species have been calculated from the open market auction rates (Table 4.3) of the Orissa Forest Department (OFD) for the year 1987. Differential prices for fuelwood, small timber and poles, and larger timber are based on crop diameters, estimated from basal area or crop diameter models. Although the actual prices vary depending on the location of plantations and their distance from markets, average rates (based on OFD estimates) for harvesting and haulage have been assumed and deducted from the auction rates to arrive at the stumpage prices.

A computer program for calculating PNW, LEV and ALR for variable rotations and discount rates has been developed in FORTRAN 77 (see Appendix, 4.2) . The program is based on the discounting of future costs and benefits assuming that they occur at the beginning of the years concerned, to make them compatible with those of the initial year which are not discounted. If the assumption is that costs and benefits occur at the end of the years concerned, discounting needs to be done from the initial year itself, for which another program was developed (see Appendix 4.3). Since results indicate that the optimum rotation will not be affected, the latter program is not used in this study. Similarly, although a computer program for calculating BCR is given in Appendix 4.4, it is not used.

### 4.2.1 Agroforestry

Cost estimates per ha (Table 4.1) for various operations in the establishment of an agroforestry system having the following specifications are taken from an Orissa Forest Department publication (OFD, 1987) :

Tree species : *Eucalyptus hybrid*

Crop species : gram (the agricultural crops are raised for initial three yeras only)

Density of tree seedlings : 4000 per ha

Spacing of seedlings = 4 m - 1 m x 1 m - 4 m i.e. two rows of trees at a spacing of 1 m x 1 m separated by alleys of 4 m width planted with gram (chick peas).

A source for tree yield could have been the yield tables prepared by Chaturvedi (1983) but these are not found useful because stocking level did not extend to 4000 trees per ha. Maiden tree crop yields per ha (V) and crop diameters (D) for *Eucalyptus hybrid* in Site Quality (SQ) I, II and III are estimated from the following variable density yield models developed by Sharma (1978):

$$D = C_0 + C_1 A + C_2 S + C_3 / N$$

$$\log_e V = C_0' + C_1' / A + C_2' S + C_3' \log_e N + C_4' / S$$

where, A is the age of the crop, S the site index (SQ I – site index 20 to 23, SQ II – site index 17 to 20, SQ III – site index 14 to17) and N is the number of trees per ha.

Mean values of site index for the three SQ classes and regression constants and coefficients are given in Table 4.2. Since Sharma's yield equations are based on densities of 800 to 1800 trees per ha, extrapolation is necessary: although theoretically inexact due to extrapolation error the results arrived at are within a plausible range and similar extrapolation has been done in many studies such as Trivedi (1986).

The interaction (both above and below ground) between trees and agricultural crops have not been yet adequately quantified due mainly to lack of field experiments. There could be complementarity, supplementarity or competition between the two: Singh's (1987) review in the Indian context, suggests no definite trend. However, since an agricultural crop is grown for the first three years only (a preplanting year when there is no forestry crop and two subsequent years when the Eucalyptus seedlings are small), it can be assumed that interaction will not greatly effect yields (Sharma, 1988a). The yield figures for an agricultural crop obtained from the agroforestry system in Orissa (Mohapatra, 1988) are shown in Table 4.4. The Tables 4.3 and 4.5 are prepared based on the differential rates of stumpage prices for the forest produce i.e. fuelwood, small timber and poles, and larger timber (based on crop diameters). The computed values of the PNW and LEV for a range of tree rotations from 5 to 20 years and at various DRs are presented in Table 4.6 (underlined figures correspond to the financial optimum tree rotations). Values of ALR have not been given because it never gave different decisions.

The results show that the rotation is highly sensitive to the DR chosen and decreases sharply with increased DR. This is due to the fact that the discount factor is an exponential function of time and as such critically influences management options in social forestry where benefits from the tree component accrue after a significant time from the initial investment. Because a major part of investments such as plantation establishment cost is invested in the initial years, it does not get discounted so heavily as the benefits.

The financial optimum rotations based on PNW for SQ I are 17, 16, 12, 11, 9, 8, 8 and 7 years at 2, 3, 5, 7, 10, 12, 14 and 15% DR respectively, while based on LEV (and ALR) criteria they are 7 years at 2% and 6 years at the remaining DRs. For SQ II the financial optimum rotations based on PNW are 20, 20, 15, 13, 12, 12, 12, and 12 years at the above DRs respectively, while based on LEV and ALR criteria the optimum rotation is 12 years at all the above DRs. In SQ III the agroforestry is not financially feasible at high DRs of 12, 14 and 15% because PNW, LEV and ALR are negative. At lower DRs of 2, 3, 5, 7, and 10% the financial optimum rotations based on PNW are 20, 20, 18, 15, and 13 years respectively, while those based on LEV and PNW are 16, 16, 14, 13 and 13 years.

The LEV and ALR criteria gave a shorter (or at least equal) rotation than that based on PNW; the main reasons for this (Sharma and McGregor, 1989; Sharma *et al,* 1990c) are:

**a.** the LEV and ALR criteria (unlike PNW) take into account benefits which could accrue from future rotations. This means that the land can be utilised earlier by successive plantation crops of shorter rotations thereby giving larger returns.

**b.** as both LEV and ALR are measures of land value, greater benefits could be achieved by shorter rotations if the land has a higher sale value for an alternative use.

**c.** shorter rotations would reduce the land payments where the land is rented. Higher land rents would have an adverse effect on the current annual returns resulting in shorter rotations.

A theoretical explanation for LEV and ALR criteria giving a shorter rotation than that based on PNW can be as follows :

The conditions for maximisation of LEV and PNW are,

$$\partial(LEV)/\partial t = 0; \quad \partial^2(LEV)/\partial^2 t < 0$$

and $$\partial(PNW)/\partial t = 0; \quad \partial^2(PNW)/\partial^2 t < 0$$ respectively.

Therefore, from equations (4.8) and (4.7),we have :

$(B_t')_{\text{based on LEV}}$ = marginal revenue product based on LEV model

$= r\ B_t + ALR$

and $(B_t')_{\text{based on PNW}}$ = marginal revenue product based on PNW model

$= r\ B_t$

It is evident from the above two equations that, unlike LEV the PNW criterion ignores the benefits which could have accrued from future rotations, as already mentioned. However, as DR increases the LEV approaches PNW and so at high to very high DRs the two criteria suggest the same optimum rotation. This is due to the fact that with increased DR the present value of the returns from future rotations becomes heavily decreased. On the other hand, from the expressions (4.5) and (4.6) it is clear at nil DR (i.e. $r = 0$) the LEV assumes a value of infinity and ALR becomes indeterminate (i.e. $0 \times \infty$). When PNWs are negative, there is advantage in delaying successor crop because cost is reduced due to discounting.

The analysis is carried out for the following silviculturally feasible alternative management options :

I. the first generation coppice crop obtained by coppicing the plantations at early age (the coppice crop loses vigour if Eucalyptus is coppiced at a latter age) and,

II. the first and second generation coppice crops.

*Eucalyptus hybrid* is a coppicer strongly producing many stools (of which the healthy ones are retained for a future crop) if it is coppiced early (5 to 10 years). Chaturvedi (1983) reports that compared with maiden stand there is no fall in the yield of the first generation coppice crop, while there is reduction in yield of the second generation coppice crop. Accordingly the PNW, LEV and ALR are computed on the assumption that the yield is same in the first coppice crop but is reduced by 25% from second coppice crop. Cost of the cultural operations for coppicing are given in Table 4.6 and the computed values of PNW and LEV at various DRs and rotations in SQ I, II and III are presented in Tables 4.8 and 4.9. The financial optimum rotations for the tree species at different DRs are summarised in the following Table 4.8.1: in this table rotation 5+5 means that the maiden crop is harvested at 5 years followed by the first generation coppice crop after 5 years and similarly 5+5+5 means that the maiden, first and second coppice crops are harvested at 5, 10 and 15 years.

**Table 4.8.1 Optimum tree rotations in Agroforestry (with first and second generation coppice crops).**

| Criterion | SQ | Discount Rate (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 3 | 5 | 7 | 10 | 12 | 14 | 15 |
| | | | | **Agroforestry with one coppice crop** | | | | |
| PNW | I | 10+10 | 10+10 | 9+9 | 8+8 | 7+7 | 7+7 | 7+7 |
| | II | 10+10 | 10+10 | 10+10 | 9+9 | 9+9 | 8+8 | 8+8 |
| | III | 10+10 | _ | _ | _ | _ | _ | _ |
| LEV & | I | 7+7 | 6+6 | 6+6 | 6+6 | 6+6 | 6+6 | 6+6 |
| ALR | II | 10+10 | 9+9 | 9+9 | 8+8 | 8+8 | 7+7 | 7+7 |
| | III | 10+10 | _ | _ | _ | _ | _ | _ |
| | | | | **Agroforestry with two coppice crops** | | | | |
| PNW | I | 10+10 | 10+10 | 8+8 | 7+7 | 7+7 | 6+6 | 6+6 |
| | II | 10+10 | 10+10 | 10+10 | 9+9 | 9+9 | 8+8 | 8+8 |
| | III | 10+10 | _ | _ | _ | _ | _ | _ |
| LEV & | I | 7+7 | 7+7 | 6+6 | 6+6 | 6+6 | 5+5 | 5+5 |
| ALR | II | 10+10 | 9+9 | 9+9 | 8+8 | 8+8 | 7+7 | 7+7 |
| | III | 10+10 | _ | _ | _ | _ | _ | _ |

The production potential of the first generation coppice crop of *Eucalyptus hybrid* is modelled in a study done by the Forest Research Institute, Dehradun, (Sharma, 1979) which has been utilised in estimating the crop yield and diameters presented in Table 4.10. The computed values of PNW and LEV for agroforestry in SQ I and II (unfortunately the Sharma's models do not give yields for SQ III) for various rotations and DRs are shown in Table 4.11.

### 4.2.2 Dense plantations

For dense plantations consisting of 4000 *Eucalyptus hybrid* seedlings per ha the data from Table 4.5 is used to compute PNW and LEV for a range of tree rotations (5 to 20 years) and DRs (Table, 4.12). This assumes that the yield is same as from the tree component of agroforestry system. The results for the dense plantations with first generation coppice crops are given in Table 4.13: results for the financial optimum rotations are summarised in the following table :

Table 4.12.1 **The financial optimum rotations for dense plantations of *Eucalyptus hybrid.***

| Cri-terion | SQ | Discount rate(%) 3 | 5 | 7 | 10 | 12 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|
| | | **Dense plantations without coppice crop** | | | | | | |
| PNW | I | 16 | 12 | 11 | 9 | 8 | 8 | 7 |
| | II | 19 | 15 | 13 | 12 | 12 | 12 | 12 |
| | III | 20 | 18 | _ | _ | _ | _ | _ |
| LEV | I | 7 | 7 | 7 | 6 | 6 | 6 | 6 |
| | II | 12 | 12 | 12 | 12 | 12 | 12 | 12 |
| | III | 17 | 16 | _ | _ | _ | _ | _ |
| | | **Dense plantations with first coppice crop** | | | | | | |
| PNW | I | 10+10 | 10+10 | 9+9 | 8+8 | 7+7 | 7+7 | 7+7 |
| | II | 10+10 | 10+10 | _ | _ | _ | _ | _ |
| LEV | I | 7+7 | 6+6 | 6+6 | 6+6 | 6+6 | 6+6 | 5+5 |
| | II | 10+10 | 10+10 | _ | _ | _ | _ | _ |

The PNW and LEV are negative in SQ III (except at low DR such as 3 and 5% per cent) which shows that Dense plantations are not profitable at high DRs.

### 4.2.3 Institutional plantations

The tree species planted under this component is *Acacia nilotica* (spacing 2.5m x 2.5m) which being suitable for fuelwood, fodder and small timber is widely grown by the villagers under varied climatic and topographic conditions. Cost estimates per ha (Table, 4.14) are taken from OFD (1987) and yield tables (which include a thinning regime) developed by FRI, Dehradun (Singh, 1982) are used in preparing a money yield table (Table, 4.15) for SQ I, II and III. Cost estimates of the cultural operations for thinnings in SQ I, II and III are shown in Table 4.16. The computed values of PNW and LEV for a range of management options and DRs are presented in Table 4.17, in which underlined figures correspond to the financial optimum management options.

Based on PNW, the financial optimum rotations in SQ I are 25, 20, 15 and 10 years (with intermediate thinnings every 5 years) at 3, 5, 7, and 10 - 15% DRs respectively. However, based on LEV (and ALR) criterion the optimum rotation is 10 years at all the DRs. In SQ II, the results are 25 years at 3%, 20 years at 5% and 15 years for the remaining DRs. In SQ III, the PNW and LEV take negative values at ≥ 10% DR, while at lower DRs the financial optimum rotation based on both the criteria is 25 years.

### 4.2.4 Village woodlots

Cost estimates for the village woodlots of *Dalbergia sissoo* (spacing 2 m x 2 m), a widely-used fast growing and multiple-use tree species, are given in Tables 4.18, 4.19 and 4.20. The following variable density yield models developed by FRI, Dehradun (Sharma, 1979) are used in estimating diameter (from basal area model) and yields for the main crop and thinnings: regression constants and coefficients are given in Table 4.21 and estimated values of diameter and yield in Table 4.22.

Basal area of the main crop (BA(M)) is given as,

$$\log_e BA(M) = C0 + C1 \log_e A \log_e S + C2\, A + C3\, S + C4 \log_e N$$

Total wood volume of the main crop (V(M)) is given as (BA(TH) = basal area of thinnings)

$$\log_e V(M) = C0' + C1'\, S + C2'\, [BA(M) / \{ BA(M) + BA(TH)\}] + C3'\, 1/A$$

Total wood volume of thinnings (V(TH)) is given as,

$$\log_e V(TH) = C0'' + C1''\, S + C2'' \log_e BA(TH) + C3''\, 1/A$$

Table 4.23 shows the computed values of PNW and LEV for different management options in SQ I, II and III for a range of DRs. Based on PNW the financial optimum rotations (with intermediate thinnings every 10 years) in SQ I are 40 years at 3, 5 and 7% DRs and 30 years at 10, 12, 14 and 15% DRs. Based on LEV criterion these change to 40 years at 3% and 30 years at the remaining DRs. In SQ II, the financial optimum rotations based on both PNW and LEV criteria are 40 years at 3, 5, 7, 10 and 12% DRs and 20 years at 14 and 15% DRs. In SQ III, the PNW criterion suggests optimum rotations of 30 years at 3% and 15+15 years (i.e. maiden crop to be harvested at 15 years followed by a coppice crop after the next 15 years) at the remaining DRs, but based on LEV these change to 20 years at 3, 5 and 7% DRs and 15+15 years at 10. 12, 14 and 15% DRs. At 15 % DR, PNW and LEV are negative suggesting that none of the management options is financially feasible at such a high DR.

### 4.2.5 Rehabilitation of degraded forests and strip plantations

The tree species chosen for these components of social forestry is *Casuarina equisitifolia*, a fast biomass growing fuelwood species which is widely grown especially in coastal Orissa. Cost estimates are the same as for institutional plantations (Table, 4.14) and yield data are taken from Singh (1983) which relate to coastal Orissa (unfortunately yield figures are given for three rotation ages only). The computed values of PNW and LEV are given in Table 4.25 which shows that at high DRs the PNW and LEV become negative. The reason for this is that the main use of Casuarina is as fuelwood which is valued less than small and larger timber.

## 4.3 A comparison of the components of social forestry

Since both agroforestry and dense plantations are practised in the same environment and within the tree zone have the same number of trees per ha it is possible to compare the financial profitability of the two. A perusal of Tables 4.7, 4.11, 4.12 and 4.13 leads to a general conclusion that the net financial benefits are larger in agroforestry systems than in dense plantations in all three site qualities. In dense plantations (i.e. pure forestry) the PNW and LEV take negative values for SQ III (above a DR of 5%) but in agroforestry they are positive for DRs less than or equal to 10%.

These differences can be explained by the fact that with the agroforestry system the land is fully utilised in the initial three years of tree establishment. Another important aspect favouring agroforestry is the reduced discounting impact on the benefit stream due to the early returns from the agricultural crop (Sharma *et al* , 1990d). Perpetual or recurrent benefits such as those found in agroforestry are usually favoured against a distant once-only return, as in forestry (with no intermediate thinnings as in this case study).

## 4.4 Discussion of management options

The financial analysis carried out in this chapter has not taken account of considerations affecting the whole economy. The evaluation of a widely implemented project such as social forestry needs to incorporate both regional and national economic aspects. But before attempting this in the following chapter a comment on the use of DR is in order. The benefits, costs and DRs in this analysis are considered in real terms (at 1987 prices). Table 4.26 gives the various DRs used by different institutions in the year 1987, which shows a wide variation. In addition, a number of empirical studies have been carried out on rural credit markets (Gangopadhyay et al, 1987, 1986; Bardhan and Rudra, 1978; Rudra, 1982) which confirm the wide variability in the rates of interest in use. These interest rates are nominal and to calculate the real interest rate an estimate of inflation rate is needed.

A time series of the GDP deflators for the years 1960 to 1986 (Table, 4.27) is therefore compiled from the International Financial Statistics yearbook 1988 (published by International Monetary Fund). Regression analysis of this data gave the following best fit equation (the values in parentheses give the t-statistics):

$$\log_e D_f = -149 + 0.0775\ T$$

(48.97) (50.30)

Standard Error = 0.062 $(R^2 = 99\%)$

where, $D_f$ is the GDP deflator for the year T. The average annual inflation rate over the period is 7.75% and so if the nominal interest rate (market interest rate) is, say, 18% the real interest rate calculated from the following formula is 9.5%, which lies within the range of DRs considered in the above analysis.

$$(1 + r)\ (1 + f) = (1 + i)$$

where, i is the nominal interest rate and f is the rate of inflation.

**Summary**

After reviewing the suitability of various decision criteria, a financial analysis is carried out for all the components of social forestry in Orissa. Based on the two criteria PNW and LEV financial optimum management options in SQ I, II and III are suggested for a range of discount rates.

# Chapter 5

## Economic Evaluation of Social Forestry

With the increasing role of national governments in the development planning of newly independent countries the principles of development economics began to be applied. Although the 'developed' economies were themselves once 'developing' and went through something akin to today's developing countries, they did not experience the same economic environment. The capitalist development of the First World has in fact adversely affected the process of development in the so called Third World because the developed countries, with their resources and technology and immense capability to renew them, have generally contributed to economic and political dependence of the developing countries.

The neoclassical economic model which seems to have worked well in the case of developed economies (where by and large the market is assumed to be almost perfect) was thought to have been suitably refined in order to be applicable in developing economies. Of course, the externalities (both socioeconomic and environmental) and related issues could not be made perfectly amenable in monetary values, but this was true in both developing and developed economies. The roles of public sector and investment were emphasised (Marglin, 1967) and pioneer appraisal methodologies, especially addressed to developing countries, were developed by the international organisations such as OECD, UNIDO and World Bank (OECD, 1968; Dasgupta *et al*, 1972; Squire and van der Tak, 1975; Bruce, 1976; Hanson, 1986). These modern cost-benefit methods started taking into consideration not only aspects of welfare and development economics but also of labour as well.

In India, however, a top-down approach of planning was adopted, and five year and annual development plans (based on data up to district level only) were designed and administered through central and State level planning agencies. The responsibility for implementing the developmental programmes was entrusted to an existing administrative set up (i.e. the civil service) whose earlier role was primarily to maintain law and order. As a result, the relevant aspects of behavioural sciences were not given their proper place in the planning process. This possibly led to dualism, since the new role as development planners and agents for social change, and the old role as administrators were not indeed generally compatible, due mainly to popular belief among the administrators that people can be protected from their own improvidence not by participatory public support but by coercion - an assumption inherent in a top-down approach to planning.

## 5.1 Economic cost-benefit analysis

Cost-benefit analysis is a method of assessing factors which need to be considered in making choices among economic states (Prest and Turvey, 1965; Lesourne, 1975) and so can be used in comparing two or more economic and/or social states. Thus the central objective of CBA is to maximise some entity - economic efficiency (and/or social welfare) subject to the constraints that one of a given set of alternatives is chosen (Sugden and Williams, 1986). CBA helps to facilitate decision-making in two ways : to determine the quantitative impact of a strategy on a desired objective function, and to identify those alternatives which contribute most to the desired objective function (Sharma, 1988b). CBA not only makes the decision-maker more accountable to the community by making the objective function explicit, it also assists the decision-maker to pursue objectives that are important by virtue of the community's assent to the decision-making process.

Economic CBA is concerned with the efficiency with which projects create net utility as measured by willingness to pay for benefits and willingness to accept compensation for benefits foregone (Mishan, 1975). To correct the distortions arising from market imperfections, the market prices for factors of production are replaced by shadow prices which measure the foregone value of their alternative potential production (i.e. opportunity cost). The shadow prices are defined as the increase in welfare resulting from any marginal change in the availability of factors of production and are determined by the interaction of the fundamental objectives, socioeconomic environment and basic resource availabilities (Squire and van der Tak, 1975).

## 5.2 Issues in market imperfections

Though there could be many sources of market imperfections such as monopoly, monopsony, oligopoly, oligopsony, bilateral oligopoly, bilateral monopoly, duopoly, duopsony, etc. the dualism in the undeveloped economies which usually favours an already rich segment of society seems to be the main reason. Governments in their quest to enhance welfare of the poor try to achieve the socioeconomic optima by redistribution mechanisms such as taxes (direct and indirect), subsidies and support prices, excise and custom duties, quota and foreign trade regulations, licensing and inflation control measures, which usually result in imperfect markets. In addition, a bias to promote some sectors of the economy at the cost of others may also result in distorted markets. All these factors give rise to a phenomenon in which the market prices are not the true representative of marginal cost of production and marginal utility of consumption and therefore violate assumption in the neoclassical model. In a perfectly competitive economy the market mechanism ensures the utilisation of scarce resources by meeting the consumers' demand and producers' supply for goods and services in order to optimise welfare. This ability of the market to produce and distribute goods and services at the minimum possible cost and to charge the prices consistent with these costs, becomes distoted in the imperfect market.

### 5.3 Economic pricing

Shadow prices for correcting market deficiencies are referred to as economic or efficiency prices and are based on the growth strategy of economic development. Little and Mirrlees (1974) overcome the deficiencies of market prices by suggesting the use of world prices (or border prices) which can be treated as unaffected by imperfections in the domestic market. They (hereafter referred to as LM) state that in order to attain economic efficiency, shadow prices should be approximated to the world prices (which are also called accounting prices when expressed in an appropriate numeraire) and should replace the domestic prices. The ratios of shadow prices to market prices, called accounting ratios (ARs) are usually used in converting the market prices into shadow prices. The rationale for this separation of production and consumption aspects lies in the argument that efficient allocation of resources can be achieved by using international prices and then consumption aspects can be dealt with separately.

On the other hand, Dasgupta, Sen and Marglin (1972) advocate the use of shadow prices to be determined in the domestic market. However, both the approaches espouse the same cause - that instead of using market prices, the true benefits and costs of resources should be included in any analysis in order to allocate the resources efficiently. The main difference between the two is in the use of the unit of account or numeraire (equivalent to money) for representing economic or social values. The uncommitted social income in terms of uncommitted foreign exchange is the numeraire in LM methodology, which is also adopted by Squire and van der Tak (1975), Bruce (1976), Scott *et al* ( 1976) and Little and Scott (1976).

Lal (1980) instead uses a variant of the above numeraire i.e. 'savings expressed in foreign exchange' due mainly to easy computation and assumption that both private and public savings are equally socially valuable. Aggregate consumption (possibly of an average income consumer although this has not been specified) measured in the domestic currency is the numeraire used by Dasgupta, Sen and Marglin (hereafter referred to as DSM). Hansen (1986) instead redefines this numeraire as 'critical consumption' rather than 'average consumption'.

### 5.3.1 Economic pricing of tradable commodities

The commodities which are actually exported or imported at the margin are treated as traded goods, while those produced and consumed within the country are non-traded; partially traded goods have both features. The LM approach prices tradables by removing the effect of taxes and tariffs (as these are only money transfer and not a real cost to the economy) by estimating border prices as c.i.f. (cost, insurance and freight) for imports and f.o.b. (free on board) for exports. If $P_i^w$ and $P_i^m$ denote the world and average market prices of a good i then accounting ratios ($A_i$) are estimated by,

$$A_i = P_i^w / P_i^m$$

The ARs are treated as stable and are estimated for individual goods used by the project. But the validity of taking world prices as a proxy for shadow prices is questionable on the grounds that world prices themselves cannot be treated as representative and invariant. Such a conclusion can be drawn because of trade policies (of dominant and influencing countries) reflecting influences of a variety of institutions and practices - product differentiation, transfer pricing, discriminatory trade practices, etc. (Irwin, 1978). Little and Mirrlees (1974) suggest that the impact of project's production on exports, imports, domestic production and price response should be taken into account, a procedure which is not only tedious but also requires the estimate of border elasticities of demand and supply as suggested by Balassa (1974). In addition, each time a project is evaluated a new set of ARs is required and so in practice many simplifying assumptions are usually made. One such simplification is the use of the following summary or standard conversion factor (SCF) to be used for all tradables in the entire country (Bruce, 1976).

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

where, M and X are the total values of imports and exports at border prices and $T_m$ and $T_x$ are the total values of taxes on imports and taxes on exports. In terms of the border elasticities of exports ($e_x$) and imports ($i_m$), the above expression becomes :

$$SCF = [\Sigma e_x X_i + \Sigma i_m M_i] / [\Sigma e_x X_i (1 - T_x) + \Sigma i_m M_i (1 + T_m)]$$

The DSM approach on the other hand suggests the use of the shadow exchange rate (SER) for converting the values of exports and imports into domestic equivalents. The SER is usually approximated by taking the domestic to border price ratio of traded commodities weighted by the share of each commodity in a country's marginal bill and therefore can be criticised on the similar grounds to SCF.

### 5.3.2 Economic pricing of non-traded goods (NTGs)

The procedure suggested by LM for estimation of economic prices of NTGs is by disaggregating these into two components, tradables and non-tradables (i.e transport, land, labour, electricity etc). Input-output (I-O) models can be used to aid the disaggregation process. However, the use of I-O models has its weaknesses as argued in Chapter 3. For instance, the latest I-O tables available in India relate to the year 1968 and are therefore not suitable because the input-output coefficients must have changed considerably due mainly to technological progress during the intervening period. The updating of such tables will necessitate many simplifying assumptions thereby introducing further errors.

The DSM approach of economic pricing of NTGs is by comparison straightforward. The domestic prices of NTGs expressed in numeraire will give the economic prices. Since almost all the inputs and outputs in subsistence-oriented projects such as social forestry fall in this category, the estimation procedure becomes free from errors.

### 5.3.3 Economic pricing of partially traded goods (PTGs)

In the case of PTGs, for which changes in domestic demand/supply are met partly by changes in domestic production and partly by imports or exports, the proportions which are met from domestic production, and from of exports and imports have to be estimated in order to apply LM methodology. The latter can be treated as tradables for which economic prices can be estimated as explained in section 5.3.1, the following consumption conversion factors (CCF) need to be estimated for each commodity i in the former category:

$$(CCF)_i = (1/100)\ \Sigma X_j (P_j^s / P_j^m)$$

$$\Sigma X_j = 100$$

where, $\Sigma X_j$ is the bundle of goods to which consumers will switch in the absence of the project (i.e. the prices of providing the bundle of goods to which consumers switch - which is the impact on domestic consumption). The approach of economic pricing based on DSM methodology, however, still remains valid for PTGs as well; the NTGs can be priced in the domestic market in numeraire equivalents and TGs with the help of SER.

### 5.3.4 Economic pricing of land and labour

The economic prices of primary factors of production such as land and labour can be estimated in terms of the foregone marginal product of land and labour (i.e. based on the principle of opportunity cost). In an agrarian economy such as India's, the marginal product of land and labour can be estimated in terms of agricultural production per unit of agricultural land and labour respectively. A standard conversion factor (based on a bundle of agricultural commodities) is estimated when using the LM approach (Lal, 1980). In the DSM approach, however, no such conversion factor is required and only the foregone marginal product has to be worked out.

In situations where there is a free demand for land, the willingness to pay for the land can also be used to develop an economic price of land. However, in India there is no such explicit demand, especially for forestry, which can be taken as representative. The alternative use of the land (i.e. in a 'without social forestry project' situation) can be known in such cases, and inputs and outputs concerning that alternative use can be worked out to arrive at the value of the land. Although in the LM approach these values of inputs and outputs need to be multiplied by the concerned ARs no such multiplication is necessary for DSM methodology.

The economic pricing of labour is complicated by the fact that besides the market for labour being not competitive, there exists unemployment and underemployment in a labour surplus economy such as India. However, the principle of opportunity cost and willingness to pay can again be invoked for economic pricing of labour inputs. According to the DSM approach, the value of output foregone in the labourer's previous occupation is taken as a measure of productivity of that labourer, i.e.

Economic Wage Rate (EWR) = the net marginal product foregone by withdrawing a worker from the alternative occupation

= referred to in equations as $m_l$

In the case of full employment situations, the market wage rate (of agricultural labour) will approximate the marginal product.

The following conversion factor is needed to convert this marginal product of labour in terms of LM numeraire :

$$CF = \Sigma\ w_i P_i^s / w_i P_i^m$$

where, $P_i^s$ and $P_i^m$ are the economic prices (expressed in LM numeraire) and market prices for the i th good in a bundle of agricultural goods consumed by the workers, and $w_i$ is the weight of the i th good in the total agricultural production of the region.

However, since seasonal labour is required for most of the forestry operations, the temporal nature of employment needs to be accounted for. Moreover, because of the erratic monsoons seasonability is predominant in alternative job opportunities in rural areas, which are mainly in agriculture (Sharma, 1988b). A method to account for this seasonability is to take the wages of the casual agricultural workers weighted by an estimate of the degree of unemployment (Bruce, 1976; Irwin, 1978) :

$$m_l = (1/n) \sum_{i=1}^{n} (D_i/S_i)\ w_i$$

where, $D_i$ is the demand for casual employment, $S_i$ is the supply of casual labour and $w_i$ is the wage rate for the casual labour in month i.

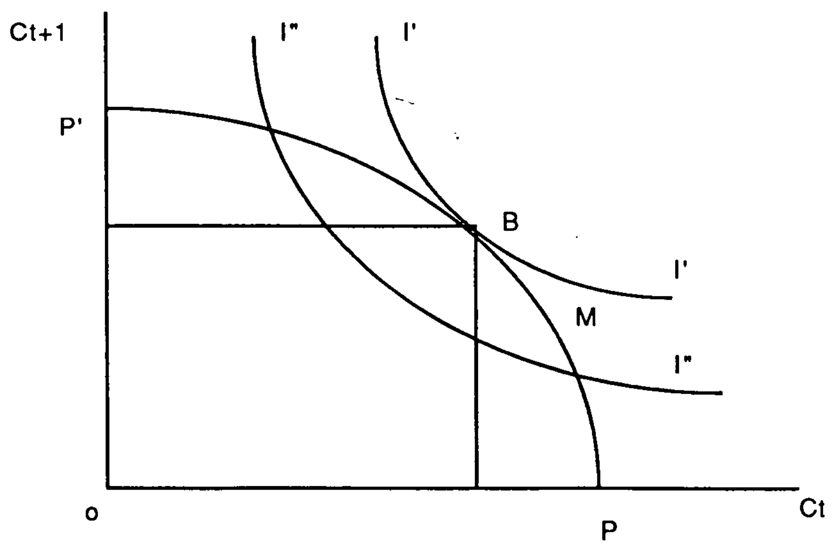
### 5.3.5 Economic pricing of capital

The conventional economic concept of capital is that it is a physical resource (not only money, but stock of all physical goods) on a par with land and labour resources. Such a concept is extensively used in growth models and production functions. The principle of opportunity cost (OC) can be used to estimate the economic value of capital (also called economic discount rate, EDR). A brief review of the nature of DR and different approaches for its estimation in an economic context is therefore in order. This is essential not only because the selection of a suitable DR is the most controversial issue in the application of CBA (Harou, 1985; Price, 1988) but also because it critically influences the choice of social forestry management alternatives as shown in the previous chapter.

It can be argued that the market interest rate reflecting the OC of investments can be taken as the appropriate DR, but there is no single market interest rate which can be applicable for various types of investments. A lower DR is not favourable (Baumol, 1968; Fisher and Krutilla, 1975) on the grounds that such a DR indiscriminately encourages all sorts of investment projects whether or not they are relevant. On the other hand, at higher DR the management alternatives favouring faster exploitation of social forestry resources will be accepted (as shown in the previous chapter). In addition, social forestry systems, which are inherently long-term in nature, will perform unfavourably compared with other short-term projects such as agriculture (Sharma, 1988a).

There are two main approaches used to estimate the DR; the social opportunity cost (SOC) of investment and social time preference (STP). However, some prefer a combined rate (i.e. SOC cum STP ) based on both the above approaches. Since capital is usually limited and a public sector investment project such as social forestry has an opportunity cost, it can be argued that the DR used should reflect the SOC of capital. The SOC rate measures the value to society of the next best alternative investment in which funds might otherwise have been employed (Kula, 1988) and can be approximated from the marginal productivity of capital. The STP rate, on the other hand, represents the willingness to trade off consumption at different points in time and therefore measures the society's sacrifices for present consumption in order to improve its prospect of future consumption. The following figure (after Fisher, 1930) help explains these concepts:

**Figure 5.1 Social time preference and opportunity cost rates**



The consumption of society (or groups of individuals) today (i.e present) and tomorrow (i.e. future) are represented on the horizontal and vertical axes respectively. PP' is the consumption possibility curve (giving all the possibilities of various combinations of present and future consumption), and I'I' and I"I" are two consumption indifference curves. According to the STP approach, discounting should be based on the position of society in the 'consumption space'. Each consumption locus indicates the desired combination of present and future consumption and the rate of trade off between them.

The SOC approach, on the other hand, suggests that the DR should be the transformation rate obtained from the consumption possibility curve. In the case of economy being optimal, the STP and SOC rates become identical as indicated by the slope of the indifference curve and that of consumption transformation curve at the point B. But the economy is rarely optimal (particularly in the case of developing economies) and so STP and SOC rates generally differ; the STP rate is usually lower than that of SOC as shown at point M.

The DR used in economic analysis is the marginal productivity of capital (**q**) in the public sector (Squire and van der Tak, 1975) which, as a measure of the OC of capital, reflects the rate of return to government investments. Therefore, if the funds for the project are drawn from investment funds (which is usually the case) the EDR is approximated with **q**. However, for estimating the economic accounting rate of interest for applying LM methodology the EDR needs to be multiplied by an additional accounting ratio in order to convert it into foreign exchange equivalent value. Such an estimation procedure has been questioned by Trivedi (1987) on the ground that use of the EARI will amount to using a DR which is not applicable for the country where the investments are being made.

If funds for the project are drawn from diverting consumption expenditure (i.e. additional savings) the appropriate economic cost is the price or rent, that savers must be paid to forgo an additional unit of present consumption, i.e. the consumption rate of interest. This will be discussed and estimated for India in Chapter 7. Milne (1986) reviews the concepts involved in STP and SOC approaches, but arbitrarily assumes a rather high value (7.5%) for STP for application in a cost benefit analysis of forestry in Newfoundland, Canada: Kula (1988) has estimated this value as 4.4%. For an extensive discussion and issues involved in use of DR, reference can be made to Feldstein (1964) and (1973), Marglin (1963), Sen (1967), Baumol (1968) and Harberger (1969) .

## 5.4 Appropriate methodology for social forestry evaluation

The LM methodology is convenient to apply where foreign trade forms an important part of a country's economy. Similarly in the case of projects funded by international agencies such as the World Bank, the main emphasis is on savings rather than consumption and hence a numeraire based on savings is appropriate. Such an approach is, however, not appropriate for India in general and social forestry in particular because of the main reason that Indian economy is relatively closed and agriculture based, which are now discussed.

The larger the number of goods that fall in the fully traded category, the greater the applicability of the LM approach (Pearce and Nash, 1981). This is more likely to be the case in relatively open economies than in closed economies and in industrial projects than in agricultural projects (Joshi, 1972; Duvvuri, 1977). The Indian economy is relatively self-sufficient and so the LM methodology is not appropriate (Dr Colin Price, per. comm.). The country's huge domestic demand is mainly met by domestic production. Exports are limited due to low productivity while imports are small because of the very low wages and purchasing power of the vast majority of the population (Reitsma and Kleinpenning, 1985).

Trade forms a very small part of the total economy and emphasis is currently on achieving self-sufficiency. This is evident from the recent negative trend in growth rates of the total value of exports (-1.00%) and imports (-2.85%) over the period 1980-84 (FAO, 1987). In addition the LM approach, which is based on top-down approach of planning, emphasises production, trade efficiency and savings (in foreign exchange) which, the proponents of the methodology argue, will enhance human welfare. But this is not always the case and the use of shadow prices based on world prices has attracted criticism by many (Joshi, 1972; Dasgupta, 1972; Stewart and Streeton, 1972, Joshi, 1972, Duvvuri, 1977 and Hammond, 1980).

On the other hand, the DSM methodology, which is based on a bottom-up approach of development planning, emphasises consumption. The approach implicitly assumes that a project's impact on foreign exchange or trade is almost negligible and a majority of inputs and outputs are non-tradables. Indeed a realistic assumption is that the trade barriers will prevail in practice and so net benefits must be maximised in this suboptimal environment (the second best paradigm) instead of artificially assuming an optimal environment based on world prices as with the LM approach. Projects selected on the assumption that constraints do not exist may be wholly inappropriate to the true situation (Sen, 1972) and using world prices does not lead to projects being adopted which guarantee welfare improvements, as long as suboptimal policies remain in force (Hammond, 1980).

However, basically the two approaches are equivalent as shown below (Irwin, 1978) and the choice of a numeraire should not affect the relative shadow prices derived for use in project appraisal (Hugh, 1986). Therefore, final decisions based on these approaches will not differ significantly (Hanson, 1986; Price, 1989). An expression for the net benefits (NB) from a project can be written as :

$$NB = OER\ (X - M) - D$$

where, OER = official exchange rate

X = f.o.b value of exports say in dollars

M = c.i.f. value of imports say in dollars and

D = value of all domestic inputs at market prices.

The DSM approach recommends the conversion of foreign exchange into domestic consumption value by using SER and so the expression can be written as :

$$NB' = SER\ (X - M) - D$$

By multiplying the above equation by a SCF (Ç=OER/SER), the following expression is obtained:

$$NB'' = OER\ (X - M) - Ç\ D$$

which is equivalent to the LM expression. If a separate conversion factor is estimated for each good i then the above expression can be written as :

$$NB'' = OER\ (X - M) - \Sigma\ Ç_i\ D_i$$

Although the DSM and LM approaches are formally equivalent, the difference arises from the level of aggregation used in deriving an index relating domestic consumption values - the DSM weights are established from the composition of the marginal trade bill, while the weights in case of LM approach and its variant as proposed by Squire and van der Tak (1975) are established from the composition of non-traded elements in the project (Irwin, 1978). The above critical review therefore favours the DSM methodoly with some modifications for appropriate application to a social forestry case study.

## 5.5 Estimation of marginal productivity of capital (q)

The national parameter **q** is difficult to estimate (Adhikari, 1987) because this poses some real problems, due mainly to ambiguities concerning the concept of capital which is amplified by a resulting lack of adequate data. Capital in economics is the contribution to productive activity made by investments in physical capital (e.g. factories, machinery, buildings, raw materials, commodities and implements) and in human resources (e.g. education, training etc ). Capital, along with other factors of production such as land and human resources, contributes to the economic growth of an economy. Therefore it is an agent of change and should be measured in terms of consumption foregone, in propelling the economy forward, instead of leaving it in a stationary state (Scott, 1976). This means that the entire resources including human which go on producing GNP form capital. Further, it is not only the cost of these resources but their expected value that is required; for example, the wear and tear of machinery should be accounted for.

As an abstraction, a second best estimate of **q** can be derived from the projected output capital ratio using national income statistics at constant labour by subtracting the wage bill (which approximates the share of labour) from the total output (Squire and van der Tak, 1975; Hanson, 1986). But the marginal efficiency of investment decreases as the amount of investment increases. This occurs because the initial investments are usually made up of the best opportunities and therefore yield higher rates of return in comparison to later investments which are generally less productive and secure progressively decreasing returns. Therefore a time series analysis has to be undertaken to arrive at a representative value of **q**.

The possible sources of data for such an analysis can be derived from National Account Statistics (NAS) published by the Government of India, IMF and United Nations (UN). Although they include figures for annual capital formation at current and constant prices, they do not give any idea about the total capital position in a particular year, possibly due to the difficulties in measuring the total capital. The estimation of capital stock in the organised sectors such as manufacturing, transport, railways, communication, etc. is comparatively easy. On the other hand, there are non-organised sectors such as land tenancy, informal markets and credits, externalities, etc. whose measurements, if not impossible, is surely difficult and so do not find a place in NAS. In addition, if the values for these sectors could be measured , there would be problems associated with aggregation of such values. Pant (1977) highlights the inadequacies of NAS in the sense that they underestimate the contribution of the forestry sector to GNP. Another problem arises due to changing the value of capital over time.

A conventional approach for the estimation of **q** is to use the following aggregate production function of Cobb - Douglas type,

$$Y = A \prod_{i=1}^{n} X_i^{\alpha_i}$$

$$= A [ X_1^{\alpha_1} . X_2^{\alpha_2} ............... X_n^{\alpha_n}]$$

where A is the efficiency parameter, $\alpha_i$ is the elasticity of output (Y) with respect to input ($X_i$). The return to scale parameter is $\Sigma\alpha_i$ because,

$$A (\beta X_1)^{\alpha_1} (\beta X_2)^{\alpha_2} ............ (\beta X_n)^{\alpha_n} = \beta^{\alpha_1 + \alpha_2 + ........ + \alpha_n} A X_1^{\alpha_1} . X_2^{\alpha_2} .......... X_n^{\alpha_n}$$

When there are only two inputs, the capital (K) and labour (L), the above production function can be written as :

$$Y = A K^{\alpha_1} L^{\alpha_2} \qquad (5.1)$$

where, $\alpha_1$ and $\alpha_2$ are respectively the elasticity of output with respect to capital and labour.

The elasticity of substitution for this Cobb - Douglas production function (i.e. the degree of substitutability between the inputs K and L) is constant and equal to unity (Desai, 1976). This means that a 1% change in a factor's relative prices will bring about a corresponding 1% change in factor proportions. Since $\alpha_1 + \alpha_2 = 1$ (i.e. returns to scale are constant) the above function can be written as ,

$$Y = A K^{\alpha_1} L^{1-\alpha_1}$$

which can be rewritten (an error term E is added) in a semi-log linear form as,

$$\log_e (Y/L) = A' + \alpha_1 \log_e (K/L) + E \qquad (5.2)$$

and can be subjected to econometric analysis. The following equation is obtained by partial differentiating expression (5.1) with respect to K,

$$q = \partial Y/\partial K = A \alpha_1 K^{\alpha_1 - 1} L^{\alpha_2} = \alpha_1 (Y/K) \qquad (5.3)$$

Values for Y (GDP) are available from NAS and the size of the economically active population (L) can be obtained from the Government of India's recent population census,

1981. As discussed above the estimates for capital (K) are not available and have been estimated in this study by substituting the annual capital formation figures available from NAS into equation (5.2). To achieve this a time series (Table, 5.1) for GDP and annual capital formation (1970 prices) for the period 1970 to 1985 was compiled from NAS published by United Nations (UN, 1987) and that for total population from the International Financial Statistics yearbook (IMF, 1987).

Since the estimation procedure for the country's NAS changed from using 1960 to 1970 as a base year, the figures (at 1970 prices) for GDP and annual capital formation before 1970 are not available. However, the constant prices at base year 1960 could have been converted to those at 1970 base year by applying a deflator estimated from the year for which figures are available for both the base years. But such a procedure has not been attempted because the application of a single deflator is not logical and in fact will lead to erroneous results. Another source of the statistics could have been from IMF, which gives data (at 1980 prices) for the years before 1970 but these do not contain the data for more recent years as is the case with figures published by the Government of India.

By dividing the total population of workers (which includes main workers and marginal workers) by the total population of the country a proportion, 36.8% is obtained. This value is then used in estimating the economically active population for the period 1970 to 1985 (Table, 5.1). The figures for annual capital formation are added cumulatively to a benchmark figure for capital for the year 1969. Such a benchmark figure is estimated as Rs 1932 billion (1970 prices) which gives the following best fit for equation (5.2) with highest regression coefficient (the values in parentheses give the t-statistics):

$$\log_e (Y/L) = -1.57 + 0.962 \log_e (K/L)$$

$$(-6.30) \qquad (9.57)$$

$$SE = 0.033 \qquad R^2 = 85.8\%$$

Therefore the value of $\alpha_1$ is estimated as 0.962 and the production function is given as,

$$Y = A\, K^{0.962}\, L^{0.038}$$

where, $\log_e A = -1.57$

The marginal product of capital for an individual year is obtained by substituting the value of $\alpha_1$ into equation (5.3),

$$q = 0.962\ (Y/K)$$

The values calculated for the period 1970 to 1985 are shown in Table 5.1. The average value of **q** over the period is 0.1837 (coefficient of variation, CV = 3.01) and therefore the estimated EDR for India is approximately 18%. Based on this approach, Phillips (1986) and Trivedi (1987) derive values for **q** as 14% and 14.52% for Nepal and India respectively . Since the marginal productivity of capital ought to approximately reflect the market rates of interest, these values are high if compared with the prevalent market rates of interest (see Table, 4.26).

Because of these high estimates the assumptions underlying such an analysis need further comments. Production functions assume that technological progress is an exogenous variable and only show the relationships between physical quantities of factor inputs and outputs in an economy. However, based on empirical evidence, the technological progress during such a long period (i.e. 1970 to 1985) was significant and therefore a part of the increase in productivity can be attributed to this factor.

In addition, the Cobb - Douglas production function assumes effective competition in factor markets which implies that the elasticity of technical substitution between the two factors of production (i.e. labour and capital in this case) will be equal to 1. In other words, labour can be replaced for capital in any given proportion without affecting the output and vice versa. Further, it also assumes that the shares of capital and labour in an economy are relatively constant. However, in practice and particularly when analysing at aggregate level, these assumptions may not be valid. For example, in many developing economies the techniques of production are limited and therefore the opportunities for labour - capital substitution are in fact very low. In the above analysis it is also assumed that the labour force remains static over the period which may not always be the case, especially if the period under consideration is long.

Scott (1976) instead suggests the use of a dynamic production function,

$$dY/dt = f\ (S,\ dL/dt)$$

(where S is the total saving and dL/dt is the growth rate of labour force) and points out the following weaknesses of conventional aggregate production function of the Cobb - Douglas type:

**a.** constant returns to scale,

**b.** static, and finally

c. exogenous technical progress, i.e. the underlying assumption that the investment increases the stock of some substance 'capital' which is then combined with the existing stock of labour according to the current technology.

But output grows either because there is more of capital, or more labour, or because current technology improves. Desai (1976) also comments that "the whole notion of the neoclassical production function is currently in flux: we have greater confidence in it at plant or firm level, where the technology of the production process can be captured, as the production function is a technological relationship between inputs and outputs and the more closely we can approximate this relationship between the two by disaggregation, the more meaningful the results will be".

An improvement in technology can be thought of as an outward shift of the production - possibility curve. To capture such effects over the period 1970 to 1985, a technology coefficient, ¶ has been defined. Empirically, ¶ can be interpreted as a vector containing all the factors (except capital and labour) that bring about differences in the production opportunities over the period under consideration. The refined Cobb - Douglas production is therefore formulated as,

$$Y = f\ (K, L, T)$$

where, each of the three variables (i.e. Y, K and L) is a function of time, T. It can be rewritten in the following form :

$$Y = A_1\ K^{œ_1}\ L^{œ_2}\ e^{¶\ T}$$

Since the impact of technological progress is rarely linear, an exponential term is included in order to capture the non-linear effects. By taking natural logarithim of both sides of the above equation the following semi-log linear equation is obtained :

$$\log_e (Y/L) = A_2 + œ_1 \log_e (K/L) + ¶\ T + E"$$

where, E" is an error term. The following best fit for this model is obtained by multiple regression analysis (based on the data from Table, 5.1) :

$$\log_e (Y/L) = -14.2 + 0.581 \log_e (K/L) + 0.0069\ T$$

$$(-0.46) \quad (0.61) \quad (0.41)$$

$$SE = 0.03414 \qquad R^2 = 84.9\%$$

As expected the value of the parameter ¶ is positive, reflecting technological progress. The refined value of $\alpha_1$ is therefore approximately 0.581 since the value of ¶ turns out to be near zero, 0.007 (in $Y = A\,K^{0.962}\,L^{0.038}$, $\alpha 1 = 0.962$, while in $Y = A_1\,K^{0.581}\,L^{0.419}\,e^{0.0069\,T}$, $\alpha 1 \approx 0.581$, after normalisation of T, if ¶ is a small number, which is the case).

The marginal productivity of capital for an individual year T is now given as,

$$q = \partial Y/\partial K = 0.581\ (Y/K)$$

The estimated values of **q** for each year are presented in Table 5.1 and the average value for the period 1970 to 1985 is 0.11099 (CV = 3.01). The EDR for India is therefore approximately 11% which compares closely to the market rates of interests applicable in the Indian economy.

The parameter **q** is important, not only in economic analysis but also in the socioeconomic analysis to be carried out in Chapter 7. Therefore it was cross checked by using another model (which is free from some of the assumptions made above) given by Rao (1983) and is also used by Kumar (1988) and Sharma and McGregor (1989). If in a year t the capital is $K_t$, which combined with other resources (not necessarily labour only, as in the Cobb - Douglas production function, but can be any number of resources) produces an annual net output $Y_t$, then using a Harrod - Domar type model:

$$Y_t = C_t\,K_t$$

where, $C_t$ is a constant of proportionality for the year t and represents net output to net capital ratio (i.e. $Y_t/K_t$). This means that as capital investment increases, there is a corresponding increase in net output. If a part **s** is saved and invested from a net product $Y_t$, this will give rise to new capital assets $K_{t+1}$ in the succeeding year t+1. Then,

$$K_{t+1} = K_t + s\,Y_t$$

where **s** is the marginal propensity to save. If capital is the only parameter changing and other non-capital inputs are assumed constant, then the annual net product from the new capital assets, $K_{t+1}$ can be expressed as :

$$Y_{t+1} = Y_t + q\,s\,Y_t = (1 + q\,s)\,Y_t \qquad (5.4)$$

The term **q s** represents the proportion of the marginal product which is saved and can therefore be termed as the productivity of savings. This model provides the basis for estimation of the expression **(1 + q s)** by auto regression analysis of the National Domestic Product (with only capital changing) lagged by one year. Since it can safely be assumed that land input will not change significantly over the period, the only other factor to be accounted for is labour input.

Unlike the Cobb - Douglas production function, this model does not require the estimation of benchmark capital. Although it can be argued that, similar to the static Cobb - Douglas production function (5.1), it does not capture the effects due to technological progress but as this model is dynamic and therefore implicitly captures such change. Dynamism in models can be achieved by the use of distributed-lag or autoregressive procedures. In a distributed-lag model the regression equation uses both the current and lagged (i.e. past) values of the explanatory variables. The model is referred to as autoregressive if there are one or more lagged values of the dependent variable. The following procedure is adopted in fitting the model (5.4).

The first step is to estimate the marginal propensity to save (**s**). This is the fraction of any marginal change in national income which is saved and reinvested, and so is also referred to as the marginal propensity of reinvestment. To achieve this a time series for GNP, government consumption and private consumption at current prices is compiled for the period 1960 to 1985 (Table, 5.2) from International Financial Statistics yearbook (IMF, 1987). Before proceeding further, a clarification is in order because it can be argued that a proportion of NAS will remain unmeasured, especially relating to rural areas where some villagers produce, consume and perhaps save without participating in the money market. Although the latter part of the argument is true, in practice the non-monetised transactions in terms of kind (classified under both monetised and non-monetised categories) are in fact reflected in NAS published by the Ministry of Planning based on a survey carried out by organisations such as National Sample Survey Organisation, National Council of Applied Economic Research and Indian Statistical Institute.

Since GNP is composed of total savings and consumption (both private and government) the savings are calculated by subtracting the total consumption from the GNP. The marginal propensity to save ($s = \Delta S/\Delta Y$) is then calculated for each year by taking the ratio of incremental difference in savings to that of GNP (Table, 5.2). The average value of **s** for the period is 0.2235 and the marginal propensity to consume is therefore 0.7765.

However, a better approach for estimating **s** would be through an econometric analysis in which total saving (S) is regressed on GNP (Y) :

$$S = C + s Y + E$$

where, C is a constant and E an additive error term. The marginal propensity to save is obtained by differentiating the above equation with respect to Y (i.e. **s** = dS/dY). The best fit for the model is :

$$S = -19.8 + 0.21\ Y$$
$$(-5.85) \qquad (63.25)$$
$$SE = 10.95 \qquad\qquad R^2 = 99.4\%$$

So the estimated value of the marginal propensity to save is 0.21, which is fairly close to the value estimated earlier and is used in the following analysis. The marginal propensity to consume is therefore 0.79.

Then next step is to estimate the value of the term **(1 + q s)** by autoregression analysis of National Domestic Product (NDP) in real terms and for constant labour. To achieve this a time series for GDP and consumption of fixed capital (GNP - Net National Product) at current prices is compiled from International Financial Statistics yearbook, 1987 (Table, 5.3). The NDP for individual years are calculated by subtracting the figures for consumption of fixed capital from that of GDP, which are then converted to 1980 prices by using deflators for the respective years.

The estimates for NDP with only capital changing are required in order to estimate NDP at constant labour. Unfortunately these figures are not included in the published NAS but figures for the private consumption expenditure (PCE) are available which can be fairly assumed to be going as payment for labour. These figures are converted at 1980 prices by using deflators for the individual years. Taking 1965 as a base year differences in the PCE are calculated for each individual year and then subtracted from the NDP to arrive at estimates of NDP at constant labour. Finally, the autoregression analysis of NDP at constant labour lagged by one year gave the following best fit model for equation (5.4) :

$$Yt{+}1 = -7.8 + 1.03\ Yt \qquad\qquad (R^2 = 95\%)$$

Therefore, **(1 + q s)** = 1.03, whence **q** = 0.142 by putting **s** = 0.211. Not only the correlation coefficient is very high, but also the figure is fairly close to some of the interest rates applicable in the Indian economy. In addition, this estimate for **q** lies in the middle of the values estimated based on Cobb - Douglas production functions, which can possibly be treated as upper and lower bounds. Since the value of **q** estimated above also reflects the monopoly power and risk differential of the public sector, a slight overestimate is justified (Squire and van der Tak, 1975). In addition, the value of **q** also reflects enterprenurship and so will obviously be on the higher side.

Harberger (1972), while estimating the marginal productivity of capital in India, concluded that the physical capital is highly productive in the industrial sector of the economy : for the private sector his estimates varied from 14.3 to 26.1%. Although these estimates are rather high, they are plausible on the ground that the productive efficiency of the private sector is better than that of the public sector (in many recent studies the comparatively poor performance of the latter has been criticised).

## 5.6 Marginal productivity of labour ($m_l$) in Orissa

Labour markets in developing countries have exhibited the most serious distortions that have to be identified in the process of macro-economic and social analysis (Gruchman *et al*, 1988). The mariginal productivity of labour employed in social forestry, also termed the economic wage rate (EWR), can be estimated on the basis of OC principle i.e. the output foregone had the workers not been employed in the social forestry. A straight forward approach suggested by Hanson (1986) and also applied by Trivedi (1986) is to classify the total labour into main and surplus labour. The EWR for the main labour (i.e. the labour required in the period coinciding with agricultural peak season) can be approximated by the current agricultural wage rate, while that for surplus labour (i.e. the labour required during the period coinciding with slack agricultural season) will be nil because there is no loss of productivity in employing such labour in social forestry. This is due to the fact that in rural India the main activity of the workers is agriculture and therefore the EWR should be a function of agricultural productivity and the timings of agricultural and forestry operations.

An important feature of social forestry systems is that the non-skilled and semi-skilled labour can be employed due to diversity of work requirements, unlike industrial production systems requiring firm-specific skills. A calender of operations for forestry and agriculture in Orissa given in Table 5.4 shows that many operations are complementary with respect to timing and therefore a dichotomous classification is possible. However, the estimation of EWR poses some problems for those overlapping operations (see Table, 54.) for which such a classification is not possible. As a crude approximation the mean of the wage rates for the peak and slack seasons is therefore usually estimated in such cases.

In reality the situation is not so simple and a dichotomous classification in terms of full employment and no employment is not appropriate. There are many informal labour opportunities and division of labour due mainly to underemployment which is more widespread than full unemployment. Not only do the villagers engage themselves in self-employment but there is division of labour among the members of a household. A self-employed worker possesses all the characterstics of a firm which because of division of labour, are separated in industrial firms. Seasonality in unemployment is quite common in many regions of India, especially in those States where agriculture is rainfed. In such a socioeconomic environment, the full unemployment is construed as either a luxury (concerning the people having adequate wealth) or physical incapability.

Many studies based on the findings of farm management surveys have reported on the existence of positive marginal product of labour in Indian agriculture (Mazumdar, 1965; Harberger, 1972; Bardhan, 1973). Indeed Sen (1966) argues that the zero marginal productivity is neither necessary nor sufficient condition for the existence of surplus labour. The necessary and sufficient conditions are given by a constant disutility of effort, i.e. a constant marginal rate of substitution between income and leisure over the relevant range of hours worked per worker in the traditional sector (Lal, 1973).

Lal further concludes that positive marginal productivity and surplus labour are compatible and that for the marginal productivity of agricultural family farm workers to be zero, they would have to be satiated with leisure. However, given the widespread poverty in rural Orissa, this does not seem to be the case at present. In addition, given a social welfare function (see the following chapter) based on consumption it is not appropriate to introduce the disutility of effort or the value of leisure into the estimation of the wage rate (Squire and van der Tak, 1975).

The discussion so far suggests the estimation of the marginal productivity of labour based on both the productivity and time criteria of unemployment. According to the productivity criterion, unemplyment and underemployment exist when the withdrawal of a worker from a sector does not affect the total production. The surplus labour theory is based on this criterion. The time criterion, however, regards a worker unemployed or underemployed if he/she is gainfully emplyed for a number of days (or hours) less than some specified days (or hours) in a reference period. However, in practice some problems are faced and those are now discussed, along with the steps adopted to circumvent some of them.

There is no agreed criterion for measuring unemployment in India: Krishna (1976) provides the following distinctions and resulting estimates (% of labour force) for rural unemployment which have substantial variation.

**a.** Unemployment rate may be measured either in units of labour time per period i.e. unemployed person-days per week as a proportion of total labour supply in the same units (6.8% in 1972/73), or in the numbers of unemployed persons at a given point of time as a proportion of the number of persons in the labour force (3.4% in 1972/73).

**b.** Unemployment measured on the basis of employment status over a short reference period (usually a week) or a long reference period , usually a year (1.0% in 1972/73).

**c.** Some estimates of unemployment include open unemployment only, while others include open unemployement as well as underemploment. Further, underemployment may either include persons available for more work (9.2% in 1964/65) or be a normative estimate based on a pre-determined time criterion such as 42 hours in a week (31.8% in 1964/65).

According to the latest Government of India population census (1981) the total working population is classified into main workers, marginal workers and non-workers based on the status of work defined as participation in any economically productive activity in the reference period (one year preceeding the date of enumeration). Main workers were those who had worked for a major part of the year: marginal workers had not worked for a major part of the year, but neverthless had done some work during any time in the reference period while non-workers had not worked at any time at all during the year. The figures for such workers in rural Orissa are compiled from General Economic Tables-Series I (GOI, 1987). The total member of marginal workers in rural Orissa is 1,347,996 while the non-workers who are available for work number 3,541,786: thus the total workers available for work (hereafter referred to as subsidiary workers) constitute 15.23% of the total rural population of Orissa (Table, 5.5).

This estimate which is fairly close to Singh's (1989) results for Orissa is plausible because Orissa is recognised as an economically backward State having high and variable unemployment rates. During 1972-73 the percentage of the labour force unemployed in Orissa was 10.54 (GOI, 1979) and coefficient of variation for the four seasons of the year was 30% (Krishnamurti, 1982). After this period , the all-India average unemployment rates have increased continuously (ILO, 1988; Rangaswami, 1987). This trend is closely followed by Orissa because the 32nd Round of National Sample Survey

Organisation (NSSO) indicates that approximately 16% of the total agricultural households in rural Orissa were unemployed in the year (Rangaswamy, 1987).

Unfortunately these aggregate statistics published by Government of India do not include details about the status of unemployment in a disaggergated form. Only NSSO (1981) has published the results of a survey about unemplyment based on a sample size of 100,822 households in rural India but these figure relate to the weekly status of unemployment and are available at the interval of half day.

The measurement of unemplyment in India has always been a contentious area and there is no unanimity with regard to the concepts to be used that would truly reflect the correct situation (Krishnamurty, 1982). Not only are the unemployment rates sensitive to seasonal factors because of vagaries of the monsoon but also the definition of unemployment has varied in different censuses, thereby making intertemporal comparisons difficult. The following estimates of $m_l$ can therefore by no means be treated as precise. However, they do give some objective estimates which are not only comparable to some of the available information but are also cross checked in order to minimise the errors.

The NSSO data is classified into two groups i.e main workers (who have worked more than 3.5 days in the reference week) and subsidiary workers (who have either worked equal to or less than 3.5 days or did not work at all in the week): the weighted averages for main and subsidiary workers are worked out in Table 5.6.

So far it has been hypothesised that the labour for social forestry will be drawn from the subsidiary workers. But some of the main workers may also be willing to work and may ultimately join the work force in social forestry. A plausible assumption is therefore made that the workers for social forestry will be drawn in proportion to the total labour days of unemployment in each category. Therefore for rural Orissa (Sharma and McGregor, 1989) :

Subsidiary worker days / main worker days =

$$\frac{\text{\% of the subsidiary workers X average no. of days unemployed for subsidiaryworkers}}{\text{\% of the main workers X average no. of days unemployed for main workers}}$$

$$= (15.23 \times 3.20) / (33.1 \times 0.1246) = 11.82$$

This means that if the total labour days (LDs) needed in social forestry projects are

12.82, then 11.82 LDs will be drawn from the subsidiary workers and the remaining 1 LD from the main workers. In other words, approximately 92% of the total LDs generated by social forestry in Orissa will go to the subsidiary workers and only 8% to the main workers - a plausible result which closely matches with the observations made by an ex-Director of social forestry (Tiwari, 1983).

The occupation profile for the work force, calculated from Table 5.6, is shown in Table 5.7 (see footnotes below the table for the steps involved in the calculation). It is clear from this table that an average main and subsdiary worker worked 6.73 and 1.94 LDs in the reference week. If the current average wage rate for an agricultural labourer is **w**, then the marginal product of an average main worker would be 0.96**w** (= 6.73/7.0) and of an average subsidiary worker as 0.278**w** (= 1.94/7.0). Hence the value of the marginal product foregone by society by emplying one labourer in social forestry would be :

$$m_l = (1.0 \times 0.96w + 11.82 \times 0.278w) / 12.82 = 0.33w$$

which is the required estimate for EWR for Orissa. Kumar (1988) estimates the value of $m_l$ for Karnataka State as 0.47w, based on a similar approach. A low value of $m_l$ for Orissa is due to a high unemployment/underemployment.

### 5.6.1 Cross-checking the value of $m_l$

Another approach to the estimation of $m_l$ could be based on a production function such as that considered in section 5.5. The following expression for the marginal product of labour is obtained by partial differentiation of equation (5.2) with respect to L:

$$m_l = \partial Y/\partial L = A\,œ_2\,K^{œ_1}\,L^{œ_2-1}$$

$$= œ_2\,(Y/L) = (1 - œ_1)\,Y/L$$

$$= (1 - 0.581)\,Y/L = 0.419\,Y/L$$

The values of Y/L and $m_l$ have been worked out for individual years over the period 1970 to 1985 in Table 5.8. The avearge value of $m_l$ for the period is 0.93 (CV = 8.63) which means that EWR is 0.93w.

However, the above analysis is based on aggregate estimates and is therefore not compararblė with the estimates arrived at in section 5.6. To work out the estimate of

$m_l$ based on aggregate analysis the workers are classified into two categories i.e. the main workers and all aggregate workers. An average aggregate and main worker worked for 6.13 and 6.73 LDs in the reference week respectively (see Table, 5.7). This means that a loss of 0.91**w** (= 6.13/6.73) worth of productivity would be incurred if one worker is drawn from the aggregate labour force and hence EWR is 0.91**w** in this case.

This estimate of EWR calculated from the aggregate data of workers is fairly close to the estimated value of $m_l$ based on aggreagte production function analysis. This suggests that the approach followed in section 5.6 *per se* is correct and therefore the value of 0.33w for EWR is used in the analysis. However, to test the sensitivity of the results with respect to EWR, the economic ananlysis is also carried by using EWR = 0.91**w**. Since the labour for social forestry is drawn almost entirely from the rural labour force, the aspects relating to rural - urban migration are not considered.

## 5.7 Estimation of shadow exchange rate (SER)

It is not envisaged that imported commodities will be used as inputs to social forestry nor that outputs from it will be actually exported, given the present demand/supply situation. Therefore use of the SER is not necessary in the following analysis. However, it is estimted in this section in order to use it as and when such a situation arises. The aggregate values of the exports and imports at border prices (f.o.b. and c.i.f. respectively) and domestic prices over the period 1965 to 1985 are compiled from the International Finanncial Statistics yearbook, 1988 (Table, 5.9). The SER is calculated for the individual years as follows :

$$SER = (Export + Import)_{at\ domestic\ prices} / (Export + Import)_{at\ border\ prices}$$

The average value of the SER over the period is estimated as 1.19 (CV = 5.64), which implies that a positive premium is to be attached to the traded goods. In other words the domestic value of the imported commodoties should be inflated by a factor of 1.19. If LM methodology is to be adopted the standard conversion factor would be 0.84 (=1/1.19) showing that a negative premium is to attached to the exported commodities. The use of a single SER as estimated above is applicable only under certain conditions which have been discussed in detail by Dasgupta (1980) and Dasgupta and Stiglitz (1974).

## 5.8 Numeraire for the economic analysis of social forestry

A numeraire is the unit of account in which unlike quantities are expressed in order to be aggregated. The discussion so far suggests the selection of domestic currency as an appropriate measure of valuation in social forestry. The consumer's willingness to pay for the goods and services in social forestry in terms of the domestic rupee is therefore selected as the numeraire for the economic analysis.

## 5.9 Economic evaluation of social forestry

The species chosen under the various components of social forestry are similar to that of the financial analysis. The computer program developed in the previous chapter was suitably modified (Appendix, 5.1) for computing the economic ananlysis for variable rotations.

The economic costs and benefits for the various components are based on the consumer's willingness to pay. All inputs which are non-tradables at the margin have been disaggregated into labour and material inputs. The economic valuation of the labour inputs is done using two EWRs (0.33w and 0.91w) estimated in section 5.6 and the economic value of the material inputs is their market price. Since the open market auction rates are used in valuing the produce from social forestry, the benefits so calculated are the relevant economic benefits. The marginal productivity of capital estimated in section 5.5 is used as an EDR in the analysis.

### 5.9.1 Agroforestry

The computed values of PNW and LEV for agroforestry with and without first generation coppice crop in SQ I, II & III and for a range of tree rotations are presented in Tables 5.10 and 5.11 respectively (the underlined figures correspond to the economic optimum tree rotations). Based on the PNW criterion the economic optimum tree rotations for a maiden crop are 8, 12 and 13 years in SQ I, II and III respectively, while those based on LEV and ALR criteria these are 5, 12 and 13 years. For a maiden and first generation coppice crop the economic optimum optimum tree rotations based on PNW criterion are 7+7 and 8+8 years in SQ I and II respectively, while those based on LEV and ALR criteria change to 5+5 years (EWR = 0.33w) and 6+6 years (EWR = 0.91w) for SQ I and II respectively.

It is clear from these tables that although the economic tree rotations are not sensitive to the EWR, the absolute values of PNW and LEV are substantially larger with EWR = 0.33w in comparison to that with EWR = 0.91w. This is due to the fact that the labour is a major input in subsistence-oriented social forestry.

### 5.9.2 Dense plantations

The economic benefits and costs for dense maiden plantations of *Eucalyptus hybrid* are the same as in the forestry component of agroforestry. The computed values of the PNW and LEV for a range of tree rotations in SQ I, II and III are presented in Tables 5.12 and 5.13. Table 5.12 shows that the values of PNW and LEV are negative in SQ III and II (except at higher tree rotations). This means that these management options are not feasible because the economic costs outweigh the economic benefits due mainly to an adverse impact of a high EDR. Based on the PNW and LEV criteria the optimum tree rotations are 8 and 6 years in SQ I and 12 years each in SQ II. Similar to the results in case of agroforestry the economic optimum tree rotation is almost invariant to the EWR.

Where dense plantations are managed with the maiden crop followed by a first generation coppice crop, the economic optimum tree rotations in SQ I are 7+7 years (at both the EWRs) based on the PNW criterion and change to 5+5 and 6+6 years based on the LEV criterion (at EWRs of 0.33w and 0.91w respectively). For SQ II the economic tree optimum rotation at EWR = 0.33w is 8+8 years based on both criteria while at EWR = 0.91w the values of PNW and LEV become negative, indicating the infeasibility of these management options at a high EWR.

### 5.9.3 Institutional plantations

The economic costs and benefits for the institutional plantations of *Acacia nilotica* are worked out by valuing both material and labour components at both the EWRs. The computed values of PNW and LEV for a range of alternative management options in SQ I, II and III are given in Table 5.14. The economic optimum tree rotation in SQ I is 10 years (with intermediate thinnings at 5 years) based on both PNW and LEV criteria, while that for SQ II is 15 years (with intermediate thinnings at 5 and 10 years). In SQ III none of the management options is found to be economically feasible. In addition, the economic tree rotation is invariant to the EWR used.

### 5.9.4 Village woodlots

Based on the economic costs and benefits of the village woodlots of *Dalbergia sissoo,* the

PNW and LEV computed for a range of the alternative mangement options in SQ I, II and III, are shown in Table 5.15. The economic optimum tree rotations based on the PNW and LEV criteria are 30 years (with intermediate thinnings at 10 and 20 years), 20 years (with intermediate thinnings at 10 years) and 15+15 years (main felling at 15 years followed by a coppice crop at 30 years) in SQ I and II and III respectively. Additionally, the economic tree rotation is invariant to the EWR used.

### 5.9.5 Rehabilitation of degraded forests and strip plantations

The computed values of the PNW and LEV for *Casuarina equisitifolia* plantations are given in Table 5.16 and the economic optimum tree rotation is 7 years (with EWR = 0.33w) while based on both PNW and LEV. At EWR = 0.91w, the PNW and LEV become negative.

### 5.9.6 A comparison of the components of social forestry

The results of the financial analysis carried out in the previous chapter are confirmed by the above economic analysis, that in general agroforestry is more profitable than pure forestry. At such a high DR (EDR = 14.2%), when almost all the management options for dense plantations, except in SQ I, are not economically feasible, the values of PNW and LEV are still positive in a majority of the management options analysed under the agroforestry system.

## Summary

Based on a system approach economic pricing of inputs and outputs of social forestry is carried out in the economic environment of Orissa. The different economic parameters have been estimated objectively in order to minimise subjectivity. Using such parameters the net economic benefits and the optimum tree rotations for the various components of social forestry are determined, based on PNW and LEV criteria for SQ I, II and III.

The economic analysis has shown that many alternative management options, although silviculturally sound, are not feasible due mainly to the adverse impact of a high DR (EDR = 14.2%) on the remotely accrued benefits of social forestry. This suggests a case for an alternative criterion for analysing the subsistence-oriented land-use projects such as social forestry which are being implemented with the objective of rural development.

In UK where the forestry does not come under subsistence-oriented land-use, a recent report (Anonymous, 1986) is highly critical of forestry investments on the ground that it fails to match the required rate of return. Even the use of a lower DR such as 10% for evaluating forestry management options by the Forestry Commission (HMSO, 1972) has attracted criticisms (Price, 1973). In Orissa with low economic costs (EWR estimted as 0.33w), only a few management options were found to be economically viable, due mainly to the adverse impact of a high EDR which not only discourages long term investments and improvements but also shortens rotations. In addition, it ignores the long term benefits and discriminates against the future generations by accepting short term options.

Possibly the future cannot be left to the mercy of a free market, as there are important externalities of investments for the public good which cry out for special attention (Baumol, 1968). Socioeconomic externalities are important in social forestry because the distribution of the income generated by social forestry and the equity of that distribution are important objectives and therefore need to accounted for in any comprehensive analysis. The correction of deficiencies in the distributional mechanism and internalization of the socioeconomic externalities arising from social forestry is therefore a subject matter of the following two chapters.

# Chapter 6

## Theoretical Framework of Social Cost-Benefit Analysis

Although the economy-wide aspects relating to allocational efficiency were accounted for in the economic analysis carried out in the last chapter, the distributional impacts accruing from social forestry in the form of socioeconomic externalities were completely ignored. That the distributional equity aspects need to be accounted for along with the efficiency aspects in order to attain social optima is evident from the failure of early development planning in many developing countries attempted during the nineteen sixties and seventies. The social welfare of a country cannot possibly be ensured by the maximisation of growth (often measured in terms of growth of GNP) based on the allocational efficiency alone : at best the growth can be a means to the end i.e. the overall social welfare of society.

For instance, if life expectancy is taken as one of the indicators of social welfare (though there could be many indicators such as health, nutrition, education, fertility, survival, etc.), then in recent years the developing countries such as South Africa, Mexico, Brazil, etc. have performed very badly when compared to many developing countries having comparatively lower per capita GNP such as India, China and Sri Lanka (World Bank, 1987).

A similar pattern can be discerned in India where States having a lower per capita GNP such as Kerala have performed better when compared to other States in terms of social welfare criteria based on health services, nutrition, fertility and mortality rates, (Kerala has the highest literacy rate in India). Such a phenomenon takes place because economic development based on growth alone does not address the vexed question of whether people enjoy the fruits of the acclerated growth. This means that if the "trickle-down" impacts of economic development are negligible, income needs to be redistributed from the advantaged to the disadvantaged through appropriate planning in order to ensure overall socioeconomic development. The current Indian budget reflects such thinking by increasing the surcharge on income tax from 5% to 8% to provide employment for the unemployed poor in undeveloped rural areas.

### 6.1 Economic models and a social welfare function for social forestry

The Pigouvian model of the welfare economics, which is based on the Benthamite doctrine, suggests that the welfare of society is the sum total of the welfares of each individual in that society, and that the welfare of an individual is the sum total of the satisfactions he/she derives (which he/she wants to maximise). An assumption implicit in this model relates to the identical marginal utility of income for all the individuals in the society, which is only possible in an environment of egalitarian distribution of income. Expressed mathematically, the social welfare function (SWF) for the society is the total sum of all utilities i.e.

$$SWF = \sum_{m}^{M} \sum_{i}^{n} U_{im}$$

where, $U_{1m}, U_{2m}, \ldots\ldots\ldots\ldots, U_{nm}$ represent the utilities of an individual m which he derives by consuming commodities $x_{1m}, x_{2m}, \ldots\ldots\ldots\ldots x_{nm}$ at fixed prices $p_1, p_2, \ldots\ldots\ldots\ldots, p_n$. Suppose that a number of sovereign consumers (m=1, 2, ......., M) are at the same consumption level Y in society (which is egalitarian), have perfect knowledge of available commodities and their prices, and are rational in their economic decision-making, then within their budget constraints ($Y = \sum \sum p_i x_{im}$), they will maximise the following (based on Lagrangian multiplier method):

$$W = \sum_{m} \sum_{i} U_{im} - \mu \left(Y - \sum_{m} \sum_{i} p_i x_{im}\right) \qquad (6.1)$$

where, $\mu$ is the Lagrangian multiplier. The first order conditions for the maxima are, $\partial W/\partial x_{im} = 0$ for all i and $\partial W/\partial \mu = 0$, and so the following expressions are obtained by differentiating equation (6.1) with respect to $x_{im}$ and $\mu$, and equating to 0:

$$\sum_{i} p_i = (1/\mu) \sum_{i} \partial U_{im}/\partial x_{im} \qquad (6.2)$$

and

$$Y - \sum_{m} \sum_{i} p_i x_{im} = 0,$$

which is the budget constraint. Multiplying both sides of equation (6.2) by $\Delta x_{im}$ (which represents a marginal change in the commodity $x_{im}$) and summing over all the individuals in society, the following expression is obtained :

$$\sum_{m} \sum_{i} p_i \Delta x_{im} = (1/\mu) \sum_{m} \sum_{i} (\partial U_{im}/\partial x_{im}) \Delta x_{im} \qquad (6.3)$$

The left hand side (LHS) of this equation represents the change in total prices (for all consumers) of commodities with respect to a small change $\Delta x_{im}$. Therefore, if the LHS of the above equation is positive then the right hand side will be positive, implying an increase in the total social utility. This means that if the assumptions underlying the above model are correct then the relative prices are the perfect measure of the relative benefit of changes in output in terms of consumer preferences. The total social welfare corresponding to a marginal change in the commodity ($\Delta x_{im}$) is therefore given as :

$$dW = \sum_m \sum_i (\partial U_{im}/\partial x_{im})\, \Delta x_{im} = \mu \sum_m \sum_i p_i\, \Delta x_{im} \qquad (6.4)$$

This implies that the market prices reflect the marginal utility of income, although the assumptions underlying the model such as homogeneity of goods, perfect knowledge, absence of externalities, acceptance of the ruling pattern of income and its egalitarian distribution, and sovereignty and rationality of consumers, are very strong. In addition, other assumptions implicit in the model are that all individuals have the utility functions in agreement with the social welfare function in order to be aggregated and that the marginal utilities of income ($\mu$) and tastes of these individuals are identical. In practice, especially in case of the developing countries (DCs), many of these assumptions may not be valid. For instance, the income distribution in a majority of DCs is highly skewed and hence the assumption that the marginal utility of income is identical for all individuals in society is untenable. The socioeconomic externalities accruing from social projects such as social forestry also need to be accounted for.

The apparent paradox of the neo-classical model is pointed out by Irwin (1978), "since the marginalist approach requires one to assume that the more one has of a good, the less utility one derives from an additional unit, it would seem to follow that welfare can be increased by redistributing marginal units of a good (or income in general) from those who have a great deal of it, to those with very little i.e. by moving towards a fully egalitarian distribution of income. .......... But by denying the possibility of interpersonal utility comparisons, orthodox theory conveniently avoided drawing egalitarian conclusions."

The problems of individual preferences are treated as that of a trade off among the desired commodities which contribute to social welfare. In a society having a large number of welfare-maximising fully informed individuals and a perfect economy, the individuals will attain a higher level of welfare due to adjustment of production and consumption through the price mechanism. In equilibrium, the net result would be attainment of the Pareto optimality (no further improvements can be made to some individuals without making others worse off). In such a perfect economy the only limitations facing the economy relate to the scarcity of resources and lack of technological knowledge.

However, in the developing countries the distribution of income is seldom equitable and therefore the Pareto optimality as discussed above may lead to a range of Pareto optimal situations, the comparisons among which would be difficult. In such cases, an alternative approach of comparing intratemporal utilities suggested by neoclassical welfare economists such as Hick and Kaldor is that a social state would be desirable (or superior) whenever those who gained from the change could so compensate the losers, that after compensation there is a net gain in order to make the compensation possible. Therefore the beneficiaries of, say, a social forestry project in such a situation would remain on a higher indifference curve after paying adequate compensation to the losers who would return to the indifference curve they would have been on in the absence of social forestry. In so doing a Pareto improvement would result because the beneficiaries are better off without making others worse off. This was possibly the beginning of intratemporal considerations being accounted for in the project analysis.

Since the payment of compensation in practice is unrealistc, due mainly to socio-political reasons, an alternative was suggested that the actual compensation may not in fact take place. Direct subsidies are seldom favoured and often reach the poor only at a very high cost which few governments can afford (Little, 1982). In addition, it is difficult to gather perfect information about the expected socioeconomic impacts of projects concerning individuals or groups of individuals in order to make Pareto-efficient allocations by lump sum compensation transfers to the disadvantaged. This seems to be a reason for not yielding the desired results through indirect measures initiated in many DCs.

For instance, in India the average daily consumption rose from 1700 to 1940 calories (14%) during the period 1949-50 to 1968-69, while the per capita income rose by 40%. If the increased income had been equally distributed, a corresponding rise in food consumption of at least 32% could have been expected (Lipton, 1977). This shows the failure of most of the extra income generated by economic development to reach the poor because the distributional aspects of socioeconomic developement have largely remained separate from economic efficiency. In other words, the compensation of losers, either through direct or indirect measures, has either been not possible or insignificant.

The case against integrating distributional equity with efficiency has been made by some economists such as Harberger (1971) and Mishan (1974). They argue that the application of distributional weights would be tantamount to using value judgements and therefore suggest that the distributional equity aspects should be left to governments for implementation. But a majority of governments have not shown adequate will power to implement such aspects. Since welfare economics is necessarily based on value judgements (Nath, 1969), there seems to be a consensus among the applied welfare economists to make those value judgements which are actually subjective judgements of facts (NG yen-Kwang, 1972) and therefore need to be reflected in the social welfare function of the decision-maker. Otherwise, the non-adoption of equity weights based on marginal utility of consumption merely signifies the evaluators' acceptance of those distributional weights which relate to the *status quo* of income (Nash *et al*, 1975).

Improvement in welfare can be achieved by supplementing the efficiency criterion with the distributional criterion (Little, 1957). For instance, a decrease in efficiency can bring about such a large gain in distributional equity that overall social welfare is increased and therefore efficiency criteria cannot by themselves provide either the necessary or sufficient conditions for welfare improvement in an economy with many consumers (Hammond, 1980). The utilitarian principle can thus be invoked for incorporating distributional impacts. It states that consumption has a different utility for people at different consumption levels and that the social welfare function representing the maximisation of social utility can be achieved by maximising the aggregate utilities enjoyed by all members of society. The assumptions required for carrying out such analysis are that the utilities enjoyed by the different groups or individuals are commensurate and additive.

So by relaxing the assumption of identical marginal utility of consumption for all the groups or individuals and adopting a realistc approach that $\mu_1, \mu_2, \ldots\ldots\ldots, \mu_m$ represent the mariginal utility of consumption for the groups of individuals 1, 2, .......,m in the society, equation (6.4) can be rewritten as :

$$dW = \sum_m \sum_i (\partial U_{im}/\partial x_{im})\, \Delta x_{im} = \sum_m \sum_i \mu_m\, p_i\, \Delta x_{im}$$

This formulation can now be expressed in a simple way. Suppose the impacts of social forestry in monetary terms to each groups of individuals 1, 2, ..........., m are given by $\Delta g_1, \Delta g_2, \ldots\ldots\ldots, \Delta g_m$, then the weighted sum of the net change in social welfare can be written as:

$$\Delta W = MU_1\, \Delta g_1 + MU_2\, \Delta g_2 + \ldots\ldots\ldots + MU_m\, \Delta g_m$$

where the weight for each group of individuals in the society is given by the marginal utilities of their consumption (i.e. $MU_1$, $MU_2$, .........., $MU_m$). Based on the principle of diminishing marginal utility of income (or consumption) the lower the income level of a group the higher its marginal utility of consumption (or distributional weight) and vice versa. In the case where all groups of individuals are at the same consumption level (i.e. the society is egalitarian) then $MU_l = MU_2 = ............ = MU_m = \mu$ and the above model becomes identical to model (6.4).

So far it has been assumed that the inter-group impact distributional weights can be applied to the cost and benefit streams accruing to different groups of individuals from a social forestry project. Although theoretically the procedure should lead to an egalitarian distribution of income, practically there are constraints preventing an optimal distribution of income being achieved. To circumvent this problem, the project selection itself can be taken as a positive way of achieving redistribution of income. This suggests that the distributional aspects along with efficiency aspects should be integrated at the micro-level planning while designing and allocating resources among the projects (or among the various alternative management options within a social forestry project).

The case for incorporating inter-group considerations at the micro-level planning is strong in DCs where alleviation of chronic and abject poverty requires some sort of redistribution and national governments are largely unable to do so through macro-level planning because of socio-political expediency. This need to redistribute income has even been realised in developed countries where welfare schemes such as social security in UK are in vogue. A recent report of the United Nation's Development Programme has recommended that any measure of social welfare should include the reduction in inequalities in society as an important objective. Based on such a criterion countries with a high growth rate of GNP such as USA have been placed well below those having less income inequalities such as Switzerland (Gittings, 1990).

The alternative of using social projects rather than direct social welfare schemes (such as social security) to achieve optimal distribution of income is preferable in DCs. This is because the latter are often not feasible due to sociopolitical reasons and scarcity of government funding. Stiglitz (1985) describes such phenomena succinctly, "The New New Welfare Economics is predicated on the assumption that the government does not have perfect information concerning different individuals; it cannot tell who is of high ability, who is of low ability, who is disadvantaged by some innovation, or who is benefited by some public program. It can elicit some information, but the process by which this information is elicited affects resource allocations. The absence of this information means that lump sum redistribution taxes in general are not feasible......... More generally a basic insight of the New New Welfare Economics is that whether an economy is or not Pareto efficient may depend on the initial distribution of wealth : the separation between equity and efficiency considerations is no longer valid."

The aspect of divergent impacts of the costs and benefits arises very widely within the community as a social project including forestry, agriculture and rural development is unlikely to have a similar impact on all the groups within a village or society. The task becomes even more important if the objective is to use the social project as a tool for a positive distributional effect in favour of poorer segments of the village commulity (Arnold, 1984; Field and Birch, 1988). This aspect of social forestry has also been emphasised by Chowdhry (1985) until recently chairperson of the National Wasteland Development Board which monitors social forestry policy implementation in India: "Develoment planners and administrators including foresters have realised that development plans from above have to be complemented by development from below, successful programmes in social forestry require the inclusion and integration of marginal and disadvantaged groups; and there should be a shift in strategy from an emphasis on achievement of targets to questions of equity."

It can be argued that labour-intensive projects such as social forestry would lead to a trade-off between productivity and employment, sometimes at the expense of the former because capital-intensive technologies of production may often involve lower capital investment than the labour-intensive technologies. But given the scarcity of capital and abundance of labour in terms of the pool of unemployed and underemployed labour such a conflict, which is based on the neoclassical assumption of the substitutability of labour and capital, does not arise at present. However, if it is assumed that there is such a conflict, additional employment is desirable for the following reasons (Stewart and Streeton, 1971; Dasgupta *et al*, 1972):

**a.** employment creation and the consequent wage payments may be the only mechanisms by which income can be redistributed to those who would otherwise remain unemployed

**b.** unemployment is demoralizing,

**c.** earned wages are better than the social welfare scheme benefits because work is intrinsically good , and finally

**d.** there are political disadvantages and dangers in widespread unemployment.

The Gandhian philosophy also advocated the production by masses instead of mass production possibly due to above-mentioned advantages of such an approach.

### 6.1.1 A Social Welfare Function (SWF) for social forestry

Suppose the utility function for a rational representative consumer i at the consumption level $C_i$ is given by $U(C_i)$. Further assume that this utility function, which transforms his consumption to utility, is differentiable and decreasing with an increase in the level of consumption (based on the principle of diminishing marginal utility of consumption which states that as consumption increases the marginal social utility of consumption decreases). Then the marginal social utility of consumption, $dU(C_i)/dC_i$ will represent the rate of change of social utility with respect to consumption change $C_i$ and $d^2U(C_i)/d^2C_i$ will represent the rate of change of marginal social utility with respect to further change in consumption by $dC_i$. Since with a percentage change in consumption, there would be a corresponding percentage change in marginal social utility of consumption, the following expression is obtained:

$$\{ d^2U(C_i)/d^2C_i \} / \{ dU(C_i)/dC_i \} = e_u ( dC_i/C_i )$$

where $e_u$ is a constant of proportionality called the elasticity of social marginal utility of consumption ($e_u < 0$ in order that the marginal social utility be decreasing with increased level of consumption). This represents the ratio of the rate of change of marginal social utility of consumption to the rate of change of consumption (both expressed in percentages). In other words, it shows how much the marginal social utility of consumption changes with each 1% increase in the average consumption level. The above expression can also be written as :

$$d[\log_e \{ dU(C_i)/dC_i \}] = d(\log_e C_i^{e_u})$$

which after integration gives the following expression:

$$\log_e \{ dU(C_i)/dC_i \} = \log_e C_i^{e_u} + a$$

where a ($=\log_e A$) is a constant of integration. This expression can be rewritten as :

$$dU(C_i)/dC_i = A\ C_i^{e_u} \qquad (6.5)$$

Integrating this equation gives the total social utility (or utility function) for an individual or a group of individuals at consumption level $C_i$, i.e.

$$U(C_i) = \int \{ dU(C_i)/dC_i \} dC_i = A \int C_i^{e_u} dC_i$$

$$= A C_i^{(1+e_u)} / (1+e_u) \qquad \text{for } e_u \neq -1, \qquad (6.6)$$

and $$= A \log_e C_i \qquad \text{for } e_u = -1$$

The above analysis is now extended to all the groups of individuals at different levels of their consumption. In determining the SWF for social forestry it is necessary to start by assuming a fixed and denumerable set of m individuals (or groups of individuals), whose members, in a non-decreasing order of consumption levels $C_1$, $C_2$, .................,$C_m$, are given by the vector:

$$\underline{C} = ( C_1, C_2, ................., C_m )$$

If $p_l$ is the poverty line (i.e. in India, the per capita consumption expenditure required to achieve a calorie intake of 2,800 calories per day) and $P(p_l)$, individuals (or groups of individuals) have consumption levels at or below this poverty line, then the consumption vector of poor individuals or groups of individuals can be written:

$$\underline{C}^{poor} = (C_1, C_2, ............, C_P)$$

and the consumption vector of the rich individuals or groups of individuals can be written as :

$$\underline{C}^{rich} = ( C_{P+1}, C_{P+2}, ............, C_m)$$

The consumption vector for the society is then,

$$\underline{C} = ( \underline{C}^{poor} , \underline{C}^{rich} )$$

As argued above, since the social projects including social forestry are concerned with improving the welfare of society the SWF should describe the decision-makers' (i.e. government's) preferences based on combinations of individuals' or group of individuals' utilities. Expressed mathematically the social welfare function is :

$$SWF = f (U_1, U_2, ...................., U_m)$$

where values of $U_m$ represents the utility of the $m^{th}$ individual (or groups of individuals) in society. Assuming that SWF is additive, increasing, symmetric and separable and the value of $e_u$ is estimated at -1.4 (refer to the following chapter), then from equation (6):

$$SWF\ (\underline{C}) = \{\ A/(1+e_u)\ \} \sum_{i=1}^{M} C_i^{(1+e_u)}$$

This function may be separated in terms of poor and rich groups of individuals :

$$SWF\ (\underline{C}) = SWF\ (\underline{C}^{poor}) + SWF\ (\underline{C}^{rich})$$

$$= \{A/(1+e_u)\}\ [\sum_{i=1}^{P} C_i^{(1+e_u)} + \sum_{i=P+1}^{M} C_i^{(1+e_u)}]$$

While formulating this model it is assumed that there are two distinct groups i.e. poor and rich, but in reality there could be many such strata within society. In the following chapter, thirteen such groups have been identified in Orissa based on their different consumption levels: the four bottom groups of individuals are at or below the poverty line and the remaing nine above it. The model still remains valid and can be written as :

$$SWF\ (\underline{C}) = \{A/(1+e_u)\}\ [\sum_{i=1}^{m_1} C_i^{(1+e_u)} + \sum_{i=m_1+1}^{m_2} C_i^{(1+e_u)} + \ldots\ldots + \sum_{i=m_{12}+1}^{m_{13}} C_i^{(1+e_u)}]$$

An explicit formulation of the social welfare function (as above) is necessary to ensure that decision-making is consistent and the parameters used in the analysis of social forestry policy are compatible with its stated objectives.

## 6.2 Model for estimation of $e_u$

An objective estimate of the parameter $e_u$ is necessary in order to not only specify the SWF formulated above, but also to estimate the distributional equity weights and the social discount rate discussed in the following sections. This means that $e_u$ which reflects the social value judgements of the national government or decision-maker is a key parameter for carrying out a social CBA. The model employed to estimate the value for $e_u$ is that suggested by Fellner (1967), which is based on the earlier work of Fisher (1927) and Frisch (1932). Alternative models, based on a complete demand system approach (see Stern, 1977 and Pearce, 1964) exist for estimating $e_u$ but Fellner's model has recently been widely applied (Lal, 1972; Kula, 1984, 1985, 1988) and has been found to give consistent and plausible estimates (Kula, 1985).

The model assumes additivity and separability of the utility function. Suppose a representative individual has the utility function $U = U(x_1, x_2)$, which is additive and separable with respect to two types of goods, namely food and non-food items (which represent an aggregate - or n-tuple - of food commodities and non-food commodities repectively i.e. $x_1 = (x_{11}, x_{12}, \ldots\ldots\ldots, x_{1n})$ and $x_2 = (x_{21}, x_{22}, \ldots\ldots\ldots, x_{2n})$).
Then we have :

$$U = U(x_1, x_2) = U_1(x_1) + U_2(x_2)$$

From equation (6.2) it follows that the first-order condition for maxima for the utility function $U(x_1, x_2)$, under the budget constraint of the representative individual, is given by the following equation (based on the Lagrangian multiplier method):

$$(1/P_f)\,\{\partial U(x_1, x_2)/\partial x_1\} = \mu = (1/P_{nf})\,\{\partial U(x_1, x_2)/\partial x_2\}$$

or,
$$\partial U(x_1, x_2)/\partial(P_f\, x_1) = \mu = \partial U(x_1, x_2)/\partial(P_{nf}\, x_1) \qquad (6.7)$$

where, $P_f$ is the price of food commodities, $P_{nf}$ is the price of non-food commidoties, the Lagrangian multiplier $\mu$ is the marginal social utility of consumption and the partial derivatives $\partial U(x_1, x_2)/\partial x_1$ and $\partial U(x_1, x_2)/\partial x_2$ represent the marginal social utility of food and of non-food commodities respectively.

Since the products $(P_f\, x_1)$ and $(P_{nf}\, x_1)$ represent the consumption expenditures on food and non-food items respectively, the expression (6.7) implies that at equilibrium an additional rupee spent on any good (i.e. food or non-food) will provide the same increase in the marginal social utility $\mu$. In addition, since $1/P_f$ and $1/P_{nf}$ represent the number of units of food and non-food commodities that can be bought with one rupee, the parameter $\mu$ can be interpreted as a number that converts money into its utility equivalents. The parameter $\mu$, which is a function of the income and prices of commodities, can therefore be estimated by monitoring the consumer's behaviour.

Suppose a change of z% in food price neutralises a change of 1% in the real income of the representative individual, so that the consumption of food remains constant. This implies that the marginal social utility of income (or consumption) has changed by -z% (negative because the marginal social utility of consumption is inversely related to price) with a 1% increase in real income, which by definition is the elasticity of the marginal social utility of income, i.e. -z. Fellner notes that the quantity -z is the reciprocal of the elasticity ($e_f$) of the function describing the dependence of the real income at which a given quantity of food is consumed, to the relative price of food., i.e.

$$-e_u = -z = -1/e_f$$

Fellner hypothesises that $e_f$ can be estimated by a ratio of the compensated or pure price elasticity of demand for food ($e_p^*$) and the income elasticity of demand for food ($e_y$), i.e.

$$-e_f = -e_p^* / e_u$$

A justification of this relation lies in the fact that at a given real income, the assumed food price increase leads to a decrease in food consumption (in the proportion of $e_p^*$) and therefore an increase in real income in the proportion of $e_p^* / e_y$ is required to keep food consumption constant at the initial level. Combining the above two expressions, the following operational expression is obtained for estimation of $e_u$:

$$e_u = e_y / e_p^* \qquad (6.8)$$

As the direct estimation of pure price elasticity is difficult the uncompensated price elasticity ($e_p$) can be estimated, which after removing the income effect will give the value of $e_p^*$. This is due to the fact that the impact of a change in price of a good on its quantity demanded is two-fold. Firstly an income effect, due to the fact that a price change implies a change in the real income of the consumer and so the individual's demand is affected. Secondly a substitution effect, due to the fact that if the price of one good changes its relative price also changes, with the result that less will be consumed of the good whose relative price increases. For estimation of $e_p^*$ the following algorithm known as the fundamental equation of the theory of value (or Slutsky equation) can be employed :

$$e_p^* = e_p - ø\, e_y \qquad (6.9)$$

where ø is the proportional share of food in the consumer's budget.

In order to estimate the values of $e_p$ and $e_y$ it is necessary to estimate a dynamic food demand model such as the following :

$$D = f\,(Y,\ P_1/P_2,\ T)$$

which can be written in a semi-log linear form:

$$\log_e D = \log_e A + e_y \log_e Y + e_p \log_e (P_1/P_2) + \Omega\, T + E \qquad (6.10)$$

where, D is the demand for food expressed in terms of per-capita food consumption expenditure, A is a constant, Y is the per-capita income, $P_1$ and $P_2$ are price indices for food and for non-food items respectively, $\Omega$ is a taste coeffecient included to capture the changes in the consumer's taste over the period, T is the time varaible and $\bar{E}$ is an error term. A time variable is included in the model in order to use time-series data of food demand in India. This model provides the basis for estimation of $e_p$ $[=\partial \log_e D/\partial \log_e (P_1/P_2)]$ and $e_y$ $(=\partial \log_e D/\partial \log_e Y)$ as shown in the following chapter.

## 6.3 The social discount rate and socioeconomic criteria

The social discount rate (SDR) needs to be estimated within the framework of SWF in order to be included in a compatible criterion for evaluating social forestry. Suppose the net aggregate consumption benefits in year t are given by $NB_t$, then an expression for the overall aggregate consumption benefits or net social benefits (NSB) can be wriiten as:

$$NSB = NB_0 + NB_1 + NB_2 + \ldots\ldots\ldots\ldots + NB_t$$

Since the aggregate consumption benefits will decline over the time (based on the principle of diminishing marginal utility of consumption), the above expression can be written as :

$$NSB = \mu_0\, NB_0 + \mu_1\, NB_1 + \mu_2\, NB_2 + \ldots\ldots\ldots\ldots + \mu_t\, NB_t$$

where, the declining weights $\mu_0, \mu_1, \mu_2, \ldots\ldots\ldots, \mu_t$ reflect the diminishing marginal utility of consumption and can also be termed as the discount factors representing the amount by which future net benefits should be discounted in order to make them comparable to the present net benefits. The NSB therefore gives the present net worth of the aggregate consumption. If the present consumption is chosen as the unit of account and initialising $\mu_0 = 1$, then the above expression can be rewritten as:

$$NSB = NB_0 + \mu_1 NB_1 + (\mu_2/\mu_1)\mu_1 NB_2 + \ldots\ldots\ldots + \{(\mu_t/\mu_{t-1})(\mu_{t-1}/\mu_{t-2})\ldots\ldots(\mu_2/\mu)\mu_1\}NB_t$$

Assuming that the weights decline over the period at a constant rate of $r_s$%, then

$$(\mu_t - \mu_{t+1}) / \mu_{t+1} = \text{a constant} = r_s \qquad (6.11)$$

or $$\mu_{t+1}/\mu_t = 1/(1 + r_s)$$

Putting these values in the above expression for NSB,

$$NSB = NB_0 + \{1/(1 + r_s)\}NB_1 + [\{1/(1 + r_s)\}\{1/(1 + r_s)\}]NB_2 + \ldots\ldots + \{1/(1 + r_s)^t\}NB_t$$

$$= \sum_{t=0}^{t} NB_t/(1 + r_s)^t \qquad (6.12)$$

which is the required criterion for socioeconomic analysis and is similar to the expression for PNW used in Chapter 4, except that the discount rate used now is the rate at which the social significance of the consumption declines over the period i.e. the consumption rate of interest (CRI). So from the expression (6.11),

$$CRI = (\mu_t - \mu_{t+1}) / \mu_{t+1} = -(\mu_{t+1} - \mu_t) / \mu_{t+1} = -\Delta\mu_{t+1}/\mu_{t+1}$$

$$= -[\{(\Delta\mu_{t+1}/\Delta C_{t+1})(C_{t+1}/\mu_{t+1})\}(\Delta C_{t+1}/C_{t+1})]$$

$$= -[\{(\Delta\mu_{t+1}/\mu_{t+1}) / (\Delta C_{t+1}/C_{t+1})\}(\Delta C_{t+1}/C_{t+1})]$$

$$= -\frac{\text{\% change in the marginal social utility}}{\text{\% change in consumption}} \times \text{\% change in per-capita consumption}$$

= - (elasticity of marginal social utility) x (growth rate of per-capita real consumption)

$$= -(-e_u)\, g$$

$$= e_u\, g \qquad (6.13)$$

which is the required expression for estimating CRI. This expression is based on STP approach and can also be derived by using equation (6.2) applicable to the representative individual i. The marginal rate of substitution of consumption between present ($C_{i1}$ at time $t_1$) and future ($C_{i2}$ at time $t_2$) can be written as (from equation 6.5):

$$[\{dU(C_i)/dC_{i1}\} \ / \ \{dU(C_{i2})/dC_{i2}\}] = (A\ C_{i1}{}^{e}u) \ / \ (A\ C_{i2}{}^{e}u)$$

Since $r_s$ is the rate at which the marginal social utility of consumption falls over the period $(t_2 - t_1)$, so

$$[\{dU(C_i)/dC_{i1}\} \ / \ \{dU(C_{i2})/dC_{i2}\}] = 1/\ (1 + r_s)^{t_2 - t_1}$$

Comparing the two expressions :

$$1/\ (1 + r_s)^{t_2 - t_1} = (C_{i1}/\ C_{i2})^{e_u}$$

whence, $r_s = \{(C_{i1}/\ C_{i2})^{-e_u/(t_2 - t_1)}\} - 1$

Since $C_{i2} = C_{i1}\ (1 + g)^{t_2 - t_1}$, the above expression can be written as :

$$r_s = (1 + g)^{-e_u} - 1$$

or $$CRI = r_s = (1 + g)^{|e_u|} - 1 \qquad (6.14)$$

where $|e_u|$ is the absolute value of the elasticity of social marginal utility of consumption ($e_u$). If g « 1 then ignoring higher order (>1) terms, the above expression becomes equivalent to expression (6.10) and if the social utility depends on pure time preference in addition to consumption level then the above expression can be written as :

$$CRI = r_s = (1 + g)^{|e_u|} - 1 + p$$

where **p** is the pure time preference rate. However, the use of the pure time preference rate raised objections from many authors (Ramsay, 1928; Rawls, 1971; Nash, 1973; Price, 1973, 1984, 1987, 1988, 1989b; Page, 1977; Kula, 1981; Pearce and Nash, 1981, Olson and Bailey, 1981; Markandya and Pearce, 1988, etc.) mainly relating to intergenerational equity in the management of natural resources.

Kula (1988) uses an additional term, © representing the probability of survival from one period to the next by which the future utility is discounted and so the above expression can be written as :

$$CRI = r_s = (1/©)\ (1 + g)^{|e_u|} - 1$$

However, since society is immortal (ignoring the possibility of any major catastrophe such as nuclear war at a wide scale) so © = 1 and then the two expressions become equal.

A brief discussion of SDR in the context of socioeconomic analysis is in order before completing this section. The SDR is a matter of national policy and therefore it is appropriate to consider it as a national parameter to be estimated at the national level (ICAI, 1983). Two main approaches (i.e. STP and SOC) of estimating SDR were discussed in the previous chapter. The CRI, which is based on a STP approach, allocates the consumption intertemporally by determining the optimal overall rate of foregone current consumption (or savings). Since the CRI as a STP rate represents the rate at which the marginal social utility of consumption decreases, it can be inferred that the higher the CRI, the lower the weight attached to the future consumption and hence the lower the present value of future consumption streams. Since CRI is dependent not only on the elasticity of marginal social utility of consumption but also on the growth rate of per capita consumption in real terms, it follows that for a given value of $e_u$ the CRI will be directly proportional to the value of **g** which in turn is indirectly influenced by the rate of economic growth.

On the other hand, the discount rate based on SOC approach may perform the function of allocating the resources intratemporally (i.e. among the potential candidate alternative uses of the investment). Since the capital funds are usually limited and a public sector project displaces the investments from some other projects, it can be argued that the projects must be evaluated using a discount rate based on the SOC approach. However, an objective estimation of SOC rate is difficult because in many cases the best alternative use of the investments is in the private sector (in India the productivity of the private sector is higher than that of the public sector) in which case the following problems may arise (Kula, 1988):

**a.** the stock market's view of a rate of return on capital can be very different from society's view of profitability and,

**b.** private profits may be quite high not only as result of an efficient operation but as a result of market imperfections which may work against public interests.

Therefore, most economists believe that the private profits and resulting rates of return on capital require a substantial social adjustment before they can be used in evaluating public projects.

However, if a combined approach ( i.e. STP cum SOC) is followed on the grounds that opportunities for transferring present consumption into future consumption through savings should also be reflected in the SDR, then an additional term [(1/v) (dv/dt) which represents the rate of fall in the social value of public income v] should be added into the expression for estimating SDR (v depends on the marginal productivity of capital as discussed in the section 6.5):

$$SDR = CRI + (1/v)dv/dt$$
$$= (1 + g)^{|e_u|} - 1 + (1/v)dv/dt$$

If the social value of public income remains constant over the period (i.e. the economy is expected to remain suboptimal over the period), then dv/dt =0 and so the above expression becomes equivalent to that for CRI. When a SWF is based on consumption as in this case study, the SDR is approximated from CRI and so the expression (6.14) will be used in estimating SDR in the following chapter. To achieve this an objective estimate of per-capita growth rate of real consumption (g) over the period is necessary for which the following semi-log-linear consumption function with respect to the time variable may be employed:

$$C = A' + g\,T + E$$

where, C is the per-capita consumption in real terms, A' is a constant, T is the time variable and E is an error term. A regression analysis of time-series data can be performed in order to obtain the best fit for the above equation.

## 6.4 Inter-group (or intratemporal) consumption impact weights

Since the specified SWF includes thirteen groups of individuals based on their levels of consumption, an objective estimation of the distributional impact weights is necessary to apply to the benefit and cost streams accruing from social forestry. Suppose the group of individuals at the poverty consumption level $p_l$ is $C_{pl}$, then from equation (6.5):

$$dU(C_{pl}) / dC_{pl} = A\, C_{pl}^{e_u} \qquad (6.15)$$

Similarly for a group of individuals at the consumption level $C_i$,

$$dU(C_i) / dC_i = A\, C_i^{e_u} \qquad (6.15a)$$

The following expression is obtained by dividing expressions (6.15) by (6.15a):

$$\{dU(C_{pl}) / dC_{pl}\} / \{dU(C_i) / dC_i\} = (C_{pl} / C_i)^{e_u}$$

Since the poverty consumption level is chosen as a reference level, so the standard weight 1 is given to the groups of individuals at the poverty consumption level and the weights for remaining groups can then be expressed relatively. Therefore, $dU(C_{pl})/dC_{pl} = 1$ and $dU(C_i)/dC_i$ will represent the weight ($d_i$) to be attached to the groups of individuals at the consumption level i with respect to the reference consumption level $C_{pl}$, i.e.

$$d_i = dU(C_i) / dC_i = (C_i / C_{pl})^{e_u} \qquad (6.16)$$

which is the required expression for inter-group impact weights applicable for marginal increases in consumption.

When the increases in consumption of some groups (from $C_{i1}$ to $C_{i2}$) due to the social forestry project are substantial (i.e. non-marginal) then the weights estimated below need to be applied. The change in social utility corresponding to the change in consumption is obtained below by integrating expression (6.5) :

$$\int_{U_1}^{U_2} dU = \int_{C_1}^{C_2} A \ C_i^{e_u} \ dC_i$$

or, $$U_2 - U_1 = \{A / (1 + e_u)\} \ (C_{i2}^{1+e_u} - C_{i1}^{1+e_u}) \qquad (\text{for } e_u \neq -1)$$

Since $dU(C_{pl}) / dC_{pl} = 1$, the value of the constant A is obtained from expression (6.15) as $1/ C_{pl}^{e_u}$ whence the following expression is obtained after putting the value of A in the above expression :

$$U_2 - U_1 = \{1 / (1 + e_u)\} \ (C_{i2}^{1+e_u} - C_{i1}^{1+e_u}) / C_{pl}^{e_u}$$

Therefore the weight applicable for a non-marginal increase in consumption is given as :

$$d_i = (U_2 - U_1)/(C_{i2} - C_{i1})$$

$$= \{1 / (1 + e_u)\} \ (C_{i2}^{1+e_u} - C_{i1}^{1+e_u}) / \{C_{pl}^{e_u} \ ( C_{i2} - C_{i1})\} \qquad (6.17)$$

These weights give a measure of the impact on consumption distribution of various groups of individuals due to the implementation of social forestry. Such consumption impacts due to income redistribution may arise for two main reasons: a resource is purchased at more than its economic value and a resource is sold to the recipients at less than its economic value. This is similar to the energy principle because there is loss for every gain and therefore there must be a redistributive gain to every redistributive loss to society. If the government is unable to take an appropriate action for socio-political reasons and wishes to select the social projects as a means for redistributing income (or consumption) either between the public and private sectors or from advantaged groups of society to disadvantaged, then such a goal should be included in the SWF by assessing and applying the distributional impact weights.

## 6.5 Intertemporal consumption impact assessment

The intertemporal consumption impacts should also be accounted for along with the inter-group consumption impacts. This is necessary because society is immortal and so the consumption of future generations arising due to savings (or less consumption) made by the present generation needs to be properly integrated into micro-level planning. These two aspects of consumption (i.e. inter-group and intertemporal) will ultimately specify the trade off between growth (i.e. transformation of present consumption into future consumption) and redistribution of present consumption from one group to another (i.e. from rich to poor).

An important aspect of intertemporal consumption has already been accounted for in the form of CRI and the indirect influence of the marginal productivity of capital (**q**) on SDR. The direct influence of **q** is investigated by assuming that the capital cost $C_0$ (with no intermittent cost) is incurred in the initial year in order to achieve a benefit stream over the period such that (from expression 6.12):

$$NSB = \sum_{t=1}^{t} NB_t/(1 + \mathbf{r_s})^t - C_0$$
$$= -C_0 + \mu_1 B_1 + \dots\dots\dots\dots + \mu_t B_t \qquad (6.18)$$

This expression for NSB is a valid alternative of the expression (6.12) only if the economy sacrifices the consumption worth initial value $C_0$. However, in practice investments in public projects such as social forestry are generally made by withdrawing funds from alternative investment opportunities. This implies that the sacrifice of consumption is deferred until the displaced investments would themselves have yielded consumption. In such a case the estimation of costs, at the time the consumption is actually sacrificed, can be done by estimating the return of public investment by the marginal productivity of capital. The modified expression of NSB can therefore be written as :

$$NSB = 0 + \mu_1 (B_1 - q\, C_0) + \ldots\ldots\ldots + \mu_t (B_t - q\, C_0) - \ldots\ldots\ldots\ldots - \mu_t\, q\, C_0$$

$$= \sum_{t=1}^{t} NB_t/(1 + r_s)^t - \sum_{t=1}^{\infty} q\, C_0 / (1 + r_s)^t$$

$$= \sum_{t=1}^{t} NB_t/(1 + r_s)^t - q\, C_0 \sum_{t=1}^{\infty} / (1 + r_s)^t$$

$$= \sum_{t=1}^{t} NB_t/(1 + r_s)^t - (q/r_s)C_0 \qquad \left(\text{as } \sum_{t=1}^{\infty} / (1 + r_s)^t = 1/r_s\right) \qquad (19)$$

This expression for NSB, which is different from expression (6.18), shows that the present value of the consumption stream foregone by displacing marginal investment is $(q/r_s)$ times the amount of investment $(C_0)$. When $q > r_s$, which is usually the case in many developing countries, then the opportunity cost of investments $(q/r_s\, C_0)$ will be more than the nominal cost $(C_0)$. Therefore if the returns from investment are consumed entirely, the relevant expression for the social value of public investments (or shadow price of investment) is given by:

$$v = q/r_s \qquad (6.20)$$

However, if a fraction **s** is saved and reinvested, and the remainder (1 - s) is consumed then the relevant expression is given as (Dasgupta *et al*, 1972):

$$v = \{(1 - s)\, q\} / (r_s - s\, q) \qquad \text{when } r_s > s\, q$$

This expresses the social value of investments as the product of the share of consumption in the marginal returns from investments and the marginal productivity of capital divided by the difference between the SDR and the rate at which the capital accumulates. It can also be interpreted as the present value of the future consumption stream due to marginal investment (1 - s) q which has been discounted at an artificial rate of discount $(r_s - s\, q)$ representing the SDR corrected for reinvestment by subtracting the rate of accumulation (s q) from SDR. However, if $r_s < sq$ (which will happen when either s is high or q is high in order to make the product s q high) the relevant expression for v is (Dasgupta *et al,* 1972):

$$v = \{(1 - s)\, q\} / (r_s - s\, q) \; [\, 1 - \{(1 + s\, q)/(1 + r_s)\}^T ] \qquad (6.21)$$

where (T+1) is the time required by the suboptimal economy to reach the optimal stage (i.e. when savings become equally valuable as consumption). Whenever savings are suboptimal (i.e. marginal increase in savings generates a stream of future consumption whose present value after discounting is greater than the normal value of increase in savings), the value of savings (foregone consumption or reinvestment) can be converted to the present discounted value of a future consumption stream generated by that savings by using v.

Since the difference between consumption and savings is equivalent to the difference between consuming now and consuming later, the parameter v is used as an intertemporal impact weight on the grounds that the interests of future generations in terms of their consumption have to be ensured by promoting reinvestment. In other words, savings are at a premium with respect to consumption. Since capital is scarce in many DCs, including India, and a rupee invested today would yield more than enough one year from now to repay the cost of waiting until then to consume, savings are obviously preferable to consumption. The investigation of impacts of a project on savings and consumption is important not only for selecting between a labour intensive and capital intensive projects, but also for different alternative management options within a labour intensive project such as social forestry.

## 6.6 Socioeconomic impacts of labour employment

Not only is labour a comparatively abundant resource in rural India but also, as seen from Chapter 4, the labour inputs in social forestry are substantially higher than the capital resources. Therefore the proper allocation of labour resources is an important aspect of planning in social forestry, due also to its potential role in mitigating unemployment and underemployment in rural areas. In addition, while modelling the operation of labour in social forestry, specific features such as a high concentration of rural labour in the agriculture sector, availability of family labour and the dependency of non-earning members on the earning members of a rural household should be considered. Some of these aspects such as the opportunity cost of employing labour in social forestry (EWR) have already been discussed in the previous chapter. Socioeconomic impacts arising due to the employment of labour drawn from the groups at different consumption levels can now be included in the model.

Consider a rural representative household of n members at the poverty consumption level, out of which N members work h hours individually. The earnings made by these N working members is consumed by all the n members of the household such that the average consumption of the household members is $C_{pl} = O/n$, where O is the total output generated by N members. Then the social utility function of the household can be specified as:

$$U = U(C_{pl}) \qquad (6.22)$$

and the technology of production is given as:

$$O = f\ (L) \qquad (6.23)$$

where L (= Nh) represent the total working hours. Leisure is not included in the model (for reasons given in the previous chapter) and the availability of land and family size are treated as exogenous variables because it is shown in the previous chapter that social forestry draws labour mainly from the subsidiary workers who hardly own any land and are in fact largely agricultural labourers. The rural household will maximise the utility function (6.22) subject to (6.23). Therefore the shadow wage rate (SWR) of labour will be a function not only of the marginal productivity of labour but also of the following two additional terms which arise because of the increased consumption (i.e. the difference between the market wage rate and economic wage rate) accruing to the labourers employed in social forestry :

**a.** socioeconomic benefits for the labourers, arising from their increased consumption, and

**b.** socioeconomic costs which the government will bear since in the new situation the suboptimal economy (the government saving is at premium to consumption) is committed to the increased consumption.

Therefore, SWR = $f$ (EWR, socioeconomic benefits, socioeconomic cost)

Since the the socioeconomic benefits would be different for the workers at different consumption levels, so

Socioeconomic benefits = $f\ (l_1, l_2)$,

where, $l_1$ and $l_2$ are socioeconomic benefits arising due to the increased consumption from social forestry to the main and subsidiary workers respectively.

Determination of the proportions of the main and subsidiary workers and their incremental consumption due to social forestry is necessary in order to estimate socioeconomic impact weights. Depending on whether there is a marginal or non-marginal increase in consumption of the main and subsidiary workers, separate distributional impact weights need to be estimated for each group of workers.

## 6.7 Specification of the numeraire

Many elements of the unit of account or numeraire for measuring the socioeconomic values for evaluating social forestry have already been specified in the above formulation. Combining these elements together the numeraire for the purposes of this study is, "net present consumption benefits in the hands of a group of individuals at poverty consumption level in the private sector in terms of constant domestic accounting rupees" (Sharma and McGregor, 1989; Sharma *et al,* 1990c, 1990d). Defining a numeraire based on poverty consumption level means that the additional income going to a group of individuals at the poverty consumption level is as valuable to the government as the additional income going to the government itself. This implies that the government income can be added directly to appropriately valued private income in equivalent terms (i.e. Rupees worth - Rsw).

## Summary

A theoretical framework of social CBA is presented in this chapter in order to assess the socioeconomic impacts of social forestry on the groups of individuals at different consumption levels. Various models for estimating the different parameters such as the elasticity of marginal social utility of consumption, social discount rate, social value of public income and shadow wage rate are presented and underlying concepts discussed in order to carry out the socioeconomic evaluation of social forestry in the following chapter.

# Chapter 7

## Socioeconomic Evaluation of Social Forestry

This chapter will show how to assess and incorporate into the social forestry analysis the divergent socioeconomic impacts to groups of individuals at different levels of consumption, the theoretical justification and formulation of which were discussed in the previous chapter. Some socio-cultural aspects have already been considered, albeit implicitly, in that the species selected for the different components of social forestry in Orissa are multipurpose and widely acceptable, i.e. adapted to the socio-cultural environment, as well as being high yielding.

Other important socioeconomic aspects such as poverty, unemployment/underemployment, the consumption levels of different groups of individuals, and the distribution of forest produce among villagers through village-level organisations are accounted for in the analysis step by step. In order to achieve this, an objective estimation of the parameters (discussed in the previous chapter) will now be considered.

### 7.1 Estimation of the elasticity of marginal social utility of consumption ($e_u$)

The parameter $e_u$ can be estimated by using expression (6.8), and the estimates of the elasticities $e_p$ and $e_y$ can be obtained from the food demand model (6.10). To achieve this a time series (at 1970 prices) for GNP, total private consumption expenditure and private consumption expenditure on food items was compiled from NAS (UN, 1987) for the period 1970 to 1985 (Table 7.1). The per-capita GNP and food consumption expenditure over the period was calculated by dividing total GNP and food consumption expenditure by mid-year estimates of total population for the respective years. Since no wholesale price index for non-food ($P_2$) was available, a time series for index numbers (at base year 1970 = 100) of wholesale prices for food ($P_1$) and for all commodities ($P_a$) was built up from the various issues of the Monthly Abstracts of Statistics and the Statistical Abstracts published by Ministry of Planning, New Delhi (GOI, 1987a, 1987b).

The following expression was then used to estimate the ratio $P_1/P_2$ for each individual year :

$$P_a = w_1 P_1 + w_2 P_2$$

where $w_1$ and $w_2$ are the weights for price indices for food and non-food items respectively. Since $w_1 + w_2 = 1$, the above expression can be rewritten as:

$$P_1 / P_2 = (1 - w_1) / [(P_a/P_1) - w_1]$$

The value of $w_1$ (= 0.298) is taken from GOI (1987a) and the ratios $P_1 / P_2$ are calculated for each year by substituting the values of $P_a$ and $P_1$ for the respective years. A multiple regression analysis gave the following best fit for model (6.10) with t-values given in parentheses:

$$\log_e D = 30.6 + 1.24 \log_e Y - 0.171 \log_e (P_1/P_2) - 0.0167\,T$$
$$(3.48) \qquad (4.49) \qquad (-1.25) \qquad (-3.12)$$

Standard Error = 0.032 $\qquad$ $R^2$ = 74.5%

The value for $\Omega$ is approximately zero (0.01), therefore the elasticities of the food demand function $e_y$ and $e_p$ are approximately 1.24 and -0.171, respectively (Sharma *et al*, 1990b). This is because in the food demand function, $D = A\, Y^{e_y} (P_1/P_2)^{e_p}$, the income elasticity and price elasticity are equal to $e_y$ and $e_p$, but in the refined food demand function, $D = A\, Y^{e_y} (P_1/P_2)^{e_p} e^{\Omega T}$, the income elasticity and price elasticity are approximately $e_y$ and $e_p$, if $\Omega$ is a small number and after the normalisation of T.

The positive and negative values obtained for $e_y$ and $e_p$ respectively conform to consumer behaviour theory: as income increases, the demand for food is expected to increase (unless it is an inferior good), while as price increases, food demand is expected to decrease. The positive value of $e_p$ arrived by Kumar (1988) is puzzling because it contradicts the theory of consumer behaviour: his sources of data are different and he does not include a time variable in the model which is necessary while using time series data.

In order to estimate the compensated price elasticity, $e_p^*$, the proportion of food expenditure in the total expenditure ($\varnothing$) is needed. This was approximated by taking the mean of ratios of food consumption expenditure to total consumption expenditure for each year (1970 to 1985). The average value was found to be ø = 0.5787 (Table, 7.1). Putting the values of $e_y$, $e_p$, and ø in the Slutsky equation (6.9) gives an estimate of compensated price elasticity:

$$e_p^* = -0.1710 - 0.5787 \times 1.2400 = -0.8886$$

Since the increase in price has two effects (due to price increase *per se* and to inflation associated with price rises which effectively reduces income), the value of $e_p^*$ is found to be further negatively high (-0.8886) after removing the income effect from $e_p$ (-0.171). The elasticity of marginal social utility $e_u$ obtained from equation (6.8), by substituting in the values for $e_y$ and $e_p$, is thus estimated as -1.4.

The negative sign for $e_u$ was expected, as the marginal social utility of consumption decreases with increases in consumption - the principle of diminishing marginal utility of consumption. The value $e_u$ = -1.4 implies that the social significance of extra consumption would decline by 1.4 per cent with each 1 per cent increase in average consumption. A value of $e_u$ = 0 implies that the government is indifferent to the consumption of the groups at different consumption levels, a situation assumed in many conventional analyses: a negative value of $e_u$ indicates an egalitarian bias, the higher the values of $e_u$ the stronger the bias.

This estimated value of $e_u$ is consistent with a number of estimates: Squire and van der Tak (1975) and ODA (1988) suggest values ranging from -0.5 to -1.5 while Little and Mirrlees (1974) suggest a range from -1.0 to -3.0. Kula (1985) also observes, "In most food demand studies income and compensated price elasticities turn out to be very close figures and as a result $e_u$ takes a value around 1. Also price elasticity always becomes negative and income elasticity positive, which yields the right sign for $e_u$."

Lal (1972) calculated a value of -2.3 for $e_u$ based on old independent estimates of $e_y$ and $e_p$ from Rudra (1967). This value is thought to be rather high for two main reasons. Lal calculates the value of ø as 0.40 from cross sectional data for the year 1959-60. This value of ø is lower than that estimated here because of the age of the data used. It is obvious from equations (6.8) and (6.9) that $e_u$ will be comparatively larger in absolute terms. The value estimated for $e_u$ in this study is based on more recent data (1970 to 1985) which corresponds with the initiation of many anti-poverty programs which significantly increased people's consumption levels (GOI, 1985). This would also suggest that the value should be comparatively less.

The social utility and welfare functions formulated in the previous chapter can now be specified as:

$$U(C_i) = \{A/(1 - 1.4)\} C_i^{(1 - 1.4)} = A'C_i^{-0.4}$$

and, $$SWF(\underline{C}) = A' [\sum_{i=1}^{P} C_i^{-0.4} + \sum_{i=P+1}^{M} C_i^{-0.4}]$$

or $$SWF(\underline{C}) = A' [\sum_{i=1}^{m_1} C_i^{-0.4} + \sum_{i=m_1+1}^{m_2} C_i^{-0.4} + \ldots\ldots + \sum_{i=m_{12}+1}^{m_{13}} C_i^{-0.4}]$$

## 7.2 Estimation of the social discount rate

Social forestry systems are inherently long-term in nature. This means that discounting remotely accrued benefits at a high discount rate critically influences decisions regarding their development compared with other, short-term projects. At high discount rates, not only do social forestry projects perform unfavourably compared with short-term projects such as agriculture but also, within social forestry options, exploitative types of management alternatives may be selected (Sharma, 1988a). On the other hand, a low discount rate favours investments that enhance long-term productivity and development of forest systems (Kio, 1979; Leslie, 1987). Early foresters recommended a low DR, sometimes equivalent to the physical growth rate of a normal forest, or even in some cases a zero rate (Harou, 1985). However the use of a SDR, reflecting long-term social welfare, is now widely accepted as appropriate for evaluating social projects, including forestry, agroforestry and rural development.

The social time preference (STP) approach for estimating SDR has been the most favoured approach and is also suggested by many analysts of forestry and agroforestry (Price, 1988, 1989; Hoekstra, 1985, 1987; Harou, 1985; Kula, 1988; Sharma, 1988b). Feldstein (1964) and Marglin (1963) also argue that the relative weights which society places on consumption at different times in the future (the STP rate) should be used to evaluate public investments. The STP rate is the normative interest rate that represents government policy with respect to the desirability of consumption at different times. The CRI accounts for intertemporal consumption by determining the optimum overall rate of foregone current consumption.

An estimate of the growth rate of per-capita real consumption (based on the consumption function discussed in the previous chapter) is needed in order to estimate the SDR by using equation (6.14). A regression analysis of time-series data for C from 1970 to 1985 gives the following best fit:

$$\log_e C = -22.5 + 0.0146\,T$$

$$(-6.11) \qquad (7.84)$$

Standard Error = 0.034 $\qquad R^2 = 81.5\%$

The annual growth rate of per-capita real consumption (g) is therefore 1.46%.

The SDR can be calculated by substituting the previously calculated values of $e_u$ and g into equation (14):

$$SDR = (1 + 0.0146)^{1.4} - 1 = 0.0205$$

$$= 2.05\%$$

This estimate of SDR may be compared with estimates for other countries. Kula (1984, 1985) found that the SDRs for Canada, the USA and the UK were 4.4%, 4.3% and 1.5% respectively based on per-capita consumption growth rates of 2.8%, 2.3% and 2.0%. Scott (1977) estimated the SDR for the UK for the periods 1946-58 and 1959-74 as 2.42% and 3.20% respectively. However, Scott assumed a value of -1.5 for $e_u$ and estimated only the growth rate of the base income level which differs from the growth rate of per-capita real consumption used in this study.

The comparatively low value found in this study for India is a reflection of that country's extreme pressure of population on resources, natural resource scarcity and low levels of capital accumulation (Sharma *et al*, 1990b). If per-capita real consumption were to grow faster than the estimated 1.46%, the SDR would be higher, thus discounting the value of additional future consumption to a greater extent.

## 7.3 Consumption impact weights for the labourers in rural Orissa

The conventional approach to estimate consumption weights is to use the per-capita national income as a reference level. For instance, in 1987 the per-capita national income for India was Rs. 2932.59 (estimated by dividing the total national income by the total population for 1987). But since an average per-capita income hides the poverty of the rural poor (Pant, 1972), a better approach should be based on a measure of poverty. However, there are a number of different approaches for measuring poverty: one such approach is based on a basket of basic need goods of an average individual fixed on normative basis. The level of per-capita income is estimated corresponding to which expenditure on the specified basic need goods equals the worked out cost of the basket (at ruling market prices).

In another approach, the Indian Planning Commission has specified the poverty line in terms of the per capita consumption expenditure level which is required to achieve a fixed calorific intake level which is the minimum for survival. Based on an average calorie intake of 2800 per consumer unit per day (prescribed by the Indian Council of Medical Research), the poverty line was estimated to be Rs. 20.00 per month of expenditure at 1960-61 prices in rural India and Rs. 25.00 in urban India.

Another study (Bardhan, 1973) has estimated a lower value of the poverty line for rural India but it used a lower daily calorific intake of 2300 per consumer unit to arrive at lower figure for poverty line of Rs. 15.00 in rural India. The debate on measuring the poverty line and the number of people below it, based on the results of surveys carried by organisations such as the National Sample Survey Organisation (NSSO) and the National Council of Applied Economic Research, is highlighted by many writers (see Dandekar and Rath, 1971; Bardhan, 1974; Ahluwalia, 1978; Srinivasan, 1982; Lipton, 1983; Gopalan, 1983; Kakwani, 1986; Dandekar, 1988; Bhagawati, 1988).

To determine whether the increase in consumption levels of the subsidiary workers and main workers due to implementation of social forestry is marginal or non-marginal, it is necessary to estimate the consumption levels of different categories of workers in situations with and without social forestry project. According to Key Population Statistics-series I (GOI, 1983) the total population of workers (based on a 5% sample) in rural Orissa was 9.047 M, while that of non-workers was 14.213 M. This gives a dependency ratio of non-workers to workers as 1.57 to 1 which means that the wages earned by an average worker are shared by 2.57 persons.

Since the ratio of subsidiary labour days to main labour days is 11.82 (calculated in the previous chapter), for every labour day required in social forestry, 1/12.82 (=0.078) labour days will be drawn from the main workers and the remaining 11.82/12.82

(=0.922) labour days will be drawn from subsidiary workers. These results are plausible on the grounds that not only is social forestry being implemented for the betterment of the poor, but also in practice labour will be largely available from the unemployed and underemployed villagers who are available and seeking work.

Table 7.3 gives the average wages earned by different categories of workers with and without a social forestry (rows 1, 7 and 4 are taken from Table 5.7 and the calculations for the remaining rows are explained below). The per-capita average weekly wages for different categories of workers have been calculated by dividing the average weekly wages per worker by 2.57 (because the wages of a worker are shared among 2.57 persons). These figures have been converted into annual average per-capita wages by multiplying by 52 (assuming 1 year = 52 weeks approximately). The implementation of social forestry increases equivalent weekly labour days to 3.2015 and 0.1246 of an average subsidiary worker and main worker respectively (Table, 7.2); if the workers are treated as homogeneous, the corresponding increase is 0.511 labour days (shown in the last column of Table, 7.3).

Since the per-capita consumption increase in the household of a subsidiary worker is 3.2015 for every 5.1455 days in employment, the increase in consumption for 0.922 labour days (estimated earlier) is 0.5737w [={(0.922 x 3.2015)/5.1455}w]. Similarly the per-capita increase in consumption of the household of main workers is 0.0014w [= {(0.078 x 0.1246)/6.8509}w]. This implies that the increase in consumption of the members of a subsidiary worker's household is substantial rather than marginal (more than half the daily wage) while in the case of the main workers the increase is only marginal.

This is a plausible result because the wage income from social forestry going to members of the households of subsidiary workers is a major source of their income and is used to buy basic commodities. If the workers are treated as homogeneous, the per-capita increase in consumption of the members of an average worker's household is 0.077w [=(0.5107 / 6.6369)w]. Since this is only a marginal increase, the assumption that the workers' population is homogeneous is not plausible, because it hides the magnitude of difference with respect to consumption levels, poverty and unemployment. By adding the increases in per capita consumption of members of the subsidiary and main worker's household a value of 0.5751w is obtained which is significantly different from the 0.077w.

Panda (1987) has recently estimated the per capita poverty consumption level ($C_{pl}$) for rural Orissa in the year 1970-71 as Rs 31.27 and 22.90 monthly (for daily calorie intakes of 2800 and 2300 per consumer unit respectively) by using estimates of consumption expenditure for the year 1971-72 available from the NSSO reports. Unfortunately Panda does not give the distribution of persons by consumer expenditure classes. However, NSSO (1968) reports include the distribution of population in rural Orissa by monthly consumption expenditure (Table, 7.2) and these have been updated and used to estimate the consumption weights for the different groups of individuals.

The consumption expenditure data are updated to the reference year 1970-71 (with respect to two base years, 1961 and 1963) by using the general consumer price indices for agricultural labourers in Orissa. The consumption weights (applicable for a marginal increase in consumption) for all thirteen groups of individuals calculated using equation (6.16) and are presented in Table 7.3. The use of rather old consumption expenditure data will not affect the final results significantly because the ratios $C_{pl}/C_i$ are calculated .

To keep the analysis within manageable limits it was decided to use only one set of weights. The weights calculated with a daily calorie intake of 2800 per consumer unit are preferable because this is the nationally accepted norm and is used in many government documents such as Five Year Plans. The consumption weights with respect to the base year 1963 are preferred (admittedly with slight error) because they give consistent results when compared with recent trends in percentage of people living below the poverty line (i.e. 40.6% at 1963 as the base year, as against 66.95% calculated with 1961 as base year): The seventh FYP (1985-90) gives the percentage of population living below the poverty line as 40.4% for the year 1983-84 and the projected figures for the year 1989-90 are 28.2%. As evident from Table 7.2, the four bottom groups are below the poverty consumption level and the remaining nine above it. The calculated values for the weighted average consumption weights for the entire society (1.005), groups of individuals at or below the poverty consumption, and above the poverty consumption level (0.57) are presented in Table 7.2.

The poverty consumption level in rural Orissa (Rs. 89.24) given by Panda (1987) for the year 1983, is updated for the year 1987 by using the general consumer price index for agricultural labourers in Orissa (GOI, 1988) as follows:

Consumption expenditure (1987), $C_{pl}$ = Rs. 95.88 monthly

= Rs. 1150.56 per year

The annual per-capita consumption of the members of a main worker's household with and without social forestry (Table, 7.2) is Rs. 1360.32 (=136.032w) and Rs. 1385.64 (= 138.564w) which means that not only is the per-capita increase in consumption marginal but also the initial consumption level of the members of a main worker's household is well above the poverty consumption level. Therefore a weight of 0.57 calculated by expression (6.16) is used for the main workers.

The consumption impact weight for subsidiary workers is calculated using expression (6.17) which is applicable for a non-marginal increase in consumption (**w** = Rs. 10.00):

$$d = \frac{(104.068 \times 10.00)^{1-1.4} - (39.312 \times 10.00)^{1-1.4}}{(1-1.4)\ (1150.56)^{-1.4}\ (104.068 \times 10.00 - 39.312 \times 10.00)}$$

$$= 2.2014$$

Since the term $(C_{i2}-C_{i1})$ occurs in the denominator of the expression (6.17), a comparison of formulae 6.16 and 6.17 for the consumption impact weights for marginal and non-marginal increases in consumption respectively shows that the weights in the former would be slightly lower than in the latter. This is because the latter takes into account the initial consumption level (i.e. without social forestry) of the workers.

## 7.4 Savings (intertemporal consumption) impact weight

A value of 6.93 is derived by putting the previously calculated values of **q** and $r_s$ in the expression (6.20) for **v** which is applicable when there is no saving (i.e. **s** = 0) because reinvestment is nil. If $q = r_s$ then from (6.20) $v = 1$, implying that the additional consumption benefits produced in a year's time would be exactly offset by the cost of waiting for it thereby leaving no premium on investments. Because there are generally some savings, (6.21) is the relevant expression for estimating **v** [note that in this case study $s\ q\ (\approx 0.3) > r_s\ (= 0.025)$] and the calculated value of **v** is:

$$v = \frac{(0.142 - 0.211 \times 0.142)}{(0.0205 - 0.211 \times 0.142)} \times [1 - \{(1 + 0.211 \times 0.142)\ /\ (1 + 0.0205)\}^{49}]$$

$$= 6.77$$

where (T+1) = 50 years, as suggested by Lal (1980). This figure is very close to the value of **v** calculated above and is used in further analysis.

Since the calculated value of **v** is high, the social value of public income is also high.

This means that the opportunity cost of investment drawn from government funds to implement social forestry is high, due mainly to the suboptimality of government investments. This implies that some of the increases in present value of the benefits from social forestry gained by using a low SDR will be offset by increases in the present value of costs incurred in establishing the social forestry plantations (see Tables 7.7, 7.8, 7.11, 7.14, 7.15, 7.18, 7.19, 7.20). The main purpose of incorporating an intertemporal criterion in terms of the parameter **v** is to prevent bias in favour of short-lived and non-durable investments which may be introduced by conventional criteria in situations where the government's marginal time preference with respect to consumption is less than the marginal productivity of capital (Dasgupta *et al*, 1972).

## 7.5 Combined distributional impact weights

The following two case studies illustrate that the combined distributional impact weights depend on whether the investment in social forestry is made from the Forest or Rural Development Department funds.

**Case I:** The main source of investment funds in social forestry is from the Forest Department. In this situation, had the social forestry not been implemented, the funds, like any other government investments, would have been invested elsewhere in the economy, yielding some level of return. As a result, the combined distributional impact weight for society's consumption losses is 6.77 x 1.005 and those for the consumption gains of main workers and subsidiary workers are 1 x 0.57 and 1 x 2.20 respectively (Table, 7.4).

**Case II:** In this case nearly 25% of the total outlay for rural development programmes is allocated for social forestry (Khan, 1987). The investment funds used in social forestry are obtained by reducing consumption expenditure in rural development programmes such as 'Food for Work', National Employment Guarantee Programme (RLEGP), National Rural Employment Programmes (NREP), etc. This means that the intertemporal consumption weight (v) of these funds will be unity because there will be no impact on savings. The combined distributional impact weight for society's consumption losses is 1 x 1.005 and those for the consumption gains of main workers and subsidiary workers are 1 x 0.57 and 1 x 2.20 respectively (Table, 7.4).

The socioeconomic cost of investment funds in Case II is thus significantly less than in Case I and hence the socioeconomic profitability of social forestry would be significantly higher in Case II. The following socioeconomic analysis is limited to the more general Case I only, although to test the results a component will be evaluated for Case II as well.

## 7.6 Shadow wage rate (SWR) of labour

The market wage rate may fail to measure the social cost of labour for the following reasons:

**a.** Labour may not be allocated according to the principles of competitive markets, especially in the traditional sectors of the economy such as forestry, fishing and agriculture. As a result, there may be a gap between the current wage rate and the marginal productivity or the opportunity cost of capital (discussed in Chapter 6).

**b.** The expansion in public sector employment results in a transfer of income from government to labourers. This means that investment is reduced as consumption increases, and since the shadow price of investment exceeds unity an indirect cost is incurred due to this transfer which should be added to the marginal productivity of labour when estimating SWR.

**c.** The result of the transfer of income from government to the labourers is two fold: the present consumption of the labourers usually increases because of the increase in their wages and their future consumption is reduced due to the reduction in the rate of investment.

No single value for SWR is estimated in this study, because its estimate will depend on the category of workers concerned. All the aspects discussed above are accounted for while estimating the socioeconomic costs and benefits of social forestry by applying the distributional consumption impact weights to different categories of workers and society. This is particularly helpful in evaluating the impacts of social forestry on the consumption of specific groups of workers as shown below.

## 7.7 Socioeconomic costs

There are two components of the socioeconomic costs to society. The first is the societal consumption loss experienced due to the economic costs of social forestry and the second is the cost resulting from the consumption loss to which the economy is committed. This latter loss is due to the increased consumption by workers, because their marginal productivity of labour is less than the market wage rate. However, raising the consumption level of the workers is a desirable effect and an objective of social forestry. Therefore, the socioeconomic benefits accruing to both the main and subsidiary workers, due to their increased consumption levels should be subtracted from the total socioeconomic costs to arrive at the net socioeconomic costs to society.

## 7.8 Socioeconomic benefits

The socioeconomic benefits of social forestry will depend on how its production is shared between the people and the Forest Department. In Orissa, it is intended that the entire production from social forestry will be distributed among the associated households for their consumption, under the supervision of a Village Forest Committee (which includes villagers' representatives and members of the staff) . As there is no reinvestment into the economy through the Forest Department in this case, the intertemporal consumption or savings impact weight would be unity (as the entire production or income is consumed). In addition, the produce from social forestry may be distributed to any of the following three categories; society in general, the main workers or the subsidiary workers.

Since social forestry is being implemented mainly for the betterment of the poor, it is plausible to assume that the produce will be shared by subsidiary workers who also provide a major share of labour for carrying out plantation activities (of each labour day required in social forestry, 0.92 labour days is drawn from the subsidiary workers). So the combined distributional impact weight 1 x 2.204 is applied to the benefit stream (referred to as Version I in the tables).

However, if a portion of the produce from social forestry is shared by the Forest Department as revenue (as in some States such as Uttar Pradesh and Tamil Nadu) the intertemporal consumption weight would be 6.77. Although this type of sharing of forest produce is not being practised in Orissa at present, it could be expected in the near future as the economic condition of the rural poor becomes better off. Therefore, to examine how the socioeconomic profitability of social forestry will be affected in this case, an analysis (referred as Version II in the tables) has been carried out for a management alternative in which 70% of the total produce from social forestry is distributed among the subsidiary workers for their consumption, and the income derived from the remaining 30% produce goes to the Forest Department as revenue. The combined distributional weight applicable for the 70% of the benefits going to the subsidiary workers would be 1 x 2.204 and that for the remaining 30% as 6.804 (=6.77 x 1.005) because this income as a revenue from the Forest Department would be ultimately reinvested in the general economy, thereby yielding returns.

Two management options have been analysed here but there could also be a case where only a part (say **s**) of the 30% income, going to the general economy through the Forest Department, is reinvested and the remaining (1-**s**) is consumed. In this case the social value of a unit (monetary) of public income is:

$$\mathbf{s\ v + (1 - s)} = (0.211 \times 6.77) + (1 - 0.211)$$
$$= 2.22$$

and therefore the combined distributional impact weight is 2.23 (=2.22 x 1.005).

## 7.9 Socioeconomic evaluation of agroforestry

The socioeconomic benefits from the agroforestry system with and without a first generation coppice crop (as described in Chapter 4) are shown in Tables 7.5 and 7.6 respectively for both Versions I and II. The socioeconomic costs of carrying out different operations for establishing the agroforestry are worked out by applying the previously estimated combined distributional impact weights based on the number of labour days drawn from the main and subsidiary workers (Tables 7.7 and 7.8).

For example, in the preplanting year, the economic costs of the goods is Rs. 770.00 (column 4) which is multiplied by the combined distributional impact weight applicable for society (=6.804) to arrive at their socioeconomic costs (column 11). As the main and subsidiary workers are employed in the proportion of 0.078 : 0.922, the economic costs of carrying out each planting operation are calculated (with EWR = 0.33w) in column 5 with respect to both the main and subsidiary workers. The socioeconomic costs of the loss in society's consumption arising from the economic cost of agroforestry is shown in column 6 (columns 4 x 5). The additional socioeconomic cost of the loss in society's consumption, arising because of extra-commitment to the economy due to the increased consumption of the main and subsidiary workers, is estimated in column 7 [column 5 x (column 3 - column 4)]; the total socioeconomic cost to society is obtained in column 8 by adding values in columns 6 and 7.

The socioeconomic benefits to the main and subsidiary workers arising due to their increased consumption calculated in column 10 [column 9 x (column 3 - column 4)] are then subtracted from the total socioeconomic costs to society in order to arrive at the net socioeconomic costs to society in column 11 (column 8 - column 10).

The computer program was modified (Appendix, 7.1) to compute the socioeconomic analysis for a number of feasible management options (with a range of tree rotations from 5 to 20 years) in Case I for SQ's I, II and III. The values calculated for the socioeconomic PNW and LEV (in Rupees worth, Rsw) for agroforestry with and without a first generation coppice crop are presented in the Tables 7.9 and 7.10 respectively (the underlined values correspond to the optimum tree rotations). In SQ I and II the values for socioeconomic PNW and LEV are high, while in SQ III they are negative (except at higher rotations in Version II). However, if investments are made from the Rural Development Department by diverting consumption oriented funds (Case II), the socioeconomic costs are substantially less (Table 7.7.1), thereby giving positive values for PNW and LEV in SQ III as well (see Table 7.9.1).

Based on the PNW criterion the socioeconomic optimum tree rotations for agroforestry (maiden crop) in SQ I and II are 17 and 18 years respectively for Version I, decreasing to 8 and 17 years based on the LEV criterion. Results in version II are the same except that at higher tree rotations positive values of PNW and LEV are obtained in SQ III. In the case of agroforestry in SQ I with a first generation coppice crop, based on both PNW and LEV criteria, the optimum tree rotation in Versions I and II is 10+10 years (10 years for the maiden crop, followed by 10 years for the first generation coppice crop). In SQ II none of the management options considered is feasible in Version I, while in Version II the optimum tree rotation is again 10+10 years.

Since the adverse impact of discounting on the remotely accrued benefits is comparatively reduced by using a low discount rate (such as a SDR =2.05%) the PNW and LEV keep on rising with increases in the mean annual increment (in volume of the tree species) and attain maximum values towards the end of the silviculturally feasible rotation. In general, although the tree rotation is found invariant with Version I and II, the socioeconomic benefits are larger in Version II because of the benefits arising due to reinvestment of 30% of the income from social forestry produce.

## 7.10 Socioeconomic evaluation of dense plantations

The socioeconomic costs of establishing dense plantations of the *Eucalypus hybrid*, coppicing and cultural operations, are shown in Tables 7.11 and 7.8 respectively. The socioeconomic benefits for the dense plantations are the same as those given in Table 7.5 and the computed values of the socioeconomic PNW and LEV with and without first generation coppice crop in SQ I, II and III are presented in Tables 7.12 and 7.13 respectively.

For dense plantations (maiden crop) in SQ I and II , the socioeconomic optimum tree rotations in both Version I and II are 17 and 20 years respectively based on PNW criterion, decreasing to 9 and 16 years in Version I and 9 and 14 years in Version II, based on LEV criterion. In SQ III none of the considered management options is feasible because the PNW and LEV are negative. In the case of dense plantations with a first generation coppice crop, the optimum tree rotation is 7+7 years in SQ I based on PNW and LEV criteria and both Version I and II, while in SQ II the values of PNW and LEV are negative.

## 7.11 Socioeconomic evaluation of institutional plantations

The PNW and LEV were calculated for a range of management options (Table 7.17) based on the socioeconomic costs and benefits of institutional plantations of *Acacia nilotica* calculated in Tables 7.14, 7.15 and 7.16. The socioeconomic optimum rotation in Version I is 25 years (with intermediate thinnings every five years) for SQ's I, II and III based on the PNW criterion, while the LEV criterion shows optimum rotations of 15, 20 and 25 years for SQ's I, II and III respectively (all with intermediate thinnings every five years). Similar results are obtained in Version II, except that a rotation of 15 years is optimal in SQ II based on the LEV criterion.

## 7.12 Socioeconomic evaluation of village woodlots

The socioeconomic costs of establishment and thinnings of village woodlots of *Dalbergia sissoo* are calculated in Tables 7.18 and 7.19 respectively, while the socioeconomic benefts are calculated in Table 7.20. The computed figures for PNW and LEV for a range of management options in SQ's I, II and III are shown in Table 7.22. For both Version I and II, the socioeconomic optimum tree rotation is 40 years in SQ's I and II, based on both PNW and LEV criteria, while in SQ III the same optimum rotation is suggested by PNW but 20 years by the LEV criterion (all with intermediate thinnings at every 10 years).

## 7.13 Socioeconomic evaluation of rehabilitation and strip plantations

The socioeconomic costs for this component of social forestry are the same as those calculated for institutional plantations and the benefts are presented in Table 7.23. The computed values of PNW and LEV are shown in Table 7.24. The only feasible optimum tree rotation based on both PNW and LEV criteria is 18 years in Version II, while in Version I the values of PNW and LEV are negative for all the tree rotations considered.

## 7.14 A comparison of the components of social forestry

It is clear from the Tables 7.9 , 7.10, 7.12 and 7.13 that the net socioeconomic benefits for SQ I (both Versions) and in SQ II and III (Version II) are substantially higher in the agroforestry options than in the dense plantation component of social forestry. This result conforms with the findings of the financial and economic analyses carried out in Chapters 4 and 5 respectively. However a different result is found for Version I in SQ II and III where the net socioeconomic benefits are comparatively less in agroforestry than in the dense plantations. This is caused by the higher socioeconomic costs incurred in the agroforestry system than in the dense plantations (i.e. additional input and operational costs due to the agricultural component) and the socioeconomic benefits for Version I in SQ II and III are not adequate enough to compensate for this additional loss.

In Version II, the benefits arising from the reinvestment of part of the income (30% of total income, income derived from produce) compensates for the higher costs in agroforestry thereby resulting in higher values of PNW and LEV (Sharma *et al* , 1990d). In SQ III , where neither agroforestry nor dense plantations are found viable from the socioeconomic point of view, investment should be made by diverting consumption oriented funds under rural development programmes such as RLEGP and NREP (as in Case II).

## 7.15 A comparison among financial, economic and socioeconomic evaluations of social forestry

The results for financial, economic and socioeconomic optimal tree rotations under the different components of social forestry, obtained in this Chapter and in Chapters 4 and 5 are summarised in the following Table 7.25. It is clear from this table that the socioeconomic optimum tree rotation is generally longer than the financial or economic optima due to the lower discount rate used (SDR = 2.05%).

**Table 7.25 Summary of the optimal tree rotations for social forestry**

| Component | Analysis | Optimal tree rotation (years) based on the criteria | | | | | |
|---|---|---|---|---|---|---|---|
| | | PNW | | | LEV | | |
| | | SQ I | SQ II | SQ III | SQ I | SQII | SQIII |
| Agroforestry (without coppice) | Financial @7% | 11 | 13 | 15 | 6 | 9 | 13 |
| | @10% | 9 | 12 | 13 | 6 | 8 | 13 |
| | Economic @$(EWR)_1$ | 8 | 9 | 13 | 5 | 5 | 13 |
| | @$(EWR)_2$ | 8 | 9 | _ | 5 | 5 | _ |
| | Socioeconomic -Version I | 17 | 18 | _ | 8 | 17 | _ |
| | Socioeconomic -Version II | 17 | 18 | 20 | 7 | 12 | 20 |
| Agroforestry (with coppice crop) | Financial @7% | 9+9 | 10+10 | _ | 6+6 | 9+9 | _ |
| | @10% | 8+8 | 10+10 | _ | 5+5 | 8+8 | _ |
| | Economic @$(EWR)_1$ | 7+7 | 8+8 | _ | 5+5 | 5+5 | _ |
| | @$(EWR)_2$ | 7+7 | 8+8 | _ | 5+5 | 7+7 | _ |
| | Socioeconomic -Version I | 10+10 | __ | _ | 7+7 | _ | _ |
| | Socioeconomic -Version II | 10+10 | 10+10 | _ | 7+7 | 10+10 | _ |
| Dense plantations (without coppice crop) | Financial @7% | 11 | 13 | _ | 7 | 12 | _ |
| | @10% | 9 | 12 | _ | 6 | 12 | _ |
| | Economic @$(EWR)_1$ | 8 | 12 | _ | 6 | 12 | _ |
| | @$(EWR)_2$ | 8 | 12 | _ | 6 | 12 | _ |
| | Socioeconomic -Version I | 17 | 20 | _ | 9 | 16 | _ |
| | Socioeconomic -Version II | 17 | 20 | 20 | 8 | 14 | 20 |
| Dense plantations (with coppice crop) | Financial @7% | 9+9 | _ | _ | 6+6 | _ | _ |
| | @10% | 8+8 | _ | _ | 6+6 | _ | _ |
| | Economic @$(EWR)_1$ | 7+7 | 8+8 | _ | 5+5 | 8+8 | _ |
| | @$(EWR)_2$ | 7+7 | _ | _ | 6+6 | _ | _ |
| | Socioeconomic -Version I | 10+10 | _ | _ | 7+7 | _ | _ |
| | Socioeconomic -Version II | 10+10 | _ | _ | 7+7 | _ | _ |
| Institutional plantations | Financial @7% | 15 | 15 | 25 | 10 | 15 | 25 |
| | @10% | 10 | 15 | _ | 10 | 15 | _ |
| | Economic @$(EWR)_1$ | 10 | 15 | _ | 10 | 15 | _ |
| | @$(EWR)_2$ | 10 | 15 | _ | 10 | 15 | _ |
| | Socioeconomic -Version I | 25 | 25 | 25 | 15 | 20 | 25 |
| | Socioeconomic -Version II | 25 | 25 | 25 | 15 | 15 | 25 |
| Village woodlots | Financial @7% | 40 | 40 | 15+15 | 30 | 40 | 20 |
| | @10% | 30 | 40 | 15+15 | 30 | 40 | 15+15 |
| | Economic @$(EWR)_1$ | 30 | 40 | 15+15 | 30 | 20 | 15+15 |
| | @$(EWR)_2$ | 30 | 20 | 15+15 | 30 | 20 | 15+15 |
| | Socioeconomic -Version I | 40 | 40 | 40 | 40 | 40 | 20 |
| | Socioeconomic -Version II | 40 | 40 | 40 | 40 | 40 | 20 |
| Rehabilitation and strip plantations | Financial @7% | NA | _ | NA | NA | _ | NA |
| | @10% | " | _ | " | " | _ | " |
| | Economic @$(EWR)_1$ | " | 7 | " | " | 7 | " |
| | @$(EWR)_2$ | " | _ | " | " | _ | " |
| | Socioeconomic -Version I | " | _ | " | " | _ | " |
| | Socioeconomic -Version II | " | 18 | " | " | 18 | " |

The socioeconomic analysis not only avoids adopting exploitative types of management options, but also takes into account the sustainability aspect of social forestry systems (Sharma and McGregor, 1989). The analysis carried out in this chapter has also shown that the net socioeconomic gains are heavily dependent on the source of investment funds for social forestry and also on the mode of distribution of produce (or income) between the villagers and the Forest Department resulting from a high value of **v** (=6.77).

## Summary

Social forestry should be evaluated within the framework of its stated objectives, because in many situations the social objectives of the policy are as equally important as the economic objectives. To achieve this the various parameters should be estimated objectively in order to carry out the socioeconomic analysis within the theoretical framework presented in Chapter 6. The net socioeconomic benefits from social forestry are substantial, especially in SQ I, and the socioeconomic optimum tree rotation is usually longer than financial or economic optimum tree rotations, due to the lower social discount rate used. In SQ III, where many mangement options are not viable, investment in social forestry should be made by diverting consumption oriented funds from the Rural Development Department (Case II) under programmes such as 'Food for Work', NREP and RLEGP.

Having incorporated the relevant socioeconomic aspects of social forestry policy into the analysis, the results for alternative management options considered under the different components of social forestry should be integrated by developing an optimal plan for a management unit consisting of a group of villages. Such a plan will fulfil the villagers' consumption needs for produce obtained from social forestry within the constraints of the available resources. To achieve this objective, a mathematical model is developed in Chapter 8, the use of which is illustrated in Chapter 9.

# Chapter 8

## A Mathematical Model for Multiple Objective Planning in Social Forestry.

Development of a suitable mathematical model should be preceded by a system analysis. This is necessary to define and critically examine the relevant issues concerning the problem at hand. It is at this stage that a system analyst becomes aware of all the objectives and limitations of the analysis. In addition, post optimal and sensitivity analyses are needed to ensure stability and robustness of the solution arrived at. Post optimal analysis can also provide dynamism to the model and further improvements can be incorporated in the light of new experiences gained during the implementation stage. This is important since social forestry systems are characterised by their dynamic nature due mainly to the villagers being a part of the system. Many management options can fulfil the desired goals including trade off between the conflicting goals. The suitability of the main programming techniques available is discussed bearing in mind the socioeconomic environment of social forestry and a suitable mathematical model is developed for socioeconomic planning in social forestry, the application of which is illustrated in the following chapter.

### 8.1 Mathematical models in forestry

Mathematical models have been used in forest management since the early 1970's. The most widely used form of programming has been LP (Bare, 1971; Bell,1977). Standard models, such as Timber RAM (Navon, 1971) and MAX-MILLON (Ware and Clutter, 1971) developed in USA, have found wide applications. Of increasing interest has been the application of goal programming to forestry problems (Field, 1973; Rustogi, 1973; Dane *et al.* 1977; Field *et al.* 1980; Hotvedt *et al.* 1982; Arp and Lavigne, 1982; Allen, 1986; Mendoza *et al.* 1987; Sankhya *et al.* 1989). However, these applications have generally been concerned with scheduling of operations and timber harvesting. Specifically they include stand development, growth , yield, harvesting, transportation, logging, recreation and meeting industrial demands for timber. Socioeconomic aspects such as social welfare, employment and income generation, and meeting subsistence needs for staple food, fuelwood and small timber have been either ignored or treated as residuals with minor importance. The reason for such a gap can be traced, not to the inappropriateness of these techniques, but to the fact that most of these studies were carried out in developed countries where production objectives, and sometimes recreation also, are the only important aims of forest management.

Mgeni's (1986) study, modelling an industrial forestry project in Tanzania, includes social welfare criterion in a LP model. However, this study emphasised savings rather than consumption - a better indicator of social welfare in a subsistence economy. Recent international interest in agroforestry has led to the development of some multiple objectives studies for agroforestry (Etherington and Mathews 1983; Mendoza, 1987). A major limitation of these studies is that they do not include a social welfare criterion and instead of developing an appropriate mathematical model, the management environment has oftenly been simplified to fit the model.

## 8.2 Multiobjective programming techniques

In general, a mathematical programming involves optimisation of some particular objective by placing specified restraints on resources allocated to alternative management strategies. Expressed mathematically,

$$\text{Optimise} \quad Z = f(\underline{x}) \qquad (8.1)$$

subject to,

$$h_i(\underline{x}) = 0 \qquad (i = 1,2,\text{--------},m)$$

where f and $h_i$ are real valued functions and x is a n-dimensional vector, i.e.

$$\underline{x} = (x_1, x_2, \text{--------} x_n)$$

which belongs to a n-dimensional real space (i.e. $\underline{x} \, E \, R^n$).

The solution to this optimisation problem can be written as a set,

$$X = [\, \underline{x} : g_1(\underline{x}) = g_2(\underline{x}) = \text{-------} = g_m(\underline{x}) = 0 \,] \qquad (8.2)$$

The domain of the solution set X is determined by physical, economic, social and technological considerations.

When the functions f and $h_i$ are linear in x, the model is known as a LP model and can be expressed as :

$$\text{Optimise} \quad Z = \underline{c}\,\underline{x} \qquad (8.3)$$

subject to,

$$A\,\underline{x} \leq \text{ or } \geq \underline{B}$$

$$\underline{x} \geq \underline{0}$$

where $\underline{c}$ is an n-dimensional row vector of values, A is an m x n matrix of technological relationships and $\underline{B}$ is an m-dimensional column vector of inputs specifying the feasibility region of x.

The models as described by equations (8.1) and (8.3) are only appropriate for handling problems having a single objective function. A general multiobjective model having following $l$ number of objective functions,

$$f_1(\underline{x}),\ f_2(\underline{x}),\ \text{------------}\ ,f_l(\underline{x})$$

can be expressed as :

$$\text{Optimise} \quad Z = f_1(\underline{x}),\ f_2(\underline{x}),\text{----------},\ f_l(\underline{x}) \qquad (8.4)$$

$$\text{subject to} \quad \underline{x}\,E\ X.$$

where Z is an aggregate of functions, $f_1(\underline{x})$, $f_2(\underline{x})$, ----------------, $fl(\underline{x})$ to be optimised. The following discussion will sumarise the main variations of this general multiobjective formulation.

### 8.2.1 Generating techniques

Generating techniques do not rely on the decision-maker's preferences, rather the decision-maker is provided with a range of management strategies represented by the non-dominated set. The main problem with the multiobjective formulations (8.4) is the aggregation of all objective functions. This is particularly difficult in those cases which have contradictory and non-commensurable objectives. For example, production of fuelwood may not be compatible with timber production and the aggregation of objectives such as staple food in quintals (qtl), small timber in $m^3$ and employment in worker days is not possible.

To overcome this problem a linear formulation of the general multiobjective problem can be obtained by combining various objectives into one overall objective function by assigning weights to each objective function. A solution to this single objective problem can then be obtained by standard LP solution algorithms such as the Simplex method. However, a drawback with this technique is that it may give an optimum value for the aggregated single objective function in which some of the goals may finally take a zero level of achievement. For example, in social forestry the single objective of maximising net profits may be fulfilled even without assigning values to its other objectives such as employment generation or production of fuelwood and small timber.

The constraint method optimises one objective while all other objectives are treated as constraints. The procedure determines minimum or maximum values for those objectives which are treated as constraints. This reduces a multiobjective problem into a single objective formulation which can then be solved by LP algorithms. The shadow prices of those objectives which are not optimised, will indicate the rate and limit of trade off between the optimised and other objectives. This process can be repeated for each of the objective functions treating remaining objectives as constraints.

The main advantages of the generating techniques :

**a.** They are basically used for generation and evaluation of management strategies rather than for prediction.

**b.** Less information is needed from the decision-maker, therefore accessibility of the decision-maker does not hinder the usefulness of the technique.

**c.** The generation of many management alternatives may aid conflict resolution.

The main disadvantages of the generating techniques are:

**a.** It may be difficult to decide which of the several objectives are fulfilled in different strategies when so many management alternatives are presented to the decision-maker.

**b.** There are situations when some of the activities may take a zero or a very high level. This problem can be overcome by assigning lower and upper bounds for the objectives to be maximised and minimised respectively. Fixing these targets may however be difficult because in order to ensure feasibility, these bounds may be fixed at a very conservative level which may not be helpful in the decision-making process.

**c.** Only part of the problem might be solved in situations where there are many conflicting decision-makers.

**d.** Computational burden is high, and interpretation becomes difficult, with more than three objectives.

**e.** The techniques are not truely multiobjective but rather single-objective with associated constraints.

### 8.2.2 Techniques based on prior articulation of preferences

These techniques rely on the explicit statement of preferences by the decision-maker prior to the solution of the multiobjective problem. The best compromise solution is then obtained without generating the non-inferior set. There are many methodological approaches but those which have been widely reported in the literature include ELECTRE method, compromise programming, surrogate worth trade off method and goal programming.

#### 8.2.2.1 ELECTRE method

There are two versions of this method, ELECTRE I and II. ELECTRE I aims at achieving those management options that are preferred for most of the criteria and do not cause an unacceptable level of preference loss. This is achieved by narrowing down the alternatives into three categories : those that can be accepted, those that can be eliminated and those that require more information.

The final result of ELECTRE I is presented in a form of preference graph which gives a partial ordering of the management alternatives. Therefore ELECTRE I is suitable for the elimination of management alternatives at the feasibility stage. This leaves the decision-maker with a limited number of management alternatives but this method does not provide a single best alternative.

However, ELECTRE II, which relies on two preference graphs obtained from ELECTRE I, achieves a single best alternative. The two graphs, called strong and weak preference graphs, reflect the upper and lower bounds of the systems performance which are acceptable to the decision-maker. Gershon *et al* (1982) describe the algorithm for ordering systems resulting from these preference graphs.

Cohen and Marks (1975) have pointed out the failures of the ELECTRE I method in providing opportunity cost information and measuring alternatives by comparative value. They have also highlighted the problem of getting a large number of value judgments from decision makers and getting them to agree on these. The technique is more suited to comparisons of discrete alternatives rather than to generate a range of alternatives.

#### 8.2.2.2 Compromise programming

Compromise programming initially starts by solving a number of single-objective linear programmes in which each objective is optimised separately subject to the constraints. Since achievement of this ideal point is infeasible, the compromise solution is obtained by minimising the deviations from the ideal point. The MINISUM approach achieves this by minimising the weighted sum of the fractional deviations from the ideal point. Another compromise approach achieves this by minimising percentage deviations from the ideal point (Dallenbach *et al*, 1983).

#### 8.2.2.3 Surrogate worth trade off method

This method assesses the relative trade off between the objectives by use of following trade off functions :

$$T_{ij} = d\ f_i(x)\ /\ d\ f_j(x)$$

where, $T_{ij}$ is the trade off function between the objective functions 'i' and 'j'. An important advantage of this method is its ability of transferring non-commensurable units by use of surrogate worth functions. These are functions of the trade off between objectives which estimate the desirability of one objective over other. Having developed the trade off functions, the set of feasible solutions is reduced by considering only non-inferior solutions. An optimal solution is any non-inferior solution that belongs to the indifference frontier and the point at which all trade offs are selected to make all surrogate functions equal to zero. The solving process makes the technique lengthy and complex, and assessment of surrogates for the trade offs is based on subjective assessments.

#### 8.2.2.4 Goal programming

A decision-maker (in this case forest manager) is usually entrusted with fixing and achieving goals which may either be based on total requirements of forest produce or total potential of supply from the forest. Having specified these goals based on a supply and demand analysis, the forest manager endeavours to actually achieve these goals with minimum deviations. GP is based on the concept of goals and tries to minimise the aggregate sum of positive and negative deviations from the specified goal vector rather than optimising a single objective (or goal). Therefore, GP is an extension of LP in the sense that the multiobjective functions are reduced to a single-objective function consisting of deviations between the goal objectives and their actual achievement and then minimising this objective function. Mathematically a general GP model can be expressed as :

Minimise $$Z = w^{*}\underline{d}^{+} + w^{**}\underline{d}^{-}$$

subject to

$$\underline{A}\,\underline{x} - \underline{I}\,\underline{d}^{+} + \underline{I}\,\underline{d}^{-} = \underline{b}$$

$$\underline{B}\,\underline{x} \leq = \geq \underline{h}$$

$$\underline{x}_j,\ \underline{d}_{k+},\ \underline{d}_{k-} \geq \underline{0} \qquad j = 1, 2, \text{---------}, n$$

$$k = 1, 2, \text{---------}, m$$

and $$\underline{d}_{k+}\ \underline{d}_{k-} = \underline{0}$$

where,

$w^*$ and $w^{**}$ are the 1 x m vectors of weighted or unweighted priority factors.

$d^+$ and $d^-$ are m x 1 vectors representing positive and negative deviations from the specified goals respectively.

$\underline{A}$ is an m x n matrix which expresses the technical relationships between goals and subgoals.

$\underline{x}$ is an n x 1 vector of decision variables (subgoals).

$\underline{I}$ is an m x m identity matrix.

$\underline{b}$ is an m x 1 vector of attainment levels of the desired goals.

$\underline{B}$ is an p x n matrix of technical relationships between subgoals and specified constraints on these subgoals.

$\underline{h}$ is a p x 1 vector of constraint levels imposed on the subgoals.

If overachievement of a goal is acceptable to the decision-maker, then $\underline{d}^+$ can be deleted from the formulation and similarly if underachievement of a goal is desired then the variable $\underline{d}^-$ can be omitted. In each case the sign of the equality will change to the inequalities, ≥ and ≤ respectively.

GP creates an artificial unidimensional objective function with multiple goals and constraints. The weighting vectors $\underline{w}^*$ and $\underline{w}^{**}$ are the special feature of a GP model.

This makes it flexible enough to include decision-maker's priorities in an environment in which certain goals are regarded more highly than others. These are particularly useful in situations where not all goals can be achieved simultaneously and some goals are attainable in whole, or part, only at the expense of other goals.

GP has the following advantages:

**a.** GP is a computationally efficient technique.

**b.** It can handle non-commensurable and conflicting goals, and trade off between them can be examined.

**c.** The technique is conceptually easy for the decision-maker to assimilate and trade offs can be made in a logical way. A vast amount of information regarding trade offs, sensitivity to changes and positive and negative slack variables is available which can be helpful to the decision-maker in making judgements.

**d.** The priority structure of the decision-maker can be incorporated into the model. This means that the goals can be ranked in order of priority and different weightings can be given to each goal.

**e.** It provides a logical procedure for analysis, proceeding from goal specification to their achievement. This enables the decision-maker to understand the problem adequately and provides an opportunity to reassess goals in absolute terms and also relative to other goals. As a result, reassessment of earlier specified goals can be made realistically. This gives the desired dynamism to the analysis and the decision-maker can interact closely with the analyst (problem solver).

**f.** Once goals and priorities have been specified, GP tries to achieve each goal level to the maximum possible extent so that the aggregate of the weighted deviations is minimised.

**g.** Post optimal and sensitivity analyses can be done to examine the effects of various changes in the variables on the management alternatives.

**I.** An otherwise infeasible problem can be reformulated to ensure its feasibility. This can be done by introducing deviation variables in the model.

**j.** It is possible to specify those goals which can not be achieved within the resources and provides the level of under and over achievement for such goals.

The disadvantages of goal programming are:

**a.** A correct and realistic specification of goals requires considerable work and judgment on the part of the decision-maker.

**b.** Sometimes GP may give inappropriate results. There is a possibility of identical solutions being generated by conventional LP and GP models for a given problem.

However, equivalence of the solution is due mainly to poor problem formulation rather than the technique (Romero and Rehman, 1984).

c. Naive prioritisation can be serious weakness when the size of the problem is small in relation to the number of the priorities (Romero and Rehman, 1985).

d. Non-efficient optimal solutions may be produced : this will happen when the target levels are fixed at a very pessimistic level (Zeleney and Cochrane, 1973; Cohen, 1978; Dyer et al, 1979; Dykstra, 1985). A parametric analysis can be done to overcome this problem and ensure an increase in the level of some goals without reducing the achievement of others.

e. The value judgments elicited are explicit and possibly incorrect because they are fixed by the decision-maker without a-priori knowledge of the likely trade off.

f. An infinite number of trade offs between the goals at different priority levels is assumed. An inherent assumption in GP is that although trade offs between goals can take place within a given priority structure, they can not be traded off across the boundaries of different priorities.

## 8.3 Requirements for application of a GP model

The following conditions need to be met if GP is to be applicable for solving a problem :

a. Statement and quantification of the goals.

b. Eliciting the priority structure of the decision-maker.

c. Input-output relationships between the management options and resources.

d. Achievement of more than one goal which may have non-market values and non-commensurable units.

## 8.4 Generic GP model for social forestry

A GP model for socioeconomic planning in social forestry can be formulated in two stages : long term multiobjective plan for afforestation and a comparatively short-term multiobjective plan for harvesting such plantations. Planning for afforestation needs to consider socioeconomic aspects such as generation of net socioeconomic benefits and employment; the afforestation budget; and production of fuelwood, small timber, timber and staple agricultural produce. Having achieved these goals through afforestation planning, the planning for harvesting should achieve a desired flow of produce and income from the plantations to be harvested over a specified period. GP models for these two stages are developed in the following sections.

### 8.4.1 Afforestation planning

Let $A_{s,a}$ denote the area of site quality s (s = I, II, III) to be afforested annually by the alternative management option a (a = 1, 2, ------- , n). The following models are formulated for each of the seven identified goals.

1. Expected net socioeconomic benefits goal : This goal can be formulated as,

$$\sum_{s=I}^{III} \left[ \sum_{a=1}^{n} \{ A_{s,a} \cdot (LEV)_{s,a} \} \right] - \underline{d}^{+}_{1} + \underline{d}^{-}_{1} = SEB$$

where, $(LEV)_{s,a}$ is the socioeconomic land expectation value in site quality s with management option a.

SEB represents the goal level for net socioeconomic benefits per unit area.

$\underline{d}^{+}_{1}$ and $\underline{d}^{-}_{1}$ are the surplus and slack deviational variables corresponding to net socioeconomic benefits.

2. Employment goal : This goal can be formulated as,

$$\sum_{s=I}^{III} \left[ \sum_{a=1}^{n} \{ A_{s,a} \cdot (WD)_{s,a} \} \right] - \underline{d}^{+}_{2} + \underline{d}^{-}_{2} = E$$

where, $(WD)_{s,a}$ represents the number of worker days required per unit area of afforestation in site quality s with management option a.

E is the goal level for employment in terms of total worker days generated per unit area.

$\underline{d}^{+}_{2}$ and $\underline{d}^{-}_{2}$ are the surplus and slack deviational variables corresponding to employment goal.

3. Afforestation budget goal : The budget goal is given as,

$$\sum_{s=I}^{III} \left[ \sum_{a=1}^{n} ( A_{s,a} \cdot C_{s,a} ) \right] - \underline{d}^{+}_{3} + \underline{d}^{-}_{3} = B$$

where, $C_{s,a}$ is the per unit area afforestation cost in site quality s with management option a.

B represents the goal level fixed for afforestation budget.

$\underline{d}^{+}_{3}$ and $\underline{d}^{-}_{3}$ are the surplus and slack deviational variables corresponding to the budget goal.

4. Produce output goal : The desired production from social forestry would be in the form of fuelwood, small timber, timber and staple food. There would be one equation for each product i.e. fuelwood, small timber, timber and staple food:

$$\sum_{s=l}^{lll} \left[ \sum_{a=1}^{n} \{ A_{s,a} \cdot (Y_{s,a})_p \} \right] - \underline{d}^{+}_{1p} + \underline{d}^{-}_{2p} = O_p$$

where, $(Y_{s,a})_p$ is the per unit area yield for produce p (p = fuelwood, small timber, timber and staple food).

$O_p$ represents the goal level for output of produce, p.

$\underline{d}^{+}_{1p}$ and $\underline{d}^{-}_{2p}$ are the surplus and slack deviational variables corresponding to output of produce, p.

5. The objective function is to minimise the aggregate sum of the weighted deviational variables, i.e.

Minimise

$$\left[ \left( \underline{w}_1^{*} \cdot \underline{d}^{+}_1 + \underline{w}_1^{**} \cdot \underline{d}^{-}_1 + \underline{w}_2^{*} \cdot \underline{d}^{+}_2 + \underline{w}_2^{**} \cdot \underline{d}^{-}_2 + \underline{w}_3^{*} \cdot \underline{d}^{-}_3 + \underline{w}_3^{**} \cdot \underline{d}^{-}_3 \right) + \sum_{p} \left( \underline{w}_4^{*} \cdot \underline{d}^{+}_{ip} + \underline{w}_4^{**} \cdot \underline{d}^{-}_{ip} \right) \right]$$

where $w_i^{*}$ and $w_j^{**}$ are priority weights assigned to the deviational variables.

6. Area constraints for afforestation can be formulated as,

$$\sum_{a} (A_{s,a}) \leq A_s$$

for site quality s, and

$$\sum_{s} \sum_{a} A_{s,a} \leq A$$

where $A_s$ is the total area available for afforestation in site quality s and A is the total area in all the three site qualities.

It could be argued that the budget goal should be treated as a constraint. The arguments for treating it as a goal are; firstly, in the Forest Department afforestation budget is usually allocated for expenditure within the financial year. The under-achievement of budget expenditure is therefore treated as a failure of afforestation planning by the Forest Manager concerned. In some cases where investment funds are limited, over expenditure also attracts punitive action. Secondly, by treating the budget as a goal, sensitivity and post optimal analyses can be done by varying the budget goal levels. In addition, given the current emphasis on social forestry and consequent availability of funds through various sources including the Forest and Rural Development Departments, the budget is easily available.

The planning framework formulated above assumes a single planning period. Such a planning period would need to be five years in the case of social forestry. This means that over this planning period costs and benefits will not vary significantly. This is thought to be a realistic assumption for short period planning such as five years. In addition, as the earlier analyses carried out in the previous chapters are also based on the costs and benefits in real terms, this assumption will not affect the final results. However, if there are significant changes in costs and benefits, many such one period models can be formulated and solved rather than formulating one large multiperiod model. Such modification is plausible and valid as the solution obtained in one year is independent of the solution for the next year.

This model can also help the decision-maker in generating various management alternatives and in understanding the trade offs between the specified goals. This can be achieved by parametric programming with a modified vector of goals and priority weights.

### 8.4. 2 Harvesting planning

Plantations established according to the afforestation planning framework developed above may be harvested at the socioeconomic optimum rotations determined in Chapter

7. A model was developed for determining annual area harvested for each site quality.

1. Produce output goal : The total yield from the plantations in a management unit will consist of the final yield and yields from intermediate thinnings. The following equations are developed for the achievement of fuelwood, small timber, timber and staple food goals :

$$\sum_{s=I}^{III} \left[ \sum_{m=1}^{M} \{A'_{m,s,i} \cdot V_{m,sp,p,i} + A''_{m,s,i} \cdot T_{m,sp,p,i}\} \right] - \underline{d}^{+}_{1p,i} + \underline{d}^{-}_{1p,i} = O_{p,i}$$

where, $A'_{m,s,i}$ is the area of the management unit m (m=1,2,------,M) in site quality s (s=I, II, III) which is to be taken up for harvesting in period i (i=1,2,-----,I).

$V_{m,sp,p,i}$ is the volume per unit area of produce p from the species, sp in management unit m due in period i.

$A''_{m,s,i}$ is the area in management unit m in site quality s which is to be taken up for thinnings in period i.

$T_{m,sp,p,i}$ is the per unit area thinning yield from the management unit m of produce p from the species sp due in period i.

$O_{p,i}$ is the output goal for the produce p in period i.

$\underline{d}^{+}_{1p,i}$ and $\underline{d}^{-}_{1p,i}$ are the surplus and slack deviational variables corresponding to the produce output goal in period i.

2. Current net socioeconomic benefits goal : This goal can be formulated as,

$$\sum_{s=I}^{III} \left[ \sum_{m=1}^{M} A_{m,s,i} \cdot (LEV)_{m,i} \right] - \underline{d}^{+}_{2i} + \underline{d}^{-}_{2i} = (SEB)_i$$

where, $(LEV)_{m,i}$ represents the socioeconomic Land Expectation Value (LEV) from the management unit m in period i,

$\underline{d}^{+}_{2i}$ and $\underline{d}^{-}_{2i}$ are the surplus and slack deviational variable corresponding to net socioeconomic benefits goal in period i,

and $(SEB)_i$ is the specified net socioeconomic benefits goal level in period i.

3. Employment goal : The goal for total employment generation in harvesting operations can be formulated as,

$$\sum_{s=I}^{III} \left[ \sum_{m=1}^{M} A_{m,s,i} \cdot (WD)_{m,s} \right] - \underline{d}^{+}_{3i} + \underline{d}^{-}_{3i} = (E)_i$$

where, $(WD)_{m,s}$ represents the total number of worker days generated in harvesting operations in SQ s of management unit m,

$\underline{d}^{+}_{3i}$ and $\underline{d}^{-}_{3i}$ are the surplus and slack deviational variables corresponding to the employment goal.

and $(E)_i$ is the specified employment goal in period i.

4. Current income goal : In addition to the net socioeconomic benefits, both the planners and villagers would also like to generate a specified income which may be either needed for future investments in plantation activities or for fulfilment of the villagers' consumption needs. The following model can be used to determine the net financial returns accruing from the harvesting of the plantations:

$$\sum_{s=I}^{III} \left[ \sum_{m=1}^{M} A_{m,s,i} \cdot (PNW)_{m,i} \right] - \underline{d}^{+}_{4i} + \underline{d}^{-}_{4i} = (I)_i$$

where, $(PNW)_{m,i}$ is the PNW of the financial returns (at some specified discount rate) from the management unit m in period i,

$\underline{d}^{+}_{4i}$ and $\underline{d}^{-}_{4i}$ are the surplus and slack deviational variables corresponding to the goals for the net financial returns,

and $(I)_i$ is the goal level for income to be generated.

4. Area constraints : There are two area constraints,

$$\sum_{m=1}^{M} A_{m,s,i} = A_{s,i}$$

where, $A_{s,i}$ is the total area in site quality s to be harvested in period i.

This means that the total area harvested in each period should be equal to that arrived at by the afforestation planning. There will be one such area constraint for each site quality and each period. The second constraint is that the total area harvested in a management unit in a SQ should not exceed the total area of that management unit ($A_{m,s}$) during the planning period:

$$\sum_{i=1} A_{m,s,i} \leq Am,s$$

6. The objective function of minimising the weighted sum of deviational variables can be written as,

$$\text{Minimise} \quad \sum_{p} (\underline{w}_1^{*}.\underline{d}^{+}_{1p,i} + \underline{w}_1^{**}.\underline{d}^{-}_{1p,i}) + \underline{w}_2^{*}.\underline{d}^{+}_{2i} + \underline{w}_2^{**}.\underline{d}^{-}_{2i} +$$
$$\underline{w}_3^{*}.\underline{d}^{-}_{3i} + \underline{w}_3^{**}.\underline{d}^{-}_{3i}$$

## Summary

A mathematical model for multiobjective planning in social forestry is developed in this chapter. The model incorporates both the rural development and production objectives of the policy and is used in a case study relating to social forestry in Orissa in the next chapter.

# Chapter 9

## The Use of a Multipleobjective Planning Framework in Social Forestry

Before applying the mathematical models developed in the previous chapter, it is necessary to evaluate the demand and supply of forest produce in order to realistically specify the goal levels for the region. Unfortunately not much work has been done on such supply and demand analysis in Orissa. However, some basic data about the demands of forest produce in rural areas of two coastal districts, Puri and Ganjam (Orissa) is available from the village studies carried out by the Operations Research Group (ORG, 1982a, 1982b). This information is used here to assess the required demand pattern and then analysed to specify realistic goal levels based on the analysis.

### 9.1 Socioeconomic environment influencing demand and supply

The following socioeconomic indicators for Puri and Ganjam are compiled from Tripathi (1973).

| | Puri | Ganjam | Orissa |
|---|---|---|---|
| Geographical area ('000 $Km^2$) | 10.2 | 12.5 | 155.8 |
| Total no. of villages | 4 336 | 4 223 | 46 992 |
| Average size village (persons) | 487 | 482 | 428 |
| Average size household (persons) | 5.6 | 4.6 | 5.2 |
| Population density (persons per $Km^2$) | 286 | 211 | 169 |

Since these figures are based on the reports of 1971 population census a conservative estimate of current village size is approximately 500 persons. The distribution of the main workers by occupation (Table 9.1) shows that nearly 70% are cultivators and agricultural labourers. Underemployment is widespread in Orissa yet unemployment is low in both Puri and Ganjam at only 1.3% and 1.2% respectively (Table 9.2). Because both Puri and Ganjam have mainly rainfed agriculture, only one agricultural crop is grown annually. This means that unemployment and underemployment are acute during the period February to May when no agricultural activities are carried out. It is during this period that social forestry can employ the villagers to carry out nursery activities and pitting operations, which help reduce the severity of poverty and malnutrition by generating an income.

It has been estimated that forestry contributes as much as 11.3% and 10.3% of the total household income in Puri and Ganjam respectively ORG (1982a, 1982b). Social forestry can further enhance this contribution by providing employment and forest produce for sale. This will particularly help small and marginal farmers and agricultural labourers, who constitute more than 78% and 67% of the total households in Puri and Ganjam respectively (Agricultural census, 1976-77) .

## 9.2 Rural households demands

For planning purposes it may be assumed that a management unit consists of twenty villages which is based on the working area entrusted to a village forest worker for carrying out social forestry activities. This means that a management unit would have nearly 10,000 persons.

### 9.2.1 Fuelwood demand

Almost all the rural households in Puri and Ganjam use fuelwood in meeting their energy needs (ORG, 1982a, 1982b) of which nearly 99% is used for cooking purposes. The average annual per capita requirement of fuelwood in Puri is 5.48 qtl of which 5.26 qtl is utilised for energy needs and remaining is utilised for village and cottage industries. In Ganjam, the total average annual requirement of fuelwood is comparatively more, 7.8 qtl, of which 6.9 qtl is used for household energy purposes. Based on these estimates the total annual demand for an average household in Puri is worked out as 2740 qtl and that of Ganjam as 3900 qtl. This gives the estimates for the total requirement for fuelwood by rural Puri and Ganjam as 1,632,658 (or 377 $m^3$ per village) and 2,271,683 $m^3$ respectively.

### 9.2.2 Small timber demand

The villagers in Puri and Ganjam use bamboos for making agricultural implements and in household construction. However, bamboo resources in Orissa and elsewhere have been greatly depleted over the years due mainly to over exploitation by bamboo-based industries such as Paper Mills with whom the Government of Orissa has settled long term leases at a very low royalty. As a result the villagers are not getting an adequate supply of bamboos and are increasingly forced to use poles both for construction and for making agricultural implements. In fact nearly 88% of the construction materials in Puri are met from poles and small timber (ORG, 1982a). The average annual per capita requirement for poles (including replacements for bamboo) in Puri for construction, agricultural implements and village industries is 2.64 poles. Assuming an average pole with diameter 15 cm. and length 4 m , the total requirements of poles and small timber for rural Puri is estimated as 403,078 $m^3$ (or nearly 93 $m^3$ per village). The total annual requirement of rural Ganjam is estimated to be 1,738,799 $m^3$, based on an average annual per capita requirement of 11.65 poles.

### 9.2.3 Timber demand

The average annual per capita requirements of timber in rural Puri and Ganjam are 1.25 and 0.3 cubic feet respectively. The total requirements for timber for each district are therefore 77,429 (or nearly 18 $m^3$ per village) and 18,099 $m^3$ respectively.

### 9.2.4 Employment generation

Based on the rough estimates of the ORG (1982a, 1982b) for unemployment and underemployment in rural Puri and Ganjam, the total number of persons available and seeking for work are 786,550 and 266,049 respectively.

## 9.3 Specification of goal levels

Having done the demand analysis the decision-maker (in this case the forest manager) needs to specify realistic goal levels. A specific multiobjective model can then be formulated to achieve these goals as closely as possible within the bounds of resource constraints. To illustrate this process only one district, Puri, is considered as the same procedure can be repeated for Ganjam.

The villagers have part of their forest produce requirements met from the existing village, protected and reserved forests. In addition, the Orissa Forest Corporation has opened some forest depots in rural areas to meet the villagers' demands. The land area available for afforestation can be divided into three following site qualities:

SQ I = 50 ha

SQ II = 3300 ha

SQ III = 350 ha

Total land area = 3700 ha

The area in SQ I (land available) is comparatively small, because in a densely populated area such as Puri most of the good land is already under cultivation and cannot be diverted for social forestry. The largest area of available land is of average quality (SQ II).

For the purposes of analysis the forest manager has specified the following realistic goal levels to be achieved within the land area constraints, taking into account existing sources of forest produce. The goal levels for fuelwood are estimated to meet the demands of 660 villages while for other produce these are for only 450 villages. These villages are generally distributed in all the social forestry ranges of Puri district in order to give priority to the scarcity areas and distribute the work load.

### 9.3.1 Fuelwood output goal

Of the total demand of fuelwood in all the 4336 villages as estimated in sec. 9.2.1 if the forest manager takes a decision to meet the demands of only 660 villages in a year, then the goal level for fuelwood (based on the previously estimated fuelwood demand of an average village) may be approximated as 250,000 $m^3$. The high level of goal for fuelwood is due to the fact that fuelwood is a major source of household energy: more than 95% households meet their energy requirements from fuelwood only (ORG, 1982a, 1982b).

### 9.3.2 Small timber and timber output goals

If the forest manager decides to meet the demands for small timber and timber for only 450 villages in a year, then the goal levels for such timber can be fixed at 42,000 $m^3$ and 8,000 $m^3$ respectively. These figures are approximated from the estimated demands (section 9.2.2 and 9.2.3) for small timber and timber of an average village in rural Puri.

### 9.3.3 Staple food output goal

Of the five components of social forestry evaluated in Chapters 4, 5 and 7, only agroforestry will give some agricultural produce. In this case study the forest manager has the goal of meeting the subsistence needs of staple food to the extent of only 4500 qtl.

### 9.3.4 Employment generation goal

In addition to the subsidiary workers who are seeking for work in rural Puri some main workers will also ultimately join the work force in social forestry, as argued in Chapter 5 . Although there are many other rural development programmes which are currently being implemented, social forestry should have a provision of giving employment to the poorest of poor. In view of this objective, the forest manager has an employment goal to generate an additional 990,000 labour days in social forestry afforestation works (over the period of four years during which the plantation activities are carried out).

### 9.3.5 Afforestation budget goal

Investment in social forestry is being made from many sources including the Forest and Rural Development Departments. The total afforestation budget for all the 13 districts of Orissa for the year 1990-91 is earmarked by the social forestry wing of the Orissa Forest Department as Rs. 110.54 million. This gives an average of Rs. 8.5 million for each district. However, Puri is a comparatively larger district in terms of both area and population and can expect a larger share of the budget. Taking into account the investment in social forestry from Orissa Plantation Development Corporation , and the Forest and Rural Development Departments, an expenditure figure of Rs. 11.94 M can be estimated. This includes the cost of cultural operations to be carried out after the planting.

### 9.3.6 Socioeconomic benefits goal

An objective specification of a level for this goal poses practical problems. This is due mainly to lack of any single criterion for fixing the net socioeconomic benefits to be generated. In the generic model developed in the previous chapter the socioeconomic LEV was taken as the decision criterion: therefore the average value of socioeconomic LEV generated per unit land provides a valid estimate of the socioeconomic benefits. An acceptable level of socioeconomic LEV for the total 3700 ha may be approximated as Rsw 62 million (or nearly Rsw 16,750 per ha).

## 9.4 Decision variables

The results and data generated in this chapter, and Chapters 4 and 7 for the species *Eucalytus hybrid, Dalbergia sissoo, Acacia nilotica, Casuarina equisitifolia* and the agroforestry system, are used in developing the multipleobjective model.

Let $A_i$ denote the area decision variable to be afforested by the management alternative i (in SQ I, II and III) to meet the specified goals for fuelwood, small timber, timber and staple food separately. Depending on the category of the output available from the alternative management strategies in SQ I,II and III, there will be in total 29 such decision variables which are used below :

The GP formulation in this case for the output goals can be written as follows :

1. Fuelwood output goal :

$$21.45\ A_{15} + 6.83\ A_{16} + 4.17\ A_{17} + 6.91\ A_{18} + 1.13\ A_{19} + 2.72\ A_{20} + 3.13\ A_{21} + 3.21\ A_{22} + 81.19\ A_{23} - \underline{d}^{+}_{1} + \underline{d}^{-}_{1} = 250000$$

2. Small timber output goal :

$$286.82\ A_{1} + 123.52\ A_{2} + 258.39\ A_{3} + 120.59\ A_{4} + 59.55\ A_{5} + 96.13\ A_{6} + 34.99\ A_{7} + 54.87\ A_{8} + 97.15\ A_{9} + 12.82\ A_{10} + 120.75\ A_{11} + 7.72\ A_{12} + 92.83\ A_{13} + 57.66\ A_{14} - \underline{d}^{+}_{2} + \underline{d}^{-}_{2} = 42000$$

3. Timber output goal :

$$132.54\ A_{24} + 280.40\ A_{25} + 70.16\ A_{26} + 192.25\ A_{27} - \underline{d}^{+}_{3} + \underline{d}^{-}_{3} = 8000$$

**4.** Staple food output goal :

$$41.8\ A_{28} + 31.44\ A_{29} - \underline{d}^{+}_{4} + \underline{d}^{-}_{4} = 4500$$

A compact formulation of the above problem can be written with the help of the following 11 decision variables :

| Decision variable | Description |
|---|---|
| $X_1$ | Area to be afforested with *Eucalyptus hybrid* in SQ I |
| $X_2$ | Area to be afforested with *Eucalyptus hybrid* in SQ II |
| $X_3$ | Area to be allotted for the agroforestry system in SQ I |
| $X_4$ | Area to be allotted for the agroforestry system in SQ I |
| $X_5$ | Area to be afforested with *Dalbergia sissoo* in SQ I |
| $X_6$ | Area to be afforested with *Dalbergia sissoo* in SQ I I |
| $X_7$ | Area to be afforested with *Dalbergia sissoo* in SQ III |
| $X_8$ | Area to be afforested with *Acacia nilotica* in SQ I |
| $X_9$ | Area to be afforested with *Acacia nilotica* in SQ II |
| $X_{10}$ | Area to be afforested with *Acacia nilotica* in SQ III |
| $X_{11}$ | Area to be afforested with *Casuarina equisitifolia* in SQ II |

A complete model for all the seven goals can be formulated in terms of these 11 decision variables as follows :

1. Socioeconomic benefits goal :

$$712219\ X_1 + 84130\ X_2 + 724357\ X_3 + 63664\ X_4 + 1332687\ X_5 + 631083\ X_6 + 93417\ X_7 + 181385\ X_8 + 83708\ X_9 + 16528\ X_{10} + 8718.6\ X_{11} - \underline{d}^{+}_{1} + \underline{d}^{-}_{1} = 62000000$$

2. Employment generation goal :

$$491\ X_1 + 491\ X_2 + 855\ X_3 + 855\ X_4 + 335.8\ X_5 + 334.1\ X_6 + 330$$

$X_7 + 230.56\ X_8 + 229.92\ X_9 + 229.85\ X_{10} + 225\ X_{11} - \underline{d}^+_2 + \underline{d}^-_2$
$= 898900$

3. Afforestation budget goal :

$6050\ X_1 + 6050\ X_2 + 11250\ X_3 + 11250\ X_4 + 4108\ X_5 + 4091\ X_6$
$+ 4050\ X_7 + 3055.55\ X_8 + 3049.12\ X_9 + 3048.42\ X_{10} + 3000$
$X_{11} - \underline{d}^+_3 + \underline{d}^-_3 = 11940000$

4. Fuelwood output goal :

$21.45\ X_7 + 6.83\ X_8 + (4.17+6.91)\ X_9 + (1.13+2.72+3.13+3.21)$
$X_{10} + 81.19\ X_{11} - \underline{d}^+_4 + \underline{d}^-_4 = 250000$

5. Small timber output goal :

$286.82\ X_1 + 123.52\ X_2 + 258.39\ X_3 + 128.59\ X_4 +$
$(59.55+96.13)\ X_5 + (34.99+54.87)\ X_6 + 97.15\ X7 +$
$(12.82+120.75)\ X8 + (7.72+92.83)\ X_9 + 57.6\ X10 - \underline{d}^+_5 + \underline{d}^-_5 =$
$42000$

6. Timber output goal :

$(132.54+280.4)\ X_5 + (70.16+192.25)\ X_6 - \underline{d}^+_6 + \underline{d}^-_6 = 8000$

7. Staple food output goal :

$41.8\ X_3 + 31.44\ X_4 - \underline{d}^+_7 + \underline{d}^-_7 = 4500$

Land area constraints are given as :

$X_1 + X_3 + X_5 + X_8 - \underline{d}^+_8 + \underline{d}^-_8 \leq 50$

$X_2 + X_4 + X_6 + X_9 + X_{11} - \underline{d}^+_9 + \underline{d}^-_9 \leq 3300$

$X_7 + X_{10} - \underline{d}^+_{10} + \underline{d}^-_{10} \leq 350$ and

$$\sum_{i=1}^{11} X_i \leq 3700$$

The objective function of minimising the weighted sum of the deviational variables can written as,

$$\text{Minimise} \quad \sum_{i=1}^{11} (\underline{w}_i^{*}\ \underline{d}^{+}_i + \underline{w}_i^{**}\ \underline{d}^{-}_i)$$

All of these equations are presented in a tableaux form in Table 9.3.

The model consists of ninety non-zero entries and eleven decision variables. Although priorities were assigned to all the seven goals, equal weightings were given to their achievements for two reasons. Firstly, there were no criteria available for determining these weights objectively as the preferences of the decision-maker were not available for the purposes of this study. Secondly, the importance of various goals would vary according to the location of the social forestry plantations within the region. For example, in some villages fuelwood production may be at premium while in others it may be small timber or the generation of employment opportunities, etc. As the priorities assigned to the goals are based on the value judgment of the decision-maker a sensitivity analysis is needed to examine the effects of the changes on the results. This was done by assigning a different set of priorities and goal levels.

## 9.5 Solution to the GP model

The model was solved using the package 'GOAL' (Bartlett *et al*, 1978) on the Edinburgh School of Agriculture micro-Vax. The software uses a lexicographic GP algorithm, which means that only ordinal priorities can be assigned to the goals. The priority structure and the type of inequalities adopted initially for each of the seven goals are as follows (these were later varied to examine the alternative management strategies and their sensitivities to change) :

| Goals | Priority | Inequality (see below) |
|---|---|---|
| Socioeconomic benefit (Rsw) | 1 | L |
| Employment (worker days) | 2 | L |
| Afforestation budget (Rs) | 3 | B |
| Fuelwood production ($m^3$) | 4 | L |
| Small timber production ($m^3$) | 5 | L |
| Timber production ($m^3$) | 6 | L |
| Staple food production (qtl) | 7 | L |

It is evident from this formulation that rural development objectives such as net socioeconomic benefits and employment are given higher priority in comparison to production objectives.

The inequalities referred above, and others are defined below :

L refers to less than or equal to (≤), in which only underachievement ($\underline{d}^-_i$) is considered: although overachievement of a goal is welcome the model minimises the underachievement of the goal.

B refers to both less than or equal to (≤) and greater than or equal to (≥) in which either or both the underachievement ($\underline{d}^-_i$) and overachievement ($\underline{d}^+_i$) can be considered.

E refers to equal to (=), in which neither the underachievement ($\underline{d}^-_i$) nor the overachievement ($\underline{d}^+_i$) is considered.

The adoption of inequality L for all goals except the afforestation budget goal means that while the overachievement of these goals is desirable it is their underachievement which must be minimised. The situation for the afforestation budget goal is different as neither the underachievement nor overachievement are desirable and hence the inequality B.

The results of first run of the model are given as below :

| Goals | Goal level | Achieved goal level |
|---|---|---|
| Socioeconomic benefits (Rsw) | 62000000 | 62002243 |
| Employment (worker days) | 898900 | 898902 |
| Afforestation budget (Rs) | 11940000 | 11940023 |
| Fuelwood production ($m^3$) | 250000 | 250000 |
| Small timber production ($m^3$) | 42000 | 42001 |
| Timber production ($m^3$) | 8000 | 8001 |
| Staple food production (qtl) | 4500 | 4506 |

It is clear from this table that all the goals were completely achieved (with slight over expenditure) with the following management options :

| Management option | Area (in ha) | Site Quality |
|---|---|---|
| $X_2$ | 15.00 | II |
| $X_3$ | 0.70 | I |
| $X_4$ | 142.38 | II |
| $X_6$ | 30.49 | II |
| $X_7$ | 3.11 | III |
| $X_8$ | 0.08 | I |
| X10 | 328.26 | III |
| $X_{11}$ | 3037.99 | II |

The large allocation of land resources to *Casuarina equisitifolia* ($X_{11}$) is due to the fact that its productivity (and calorific value) as fuelwood is substantially higher in comparison to the other species, and the goal level for fuelwood production is also comparatively high. In Puri *Casuarina equisitifolia* is widely planted and grows very well, especially in sandy soils. The results also show that 49, 74 and 22 ha of land in SQ's I, II and III remain unutilised: such an outcome is a desirable result as the underutilisation of land resources will not pose any problem to a forest manager, as would its overuse.

To explore the possibilities of generating an increased employment, the model was again run with a modified vector of goal levels for socioeconomic benefits and employment, and gave following results :

| Goals | Goal level | Achieved goal level |
|---|---|---|
| Socioeconomic benefits (Rsw) | 61690000 | 61691838 |
| Employment (worker days) | 900000 | 900000 |
| Afforestation budget (Rs) | 11940000 | 11949488 |
| Fuelwood production ($m^3$) | 250000 | 250000 |
| Small timber production ($m^3$) | 40000 | 42000 |
| Timber production ($m^3$) | 8000 | 7801 |
| Staple food production (qtl) | 4500 | 4506 |

This table shows that although the employment goal was achieved, funds were overused by Rs 9488 and the timber goal was underachieved by 199 $m^3$. A different combination of the management options was represented in the solution space (see Appendix 9.1 for a sample of computer print out):

| Management option | Area (in ha) | Site Quality |
|---|---|---|
| $X_2$ | 26.64 | II |
| $X_4$ | 143.31 | II |
| $X_6$ | 29.73 | II |
| $X_{10}$ | 305.73 | III |
| $X_{11}$ | 3040.82 | II |

This analysis shows that the solution is not only sensitive to the formulation of the model (e.g. type of inequalities for various goal equations) but also to the specification of the goal levels. In this case increasing the level of the employment goal has resulted in the underachievement of the timber goal and has utilised more funds, showing the trade off among the goals. This suggests that extensive sensitivity and post optimal analyses need to be carried out.

## 9.6 Sensitivity and post optimal analysis

The underachievement and overachievement of the afforestation budget needs to be ignored in those cases where the government allocates a finite level of funds for any financial year, in which case the goal equation should be modified to an equality. The results of such an analysis are presented in Tables 9.4 and 9.5. They show that all the goals were achieved and the management options $X_2$, $X_3$, $X_4$, $X_6$, $X_8$, $X_{10}$ and $X_{11}$ are represented in the final solution.

To examine how the changes in the levels of budget goal would affect the solution, two runs were made with budget goals fixed at Rs. 11.93 and 11.92 M. In both of these cases the timber and staple food goals could not be met (Tables 9.4 and 9.5). A similar analysis was done with an equality sign for utilisation of the land resources in different site qualities. This showed that not all of the goals were achieved with this type of specification (Tables 9.4 and 9.5).

Sensitivity analysis was also done by changing the levels of various goals and the results of such analysis are presented in Tables 9.6 and 9.7. Lowering the goal levels for both the socioeconomic benefits and employment, to Rsw 61,690,000 and 898,900 worker days respectively, resulted in a different combination of management options but all goals were completely achieved. The land resources which remain unutilised in SQ I,II and III are 50, 76 and 18 ha respectively.

When goal levels for afforestation budget were increased to Rs. 11.9405 and 11.9410 M a different set of combinations of the management options are achieved. When goal levels for forest and agricultural produce were increased , the budget was invariably overused and when the goal level for fuelwood production was increased to 260,000 $m^3$, not only was the budget overutilised but staple food production was underachieved. This suggests that the production of fuelwood can be increased only at the cost of staple food production. The results for various levels of different goals are shown in Tables 9.6 and 9.7, the goal levels achieved being underlined.

To examine the effects of changes in the goal ranking priorities, the goals were set in the following order of descending priorities :

| Goal | Priority |
|---|---|
| Fuelwood production | 1 |
| Small timber production | 2 |
| Timber production | 3 |
| Staple food production | 4 |
| Employment | 5 |
| Afforestation budget | 6 |
| Socioeconomic benefits | 7 |

This priority structure means that production objectives would be achieved first followed by the rural development objectives. The results obtained are shown in Tables 9.8 and 9.9, which show that some goals have not been completely achieved. For example, the second and ninth rows of the Table 9.8 show that small timber production and socioeconomic benefits goals are not achieved. Similarly, from the fifth row, it is evident that the employment could not be completely achieved and in many cases (rows 7, 10, 11, 12, and 13) the budget was overutilised. Employment (tenth and fifteenth rows) and the staple food production (sixteenth and seventeenth rows) are both underachieved.

Although the model for harvesting planning can be run similarly, it has not been attempted for the following reasons : Firstly, except for the rehabilitation of degraded forests, all the plantations raised in other components are in very small blocks (or strips) and would be handed over to the Village Forest Committees for their management including harvesting. This means that the villager's decisions about harvesting these plantations would not only be location specific but also be guided by many other socioeconomic aspects such as needs, contingencies, agricultural productivity, market conditions, etc. This limits the scope for any large scale planning strategy to be uniformly applicable.

Secondly, if the Forest Department is no longer the managing agency for these plantations, any harvesting schedule which demands a high degree of technical expertise, as suggested by the model, would not be practically feasible in the absence of any technical guidance to the villagers.

## Summary

This chapter has described the formulation and results from a lexicographic goal programming model which represents the multiple objectives of social forestry and incorporates these into socioeconomic planning. The model gives useful results for the afforestation planning and the alternative management strategies as suggested by the model are feasible based on technical, silvicultural and socioeconomic criteria. The results from the post optimal and sensitivity analyses show that the model is flexible and can accommodate the changing environment of social forestry implementation.

This exercise in Puri District has been for demonstration purposes but in actual practice it is of vital importance that input from those villagers for whom the social forestry is aimed is included. In addition, social forestry decision-makers require a dynamic analytical framework from which they can determine the level and speed of policy uptake. Such a framework is described in the next two chapters.

PART

III

# QUALITATIVE FRAMEWORK

## Chapter 10

# An Evaluation of Socioeconomic Uptake of Social Forestry

The villagers' decision-making with regard to land-use projects such as social forestry is influenced not only by the agro-ecological, technological and policy package but also by the relevant socioeconomic aspects of the environment in which they are implemented. Within the same agro-ecological zone a given package of social forestry may be adopted at a differing rate and intensity due mainly to the differing socioeconomic milieu of the environment. The various socioeconomic attributes, endogenous or exogenous, influencing the uptake of social forestry may be related to the villagers (individuals and communities) and to the implementing agency such as the Forest Department. This chapter identifies such variables based on a socioeconomic survey carried out in Orissa.

## 10.1 Lessons from the community development planning

The socioeconomic realities of India are highly complex and so the socioeconomic and cultural attributes of the villagers are important considerations in the adoption of rural development technologies such as social forestry. Such adoption may to a large extent be determined by the degree of fit between technological innovations, the existing socioeconomic environment and cultural practices. Failure to incorporate these aspects may result in poor uptake of a socially relevant policy because its introduction introduces a perturbation in the existing socioeconomic system. The forces released through this process, if not channelled in the desirable direction, may affect the uptake of social forestry adversely. The reason for this is that development of any kind is usually associated with a disruptive force bringing about a direct clash between traditionally entrenched forces and the newly released ones, affecting in various ways and intensities the existing socioeconomic arrangement, and discord inbuilt in the process (Maheswari, 1985).

As an illustration, the much publicised rural development programmes initiated during 1950's and 1960's, which included a large number of schemes for agricultural development could not produce the desired results due mainly to non-cognisance of the relevant socioeconomic environment. This pioneer Indian experience of rural development provides some empirical evidence about the importance of socioeconomic factors in adoption of any rural development scheme. As such it is worth reviewing in the context of social forestry. In developing countries such as India, the person:land ratio together with the utilisation of the land and labour availability are of critical importance for the prospects of development (Myrdal, 1968). Social forestry implementation can therefore benefit from such experiences and avoid the deficiencies of the earlier rural development planning. Similar approaches to socioeconomic planning have recently been suggested by many analysts of rural development projects (Cernea, 1985; Chowdhry, 1985; Chambers, 1985; Raintree, 1983, 1987; Hosking, 1987; Wiersum, 1988) and the socio-psychological aspects of development have been shown to be as important as the economic (Meir and Baldwin, 1957).

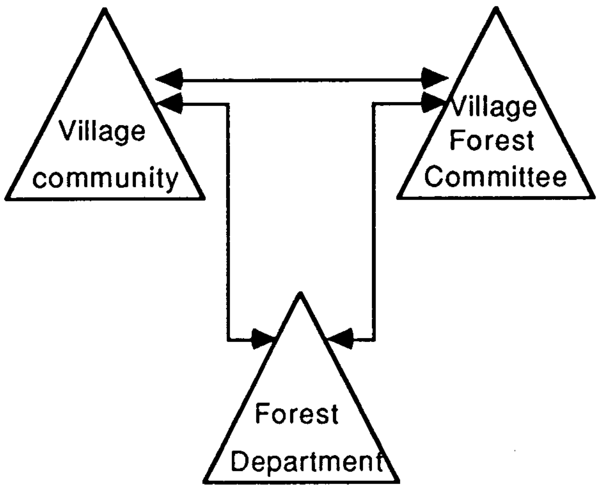
Many socioeconomic issues (such as socio-cultural and economic structures of a village community) of vital importance, which were overlooked during the planning process, later became constraints or limiting factors to the successful implementation. Realising that small communities are the only persistent social groups, the village was selected as a basic socioeconomic unit and the village community as a unit of the integrated development. Many programmes were increasingly linked with five year plans emphasising the productivity aspects (Dubey, 1963; Bhattacharjee, 1970): although there was a growing realisation that even some of the less involved technological or economic innovations had latent cultural and social dimensions these need careful consideration if the success of community development programmes is to be assured.

The Panchayats became extremely important for the organisation of 'super village' politics, reinforcing elitism in some States, but nowhere have they yet brought about widespread participation by the poorest people in communities with least resources (Franda, 1979). It seems that rural development planning was based on an unrealistic assumption that a village is a monolithic entity. But in fact, a village is a complex socioeconomic system with close interactions. Therefore, the identification, interpretation and incorporation of the relevant socioeconomic variables affecting the uptake of social forestry is important not only in designing a social forestry package for a particular region but also in its successful implementation. This chapter addresses this important task in the context of social forestry uptake in the socioeconomic and cultural environment of the State of Orissa.

## 10.2 Survey methodology

Since the impact of socioeconomic development is not felt evenly in all regions of the country the cross-sectional and cross-temporal comparisons among the different regions of Orissa can provide a basis for studying the relationships between social forestry uptake and socioeconomic parameters. To date such a comprehensive study has not been attempted in Orissa (or elsewhere in India) so that little useful data were available to form the basis for this study. It was therefore felt necessary to identify relevant parameters based on an exhaustive socioeconomic survey carried out in the State of Orissa. In carrying out this survey it was hypothesised that it is appropriate and easier to introduce comprehensive changes enhancing overall social welfare and security than to effect small and piecemeal technical and silvicultural changes. These latter take away the security which the villagers enjoyed without the innovative technology such as social forestry. The socioeconomic interactions among the various participants in social forestry were recognised as shown in the Figure 10.1.

**Figure 10.1 Participative human resource model**




Although each State and each social forestry scheme is unique, it is recognised that social forestry policy in Orissa could serve as a case study to illustrate the methodology. However, some of the broad distinguishing features of other distinct regions of India have also been investigated mainly to determine the salient socioeconomic aspects. For this reason two social forestry divisions were sampled in western Uttar Pradesh. The main findings discussed in this chapter are for Orissa and any extrapolation without adequate judgment would not be appropriate.

Since the State of Orissa is quite large and has distinct physical and agro-ecological zones, a stratified multistage (3 stages) sampling design was adopted for sampling the project villages and the households participating in the social forestry programme. The following division of Orissa is based on physical and agro-ecological features :

| Zone | % of total area | Districts |
|---|---|---|
| I. Northern Plateau | 23 | Dhenkanal |
| | | Keonjhar |
| | | Sundargarh |
| | | Mayurbhanj |
| II. Central Table Land | 23 | Sambalpur |
| | | Bolangir |
| | | Phulbani (part) |
| III. Central and Eastern Ghats | 36 | Koraput |
| | | Kalahandi |
| | | Phulbani (part) |
| IV. Coastal Plains | 18 | Puri |
| | | Cuttack |
| | | Balasore |
| | | Ganjam* |

* a part of Ganjam, especially north Ganjam can also be classified in Central and Eastern Ghats.

Recognition of differing agricultural practices and the behaviour patterns associated with these practices is important in understanding the differential uptake of social forestry. Nearly 23% of the total area of the State is in the Northern plateau zone which consists of hill ranges covered with forests and interspersed with cultivated valleys. This region has the highest rainfall in Orissa and 45% of the total area is covered by forests. Although the area under agriculture is 36%, the agricultural productivity is low. The Central Table Land is almost equal to the Northern plateau in area and is suitable for rice cultivation on the great plains of the region which have an undulating topography. The Central and Eastern Ghat region, which is the largest among all the four regions (covering 36% of the total area, mainly hills), has the lowest agricultural productivity in the State. The Coastal Plains, (which cover nearly 18% of the total area and are characterised by a number of deltas formed by the rivers such as the Mahanadi and Brahimini), are characterised by good agricultural productivity and a well developed infrastructure.

All the 13 districts of the State were grouped into the four agro-ecological zones. Districts were chosen as first stage units and from each zone (taken as a frame) one district was sampled randomly. The Central and Eastern Ghat zone was excluded from consideration because social forestry was only initiated in this zone in 1989 and therefore poor empirical information would have been generated: it was replaced with another district sampled from the Central Table Land.

A list of the project villages in each of the four sample districts was obtained from the office of the local Deputy Director of Social Forestry. These lists were used as the sampling frame for selecting second stage units (i.e. villages). Six villages in each social forestry division were sampled systematically, with a random start. A control was exercised by using an equal sampling procedure to ensure an equal number of villages (i.e. two) for each of the following three categories: high, moderate and low uptake of social forestry. Project villages were classified on the basis of the success of social forestry plantations and the participation of villagers, this information being obtained from the staff of the divisions concerned and the participating villagers. Those villages having more than 60% of the total households participating, and the same 60% survival (percentage for the plantations), were classified as high uptake villages, while those having 30-60% and less than 30% were classified as moderate and low uptake villages respectively. This classification was also cross checked with the sample survey reports carried by the social forestry directorate for some plantations.

Sampling of the households was done in the field with the help of a list of households in the sample villages. Based on such a list as a frame, a minimum of seven households were chosen including village forest committee members and beneficiary households, using the same sampling procedure. The heads of the sampled households were interviewed personally with the help of a schedule of enquiry (Appendix, 10.1) consisting of both open and closed attitudinal, qualitative and quantitative questions. In addition, they were questioned about the socioeconomic factors which were influencing the social forestry uptake at regional and village levels. Such questioning was a special feature of the multi-stage sampling: after selecting a unit at any stage not only could information be collected about the units at the current stage but also supplementary information about the next stage, which could then be utilised for either sampling the next stage units, or estimation, or both.

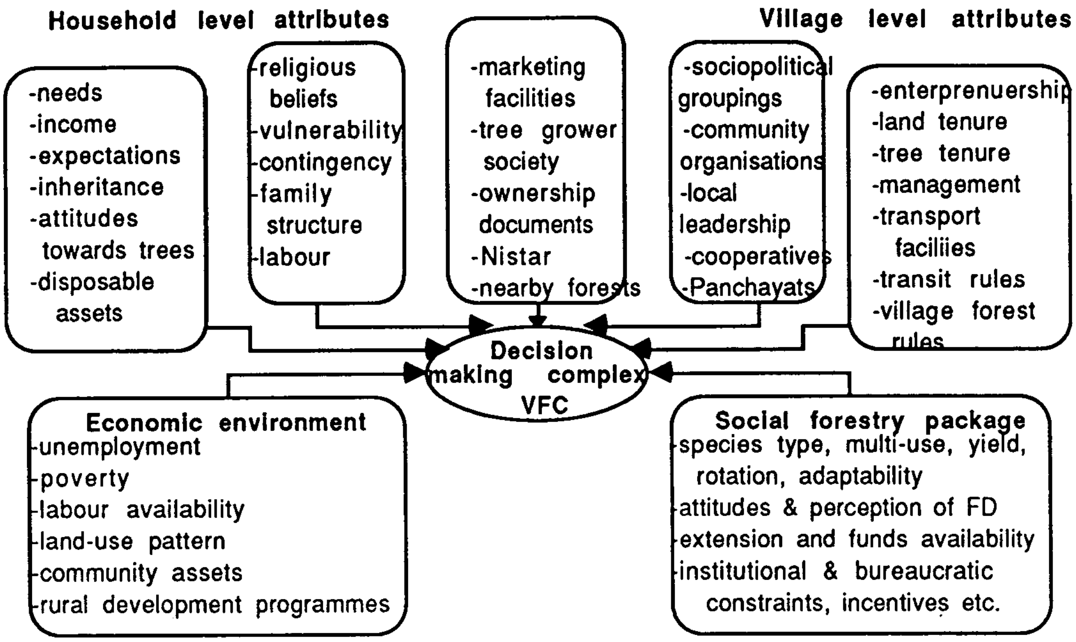
The schedule of enquiry, unlike a rigid questionnaire, ensured the required flexibility and freedom to the respondents because each interview enabled the villagers to clarify some of the questions which they found difficult to understand. In addition, an interview also allowed for certain amount of judgment, albeit subjective, about the villager's attitudes towards the social forestry and its implementing agency. The open ended questions were included mainly to capture instantaneous responses and thoughts of the villagers, unencumbered by a prepared set of replies. This spontaneity was useful in testing the new hypotheses. Although easy to ask, the free response questions were difficult to answer and analyse. To overcome this practical problem, an approach based on a combination of both open and closed questions was adopted. As a result of having already obtained the spontaneous response through open questions, it was useful to introduce a set of ideas which might have not occurred to the respondents. In addition, some questions required the respondents to put a weight (low, medium and high) on their answers so as to capture the intensity of the villager's attitudes. This information was useful in analysing their behaviour.

A separate questionnaire was developed (Appendix, 10.2) to be used with the staff responsible for social forestry implementation. This was done in order to capture the expert knowledge accumulated from their experiences while implementing social forestry. In all 45 officers including Joint and Deputy Directors, Assistant Conservators of Forests and Social Forestry Supervisors, were interviewed using a structured questionnaire containing both open and closed questions. Some refused to respond to the questionnaire but 40 officers participated, although some answered only a few questions.

## 10.3 Results of the survey

The relevant socioeconomic and policy aspects of the social forestry systems were identified based on the survey methodology outlined above. Secondary sources of data were also used when such information was available. The results are discussed at two levels: at general State level for India and at regional, village and household levels for Orissa. The results at State level are by no means exhaustive due to a very limited survey, but do give some broad indications based on macro-level evidence. Similarly it is plausible that there are interrelationships between levels (State to local, for instance) but to keep the analysis within manageable proportions these aspects have been identified at regional, village and household levels as shown in Figure 10.2

**Figure 10.2 Decision-making in Social forestry.**




## 10.4 State level attributes

A total of 16 households were selected in four villages of Moradabad and Barrielly social forestry divisions of western Uttar Pradesh (UP) in order to discern the macro-level trends at the inter State level. Western UP (an economically well developed region of India) was chosen because it offered a sharp contrast to Orissa. Since it was not possible to visit other States of India mainly due to limited resources, empirical evidence based on published records was also considered.

In India, as in many agrarian economies, land is not only a main source of livelihood but also a basis of social stratification because the groups in control of land resources also derive adequate resources to influence the social structure and value system. The land tenure system introduced during the pre-independence and the consequent agrarian structure not only influenced the management of forests (Sharma *et al*, 1990a) but also generated a tradition of unsettled tenurial security in those States where the Zamindari (landlord) system was implemented.

Permanent settlement of Bengal (1793) conferred the rights of land ownership to Zamindars (who acted as intermediateries between the government and the tenants) by sacrificing the cultivators' interests. As a result a landlord class - the Zamindars and Jagirdars (who also acted as money lenders to poor at usurious interest rates) - were at the apex of agrarian social structure. They had superior rights over the land, allowing them to lease out land and to extract a surplus in the form of rent. At the same time the cultivator was reduced from the status of proprietor of land to a mere tenant, losing the fixity of tenure which he enjoyed earlier (Byres, 1985). In those States of India where the Ryotwari (tenant) and Mahalwari systems were introduced (with tenurial security and owner cultivation) the villagers were enthusiastic about adopting new technologies such as the Green Revolution strategy. This attitude of the villagers is reflected in their enterprinership and innovation. A natural corollary of this is the development of an infrastructure in these regions due to ancillary impacts. As a result of the market facilities developed in these regions, the villagers started growing commercial crops which led to a shift from subsistence economy to a more monetised one.

In contrast, most of the States in north-eastern and eastern India, are still characterised by subsistence agriculture and lack of an infrastructure. An illustration of this argument can be given from eastern India and western UP. The parasitic landlordism of the first type of agrarian economies with a subject peasantry stood in sharp contrast to the second type of agrarian economies with a more dynamic peasantry having respect for manual labour, industriousness, thrift and economic rationality (Joshi, 1981). Peasantism in non-Zamindari regions proved a socioeconomic and cultural force which served as a source of economic rationalism and provided a social base which has been responsible for the capitalistic transformation in such areas.

These attitudes of villagers combined with the differing socioeconomic environment between regions have resulted in a differential uptake of the Green Revolution technology (biochemical and mechanical innovations). The peasants in the States of western, north-western and parts of southern India (the region endowed with a comparatively well developed infrastructure and irrigation facilities) responded favourably to this new technology and have greatly benefited by it. Given the high input nature of the new technology, the already rich peasants were the early adopters and beneficiaries (less than 15% of the area under foodgrain which mainly lies in the Green Revolution belt, contributed as much as 56% of the increase in foodgrain production) because they had the ability to secure the scarce resources including information about the performance and utilisation of the new technology. In addition the rich farmers of these regions (unlike the poor farmers of the eastern India) could ignore the risk usually associated with a new technology and have also benefited from the infrastructural and institutional facilities. The participation of large and medium farmers in the formal credit market is generally high, while the poorer households participate in an informal credit market which makes credit available at a very high interest rates (Sarap, 1985).

Although after independence, the Zamindari system was abolished and land reforms were carried out, the legislation extended protection inequaitably to the upper layers of tenants. This has resulted in commercial tendencies more marked in Ryotwari and Mahalwari regions than in Zamindari and although a majority of peasants in Ryotwari and Mahalwari regions have benefited from the Green Revolution the poor peasants, landless labourers and artisans of Zamindari region have gained very little.

The arguments made so far partially explain a higher uptake of social forestry in western and north western States of Gujarat, Haryana, Punjab and western UP. In these States the villagers have adopted commercially oriented social forestry (farm forestry) on their own holdings.

An important factor which has contributed to higher adoption of farm forestry in non-eastern India, especially in industrially developed regions, is the large demand for constructional timber such as poles. In western and north-western India, the situation is acute because of the small number of government forests resulting in a smaller supply of timber for construction. This explains the large scale plantings of Eucalyptus between 1974 and 1984 when it accounted for two-third of the total seedlings distributed. Eucalyptus species are not only fast growing and non-browsable, having narrow crowns so that more trees can be grown per unit area, but they also provide excellent timber for poles because of their straight boles.

In some regions of the Green Revolution belt such as Haryana and western UP where labour supply is short, the villagers, especially rich farmers, have shifted to farm forestry because it requires less labour overall. Apart from plantation establishment and the cultural operations carried out during the two subsequent years, the labour requirement in a forestry crop is small unlike agriculture which requires seasonal labour each time a crop is grown. In addition, the irrigation and managerial inputs (in the form of maintenance and supervision) associated with a forestry crop are less than those for agricultural crops (which are raised biannually or annually). Because of these factors many absentee landowners have preferred forestry which has also reduced the risk of encroachment by villagers because the land is occupied for a comparatively longer period. Although this phenomenon can also be observed in some pockets of eastern India, the reason for this change in land-use is quite different. In eastern India most of the land is infertile, making it more suitable for tree rather than agricultural crops and so wherever demand for forest produce exists absentee landowners have gone for forestry to obtain financial returns from the hitherto unproductive lands.

In the southern Indian State of Kerela, where the population density is the highest in the country, villagers have exploited the land potential (good soil fertility and high rainfall) by adopting multi-storeyed home gardens so as to maximise the overall output from the scarce land resources. This age old tradition of growing home gardens along with the higher consciousness (as reflected by Kerala having the highest literacy rate in the country) seems to be a major contributory factor in the higher involvement of the villagers in social forestry. In the adjoining State of Tamil Nadu, where irrigated agriculture using tank stored water has a long history, community plantations raised on the shores of such tanks is an important component of social forestry. In the semi-arid regions of Rajasthan and Haryana, the villagers grow trees on their farms mainly to increase soil productivity and sustain land capability.

In eastern, north-eastern and parts of central India, the differing socioeconomic environment has shaped the uptake of social forestry. In these areas the government forests are still a source of forest produce for meeting household needs. This is a consequence of low industrial developmental activities in these areas which have resulted in less market development. The villagers are therefore not motivated to adopt social forestry with their own resources: instead they consider it a government activity. Social forestry has become more of a community-oriented rural development programme in these areas, to be implemented largely with the support of the Forest Department on communal, or unused government lands. Although community-based social forestry has gained support in some regions of western India such as Gujarat, the reason for this success can be traced to a cooperative movement known as the White Revolution - the production and marketing of milk and milk-based products through cooperatives. The model of development through the cooperatives as provided by Gujarat seems to have helped the uptake of social forestry, mainly through the institutional support offered by the cooperatives.

The subsistence nature of agriculture and the poverty of the region do not usually permit the peasants to take risks by adopting a new technology such as social forestry, without adequate assistance from government. In addition, communal and government wastelands are more accessible in this region, mainly due to low levels of fertility and economic activity. In contrast, most of the land in other parts of the country which is under high population pressure has been brought under the plough, leaving little land on which community forestry can be practised.

As agriculture is mainly a private sector activity, the lack of capital markets in eastern and north-eastern India has decelerated the rate of reinvestment and consequently reduced the growth of production surplus. With the resulting poverty and economic dependency productive investment has been low which, coupled with high population pressure, has resulted in inadequate improvements in productive forces including labour. The preponderance of an increasingly differentiated peasantry consisting of a large number of small and marginal peasants has further increased subsistence agriculture. The situation has further deteriorated due to lack of investment in the industrial sector which would have otherwise provided some opportunities, lessening the population pressure on cultivated lands.

The backward economy of the eastern and north-eastern India, characterised by these socioeconomic factors, has given rise to peculiar labour conditions. The non-availability of assured and timely employment has induced landless labourers and marginal and small peasants to cling to their fragmented and tiny holdings which they cultivate intensively with the help of surplus family labour thus avoiding the risk of not securing off farm employment. The consequence is high intensity of cultivation, high land productivity but low labour productivity, and intensive use of family labour.

Such a socioeconomic environment has led to the inclusion of a special component to social forestry policy in Orissa and West Bengal aimed at the bettering and rehabilitating the rural poor by generating adequate income. The Group Farm Forestry in West Bengal aims at motivating groups of poor households to establish plantations on contiguous plots of 20 ha or more of unused government lands. Seedlings and technical know how are provided by the Forest Department. The motivating force for villager participation is income generation and the production of forest produce mainly for their own consumption. Surplus production can be sold and the income used for long term investments such as the purchase of additional land for paddy cultivation. The scheme is quite similar to the FFRP component in Orissa social forestry (described in Chapter 1) except that in this case the individual households are allotted government land. However, one distinction between the socioeconomic environment of Orissa and West Bengal which has influenced the uptake of social forestry in the latter needs to be noted. West Bengal, unlike Orissa, has a long tradition of structural changes in terms of instituting land tenure legislation including land ceilings in favour of small peasants. Surplus land distribution to the landless poor has been operated by party cadres of the Marxist State government through village Panchayats. Such a model would be applicable in Orissa but requires a similar social commitment at political level.

Another important factor contributing to uptake of community based social forestry in India is related to the increasing privatisation of village common lands, such as village forests and pastures, which have played a significant role in the socioeconomic life of the rural poor. A study by Jodha (1983) of 80 villages in the dry zones of 7 States reveals that the annual per household income derived from common property resources (CPR) ranged between Rs. 530 to 830. This is higher than the income generated by a number of anti-poverty programmes which were being implemented in these States. However, a large scale privatisation of these CPRs in the last decade (between 49 and 86% of CPRs ended up in the hands of the non-poor) coupled with the commercialisation of the activities based on these CPRs (such as marketing of fuelwood and fodder) have almost completely marginalised the weaker sections. They increasingly find that they have to buy things which they formerly used to receive in the forms of traditional claims. This on the one hand suggests that what the government gives to the poor through its anti-poverty programmes is taken away by the socioeconomic processes dominated by the rich, while on the other that these wasted communal lands need to be rejuvenated through social forestry if such adverse trends are to be halted.

In those areas where there is surplus labour and where alternative economic opportunities are low the villagers are motivated to participate in social forestry because of a need to earn their livelihood and obtain for fuelwood, fodder and small timber. The labour intensive subsistence agriculture in these regions requires a net transfer of fertility from the forests through fodder and leaflitter. This means that agriculture draws heavy inputs from the already deteriorating forests. With declining forest availability and productivity the agricultural productivity is also adversely affected. Gadgil (1987) reports that in the Eastern Ghat region the paddy fields and arecanut orchards are well managed with above ground annual production of 9 and 20 tonnes per ha respectively but this production is at the cost of forests which annually provide plant organic matter inputs to the tune of 16.6 tonnes per ha. Similar conclusions are also drawn by Singh *et al* (1988), based on a study from the hills of UP showing that the viability of farms is related to that of CPRs, and Shah (1989) who demonstrated that the major criteria influencing the choice of agroforestry as a land-use were the size of village CPRs and the extent to which fuelwood and fodder needs are met from these CPRs. The discussion so far suggests that the existing land-use pattern can influence the uptake of social forestry to a great extent.

The distinctive attitude of the peasants of eastern and north-eastern India seems to be due to the impact of nature and the geophysical features of that region. The fatalism among the peasants, which affects the social forestry uptake, has much greater sway in those regions where nature oscillates between excessive bounty (the fertile plains of eastern UP) and poverty (the hills of UP and parts of eastern India). In the former the very fertility of the soil has minimised the role of human effort, while in the latter the meanness of nature has set limits to what man can achieve through his efforts (Joshi, 1981). Natural disasters such as cyclones, droughts, floods and epidemics occur frequently in eastern States including Orissa, destroying crops, property and life. Therefore the peasant fatalism has evolved as an internal mechanism in order to avoid the total breakdown of the socioeconomic system which is influenced by geographical conditions, historical influences and an interplay of the endogenous and exogenous environment. This suggests that the fatalism represents an ability of human beings, both as individuals and communities, to respond to harsh environmental conditions in a manner best suited to the prevailing conditions.

## 10.5 Regional attributes of Orissa

Not only does the uptake of social forestry differ between States but also within regions and communities in Orissa. Orissan villagers' attitudes to work and life, hardened by stagnation, isolation, ignorance and poverty, and underpinned by tradition, culture and often by religion, are thought to be inimical to any socioeconomic change including social forestry. This is compounded by elements of the social forestry package such as its supporting legal framework and implementing agency (i.e. the Forest Department).

The disparities among the districts of Orissa have increased over the period starting from the 1950's. Nearly two-thirds of the cultivated area operates under a negative or very low growth rate. This is because of uncertainty of monsoons and the lack of infrastucture and irrigation for rice cultivation (the area under irrigation constitutes below 20% of the total cropped area). It is estimated that during the period 1951 to 1966, 40% of the variation in agriculture production was accounted for by erratic monsoon rains; increasing to 60% during the period 1958 to 1978 (Mishra, 1983). This meant that Orissa, having rice as the main agricultural crop, could not benefit from the Green Revolution which took place mainly in wheat growing areas.

The implementation of social forestry has been given less attention in the Central and Eastern Ghat regions because they still have good forests which are easily accessible to the less densely settled population of the region. In contrast, the densely populated coastal plains (which have little land under forests) are more developed in terms of agriculture and industry due to good soil and infrastucture such as markets and transport. Villagers are accustomed to growing cash crops and trees on their farm land to meet their demand for forest produce with any surplus being sold. This attitude is reflected in a higher uptake of farm forestry such that the villagers plant seedlings, provided by the Forest Department, on their farms. However, as the size of land holding is comparatively small, large scale plantations are not possible, a factor which inhibits a substantial uptake of social forestry.

Another obstacle in successful implementation of community oriented social forestry is that a rapidly growing population has increasingly resulted in the encroachment of unused government land and CPRs. This has been compounded by a fragmented political leadership which has precluded to some extent the required village homogeneity for rapid uptake of social forestry. *Casuarina equisitifolia* is grown extensively on whatever unused land available due to an acute fuelwood sarcity in the region . In the industrial areas adjoining Cuttack and Bhubaneswar, the villagers prefer to take more attractive jobs in industry rather than those in social forestry. The major consequence is that plantations suffer due to the lack of a regular and trained workforce. However, some successful plantations can be seen near Khurda, in which unemployed village youths are participating with the help of Non Government Organisition (NGO) such as the Youth Club.

In the economically backward and less densely populated regions of the Central Table

Land, community-oriented social forestry has proved more acceptable and successful. In this region adequate community and unused government land (which in most cases are village forest and pasture lands which have become devoid of vegetation due to overuse and mismanagement) is available for raising plantations for the village communities. Also the community-centred social structure of the predominantly tribal population has created a suitable environment for the success of social forestry. Strong traditional leadership in which the communities have confidence has proved an asset in motivating the villagers.

Many long standing rural and tribal development schemes have instilled a feeling of trust in the implementing agency and villagers were found to be optimistic about the results of social forestry. However, this has also generated a passivism among some villagers who have come to know social forestry as a purely government scheme (similar to other rural development schemes) with the responsibility of providing them with forest produce. Many villagers are not enthusiastic about farm forestry and would prefer to go to nearby government forests (which are still found around many villages) to obtain forest produce to meet their needs. In some areas where natural forests of Sal (*Shorea robusta* ) shoots (coppice origin) are found, the villagers protect these rather than planting new trees because they are of multiple use to them. In areas with good irrigation facilities, such as the Hirakud dam catchment in Sambalpur, villagers prefer to practice paddy cultivation and are less attracted to tree cultivation.

The Northern Plateau has characteristics which are found in both the Coastal Plains and Central Table Land due to its proximity to these regions. In this area community oriented social forestry has achieved a higher level of acceptance than farm forestry. An attempt has recently been made in Dhenkanal to start tree grower cooperatives as a pilot scheme in collaboration with the existing cooperative societies for milk.

### 10.5.1 Social forestry uptake and economic activities

Although Orissa is backward both economically and agriculturally, it offers a great opportunity for the development of social forestry, due in large measure to its surplus labour and land resources. Statistics about the socioeconomic indicators over the period 1971-1981 (latest available) compiled from GOI (1986) have been presented to provide a picture of the inter-temporal trend in economic activities and its likely impact on uptake of social forestry in all the four regions of rural Orissa (see Table 10.1).

Recent data for analysing inter-temporal trends in agriculture could not be found but as the Green Revolution has had little impact on Orissa because of limited success with the new seed varieties of paddy (grown on more than 65% of the total cultivated area under food crops) it is thought appropriate to use the available data which relates for the period 1963 to 1971 (Table 10.2).

In the coastal districts the increase in rural population over the decade varies from 13 to 19%, with a similar increase in the number of cultivators in Puri and Baleswar. The number of cultivators in Ganjam increased faster than the total population, while in Cuttack it decreased over the same period (which may be due to increasing diversification of its economy towards industry). A similar trend is evident in the case of agricultural labourers but the situation is different in the case of village artisans. A dramatic decrease in the percentage of the workers engaged in household industries including forestry and fishing is seen in all the districts (except Balasore). This suggests that an increasing number of workers find the household industries economically less attractive and either become landless labourers or adopt agriculture (further decreasing the size of land holding).

This increasing labour force in agriculture along with an increase in area under cultivation has resulted in a high growth of overall agricultural output in the region but such growth cannot be sustained over a long period due to high rate of population growth and a declining resource of suitable land for reclamation. The lack of improvement in the agricultural productivity indicates either too much pressure on land resources or inefficient utilisation of labour resources.

An alarming trend in Northern Plateau is the increase in the number of agricultural labourers and a decrease in the number of workers engaged in household industries. Despite an increase in labour force employed in agriculture, the agricultural growth in terms of the area and its productivity is very low (in fact negative in some districts such as Sundargarh which has witnessed a very sharp increase in agricultural labourers). Although there are large patches of unused land which can be brought into agriculture, they have neither been reclaimed by the villagers (who lack the appropriate resources required for such laterite soils) nor by the governemnt. The neglect of land reclamation programmes therefore seems to be the most obvious gap in current land-use policy. Such lands, if reclaimed through social forestry, would greatly benefit the impoverished rural populace. The villagers used to get three-quarters of their food from the nearby forests and are now finding it difficult due to the degradation of these forests. They are consequently forced to sell their land holdings in order to meet their subsistence needs (Hota, 1986). However, because of a good resource base many industries such as mining and steel have sprunged up which has resulted in diversion of some of the labour force to such industries. The deindustrilaisation of the cottage and village industries (which are dependent on forests for raw material) can be checked by developing social forestry and its ancillary forest-based industries.

There has been a sharp increase in the percentage of agricultural labourers in the Central Table Land (35% in Sambalpur and 31% in Bolangir). This possibly explains a higher uptake of social forestry by the resource poor villagers in these districts. The irrigation facilities provided by the Hirakud dam and a large scale influx of industrious people from the neighbouring State of Andhra Pradesh, who have started cultivation in irrigated areas, has made it possible for agricultural output and productivity to increase despite a comparatively lower increase in the area under cultivation.

In the sparsely populated Central and Eastern ghat region, a sharp increase in the percentage of cultivators is possibly due to easy access to unused land and the lack of economic opportunities. This has resulted in a large number of workers becoming agricultural labourers. Such developments mean that social forestry can be adopted by these poor villagers, mainly as a means of earning income through employment and not for forest production, because of the relative ease of access to forests in the region.

### 10.5.2 Social forestry uptake and policy package

Although many aspects of policy implementation will be discussed in the following two sections, the general aspects influencing social forestry uptake at Orissa level are discussed here. The major objective of traditional forestry and foresters is the regularisation of forests (see Chapter 2 for discussion). Social forestry requires a people-centred developmental approach which suggests not only reorientation of the forester's outlook but also a sympathetic understanding of needs and social behaviour of the villagers whose beliefs and values are ingrained in traditonal culture, including agriculture. This also suggests an integrated approach in which other departments such as the Rural Development and Tribal Development can contribute substantially. In those areas where such an attitude was found among the foresters, such as parts of Sambalpur and Puri, villager response was encouraging. There is not only a need for a package of incentives and disincentives but also a requirement for consistent planning based on well defined goals and objectives (see Chapters 8 and 9). To date no study has been done in Orissa which determines the socioeconomic optimum rotations for various species being raised under the different components of social forestry. This is an obvious gap which has been closed in Chapters 4, 5 and 7.

Another important aspect inhibiting social forestry uptake invariably found during the field study relates to the legal framework under which the policy is operating. Social forestry plantations need to be notified as village forests, preferably before establishment if they are to be protected legally like village forests. For example, the revised village forest rules (GOO, 1985) ensure some rights to the villagers and their involvement, but these are not applicable because the land has not so far been declared as village forests. Similarly no formal ownership documents including that for FFRP component are given to villagers which can ensure their rights to trees or land (Olsson, 1987). In some social forestry divisions the villagers were very apprehensive while in others the local staff have assured them about the future benefits, although only verbally. It was revealed during the survey that the State government is contemplating some action in this regard and a revised draft of the village forest rules is under consideration.

To transport forest produce currently requires a transit permit issued by a Divisional Forest Officer. The procedure of granting such a permit is cumbersome and the issuing of permits is discouraged in general, due to the fear of their misuse in the transport of illicit forest produce stolen from government forests. Such restrictions discourage the *bonafide* villagers who want to participate in social forestry for cash sale in nearby markets.

## 10.6 Village and Household level attributes

The expert knowledge elicited from the staff responsible for implementation of social forestry through questionnaire is presented in Tables 10.3 and 10.4. A weighting scheme based on the Likert technique as described by Oppenheim (1966) was adopted by putting weights 3, 2 and 1 to high, moderate and low intensity of responses towards a particular attitude. Although the reliability of the Likert scale is good (ibid, 1966), a shortcoming of the technique is that the same total score may be obtained in many ways. However, the severity of such shortcoming was reduced by noting the comments of the concerned villagers and staff, allowing a subjective judgement in case of conflict. Based on the weighted frequencies for open ended questions and frequencies of closed questions, the aspects responsible for a differential uptake of social are identified in Tables 10.3 and 10.4. The following discussion is based on the responses from the villagers of the surveyed villages.

### 10.6.1 Village level attributes

A typology of the villages as discussed below is developed from the information given by the villagers :

1. The existence of schools (primary, middle and high) is positively correlated with the level of success of social forestry :

| Impact level | No. of schools | | | |
|---|---|---|---|---|
| | High | Middle | Primary | None |
| High | 1 | 3 | 6 | _ |
| Moderate | 1 | 3 | 6 | _ |
| Low | _ | 2 | 5 | 3 |

2. In all the surveyed villages VFCs have been constituted although in some villages they are not functioning satisfactorily. This is reflected in responses given by 111 households that the village as a whole should participate in social forestry rather than a VFC. Similarly, in all but five villages Joint Management Plans (JMP) have been drafted for the plantations but almost half of the village households were not aware of the provisions of the JMP.

3. There does not seem to be any correlation between the presence of a cooperative society and social forestry uptake :

| Impact level | Cooperative society | |
|---|---|---|
| | Present | Absent |
| High | 5 | 5 |
| Moderate | 4 | 6 |
| Low | 3 | 7 |

A possible reason for this finding (which was also confirmed by the Forest Department staff) is that most of the existing cooperative societies are either performing poorly or not functioning at all.

4. The existence of the community centres in villages is found to be strongly correlated with the level of success of social forestry :

| Impact level | Community centres | |
|---|---|---|
| | Present | Absent |
| High | 8 | 2 |
| Moderate | 8 | 2 |
| Low | 4 | 6 |

A possible reason for this result is that a bond of community feelings shown by the community centres is largely responsible for engendering the cooperative efforts required for the success of social forestry. It also suggests that a village is more cohesive and homogeneous with respect to socioeconomic structure which leads to a higher uptake of social forestry. This was noticed in some of the comparatively smaller villages in the Puri Division. A similar result was found with respect to the management of these community centres :

| Impact level | Management level | | |
|---|---|---|---|
| | Good | Moderate | Low |
| High | 7 | 3 | _ |
| Moderate | 1 | 8 | 1 |
| Low | 1 | 2 | 7 |

Youth clubs play a significant role in the mangement of many of the well managed community centres. They possibly act as agents for social change in respect of community's attitudes towards social forestry.

5. The presence of village community lands such as village forests and grazing land (Gochar) is correlated with the level of success of social forestry:

| Impact level | Community land | |
|---|---|---|
| | Adequate | Inadequate |
| High | 8 | 2 |
| Moderate | 8 | 2 |
| Low | 3 | 7 |

The explanation for this result is that not only do the village community lands provide much needed land resources for plantations but they also reduce the biotic pressure, especially grazing, thereby providing protection to the plantations.

6. Factionalism in the villages is inversely correlated to social forestry uptake :

| Impact level | Degree of factionalism | | |
|---|---|---|---|
| | Low | Moderate | High |
| High | 5 | 4 | 1 |
| Moderate | 5 | 4 | 1 |

| | | | |
|---|---|---|---|
| Low | 2 | 1 | 7 |

7. Involvement of the village leadership in social forestry activities is strongly correlated with the level of success of social forestry :

| Impact level | Leadership involvement | | |
|---|---|---|---|
| | High | Moderate | Low |
| High | 8 | 1 | 1 |
| Moderate | 4 | 4 | 2 |
| Low | 1 | 2 | 7 |

A similarly result is found with respect to the involvement of local NGOs such as youth club and women's councils (Mahila Mandals) in social forestry uptake :

| Impact level | NGOs involvement | | |
|---|---|---|---|
| | High | Moderate | Low |
| High | 7 | 2 | 1 |
| Moderate | 6 | 3 | 1 |
| Low | 1 | 3 | 6 |

8. As expected those villages having surplus labour were found to have a higher uptake of social forestry :

| Impact level | Labour availability | | |
|---|---|---|---|
| | Surplus | Adequate | Deficient |
| High | 8 | 2 | _ |
| Moderate | 8 | 2 | _ |
| Low | 2 | 4 | 4 |

9. People of the villages having inadequate forests (such as RFs, PFs or Village forests) in close proximity were found to be more enthusiastic about participating in social forestry :

| | Forests in village proximity | | |
|---|---|---|---|
| Impact level | Adequate | Not adequate | No forests |
| High | 1 | 1 | 8 |
| Moderate | 1 | 3 | 6 |
| Low | 4 | 4 | 2 |

10. Plantations, especially VWLs and FFRP, close to the villages were found well protected and the villagers were optimistic about their success. This has resulted in higher uptake of social forestry by the villagers as seen from the following :

| Impact level | Distance ($Km^2$) from the village | | |
|---|---|---|---|
| | <1.0 | $1.0 \leq 2.0$ | > 2.0 |
| High | 8 | 1 | 1 |

| | | | |
|---|---|---|---|
| Moderate | 7 | 2 | 1 |
| Low | 2 | 4 | 4 |

A reason for this result is that the villagers who engage in other household activities are attracted to social forestry as a complementary activity and so prefer their plantations nearby. This allows them to utilise even small amounts of spare time to carry out social forestry activities.

### 10.6.2 Household level attributes

The attributes influencing the uptake of social forestry at the household level are presented below. These results are based on answers recieved from 210 surveyed households.

1. A majority of households (122) approved the choice of species planted under various components. However, the following results show that a higher proportion approved of the species in those households which were in the high or moderate uptake categories :

| Impact level | Approval of the species | Non-approval of the species |
|---|---|---|
| High | 59 | 11 |
| Moderate | 54 | 16 |
| Low | 9 | 61 |

From these results it can be inferred that use of preferred species has a positive effect on social forestry uptake.

2. Although many villagers still do not see the protection of the social forestry plantations as their primary responsibilty, the distance that plantations were from the village affected the level of protection given to the plantations and was less for villages with a high impact level:

| Impact level | Distance ($Km^2$) from the village | | |
|---|---|---|---|
| | < 1.0 | 1.0 ≤ 2.0 | > 2.0 |
| High | 55 | 10 | 5 |
| Moderate | 47 | 16 | 7 |
| Low | 13 | 29 | 28 |

In those plantations for which watchers have been engaged by the Forest Deartment the villagers were more optimistic about their success.

3. A majority of the households replied that the primary objective of VWLs is to supply fuelwood and small timber followed by additional income generation :

| Impact level | Forest produce needs | Income needs | Both | None |
|---|---|---|---|---|
| High | 16 | 9 | 44 | _ |

| | | | | |
|---|---|---|---|---|
| Moderate | 14 | 17 | 37 | 2 |
| Low | 8 | 7 | 6 | 49 |

The uptake of social forestry was low where the households lacked the need for forest produce or income.

**4.** It was found that an important objective (101 households) of creating assets in the form of trees is to meet contingencies such as natural calamities, medical problems and marriage. A large number of these households are either landless labourers or small peasants lacking any permanent source of income and so are poor and vulnerable.

**5.** 168 households replied that it is the responsibility of the Forest Department to manage the VWLs and only 34 replied that it is the community's responsibilty. This suggests a majority of the villagers still consider social forestry largely a government programme. This implies that there is a need for strengthning the extension activities in order to create an awareness of social forestry objectives among the villagers. Only 107 households replied that the VFCs could manage the VWLs if they were handed over to them fully, while 66 households thought they could not and the remainder were not sure.

| Impact level | VFCs can manage | VFCs can not manage | Not sure |
|---|---|---|---|
| High | 64 | 4 | 2 |
| Moderate | 39 | 25 | 6 |
| Low | 4 | 36 | 30 |

Reasons mentioned for the inability to manage the VWL's were; lack of forestry skill, factions within the village and malfunctioning of the VFC. In all 134 households reported a need for continuing support from the Forest Department in carrying out social forestry activities.

**6.** Although a majority of households (168) recognise the potential role of VFCs in management of social forestry plantations, they were not aware of their rights and responsibilities, especially about the distribition of forest produce after maturity of the plantations. In fact no formal mechanism has been worked out either by the Forest Department or by VFCs for distribution of the forest produce.

**7.** Most of the VFCs have women as members (at least one in each) but their participation is generally lacking. Only 25 households reported about the active involvement of women in VFC deliberations. This lack of adequate involvement is partly due to the social structure of Indian society in which women have traditionally been taken for granted and most of the decision-making is done by the male members of the households. In fact 53 households were not in favour of involving women at all. Such attitudes were also noticed among few staff of the Forest Department who were not generally happy with the appointment of women social forestry workers and supervisors. However, women carried out 29 - 30% of paid works in social forestry operations during 1984-86. This corresponds closely with their participation in agriculture which was found to be 32% of total labourers in the 1981 census. In some districts such as Sambalpur and Bolangir 39% and 34% of the total work days were generated by women workers respectively (Olsson, 1987) but in coastal Orissa women's involvement was very low, at 13% and 20% in Balasore and Cuttack respectively. An explanation for this difference lies in the social structure of these markedly different regions. In coastal Orissa the upper caste families, which are in the majority, do not allow their women folk to work in the fields becuase of social customs while in predominantlly tribal western Orissa, no such taboo exists. In fact in western Orissa women contribute jointly with their male counterparts in earning the family livelihood. The highest levels of female participation were found in nursery works because it was less strenuous.

8. Almost all the households reported regular contacts with the Forest Department staff such as social forestry worker and supervisors but only 126 households reported that they recieved adequate support from the Forest Department, while the remainder wanted further support such as technical skills and watch and ward provisions.

| | Support from the Forest Department | |
|---|---|---|
| Impact level | Adequate | Inadequate |
| High | 51 | 19 |
| Moderate | 42 | 28 |
| Low | 34 | 36 |

9. Only 7 of the 15 FFRP beneficiaries were involved in identification and selection of land for plantations and more than half of them stated that without the continuous support of the Forest Department it would be difficult for them to carry out the plantation activities satisfactorily.

10. Lack of follow up contacts with the Forest Department staff after raising plantations was found to be responsible for the neglect of some of the plantations by the villagers :

| Impact level | Follow up contacts and action | |
|---|---|---|
| | Adequate | Inadequate |
| High | 49 | 21 |
| Moderate | 39 | 29 |
| Low | 24 | 46 |

11. Extension activities such as publicity through posters, drama and meetings was inadequate as only 25, 16 and 42 households respectively reported such activities.

12. A shortage of dung for agricultural fields was reported by 111 households and 94 of these thought that increasing the area under plantations would help divert the dung from burning to agricultural fields. This value is lower than expected because many of the remaining villagers were landless labourers without any landholdings. More than 70% of the total households (151) experienced some problem or other in meeting their fuelwood needs and 109 households were directly dependent on forests for meeting thier fuelwood needs.

13. Although in many parts of Orissa (unlike western and north-western India) markets for construction timber are not well developed, 109 households replied that at present there is adequate demand for forest produce mainly for subsistence needs.

14. Only 25 households declared a willingness to reinvest a part of their forestry income in raising plantations in future. The remainder reported investments in the purchase of permanent assets such as land for paddy cultivation. It can be inferred, therefore, that villagers should be made aware of the long term benefits of such investments and a statuatory provision could be put into village forest rules which required that a fixed proportion of the total forestry income should be invested in raising new plantations.

15. Inter-generational conflict was not found to be of any significance. A total of 11 households reported that initially their sons were apprehensive about the scheme but showed enthusiasm after pursuance. 188 households had successors to take over the plantations.

16. Except in coastal areas Orissan villagers are not yet encouraged to raise trees on their own farmland. Only 39 households, mainly in coastal areas, reported raising trees on their own farms while the remainder preferred to raise plantations on either communal or government land. In fact 136 households mainly in Sambalpur, Bolangir and Dhenkanal, replied that they have not seen anything other than government forests.

17. Backward communities such as sheduled tribes (ST) and castes (SC) were found to be more involved in social forestry plantations :

| Impact level | SC | ST | Others |
|---|---|---|---|
| High | 25 | 32 | 13 |
| Moderate | 21 | 28 | 21 |
| Low | 11 | 12 | 47 |

18. Agricultural labourers and marginal peasants are found more enthusiastic about social forestry participation:

| Impact level | Category (with respect to size of land holding) | | | |
|---|---|---|---|---|
| | Landless | Marginal | Small | Large |

| | | | | |
|---|---|---|---|---|
| High | 37 | 20 | 11 | 2 |
| Moderate | 33 | 26 | 7 | 4 |
| Low | 4 | 16 | 34 | 16 |

This suggests that the smaller the land resource the higher is the social forestry uptake. This is possibly due to a need for additional income in addition to a requirement for forest produce. A similar pattern is seen when households are classified according to their levels of income :

| Impact level | Income group | | |
|---|---|---|---|
| | Subsistence | Low | Medium |
| High | 47 | 21 | 2 |
| Moderate | 32 | 30 | 8 |
| Low | 6 | 19 | 45 |

This suggests that the beneficiary households who are at or below poverty level of consumption should be the target groups for social forestry. For identification of such groups a consumption analyis is required as discussed in the following section.

### 10.6.2.1 Consumption analysis

In order to analyse the consumption levels of participant households it is necessary to specify a consumption function based on consumer behaviour. Once the consumption level of a household is known it is possible to explore whether the utility of consumption (accrued through social forestry) for a particular household would be high or low. A brief review of the consumer behaviour theory follows.

The level of disposable income is the main determinant of a consumption function, although other factors which may influence it include income and price expectations, liquid assets, credit facilities, life cycle etc. There are three approaches of estimating a consumption function; the absolute income hypothesis (Keynes, 1936), the relative income hypothesis (Duesenberry, 1952); and the permanent income hypothesis (Friedman, 1957). Each approach advocates a relationship between an individual's consumption and income, *ceteris paribus*. However, these differ in their implications.

#### 10.6.2.1.1 The absolute income hypothesis

The Keynesian consumption function shown below implies that the consumption $C_t$ in period t depends only on the income $Y_t$ in that period,

$$C_t = a + b\,Y_t$$

where the intercept 'a' is the minimum required level of consumption and the slope of the consumption function 'b' is the mariginal propensity to consume (MPC). However, as adjustment of the consumption corresponding to new level of income is not usually instantaneous such that the previous income also affects the current consumption, the model will take the form:

$$C_t = a + b_0\,Y_t + b_1\,Y_{t-1} + \ldots\ldots\ldots\ldots\ldots\ldots\ldots + b_n\,Y_{t-n}$$

where, $b = b_0 + b_1 + \ldots\ldots\ldots\ldots\ldots + b_n$ is the long term MPC and $b_0$ is the short term MPC. This can be reformulated to incorporate the consumer behaviour in terms of the previous year's consumption ($C_{t-1}$) as follows :

$$C_t = a + b\,Y_t + c\,C_{t-1}$$

The short term MPC is represented by 'b', while the long term MPC by b/(1-c). The formula not only accounts for the impacts of the previous year's consumption but also for changes in the wealth and income distribution of the consumer.

### 10.6.2.2 The relative income hypothesis

Duesenburry (1952) suggested that consumption depends not only on the consumer's level of income but also on their relative standard of living, a hypothesis supported by psychological theory. Expressed mathematically, the consumption function can be represented as :

$$C_t / Y_t = a + b\,(Y_t / Y_0)$$

where $Y_0$ represents the previous highest recorded income. Another expression for the consumption fuction can be wriiten as :

$$C_t = a + b\,Y_t + c\,(Y_t - Y_0)$$

The hypothesis is particularly useful in those cases where consumption and savings keep fluctuating due to fluctuating income; for example income dependent on rainfed agriculture.

#### 10.6.2.3 The permanent income hypothesis

Friedman (1957), postulated that income is made up of permanent and transitory components and the permanent changes in income have direct impact on expected consumption, while transitory changes have no impact at all (i.e. transitory components are stochastically independent). This means that the consumption function can be written as (where T and P refer to permanent and transitory components) :

$$C_t^P = a + b\,Y_t^P$$

where,

$$Y_t = f(Y_t^P, Y_t^T) = Y_t^P + Y_t^T$$

$$C_t = f(C_t^P, C_t^T) = C_t^P + C_t^T \quad \text{and}$$

$$\text{corr}(Y_P, Y_T) = \text{corr}(C_P, C_T) = \text{corr}(C_T, Y_T) = 0$$

Therefore,

$$C_t = a + b\,Y_t^P + C_t^T$$

A similar hypothesis is known as life cycle hypothesis.

#### 10.6.2.4 Estimation of the consumption function

Reliable statistics about rural income and consumption which would be suitable for estimating a consumption function are not available. The following estimates have been developed indirectly as follows. Total rural income ($Y_r$) is composed of total rural savings ($S_r$) and rural consumption ($C_r$). The later can be calculated once estimates of total rural income and savings are known. Krishna and Roychaudhuri (1982) have generated rural household savings (in current prices) for the period 1950/51 to 1973/74 based on figures published by the Reserve Bank of India (RBI, 1965) for the period 1950-51 to 1959-60 and National Account Statistics (CSO, 1976) for 1960/61 to 1973/74. Values for the later period were obtained by applying a constant ratio of 25% (estimated from the RBI figures) to the total household saving series. A similar approach was adopted to complete the time series for total rural savings (current prices) for the period 1974/75 to 1984/85 (Table, 10.5). These figures are converted to constant prices (1970-71) by applying deflators for each respective year. A time series for rural income (at current prices) for the period 1950/51 to 1973/74 is taken from Krishna and Roychoudhri (1982). Estimates for the remaing period are not available and so a regression analysis was necessary to complete the series. It was hypothesised that total rural income is either a function of the NDPs for agriculture, forestry and fishery subsector, or of total NDP. These figures (1970-71 prices) were compiled from National Account Statiostics (NAS) and the following results obtained using regression analysis:

$$Y_{r1} = -6438 + 1.81\ (NDP)_{agri.}$$

$$S\,E = 1342 \qquad R^2 = 88\%$$

where, $Y_{r1}$ and $(NDP)_{agri.}$ are in Rs. 10 millions and

$$Y_{r2} = 18263 + 0.623\ NDP$$

$$S\,E = 6435 \qquad R^2 = 99.3\%$$

where, $Y_{r2}$ and NDP are in Rs. millions.

The later model was adopted as 99.3 % of the total variation in rural income is explained by this model in comparison to only 88% in the former. The figures for total NDP (at 1970-71 prices) were compiled from the NAS and the estimated values of the rural income for the different years calculated by using this model are presented in Table 10.5. The estimates of the per capita rural consumption and income were then obtained by dividing the total figures by the respective mid year estimates of the rural population (Table, 10.5). The consumption functions are estimated using the absolute income approach:

$$(C_t)_{1970\text{-}71} = 55.2 + 0.855\ (Y_t)_{1970\text{-}71}$$

$$S\,E = 3.3 \qquad R^2 = 99.7\%$$

$$C_t = 13.2 + 0.933\ Y_t$$

$$S\,E = 4.13 \qquad R^2 = 100\%$$

$$(C_t)_{1970\text{-}71} = 61.6 + 0.893\ (Y_t)_{1970\text{-}71} - 0.053\ (C_{t-1})_{1970\text{-}71}$$

$$S\,E = 3.3 \qquad R^2 = 99.7\%$$

$$C_t = 14.4 + 0.957\ Y_t - 0.029\ C_{t-1}$$

$$S\,E = 4.13 \qquad R^2 = 100\%$$

Estimation of the consumption function based on the permanent income hypothesis requires estimates of permanent per capita rural income. The permanent income can be estimated as a weighted average of the incomes in different periods, i.e.

$$Y_t^P = \sum_t w_t Y_t$$

where, $w_t$ and $Y_t$ are the weights and measured income in time period t. Although there could be many such combinations, the following two have been adopted to estimate permanent income :

$$(Y_t^P)_1 = (Y_t + Y_{t-1} + Y_{t-2}) / 3$$

(i.e. the permanent income is an average of current and previous two year's income) and

$$(Y_t^P)_2 = (2Y_t + Y_{t-1} + Y_{t-2}) / 4$$

(i.e. the current income is weighted twice that of previous two year's income).
The later measure of permanent income is quite close to that estimated by Bhalla (1980) based on an all India earning function. The following consumption functions are based on these two estimates of permanent income :

$$Ct = 24.3 + 0.924 (Y_t^P)_1 + 0.462 (Y_t^T)_1$$

S E = 12.05 $R^2 = 95.9\%$

$$Ct = 63.4 + 0.838 (Y_t^P)_2 + 1.01 (Y_t^T)_2$$

S E = 2.83 $R^2 = 99.8\%$

## Summary

The socioeconomic aspects, influencing the villagers' uptake of social forestry, were identified at regional, village and household levels, by carrying out a socioeconomic survey based on a stratified multistage (3-stages) sampling design. A consumption function has also been estimated in order to identify groups of villagers at different consumption levels. The knowledge base developed in this chapter and the previous chapters is used to present the dynamic decision-making framework shown in the following chapter.

# Chapter 11

# An Application of Artificial Intelligence to Socioeconomic Evaluation of Social Forestry Uptake

The knowledge generated so far, and especially that in the previous chapter, consists of both soft (or subjective) and hard (or objective) data. The use of Expert Systems (ES) to represent such data has been discussed in Chapter 3. This chapter discusses how approximate knowledge is structured in order to develop a rule based system which enables symbolic non-numerical computations to take place when modelling the socioeconomic uptake of social forestry. Once soft data is structured in a formal logical way, theoretically it is possible to test and generate any logical consequences that stem from it.

## 11.1 Knowledge based systems

Knowledge based (KB) systems can be used to evaluate the uptake of social forestry by drawing inferences based on symbolic representation of the soft data within the KB, rather than employing statistical or algorithmic methods for numerical analysis (based on a hard data base) using conventional programming techniques. The emphasis in computing has shifted from numeric processing in the sixties, to data processing in the seventies and knowledge processing in the eighties and nineties. Basically, two contrasting approaches can be identified in knowledge processing. The symbol manipulation approach treats knowledge as a collection of assertions represented by formal symbols in a suitable language, and that 'thinking' is the process of making deductions by manipulating these symbols. The connectionist approach, on the other hand, is based on brain psychology. In this approach 'thinking' emerges from the neural connections forming and reforming in the brain.

Programming languages for knowledge based applications divide into 4 broad classes (Refenes, 1989) : functional languages (e.g. LISP), logic languages (e.g. PROLOG), rule based languages (e.g. OPS5) and what are known as self-organising networks (e.g. BOLTZMANN machines). Functional languages, in which a program is regarded as a collection of functions, are based on rigorous mathematical formalism such as recursion equation systems. A function is then applied to its arguments (i.e. input) resulting in output values . Since expressions are either atomic or can be constructed by applying functions, execution of these languages is based on systematically transferring expressions to equivalent and simpler expressions using the definitions rewritten as rules until they contain no further functions, only constants.

Logic programming is concerned with the logical representation of the knowledge. A problem environment is described in clausal form of first-order predicate logic. The founders of modern formal logic were the mathematicians such as Boole and De Morgan and the economists such as Jevons who was responsible for the concepts of marginal utility theory (Jevons, 1970). Logic, which is concerned with the process of cognition, is the analysis of all human methods of purposeful thoughts and rationale practice. In first-order logic the quantifiers (such as 'for all' and 'there exists') can be applied only to the elements of the domain of discourse (for instance, in Set Theory to the elements but not to the sets themselves); second-order logic allows quantification over sets and functions, and so on.

The first-order logic is classified into two parts: the first part, called propositional logic, deals with the connectives such as 'and', 'or' , 'not' , and 'implies'. The second part, called predicate logic deals with quantification and equality (for instance, Set Theory is a model for the first-order predicate calculus).

Logic languages such as PROLOG are rooted to a branch of mathematics known as the predicate calculus (horn-clause subset of the first order) in which an inference generally consists of a number of assumptions implying a certain conclusion. A predicate in horn-clause logic is of the general form :

$$
\begin{array}{l}
O_1 \text{ :- } C_{11}, \ldots\ldots\ldots\ldots, C_{1m} \\
\vdots \\
O_n \text{ :- } C_{n1}, \ldots\ldots\ldots\ldots, C_{nm}
\end{array}
$$

The clauses $O_1, \ldots\ldots\ldots, O_n$ are a set of alternative conclusions where the clause $O_i$ is true if all the conditions $C_{i1}, \ldots\ldots\ldots, C_{im}$ are true. Implementation of logic languages is achieved by a theorem prover. The most common mechanism for this purpose is provided by resolution methods such as Robinson's resolution inference rule which is used to infer from the clauses (Robinson, 1965). Other mechanisms such as the logical connection method are also being used. In rule based languages, the KB consists of rules while connectionist languages are used for describing semantic networks.

ES are developed to solve problems in specialised domains (containing either qualitative data or both quantitative and qualitative data) in which the user inputs the domain specific information describing the problem. The system then uses the problem-solving techniques present in the inference engine to arrive at solutions to the problem based on knowledge stored in KB. The distinguishing features of an ES from other subtopics of AI such as robotics, natural-language interpretation and computer vision are, heuristics, transparency and flexibility. Jackson (1985) describes the following advantages attached to the strategy of representing human knowledge explicitly in pattern-directed modules, instead of encoding it into an algorithm:

(I) The process of rendering the knowledge explicitly in a piece-meal fashion seemed to be more in tune with the way in which experts store and apply their knowledge.

(II) This method of programming allows for fast prototyping and incremental system development. The resultant programme is easy to modify and extend, so that errors and gaps can be rectified without major adjustments to the existing code.

(III) Researchers realised that a programme does not have to solve the whole problem, or even be right all of the time, in order to be useful. An ES can function as an intelligent assistant, which does some of the tedious enumeration of alternatives in the search for a solution, and rules out some of the less promising ones, leaving the final judgment, and some of the intermediate strategic decisions to the user.

Modelling an aspect of intelligence usually requires the following;

a. knowledge about the domain which is specific for the problem problem,

b. an ability to reason with that knowledge, and

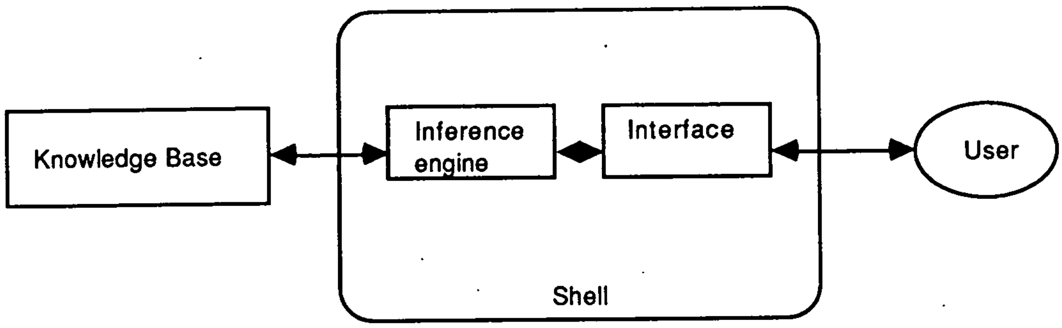
c. the need for knowledge regarding guidance to that reasoning.

Accordingly ES will normally have 3 main components.

## 11.2 Components of an Expert System

Knowledge engineering is concerned with the construction of an ES and is applied artificial intelligence (AI). The essential components of an ES are shown below :

Figure 11.1 Essential components of an Expert System.




### 11.2.1 Knowledge base

The KB stores expert knowledge, typically as a set of facts and rules but it can also be scripts, logic, processes, frames and semantic nets. The power of an ES basically lies in its KB which represents the system's understanding of its domain. The rules in a rule based system have the following form (the IF part is called an antecedent clause and the THEN part a consequent clause):

IF[condition]
THEN[action]

For example, John and Murray are supervisors of Ram, is a fact. A rule based on this fact could be :

**IF** Ram is a student of John
THEN John is a supervisor of Ram

IF Ram is a student of Murray
THEN Murray is a supervisor of Ram

In PROLOG (which stands for PROgramming in LOGic) the above relation can be expressed as :

supervisor (John, Ram) :–
student (Ram, John)

supervisor (Murray, Ram) :–
student (Ram, Murray)

Here student is a relation name or predicate name and the objects in parentheses i.e. Ram and John, and Ram and Murray are called arguments which can either be a value or variable. This relation can also be expressed in the form of variables :

student (X, Y)
supervisor (Y, X)

which in PROLOG can be written as :

supervisor (Y, X) : -
student (X, Y)

The above rule is written in as a horn clause in which a conclusion is followed by a number (≥ 0) of conditions. In PROLOG : - stands for 'IF' and , for 'AND'. The part of the PROLOG clause, written to the left of the : - is called the 'head' of the rule and the IF part (written to the right of the : - ) is called the body of the clause containing a number of items separated by commas.

The condition part of a rule can be any pattern that can be matched against a stated KB containing facts regarding the problem at hand. Once a pattern is matched by the rule interpreter, the action part of the rule is executed, which may either result in addition of new facts to the KB or their modification. Since rules are modular, an addition or deletion of rules is easy and does not have impact on other rules - a capability of great importance in the development of large systems.

A semantic net uses both predicates and attributes to represent objects and to show relationships between the objects. For example,

John **is - a** Lecturer
Supervisor **Is - a** Lecturer
Lecturer **Is - a** staff member

Here John, supervisor, Lecturer and staff member form nodes in a network and the links in the network represent the relation **is - a**. Frames represent the knowledge about objects, while scripts which are a frame-like structure represent a sequence of events. Both frames and scripts are based on the concept that when people see a context or a broad framework representing incomplete knowledge about the context, they infer and fill up the incomplete parts based on their past experience and intuition. Frames are similar to the concept of fields used in conventional programming languages such as FORTRAN and consist of variable sized memory units called slots which , like a data base, may contain attributes. In addition, slots may also contain hypotheses, rules about a particular situation, the action to take and pointers to other frames. This hierarchy between slots and frames is very useful in knowledge representation and is not available in databases.

### 11.2.2 Inference engine

The inference engine or control structure, which consists of one or more computer programmes, reasons with the KB in order to solve the problem at hand. A problem solving approach known as the state-space approach, represents the problem in the form of an array, decision-tree or graph and searches through this structure by employing rules and operators. Transformation of the problem from one state to another is achieved by applying the operators to the various descriptions of the problem stored as nodes or states in the graph or tree, through either blind search or heuristic search. However, heuristic search avoids combinational explosion and is preferred in comparison to blind search.

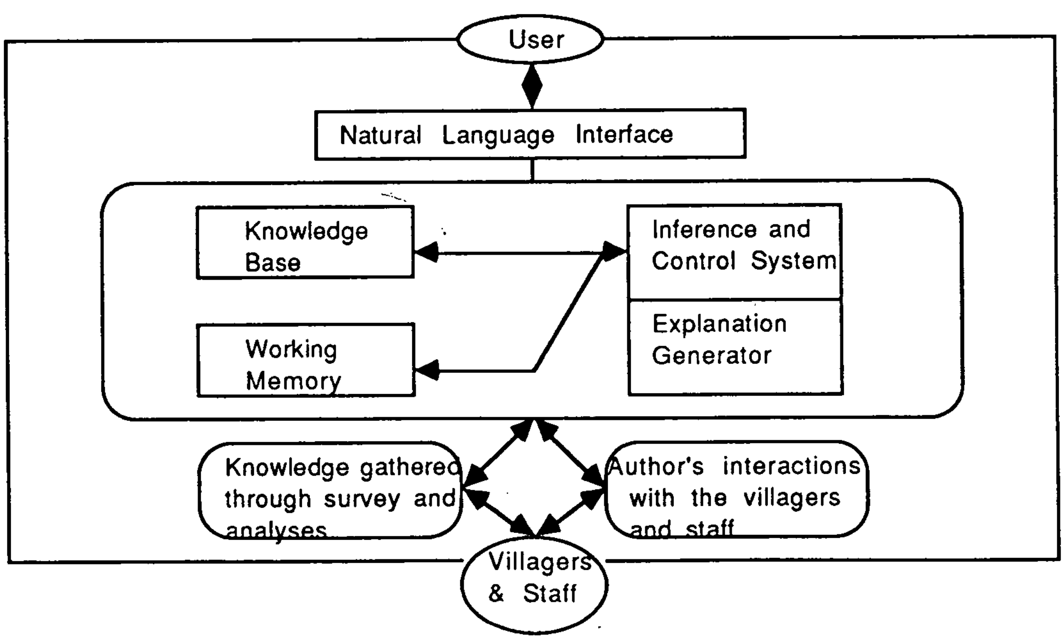
Since the system is supposed to choose one rule at a time, a conflict resolution phase is usually incorporated. The rule interpreter can adopt three main control strategies to perform such a task. A data driven control strategy (also known as forward chaining) executes those rules whose conditions only match the knowledge in the current KB. The user begins by entering information about the problem as facts in the KB. If these facts match the condition part of the rule, the rule is applied otherwise the user is asked for more information. A disadvantage of this strategy is that the process can be viewed as aimless because one rule after another is presented to the user, based on the match achieved.

On the other hand in the goal driven strategy (also known as backward chaining) a conclusion is assumed to be true, and then the KB consisting of the facts and rules is examined to see if it supports the assumption. If the assumption turns out not to be correct, a technique known as backtracking is used to erase the original assumption and replace it with a new one. The strategy is, however, comparatively slower and does not give scope to the user to volunteer relevant information about the problem. A mixed strategy combining both data and goal driven strategies is mainly used to overcome the shortcomings of both strategies. It alternates between the two strategies, using the information volunteered by the user to determine a goal and then querying the user for additional information while working on the problem (Duda *et al,* 1979).

### 11.2.3 Interface

The interface component allows communication between the user and the inference engine. It consists of one or more computer programs. The input and output of information is made possible by the interface facility and the explanations of the conclusions arrived at by the system are displayed through the interface mechanism. The interactions between these components in an ES to evaluate the uptake of social forestry are shown in Figure 11.2

**Figure 11.2 The interactions among the components of an Expert System to evaluate the uptake of social forestry.**



## 11.3 Selection of an Expert System Shell

An ES needs to have an interpretation mechanism so that reasoning with the information contained in the KB is possible and conclusions arrived at by such reasoning are made transparent to the user. Shells provide a user friendly development environment which enables the smooth interaction with the user and the program. ES shells are neutral and content-empty and so need specific knowledge in order to represent a problem area. In PROLOG such a shell can be developed, as described by Bracto (1986), by using concepts such as explore, user answer, present answer and driver. However, as the aim of this study is to develop a methodology and not the construction of a shell, the decision was made to use a proprietory ES shell. CRYSTAL (written in language **C**) was the ES shell (developed by Intelligent Environments, 1987) used to analyse the uptake of social forestry policy. The choice of the shell, in this case, was restricted due to the fact that CRYSTAL was the only shell available within The Edinburgh School of Agriculture when this work was started.

## 11.4 Designing the KB for social forestry

The development of the ES program had the following stages (similar to most software development);

a. Identification
b. Conceptualisation
c. Formalisation
d. Implementation, and
e. Testing

The first three stages have already been covered in Chapter 10 when a system analysis was carried out and the knowledge was gathered and structured based on a survey. To complete the implementation stage, the KB had to be designed in the form of rules for which a decision tree concept as described by Levine *et al* (1986) was used.

A decision-tree (see Figure 11.3) consists of conclusions (goals or subgoals) enclosed in rectangles at the very end of each branch and the decision nodes in the form of circles containing questions (which become conditions for the conclusion to be true). The direction of the diagram and pathways to other nodes are generally shown by arrows and the user's response to the encircled conditions determine the path of each node. For example in Figure 11.3 the rectangles contain goals (e.g. socioeconomic uptake of social forestry is high) or subgoals (e.g. the villagers have felt needs for forest produce) which signify conclusions. The circles which contain questions (e.g. Are the market facilities for forest produce adequate?) are decision nodes which may have two possible answers (i.e. Yes or No) and therefore two possible paths depending upon the response. The arrow lines designate the direction of the flow diagram and the path taken from each node is determined by the response to the question contained in the circle.

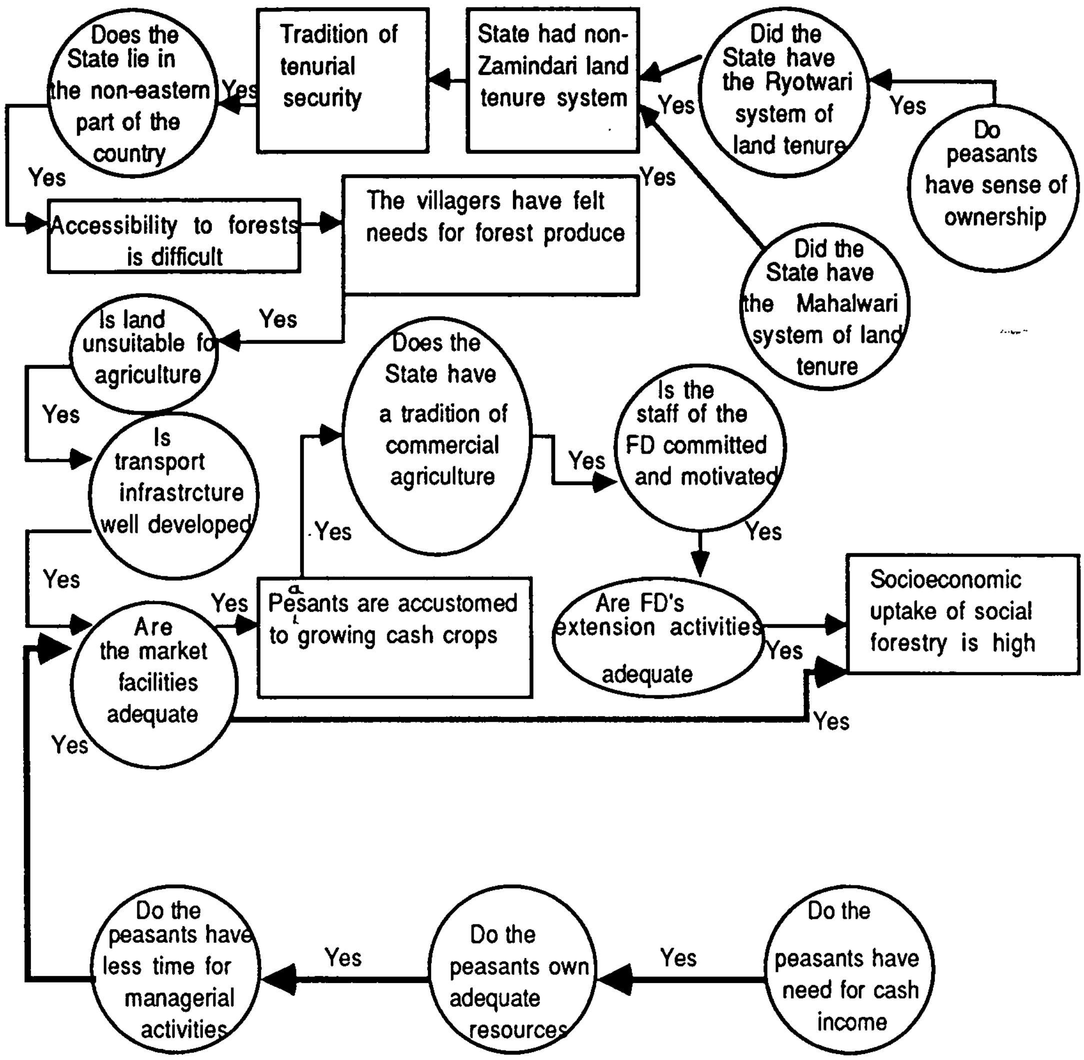
All the factors that must be considered in reaching a decision, and their interactions, can easily be visualised with the help of a decision-tree as illustrated below. The formation of rules at the state, regional, village and household levels based on this decision-tree procedure is described below.

### 11.4.1 Rules at State level

The flow diagrams; Figures 11.3, 11.4 and 11.5, developed on the decision-tree concept, give the conditions, subconclusions and conclusions with respect to the high, low and moderate uptake of social forestry respectively. These diagrams can be represented in a single diagram because all the three final conclusions (high, moderate and low uptake) are mutually exclusive but these have been shown separately in order to illustrate the procedure with simplicity.

Consider Figure 11.3 which starts by asking about the sense of ownership among the villagers followed by the question about the land tenure system. The user inputs information in the form of Yes and No responses. If the answer is, say, Yes the user will then be asked the second question. Suppose the response to the second question (i.e. does the State have the Ryotwari system) is in affirmative then the sub conclusion `State had non-Zamindari land tenure system` will be drawn. If the response is negative the user will be asked whether the State had a Mahalwari system of land tenure and if his answer is in the affirmative the same conclusion is drawn otherwise the opposite sub conclusion i.e. `State had Zamindari land tenure system` is drawn. This is shown in Figure 11.3 by two arrows going to the same rectangle which means that the subconclsuion is true in two alternative cases.

**Figure 11.3 Flow diagram for the high uptake of social forestry**




When formulating rules, the logical operator OR is used in such situations while AND is used when two or more conditions need to be true for a subconclusion or conclusion to be drawn. Each question (enclosed in a circle) can be considered a variable and its value the instantiation of that variable: in the above example land tenure system is a variable and Ryotwari and Mahalwari are its values. In fact many such variables can be generated and presented to the user in a menu form. These may take a range of values (illustrated below) either in quantitative (e.g. more, equal or less than 5 years) or qualitative (e.g. none, little, good, excellent, etc) capturing the strength of feelings. A subconclusion is also a clause in an IF statement: for example, the subconclusion `State had non-Zamindari land tenure system` is in the IF statement of the subconclusion

Tradition of tenurial security among the peasants.

The combination of linked decision nodes (circles) and a subconclusion or conclusion node (rectangle) represents an IF-THEN rule. The IF part is comprised of conditions (clauses) connected to one another with the logical operators such as OR, AND and NOT. The THEN part, which is true if the IF part is true, forms the conclusion with respect to all the conditions included in the IF part.

The following rules (conditions marked with * in the IF part are the subconclusions) are generated from Figure 11.3 based on this procedure:

| | | |
|---|---|---|
| | IF | Sense of ownership among peasants |
| * | AND | Tradition of tenurial security among peasants |
| * | AND | Villagers have felt needs for forest produce |
| | AND | Land for plantations is generally unsuitable for cultivation |
| * | AND | Villagers are accustomed to growing cash crops |
| | AND | State has a tradition of commercial agriculture |
| | AND | The staff of the Forest Department is committed and motivated |
| | AND | Extension activities of the Forest Department are adequate |
| | THEN | **Socioeconomic uptake of social forestry at the State level is high** |

| | | |
|---|---|---|
| * | IF | State had experienced a non-Zamindari system of land tenure |
| | THEN | **Tradition of tenurial security among peasants** |

| | | |
|---|---|---|
| | IF | State had the Ryotwari system of land tenure |
| | OR | State had the Mahalwari system of land tenure |
| | THEN | **State had experienced a non-Zamindari system of land tenure** |

| | | |
|---|---|---|
| * | IF | Accessibility to forests is difficult |
| | THEN | **Villagers have felt needs for forest produce** |

| | | |
|---|---|---|
| | IF | State lies in the non-eastern part of the country |
| | THEN | **Accessibility to forests is difficult** |

| | | |
|---|---|---|
| | IF | Market facilities for the forest produce are adequate |
| | AND | Transport infrastucture is well developed |
| | THEN | **Villagers are accustomed to growing cash crops** |

Since there is another path (shown in the dark lines in Figure 11.3) leading to the same final conclusion, i.e. Socioeconomic uptake of social forestry is high, the following rule (which is true in those cases where the resource rich farmers are attracted to social forestry, particularly farm forestry, due mainly to their need for cash income) is also applicable:

IF Need for cash income
AND Peasants own adequate resources
AND Peasants have less time for managerial activities
AND Market facilities for the forest produce are adequate
THEN **Socioeconomic uptake of social forestry at the State level is high**

In its simplest form the program could be designed so that the user is asked to respond to queries with either a Yes or a No. But in many cases the user may like to input their response by selecting from a menu having a range of alternatives. Therefore the program was refined by using variables and menu questions. The user is given a series of options from which they are required to select the one which most closely matches their response. For example, the first question asked in the above program was 'Sense of ownership among peasants', to which the user responded Yes or No. The following procedure was adopted in order to present four mutually exclusive options to the user, along with a message explaining the description and context of options:

The condition (Sense of ownership among peasants) was expanded and the Yes/No question was deleted. The question was split into an asking and a testing part as follows:

* IF Ask for the degree of sense of ownership among the peasants
* AND Test for the sense of ownership among the peasants
THEN **Sense of ownership among peasants**

The first sentence was further expanded and the command Menu Questions were selected from the list of commands. The following message was typed into the box which appeared after selecting the Menu command:

> The peasants were only tenants in those regions which had Zamindari land tenure system because they were not given land ownership rights. Such rights were given to the peasants in the regions which had Ryotwari or Mahalwari system. This historical fact has instilled feelings of dependence and independence among the peasants of these regions respectively. Please select the best description of the degree of sense of ownership among the peasants of the region concerned:

Next the following four options were specified:

**None** **Little** **Average** **Strong**

Each of these options is represented by a 1, 2, 3 or a 4 by CRYSTAL. The next step was to define a variable to represent the Menu and its options. The variable ***ownershipsense*** was used in this stance. The second condition was expanded and the

Test Expression command was selected from the list of commands in order to incorporate the following test for the variable:

***ownershipsense*** >= 3

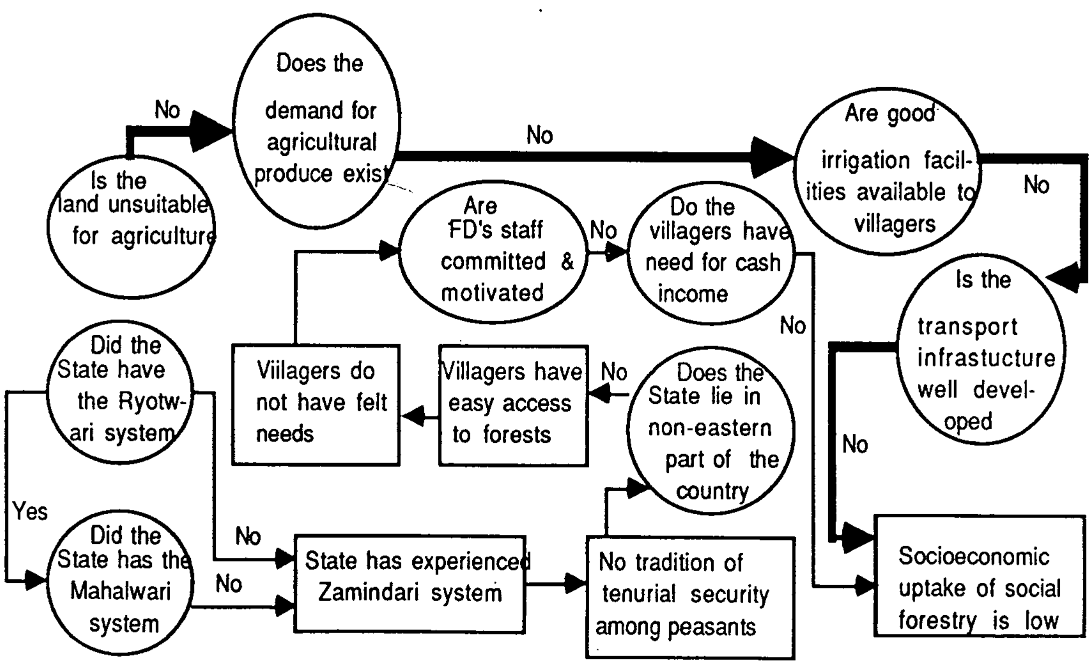
This expression indicates that the test will succeed if the user selects the options either `Average` or `Strong`, otherwise the test will fail. This same procedure was used for a large number of rules in the program. Table 11.1 shows that 42 variables, 126 commands and 231 rules are used in the program :

**Table 11.1 Summary of expert system statistics**

| | |
|---|---|
| Knowledge base name | Social Forestry |
| Total disk space | 713 K |
| Disk space free | 119 K |
| Normal memory used | 176 K |
| Expanded memory used | 0 K |
| Expanded memory free | 0 K |
| Number of rules | 231 |
| Number of commands | 126 |
| Number of variables | 42 |
| Size of text area | 30 K |
| Memory for DOS program | 50 K |

The following rules for the low uptake of social forestry were generated by using the flow diagram shown in Figure 11.4.

**Figure 11.4 Flow diagram for the low uptake of social forestry.**



* IF NOT Felt needs for forest produce
AND NOT Committed and motivated staff of the Forest Deaprtment
AND NOT Need for cash income
* AND NOT Tradition of tenurial security among peasants
THEN **Socioeconomic uptake of social forestry is low**

IF NOT Land for plantation is generally unsuitable for cultivation
AND Demand for agricultural produce exists in proximity
AND Irrigation facilities are adequate
AND Transport infrastucture is well developed
THEN **Socioeconomic uptake evaluation of social forestry is low**

The flow diagram shown in Figure 11.5 for the moderate uptake of social forestry is complex because there are four alternative combinations of the conditions which result in the moderate uptake of social forestry. The following four sets of the rules are generated based on this diagram and the procedure described above.

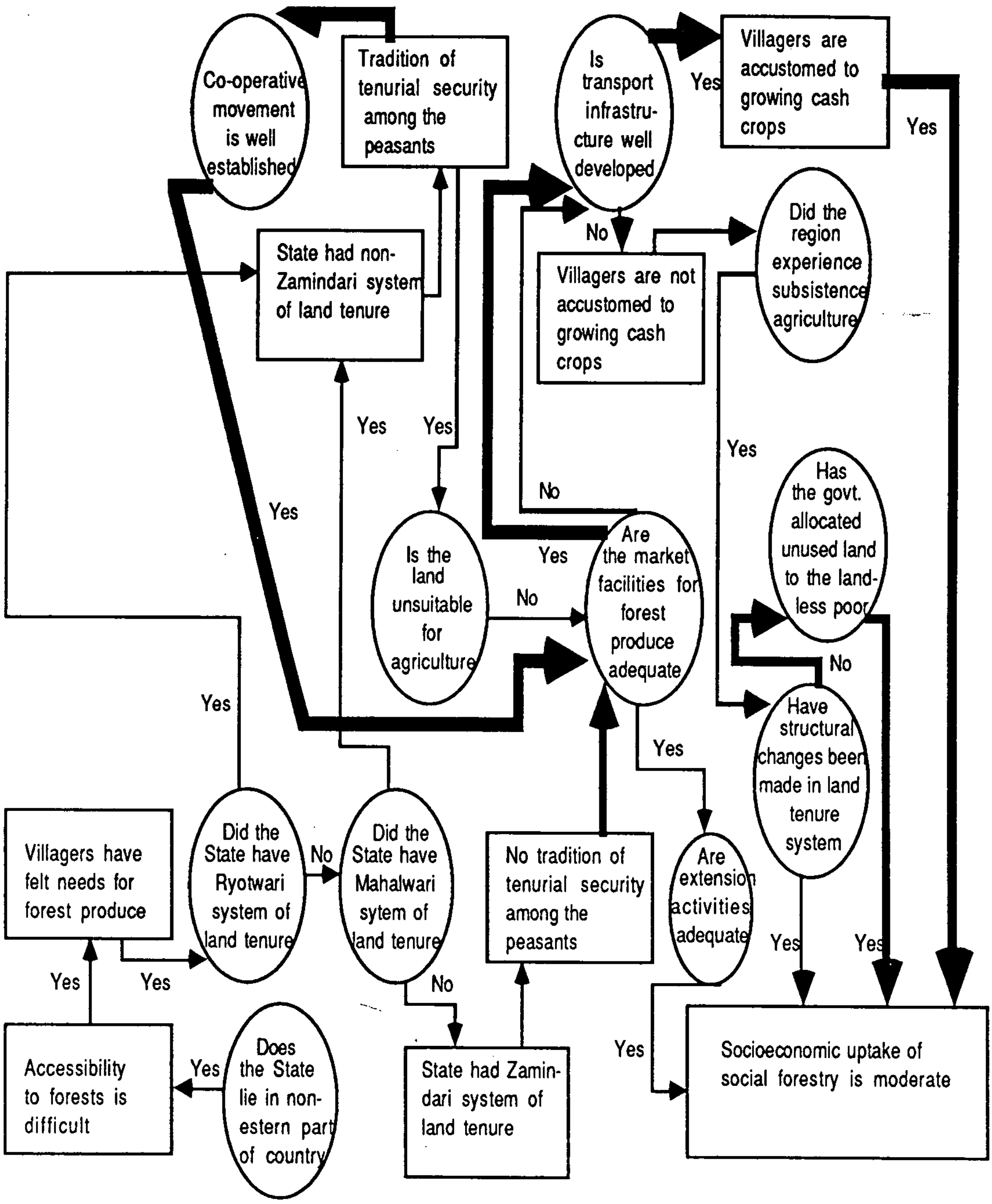
* IF Felt needs for forest produce
* AND Tradition of tenurial security among the peasants
AND NOT Land for plantations is generally unsuitable for cultivation
AND Adequate market facilities for the forest produce
AND The extension activities of the Forest Deaprtment are adequate
THEN **Socioeconomic uptake of social forestry is moderate**

* IF Felt needs for forest produce
* AND Tradition of tenurial security among the peasants
* AND NOT Villagers are accustomed to growing cash crops
AND Region has experienced subsistence agriculture
AND Structural changes have been made in the land tenure system
THEN **Socioeconomic uptake of social forestry is moderate**

* IF Felt needs for forest produce
* AND NOT Tradition of tenurial security among the peasants
AND Land for plantations is generally unsuitable for cultivation
* AND Villagers are accustomed fo growing cash crops
AND Region has experienced subsistence agriculture
AND NOT Structural changes have been made in the land tenure system
AND Government allocates lands for the landless poor
THEN **Socioeconomic uptake of social forestry is moderate**

* IF Felt needs for forest produce
* AND Tradition of tenurial security among the peasants
AND Co-operative movement is well established
* AND Villagers are accustomed to growing cash crops
THEN **Socioeconomic uptake of social forestry is moderate**

**Figure 11.5 Flow diagram for the moderate uptake of social forestry.**




### 11.4.2 The regional level rules in Orissa State

Similar flow diagrams were developed in order to generate the following rules which are applicable at regional level in Orissa State. They are included in the second stage of the program - after the rules at the State level.

IF Land is declared as village forests before planting
AND Good rapport between the villagers and staff of the Forest Department
AND Staff of the Forest Department adopt a participatory approach
AND Staff of the Forest Department are receptive towards the needs of villagers
AND Staff are competent and well trained
* AND Staff are motivated
AND Staff are committed to the basic philosophy of social forestry
AND Ownership documents are given to the villagers
AND Social forestry practices are compatible to social behaviour and agricultural cycle
AND Developmental goals are clearly defined
AND Resources required are made available in a timely fashion
AND Decision-making is consistent and well thought out
AND Tree cutting rules are simple and adequate
AND Optimal rotations for the species, planted in each component of social forestry, are determined and conveyed to the villagers
AND The village forest rules are amended suitably
AND Timber transit rules are simple and adequate
AND Villagers are aware of tree and land tenures
THEN **Socioeconomic uptake of social forestry is high**

IF Provision of incentives and rewards to staff for their good work
THEN **Staff are motivated**

Similar set of rules for the low and moderate uptake of social forestry at regional level are presented in Appendix 11.1.

### 11.4.3 Rules at village level

The following rules, applicable at the village level, were developed based on a similar approach:

* IF Participation of the villagers is adequate
AND Local NGOs are actively involved in social forestry activities
* AND Representative village leadership exists
* AND Satisfactory functioning of VFC
* AND Adequate prices for the villagers' forest produce
AND Need for additional income
AND Adequate community or government unused land exists in proximity
AND Nurseries are in proximity of the village
* AND Plantations are well protected
* AND Surplus labour is available in the village
AND Adequate stock for seedlings is available
AND Planting techniques and other necessary know-how is disseminated to the villagers
AND Villagers are generally risk takers
* AND Villagers have felt needs for forest produce
THEN **Socioeconomic uptake of social forestry is high**

IF Co-operative and receptive villagers
AND Economically rational and enterprising villagers
OR Economically rational and enterprising villagers
THEN **Participation of the villagers is adequate**

IF Leadership advocates the interests of rural poor
* AND Leadership is based on all the socio-political groups in the village
THEN **Representative village leadership exists**

IF Community centres exist in a village
AND Management of community centres is proper
THEN **Leadership is based on all the socio-political groups in the village**

IF Members of a VFC are actively involved in any decision-making
AND Members are properly elected
* AND All the socio-political groups are represented in VFC
AND Meetings of a VFC are conducted regularly
AND VFC maintains good relations with Panchayats
* AND Social structure of a village is accounted for while constituting VFC
THEN **Satisfactory functioning of VFC**

IF Women are adequately represented
AND Scheduled caste and tribe are adequately represented
THEN **All the socio-political groups are represented in VFC**

IF Social organisations are involved in decision-making
AND Power structure of the village is considered
AND Caste-heirarchy is considered
AND Social and intergenerational mobility is accounted for
AND Value system of the villagers is respected
AND Occupational diversification is accounted for
THEN **Social structure of a village is accounted for while constituting VFC**

IF Protection to plantations is provided by the Forest Department through watchers
* OR Participatory protection of plantations by villagers
THEN **Plantations are well protected**

* IF Village has surplus labour
AND Plantations are in proximity of the village
THEN **Participatory protection of plantations by villagers**

IF Land is generally infertile
AND Off-farm income opportunities are low
THEN **Village has surplus labour**

IF Adequate village forests do not exist in proximity
* OR The Forest Department is unable to meet the demands for Nistar
THEN **Villagers have felt needs for forest produce**

IF Inadequate PF and RF in proximity of the village
THEN **The Forest Department is unable to meet the demands for Nistar**

This one set of rules for concluding a high uptake of social forestry shows the close interactions among various aspects present at the village level. A complete listing of the rules for the low and moderate uptake of social forestry is given in Appendix 11.1.

### 11.4.4 Rules at household level

The following rules were developed with respect to the attributes identified among the surveyed households for a differential uptake of social forestry, although it is recognised that there may be a close interaction between the rules at the village and household levels.

IF Expectations of the household are high
* AND Motivation of the household members is high
* AND Household is at subsistence consumption level
* THEN **Socioeconomic uptake of social forestry is high**

* IF Goals of the household members are high
THEN **Motivation of the household members is high**

* IF Household members are in need for forest produce
OR Household members need income for basic needs
THEN **Goals of the household members are high**

IF Inadequate forests in proximity
THEN **Household members are in need of forest produce**

IF Consumption of the members of household is at or below poverty level
THEN **Household is at subsistence consumption level**

* IF NOT Expectations of the household are high
* AND NOT Motivation of the household members is high
* AND NOT Household is at subsistence consumption level
THEN **Socioeconomic uptake of social forestry is low**

* IF NOT Expectations of the household are high
* AND NOT Motivation of the household members is high
AND NOT Trees have religious connotations or sanctity
AND NOT Trees are treated as disposable assets
AND NOT Land holding has low productivity
THEN **Socioeconomic uptake of social forestry is low**

IF Expectations of the household are high
AND Motivation of the household members is high

AND Trees have religious connotations or sanctity
AND Trees have contingency values
THEN **Socioeconomic uptake of social forestry is moderate**

IF Expectations of the household are high
AND NOT Household is at subsistence consumption level
AND Inadequate forests in proximity
AND NOT Household members need income for basic needs
AND Tress are treated as disposable assets
AND NOT Household belongs to the vulnerable group
AND NOT Off-farm income opportunities are low
THEN **Socioeconomic uptake of social forestry is moderate**

IF NOT Expectations of the household are high
AND NOT Motivation of the household members is high
AND Trees are treated as disposable assets
AND Trees have contingency values
AND Household is at subsistence consumption level
THEN **Socioeconomic uptake of social forestry is moderate**

IF Expectations of the household are high
AND NOT Trees have contingency values
AND NOT Off-farm income opportunities are low
AND NOT Land holding has low productivity
AND Trees are treated as disposable assets
THEN **Socioeconomic uptake of social forestry is moderate**

IF NOT Expectations of the household are high
AND Inadequate forests in proximity
AND Household members need income for basic needs
AND Trees are treated as disposable assets
AND Household belongs to the vulnerable group
AND Landless labourer
AND Off-farm income opportunities are low
THEN **Socioeconomic uptake of social forestry is moderate**

IF Expectations of the household are high
AND Inadequate forests in proximity
AND Household members need income for basic needs
AND Trees are treated as disposable assets
AND Household belongs to the vulnerable group
AND Household belongs to Marginal peasant category
AND Land holding has low productivit
AND Off-farm income opportunities are low
THEN **Socioeconomic uptake of social forestry is moderate**

IF Expectations of the household are high
AND NOT Household is at subsistence consumption level
AND Adequate forests in proximity
AND NOT Household members need income for basic needs
AND Trees are treated as disposable assets
AND NOT Household belongs to the vulnerable group
AND Off-farm income opportunities are low
THEN **Socioeconomic uptake of social forestry is moderate**

IF Expectations of the household are high
AND NOT Household is at subsistence consumption level
AND Adequate forests in proximity
AND NOT Household members need income for basic needs
AND Trees are treated as disposable assets
AND NOT Household belongs to the vulnerable group
AND NOT Land holding has low productivity
THEN **Socioeconomic uptake of social forestry is moderate**

## 11.5 Limitations of Expert Systems

There are a number of problems associated with ES development. The major one listed in the literature is that of extracting adequate and relevant knowledge in the given domain. Other problems related to the representation and structuring of such knowledge and drawing valid inferences from it. The underlying assumption of AI is that by providing specific facts and inference rules the system will behave intelligently even without the general thinking power possessed by humans. But so far no ES has been designed which can match the human experts (Dascal, 1989). The following discussion of the inadequacies of ES is based on the problems faced during the development of the ES developed as part of this study.

### 11.5.1 Context-specificity

An implicit assumption in the development of an ES is that human knowledge and behaviour can be formalised in an atomistic (discrete chunks) and bottom-up way so that appropriate mathematical logic can be applied to arrive at conclusions. Therefore, all contextual factors are packaged in organised structures such as rules, frames, schemata and semantic networks. Intelligent interpretations are then made based on the knowledge contained in these structures and reorganisation of the related information about the inputs. A problem with such a system is that it cannot always draw conclusions from the structures, although this is possible in narrowly defined areas of knowledge. To overcome this limitation the program logic must be able to shift from one structure, say a rule, to another as and when required. However, such a task is very difficult within an environment characterised by unpredictable and stochastic decision-making.

Human beings, while taking decisions in such situations, normally apply their implicit and unarticulated intuition or common sense. This is difficult to incorporate in an ES mainly because it cannot be simplified into rules. For instance, in the program developed in this study inputs occur in form of menu questions or in Yes and No responses to the program queries. The program is only able to display conclusions with respect to those combinations of rules for which it has been programmed. Therefore, when an operator (who may not be aquinted with the location specific environment of the social forestry problem) inputs those combinations of conditions which do not match with those contained in the program, no conclusion is displayed.

### 11.5.2 Imputation

By letting a system 'understand too much' (say a given input) in terms of the system's stock of packaged 'knowledge', the result may be that it will instead misunderstand, without being able - as humans normally are - to detect and correct such misunderstandings (Dascal, 1989). This suggests the need for additional human judgment of the results generated by the program, to ensure acceptability, relevance and adequacy. Otherwise the resulting policy recommendations based on the systems behaviour would be blind or dogmatic, defeating the very purpose of the intelligent systems. This is important because a general belief is that computers are not only efficient but also give accurate results (CSS, 1989), whereas the program as designed is inexact dealing with belief, heuristics, and uncertain and missing information.

The user may give undeserved credibility to conclusions arrived at on the basis of the rules because these are hidden inside the program. Although some of the aspects related to uncertainty can be handled by using probability or Fuzzy set theory (discussed in the following Chapter), the bias created may not be obvious to the user. Therefore, a clear statement of the assumptions and limitations should be incorporated into the program documentation to stop users treating the result as the only possible course open to them.

#### Summary

This chapter has shown the potential of ES in decision-making, based on an exhaustive knowledge base (including the relevant parameters and their interrelationships) in order to achieve a broader holistic approach. The structure of the program, although context-sensitive, is sufficiently flexible and modular to enable its further development as and when required. This means that the framework can be transferred, possibly in skeletal form and applied within another policy and geographical context. In developing the program both tangible knowledge (generated by carrying out the analyses in the earlier chapters) and intangible knowledge (generated by the survey) have been used, which means that in this study ES are used as integrators (Sharma *et al*, 1990e) in order to evaluate social forestry realistically. Such a use of ES has hitherto remained unexplored.

# Chapter 12

## Conclusions, and Suggestions for Improvements in the Methodology

This chapter does not attempt to recapitulate the detailed analyses considered in previous chapters because such details have already been discussed adequately in the individual chapters. Rather it is thought more relevant to discuss the wider role; realities, possibilities and implications of the methodology proposed in this study. This is important because not only will it give scope for a socioeconomic critique of the methodology but it will also point a way forward for further refinements.

In ancient and medieval India, local inhabitants used forests to meet their consumption needs and in the non-monetised economy an equilibrium was maintained between the needs of people and state of health of the forests. This symbiotic relationship changed when forest management, under the influence of commercial interests, adopted revenue-oriented practices and population increased significantly.

The needs of communities were realised when the village forests were earmarked for their use, and rights and concessions in government forests were recognised. However, increasing restrictions on villagers' use of the forests were imposed by reserving more forested lands. As a result the forests under the Forest Department management were better stocked, but the village forests deteriorated due to over use and lack of any management policy (Sharma *et al*, 1990a). The socioeconomic environment was characterised by commercialisation, free trade, deindustrialisation and high growth of population (hence increased pressure on agriculture and consequent large scale diversion of forest land to agriculture), new land tenure systems and consequent agrarian restructuring. As a result forestry was recognised as a subservient land-use to agriculture, and overall result was rapid deterioration of forests and alienation of locals (ibid, 1990a).

The situation did not improve in the post-independence period. The growth rate of GDP was nearly 4%, but the per capita growth rate was only 1.9% (see Chapter 1) due to the rapid growth in population, which did not provide enough for any 'trickle-down effects'. In fact the 'trickle-down' mechanism is presumed to have broken down (Bardhan, 1984).

Investment in the primary sector and its share of total GDP has decreased over the period, while the share of the secondary and tertiary sectors has increased only marginally which is a disturbing trend in view of the country's land-labour situation (Sharma *et al*, 1990a). In fact the capital-intensive industrialisation has led to the increased unemployment and underemployment resulting in chronic poverty, despite large capital investments (Lal, 1989).

Since the secondary and tertiary sectors had limited employment capacity, especially to non-wage earners, the bulk of gainful employment opportunities could only be created by increasing the productivity of the primary sector (Sharma *et al*, 1990a). However, given the agro-ecological constraints, any substantial acceleration of the agricultural growth (in terms of both productivity and employment capacity) can not be envisaged in the near future and especially until the irrigation network is improved substantially. In fact the much publicised Green Revolution has not resulted in any significant increase in agricultural productivity, as argued in Chapter 1.

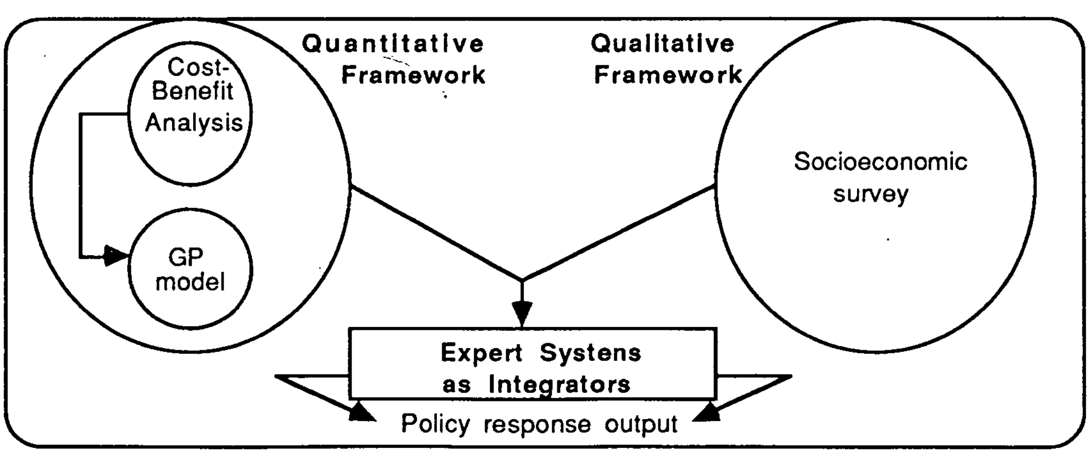
The potential of social forestry in improving energy, employment, income and welfare of the rural populace (as demonstrated in the previous chapters) should, therefore, be harnessed by utilising the surplus land and labour resources. A direct attack on the poverty nexus through labour-intensive land-use technology such as social forestry is essential. This will not only help rejuvenate the over-used village forests on which the communities depended for their sustenance but also improve the labour-output ratio and hence reduce underemployment/unemployment and poverty.

To achieve successful implementation of social forestry the planning framework should be based on a villager-centred approach because it is meant to achieve their welfare. Therefore, besides the technicalities of forest management and silviculture, their relevant socioeconomic needs must be incorporated, into the design and planning for social forestry programmes. This study suggests a systems approach to the planning methodology by focusing on such issues. The use of the methodology is illustrated by pursuing a case study from Orissa State thereby proving the hypothesis set up in the introductory section.

The methodology proposed is based on the synthesis of hard and soft analytical techniques (Figure 12.1) in order to deal with both the qualitative and quantitative knowledge necessary to achieve a broader holistic approach. The goal programming model developed in this study incorporated the multiple socioeconomic objectives of social forestry. Since social welfare in terms of net socioeconomic benefits was one of the seven goals included into the model it was found necessary to carry out social cost-benefit analysis for all the five components of social forestry: socioeconomic profitability and optimum tree rotations were determined having specified the social welfare function incorporating consumption of different groups of individuals as its argument. The use of data, generated by carrying out social CBA in order to develop a GP model for social forestry planning is, therefore, an innovative contribution of this study.

Further, it was found essential to develop a dynamic analytical framework from which the level and speed of uptake of social forestry policy, designed according to the multiple objective planning, can be determined. The socioeconomic variables which influenced villagers' decision-making regarding the uptake of social forestry were, therefore, identified, based on an exhaustive socioeconomic survey. Because the knowledge it generated was mainly qualitative, an Expert Systems (ES) approach has been shown to be suitable in order to organise both quantitative and qualitative knowledge into a dynamic analytical framework. The policy recommendations based on such a representative and exhuastive knowledge base must surely be useful and applicable in practice. ES are, therefore, used as synthesiser which is a new field for their application and can be regarded as an important contribution of this study.

**Figure 12.1 A diagrammatic overview of the methodology proposed**




The planning methodology developed in this study is demonstrably adequate to incorporate and evaluate social forestry within the framework of its socioeconomic objectives. However, it is acknowledged that further research is needed despite a serious effort being made in this study to develop such a planning framework, which is not only technically and silviculturally feasible but also socially adaptable. This is true with all economic analyses and is applicable to this methodology as well.

## 12.1 Socioeconomic critique

Any planning methodology must be accepted as a decision support methodology rather than an action oriented one. This introduces subjectivity or value judgments to the objective nature of the methodology because if policy recommendations based on its results are made uniformly without applying relevant human judgments it may result in undesirable consequences. In fact the real world problems including social forestry are rarely so amenable to the exact solutions arrived at by any theoretical construct and in practice the cultural and sociopolitical structure does influence the implementation of any social policy.

Not only is the proposed methodology based on an objective estimation of the various parameters (often requiring a lot of data) but it is also based on the reliability of different assumptions underlying the models included in the framework. Explicit and/or implicit assumptions about data values and about the consequences likely to flow from a given decision seem to be inevitable in any type of planning framework involving predictions about the future. Therefore, it is essential to make assumptions which are plausible and can be verified empirically.

The global problem of quantifying the environmental externalities of forestry in general and social forestry in particular has not been addressed at all.

However, an important feature of the methodology is its flexibility which means that the modifications and refinements suggested below can be incorporated as and when they are required. Such changes will occur when new data are generated or the operational socioeconomic environment is changed. This can only be achieved by monitoring the planning process as it progresses and then using the feedback information in an iterative manner to improve the assumptions embedded in the methodology. Such a qualification of the methodology makes it adaptable to social forestry planning not only in other States of India but also in other developing countries. The following possible improvements should be flagged for future research.

The assumption of social utility based on consumption as a criterion of social welfare can be questioned on two grounds. It can be argued that the satisfaction derived from one unit of consumption not only depends on the income level of an individual but also on other social aspects such as expectations, mental health, life expectancy and literacy. However, these factors will have little effect on the analysis when dealing with the aggregate (or groups of individuals) at set levels of consumption, as was the situation in this case study. In fact the whole issue of measuring utility has been long debated among economists, resulting in two school of thoughts represented by the cardinal and ordinal theories of utility. Having elicited the government or decision maker's preferences, in the form of objectives of social forestry, it is inevitable that both inter-temporal and intra-temporal consumption aspects are considered in the analysis (by specifying social utility and social welfare functions).

A related but not similar problem, is the aspect of the underlying assumptions associated with the estimates of national parameters such as **q**, **s**, **g**, $e_u$ and CRI, based on per capita figures and calculated from aggregate national statistics. Price and Nair (1985) argue against the use of per capita figures in estimating both **g** and CRI, as the beneficiaries associated with the social forestry project may have different consumption levels and so the application of a uniform CRI is not appropriate. Because the numeraire in this case study is based on the poverty consumption level the CRI should ideally have been estimated in terms of poverty consumption level rather than the average consumption level. Although there is no doubt about the theoretical strengths of these arguments, the practical problem lies in availability of such group-specific disaggregated data for an individual region. Use of national statistics is invariably suggested in estimation of parameters (Philip, 1974) because disaggregated data are not generally available.

Indeed the issue is related to the applied economics discipline *per se*, including the marginality principle, and not only to this methodology. Social scientists often complain about the inadequacy of statistical analyses due to the lack of insight and mechanical nature of such analyses and as a result suggest detailed micro-level studies. Although there are some positive aspects of micro level studies, which can be a complementary approach, it is also good to recognise the strengths as well as the practical feasibility offered by quantitative analyses.

A solution to the problem is extensive sensitivity analyses with respect to the parameters having impact on the final results. For example, the estimated value of **v** had a substantial effect on the net socioeconomic benefits (see Chapter 7). This suggests that a sensitivity analysis should be carried out with low values of **v** in order to examine its effect on the net socioeconomic profitability and tree rotation. To illustrate the process the sensitivity analysis of an agroforestry component of social forestry was performed with a lower value of **v** (= 3).

Estimated values of the net socioeconomic benefits, expressed as PNW and LEV, are presented in Tables 12.1 and 12.2. The final results are sensitive to the value of **v** and the values of PNW and LEV for many management options, especially in SQ III, are positive in this case (which were previously negative, see Chapter 7) . Indeed, the time period assumed (i.e. 50 years) to estimate the value of **v** needs to be specified exactly, based on an extensive study of the national economy. In addition, social value of public income can be distinguished from social value of investment because while the former is applicable in case of general funds, the later is applicable to investment funds only.

Price (1988) argues that CBA does not account for the ripple effects of a project on the total economy which may become sub-optimal requiring a new set of shadow prices with each change. The task of tracing such ripples is very difficult in subsistence-oriented projects in developing economies but such effects can be more easily traced in well defined industrial projects in developed economies. The former operate at a comparatively smaller scale and are also characterised by imperfect or non-existent relevant information : public action is constrained because such information is not generally available for the choice of public policy, although it may be known privately.

Secondary effects have largely been ignored in CBA mainly on two grounds. Firstly, if the resources are fully employed the secondary effects cannot produce a net increase in economic activity from the national viewpoint because any increase in one region will be matched by a decrease elsewhere. Secondly, if the resources are not fully employed it is assumed that the secondary effects arising from any public project investment will be similar.

CBA is not a unified and agreed methodology, but a general philosophy of evaluation, within which differences of opinion flourish among theoreticians and practioners alike (Price, 1989). Obviously CBA has imperfections but those imperfections should be compared with the imperfections of alternative forms of evaluation (ibid, 1989).

This brings the discussion to the second best paradigm, which has been adopted in this case study. In fact the goal programming (GP) model developed in Chapter 8 is based on this paradigm as it does not give the best solution but presents adequate and feasible alternatives or policy scenarios within the constraints of available resources.

In the analysis carried out in Chapter 9 equal weights were given to all the seven goals because the decision-makers' preferences were not available for this study. The weights can be elicited from the decision-makers based on their preferences i.e. the model can be solved by giving the weights to each goal separately.

As the planning process is dynamic and must go on with whatever useful information is available, the utility of any proposed methodology must be judged by its adequacy rather than the precision achieved. The later part of the methodology includes the use of expert systems (ES), a technique which has been found to be suitable for qualitative and quantitative data albeit with inherent limitations.

However, the importance of AI in general and ES in particular is not due to what has been achieved so far, but to its future potential, which has been demonstrated in this study. The methodology developed here should be further researched. Despite the shortcomings discussed above, the planning methodology is an improvement upon existing techniques, particularly due to its ability to account for both hard and soft knowledge. The planning methodology can be used both in other developing countries and outside the forestry sector, and in particular for social projects which are concerned with rural development and land-use planning. Some possible areas of research which would further enhance the methodology are illustrated below.

## 12.2 Measuring uncertainty and fuzziness of villagers' responses

Two important tools for handling uncertainty i.e. sensitivity and post optimality analyses, were used extensively in this study. The procedure adopted was to ask 'what if' and then test the results. A further concept underpinning uncertainty was used, albeit implicitly, when the villagers and foresters were asked about the verbal descriptions of few events based on their experiences. In other cases statistical measures such as t-test and coefficient of variation were estimated in order to indicate variability about mean values. Bayesian probability and Fuzzy set theory are important concepts which should be explored as means of improving the ES developed in this study.

### 12.2.1 Bayesian Probability

Statistical theory is based on the following main assumptions:

**a.** a valid hypothesis exists that survey data are complete and unbiased, and

**b.** the mechanism generating the survey data continues in force unchanged over time .

The following measure of probability is based on classical theory and can be used in any decision-making:

$$p(A) = \lim_{N \to \infty} (n / N)$$

where n is the frequency of an event A happening from a total of N mutually exclusive and exhaustive events.

This formulation rests on the following three postulates:

**a.** a value may be assigned in advance to the probability of an event,

**b.** consistent decisions can be taken based on a rule stated in advance, irrespective of accruing evidence, and

**c.** events themselves are the result of random processes.

Although some of these demanding requirements can be met by data generated in controlled experiments, their applicability is surely untenable for analysing social forestry systems because of the lack of knowledge about objective reality. Therefore it is necessary to form reasonable hypotheses for those facts of reality which are known even with imprecision, and regularly update them in the light of new information received. It is in this situation that Bayesian probability theory, which deals with inverse probability (the likelihood of an event having a given cause rather than a cause giving rise to a given event) may be helpful.

The hypotheses can be formed given some degree of uncertainty about reality and an initial likelihood (a-priori probability) can be assigned to each hypothesis. The probabilities of each hypothesis may then be revised on the basis of the outcome. The revised probabilities (called the posterior probabilities) may then be used as a-priori probabilities for further testing provided the parameters being measured are independent of the measurement taken in the initial test. Mathematically, the posterior probability of an hypothesis $H_i$ given evidence $E_j$ is:

$$P(H_i / E_j) = [P(H_i)\, P(E_j / H_i)] / P(E_j)$$

$$= [P(H_i)\, P(E_j / H_i)] / [P(H_i)\, P(E_j / H_i) + P(H_i')\, P(E_j / H_i')]$$

where, $\Sigma P(H_i) = 1$, $\Sigma P(E_j / H_i) = 1$ and $P(H_i') = 1 - P(H_i)$.

A great advantage of Bayesian probability theory is that for analysing social forestry policy subjective a-priori probabilities can be assigned to different hypotheses where exact probabilities cannot be calculated due to incomplete knowledge. In fact the "Principle of Insufficient Reason" can be invoked in assigning equal a-priori probabilities to alternative hypotheses in the absence of any "Sufficient Reason" to the contrary. The following example from social forestry will illustrate the process.

**Example:** In a rule considered in the previous Chapter it was stated that due to pest attack plantations may get damaged, thereby affecting the speed of social forestry uptake. Suppose that for any plantation a damaging event occurs in three-quarters of a given time period, say 10 years. In two-third of these cases the damage was fatal and in the remaining one-third (one-quarter of the total time period) the plantations recovered, which can be considered mathematically as undamaged. The following events then can be defined:

A = Attack by pests

D = Damaged plantations

Then, the probability of damaged plantations is $P(D) = 3/4$ and the probability of plantations having survived the damage is $P(D') = 1 - P(D) = 1/4$. The a-priori probability of pest attack resulting in fatal damage is then $P(A / D) = 2/3$ and the a-priori probability of pest attack from which the plantations recovered is $P(A / D') = 1/4$. The posterior probability of plantations being damaged when there is a pest attack will then be estimated as,

$$P(D/A) = P(A/D)\,P(D) / [P(A/D)\,P(D) + P(A/D')\,P(D')]$$
$$= [2/3 \times 3/4] / [2/3 \times 3/4 + 1/4 \times 1/4]$$
$$= 50\%$$

When adequate data are available, the a-priori probabilities can be estimated by using distributions such as binomial (in case of discrete variables) and normal (in case of continuous variables) and that of rare events (such as fire or wind damage) can be estimated by using a Poisson distribution.

The estimated Bayesian probabilities can then be used in the ES program (CRYSTAL has functions which incorporate Bayesian probabilities) or else the following procedure can be adopted to choose between alternative actions:

| Probability | | Action-behaviour $A_1$ | $A_2$ |
|---|---|---|---|
| State 1 | $P_1$ | $V_{11}$ | $V_{21}$ |
| State 2 | $P_2$ | $V_{12}$ | $V_{22}$ |

The expected value in the State 1 and 2 (where $V_{11}$ etc. are the values of outcomes) will be given by :

$$(\Sigma\, PV)_1 = P_1 V_{11} + P_2 V_{12}$$
$$(\Sigma\, PV)_2 = P_1 V_{21} + P_2 V_{22}$$

The test will then be that the behaviour based on action 1 is preferable if

$$(\Sigma\, PV)_1 > (\Sigma\, PV)_2$$

otherwise behaviour based on action 2 is preferable.

An alternative method of weighting the aggregation of evidence in favour of some a-priori hypothesis is by using the certainity factor (CF) which is based on the concept that at any point in time there is a CF associated with any given a-priori hypothesis. CF can take a value between -1 to 1 representing the statements, 'believed to be wholly untrue' and 'believed to be wholly true' respectively. The CF is estimated as the difference between the current measure of belief (MB) and the current measure of disbelief (MD). So for each hypothesis H given evidence E, the CF is

$$CF (H / E) = MB (H / E) - MD (H / E)$$

There is a link between CF and Bayesian probabilities as below (Graham and Jones, 1988):

$$CF (H / E) = [P (H / E) - P (H)] / P (H)$$

This means that the certainty associated with the hypothesis H given evidence E is a function of the change in probability proportional to the previous probability.

### 12.2.2 Measuring the fuzziness of villagers' responses

In addition to the problems associated with the data requirements, the assumptions underlying the Bayesian model are generally eroded when the Bayesian probabilities are calculated in practice. This is because there is no guarantee that the conditional probabilities of the events obtained under all tests will sum to unity for each of the hypotheses. The problem is compounded further due to the demanding condition that all tests performed should be independent. Indeed there are some serious difficulties in ascertaining whether or not a given event concerning social forestry has in fact occurred and therefore villagers may respond fuzzily.

In estimating the probability of an event it is usually assumed that either it has or has not happened; plantations are damaged fatally or recovered, for instance. There are certain villagers' responses which are not only uncertain, but which are also unstructured i.e. they have fuzzy definition. Social systems are generally characterized by their unstructured nature such that the problem itself does not have a formal definition (Checkland, 1981).

For example, the definition of a 'marginal peasant' or 'small peasant' does not have a clear boundary; the boundary moves depending on the social forestry environment. In such situations a membership function or measure of fuzziness (equivalent to a probability measure) should be estimated in order to capture the degree of strength of the villagers' responses. Fuzzy set theory as described by Zadeh (1965) can be used in such situations.

Fuzzy logic may be used alongside fuzzy rules because if the antecedent clause is true with a described degree of certainty then the consequent clause can be true to with no more than the same degree of certainty. This means that by applying fuzzy rules the degree of membership (a real number in the closed interval [0, 1]) of an attribute (or object under consideration) to the fuzzy set in the antecedent clause can be assessed. The theory is particularly useful in dealing with common sense logic and concept representation. A fuzzy set is a function ¥ from a set A, called its domain , to the closed unit interval [0, 1], i.e

$$¥ : A \longrightarrow [0,1]$$

This means that a fuzzy set theory is an expansion of an ordinary set theory where an element can be a member of a set to some degree. The function ¥ can also be identified with its graph by considering it to consist of the set of ordered pairs {(a, ¥ (a)) : a belongs to A}. For any **a** belonging to set A, ¥ (a) is called the degree or grade of membership of **a** in A. The concept of the fuzzy relation can be used in dealing with two or more incomparable predicates (poor and risk averse peasant, for instance). A fuzzy relation between two sets A and B is a fuzzy subset of their cartesian product; which is defined as the set of all ordered pairs of elements from A and B. The following example from social forestry will illustrate the procedure and concepts involved.

Suppose the degree of membership of a household H to the 'marginal peasant' is to be determined according to some criteria. The following sets can then be defined,

V = { set of all the villagers }
A = { set of all the marginal peasants }
where, A is a subset of V.

In the previous chapter, the following characteristic function,

$V(x) : V \longrightarrow \{0, 1\}$

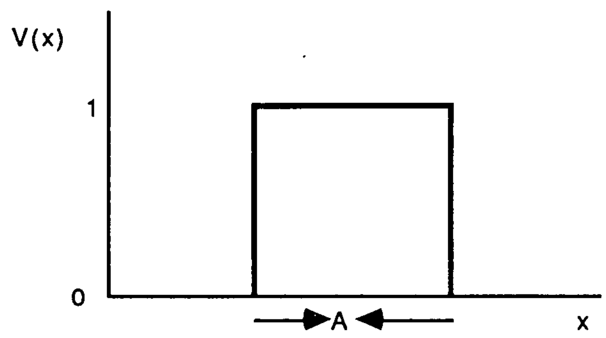
where, for every element $x$ (i.e. a villager or an household) belonging to V,

$V(x) = 1$ if and only if $x$ belongs to set A, and

$= 0$ otherwise

was used (implicitly) while handling such concepts using CRYSTAL. This means that V(x) takes values either 1 or 0 as shown in Figure 12.2.

**Figure 12.2 Characteristic function of 'marginal peasants'.**




However, in practice this characteristic function will take any real values in the closed interval [0, 1]. For instance, the fuzzy subset of V in the following situation,

a villager $x_1$ may not be a marginal peasant i.e. $V(x) = 0$

a villager $x_2$ may be a marginal peasant slightly i.e. $V(x) = 0+$

a villager $x_3$ may be more or less a marginal peasant i.e. $V(x) \neq 0+$ and $V(x) \neq 1-$

a villager $x_4$ may be a strongly marginal peasant i.e. $V(x) = 1-$

a villager $x_5$ may be a fully marginal peasant i.e. $V(x) = 1$

can be given as,

$A_f = \{ (x_1 / 0.0) \ (x_2 / 0.3) \ (x_3 / 0.5) \ (x_4 / 0.8) \ (x_5 / 1.0) \}$

The fuzzy membership function can be derived from the fuzzy measure based on a socioeconomic survey. For example, consider a fixed element • of V (i.e. • is a villager). Based on the response of a villager i, an ordinary subset $A_i$ (a set of 'marginal peasants' according to the i $^{th}$ villager's perception) of the set **A** (i.e. set of all the marginal peasants) can be generated after the judgement of whether • belongs to $A_i$. Then the degree of membership of • to the fuzzy set $A_f$ is given by the constant,

$$V_{A_f}(\cdot) = (\text{number of i for which} \cdot \text{belongs to } A_f) / N$$

where N is the number of villagers who responded.

Taking a specific example, suppose L represents the land area (ha) owned by the villagers in the closed interval [0.1, 2.0] (i.e. land area ranges from 0.1 ha to 2 ha). The villagers in a sample size of ten (i.e. N = 10) are asked to fill in the following questionaire:

"Use any number (0.1, 0.2, ..............., 2.0) or any
range (0.1 - 0.5, 0.5 - 1.2, 1.2 - 1.6, 1.6 - 2.0)
to indicate your perception of a marginal peasant".

The following ten sets ($A_i$) may be generated depending upon the responses of these ten villagers (figures are hypothetical):

$A_1$ = {0.1, 0.2, 0.3, 0.4}

$A_2$ = {0.3, 0.4, 0.5, 0.6, 0.7}

$A_3$ = {0.3, 0.4, 0.5, 0.6}

$A_4$ = {0.3, 0.4, 0.5, 0.8, 0.9, 1.2}

$A_5$ = {0.3, 0.4, 0.5, 0.9, 1.0, 1.1, 1.5}

$A_6$ = {0.3, 0.4, 0.5}

$A_7$ = {0.3, 0.4, 0.7, 0.8, 1.0, 1.1, 1.3}

$A_8$ = {1.6, 1.7}

$A_9$ = {1.8, 1.9}

$A_{10}$ = {0.3, 1.2, 1.4}

The following Table can then be developed from these sets:

**Table 12.1.1 Fuzzy membership function values for 'marginal peasants'.**

| Land area $(y_i)$ | Frequency $(f_i)$ | $V_{A_f}(\cdot) = f_i/N$ |
|---|---|---|
| 0.1 | 1 | 0.1 |
| 0.2 | 1 | 0.1 |
| 0.3 | 8 | 0.8 |
| 0.4 | 7 | 0.7 |
| 0.5 | 5 | 0.5 |
| 0.6 | 2 | 0.2 |
| 0.7 | 2 | 0.2 |
| 0.8 | 2 | 0.2 |
| 0.9 | 2 | 0.2 |
| 1.0 | 2 | 0.2 |
| 1.1 | 2 | 0.2 |
| 1.2 | 2 | 0.2 |
| 1.3 | 1 | 0.1 |
| 1.4 | 1 | 0.1 |
| 1.5 | 1 | 0.1 |
| 1.6 | 1 | 0.1 |
| 1.7 | 1 | 0.1 |
| 1.8 | 1 | 0.1 |
| 1.9 | 1 | 0.1 |
| 2.0 | _ | _ |

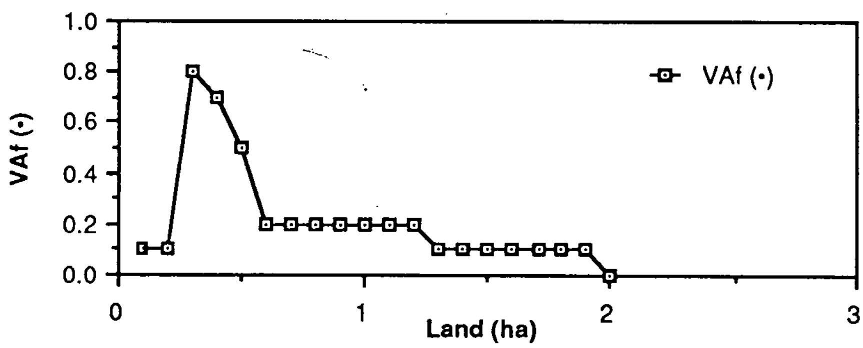
The fuzzy set is then given by,

$A_f = \{ y_1/0.1,\ y_2/0.1,\ y_3/0.8,\ y_4/0.7,\ y_5/0.5,\ y_6/0.2, \ldots\ldots,\ y_{19}/0.1,\ y_{20}/0.0\}$

and the fuzzy membership function of the "marginal peasant" $V_{A_f}(\cdot)$ can be graphed as follows.

**Figure 12.3**

**Fuzzy membership function of marginal peasants**



The shape of membership function in Figure 12.3, is different from that in Figure 12.2 and shows how the membership function can capture the inexactness of the 'marginal peasant' concept. The function can also be fitted in an equation form (polynomial, logarithmic or exponential). Such fuzzy membership functions can be developed for all the fuzzy responses of villagers and then incorporated into the program.

Fuzzy numbers, as a subset of the real numbers, can also be developed in those cases where villagers wish to express numerical quantities fuzzily (price of fuelwood is 'about Rs 90' per quintal, for instance). A rigid structure is imposed when the concepts such as poverty consumption level are defined precisely and clearly in terms of integers. That the monthly poverty consumption level (at 1987 prices) is 'about Rs 96' can be expressed as,

$$\text{'about 96'} \quad x = \begin{cases} x - 95 & \text{if } 95 < x \leq 96 \\ -x + 97 & \text{if } 96 \leq x < 97 \\ 0 & \text{otherwise} \end{cases}$$

Finally, since funds and time are always limited for such studies, one final comment is essential. There is a scope of further refinements (some of which have been illustrated in this Chapter) in the planning methodology developed in this study. I hope that these will provide an incentive for future researchers to take up where I have left off.

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# POSITION OF ORISSA IN INDIA


Drawn in the Office of the Director of Census Operations Orissa, based upon Survey of India map with the permission of the Surveyor General of India.

## Abstract of the papers

1 Sharma, R. A. (1988a) Financial Appraisal of Agroforestry. In Sinclair, F. L. *et al* (eds) Economic Evaluation of Agroforestry: A Novel Problem?. Proceedings of a workshop held in Department of Forestry & Natural Resources, University of Edinburgh, 33-41.

**Abstract:** The applicability of various decision criteria and discount rates are discussed in the context of labour-intensive agroforestry systems. A procedure for estimating indicators such as Net Present Value (NPV) is illustrated by an example of the agroforestry system from Orissa State, India.

2 Sharma, R. A. (1988b) Economic and Social Appraisal of Agroforestry. In Sinclair, F. L. *et al* (eds.) Economic Evaluation of Agroforestry: A Novel Problem?. Proceedings of a workshop held in Department of Forestry & Natural Resources, University of Edinburgh, 70-76.

**Abstract:** The use of economic and social cost-benefit analyses in appraising an agroforestry project is discussed in the Indian context. Interactions of labour employment in forestry and agriculture are stated in order to estimate the shadow wage rate. Further, it is argued that the social discount rate should be approximated from the consumption rate of interest which is based on the social time preference approach.

3 Sharma, R. A. and McGregor, M. J. (1989) The Socio-economic Evaluation of Agroforestry in Orissa (India). Paper presented to International Conference on Agroforestry: Principle and Practice. IUFRO. Edinburgh, 23-28 July. Also accepted in Forest Ecology and Management (in press)

**Abstract:** The paper evaluates agroforestry in the State of Orissa within the framework of its stated socio-economic objectives. The estimated values of socio-economic parameters such as the elasticity of social marginal utility of consumption, social discount rate, marginal productivity of capital, marginal productivity of labour, and inter-temporal consumption weight are -1.4, 2.05%, 0.142, 0.33xwage rate and 6.77 respectively. The intra-temporal consumption weights for the society, the main workers and the subsidiary workers are 1.005, 0.573 and 2.204 respectively. Both the distributional equity and efficiency aspects have been accounted for in the analysis. Based on two criteria (present net worth and land expectation value) the socio-economic profitability and optimum rotations have been determined for agroforestry in three site qualities; SQ I (Site index = 20-23), SQ II (Site index = 17-20) and SQ III (Site index = 14-17), and contrasted with the results of fianancial analysis. The net socio-economic benefits are shown to be quite large for SQ I and II. In SQ III, as socio-economic costs outweigh the socio-economic benefits, it is suggested that for the agroforestry system to socially profitable, the investment funds should be acquired by diverting consumption oriented funds from rural development programmes such as 'Food for Work'.

4 Sharma, R. A., Blyth, J. F. and McGregor, M. J. (1990a) The Socio-Economic Environment of Forestry Development in India (since British Period): A Historical Perspective. Indian Forester (in press).

**Abstract:** Based on empirical evidence, an evaluation of socio-economic environment of forestry developement is made. The forests have been under biotic pressure for a long time: Social Forestry can help reduce this pressure, but the planning in Social Forestry need to incorporate the relevant socio-economic aspects.

5 Sharma, R. A., McGregor, M. J. and Blyth, J. F. (1990b) The social discount rate for land-use projects in India. Journal of Agricultural Economics (in press).

**Abstract:** The social discount rate is a function of two parameters : the elasticity of social marginal utility of consumption and the growth rate of per capita real consumption. The final results for the social discount rate and the elasticity of social marginal utility of consumption are 2 per cent and -1.4 respectively. These values are plausible and comparable with other estimates found in the literature.

6 Sharma, R. A., McGregor, M. J. and Blyth, J. F. (1990c) The Socio-Economic Evaluation of Social Forestry in Orissa (India). International Journal of Tree Crops (in press).

**Abstract:** This paper evaluates social forestry in the State of Orissa (India) within the framework of the stated socio-economic policy objectives. Both the distributional equity and efficiency aspects have been accounted for in the analysis. Based on three criteria (net present value, land expectation value and annualised land rent), the socio-economic profitability and optimum rotations have been determined for village woodlots and institutional plantations in three site qualities. The net socio-economic benefits are shown to be large in SQ I and II. It is also found that for social forestry to be socio-economically profitable in SQ III, the investment funds should be acquired by diverting consumption oriented funds from rural development programmes.

7 Sharma, R. A., McGregor, M. J. and Blyth, J. F. (1990d) Forestry vs Agroforestry for Rural Poor: A Socio-Economic Evaluation. Unpublished.

**Abstract:** The paper evaluates Forest Farming for Rural Poor (FFRP) component of social forestry in the State of Orissa (India) within the framework of the stated socio-economic policy objectives. Both the distributional equity and efficiency aspects have been accounted for in the analysis. Based on two criteria (net present value and land expectation value) the socio-economic profitability and optimum rotations have been determined for dense plantations in three site qualities, and compared with the results for agroforestry. The net socio-economic benefits for agroforestry are shown to be larger than for dense plantations in SQ I. The reverse was found for SQ II. It is also found that for the FFRP policy to be socio-economically profitable in SQ III, the investment funds should be acquired by diverting consumption oriented funds from rural development programmes.

8 Sharma, R. A., Skerratt, S. J. and McGregor, M. J. (1990e) An Expert System Approach to the Socio-Economic Evaluation of Rural Land-use Policy. Unpublished.

**Abstract:** Rural policy makers are only now recognising the importance of incorporating socio-economic data into policy analysis in order to increase policy impact and uptake. This paper uses two specific case studies; the impact and uptake of social forestry policy in Orissa (India) and of Environmentally Sensitive Area Policy in Breadalbane (UK), to highlight the need and opportunities for incorporating qualitative socio-economic data into policy analysis. The role of expert systems as a means of synthesising both qualitative and quantitative data is discussed and illustrated. Expert systems are found to have a potential role in the socio-economic evaluation of land-use policy but they are not seen as a replacement for analytical techniques, such as social cost-benefit analysis, but rather as a means of enhancing the analysis in order to provide for better decision making.

## Appendix 1

## Forest Economy and Socioeconomic Environment of Orissa

The State of Orissa, covering nearly 15.5 M ha of land area (5% of the total for India) has a human population of about 26.3 M and a cattle population as 20.7 M. The population density (169/Km2 in 1981) is only 75% of the all India average and 39% of the population belong to traditionally disadvantaged groups such as scheduled tribes and castes, the largest proportion among the States of India. In 1983 the incidence of poverty in Orissa was higher than the national average ( Panda, 1987 ) and 51% of the total population were below the poverty consumption level. Cultivators and agricultural labourers account for 49 % and 28 % of the total labour force respectively. There is a great disparity between the average per capita incomes of Orissa and India which is increasing over the years : a gap of Rs. 155 in 1970-71 increased to Rs. 204 (at 1970-71 prices) in 1982-83 (GOO, 1985).

### 1.1 Climate

The State has a tropical monsoon climate with average annual rainfall of 1500 mm (mainly derived from South West monsoons occurring during June-October): the average number of rainy days is 75.

### 1.2 Geology

Archean rocks are found in a large part of the state and form a basement to all the younger groups such as Cudhapah and Gondwana. These can be divided into two main groups:

a. sedimentary rocks and their metamorphic variants, and
b. widespread intrusions of granite and charnockite.

### 1.3 Soils

Orissan soils can be broadly classified into the following eight groups :

a. Red soils ( Alfisols )
b. Laterite soils ( Ultisols and Oxisols )
c. Black soils ( Vertisols )
d. Mixed red and black soils ( Ultisols and Vertisols )
e. Red and Yellow soils ( Ultisols )
f. Brown forest soils ( Humults )
g. Alluvial soils ( Entisols )
h. Coastal saline and sandy soils ( Haplaquents and Ustipsamnuts )

### 1.4 Economy

Although Orissa is endowed with comparatively rich natural resources such as forests, minerals, rivers (capable of providing opportunities for generation of hydroelectric power, irrigation and fisheries) and an extensive coast line offering opportunities for trade and ports, the economy which is backward and predominantly agrarian, has not benefited from these resources due mainly to lack of infrastructure. In contrast to the increase in national GDP, the state domestic product (per capita) has declined at an annual rate of 1.4% during 1970-71 and 1979-80. The industry sector provides only 12% of total domestic product and 7% of total employment (primary sector accounts for 75% and remaining by tertiary sector).

### 1.5 Agriculture

The 'Green Revolution', which resulted in substantial increase in foodgrain production in western and north-western India, had little impact in Orissa as shown by the following equation which relates to foodgrain production (Kg/ha) from the year 1960-61 to 1982-83 compiled from Govt. of Orissa records:

$$Y = 2020 - 1.00\,T \qquad R^2 = 99.9\%$$

This shows that the overall rate of production was negative during the period. However, this negative trend is possibly due to a very sharp decrease in foodgrain yield in those years when the monsoon was erratic (e.g., 1974-75, 1982-83 etc.) because the rate of growth in foodgrain production during the period 1968-69 to 1981-82 was positive as shown by following equation :

$$Y = 418 + 0.24\,T$$

This low production is due to the fact that Orissa not only lacks irrigation facilities (only 20% of the total cropped area is under irrigation) but is also prone to uncertain monsoons and natural calamities such as drought, flood and cyclones, which adversely affect the agricultural yield. In addition, the Green Revolution brought little benefit to eastern and north - eastern India including Orissa where paddy cultivation constitutes a major part of the total area under food crops (the Green Revolution had limited success in rice production, due to lack of high yielding variety seeds for rice, and occurred mainly in wheat cultivation areas). Even within Orissa there was a large variation in agricultural productivity (Table, 1) due to variability in land resources. Socioeconomic constraints such as lack of knowledge, risk aversion, inadequate market and credit facilities , traditions, non-availibility of inputs, poor soils and inefficient cultural practices also hinder the agricultural development.

**Table 1 : Agricultural regions of Orissa ( All India Index = 100 ).**

| Region | District | Index<br>Land resources | Gross value productivity |
|---|---|---|---|
| Coastal | Ganjam | 103 | 151 |
| | Puri | 107 | 146 |
| | Cuttack | 105 | 145 |
| | Balasore | 95 | 122 |
| Northern | Dhenkanal | 106 | 140 |
| | Sundargarh | 100 | 125 |
| | Keonjhar | 96 | 142 |
| | Mayurbhanj | 96 | 123 |
| Central | Sambalpur | 118 | 137 |
| | Bolangir | 126 | 132 |
| Eastern Ghats | Phulbani | 111 | 105 |
| | Kalahandi | 121 | 112 |
| | Koraput | 76 | 132 |

Source : Sharma, P. S. ( 1972 ).

Land ownership is highly skewed in favour of the big farmers and the remaining holdings are small and fragmented. Small and marginal farmers owning less than 2 ha farm 75% of the land holdings but control less than 40% of the agricultural land, while farmers with more 5 ha account for only 7% of the total holdings and control 35% of the land. Although during the fourth FYP, the Orissa Consolidation and Prevention of Fragmentation of Land Act, 1972 was enacted and ceiling laws were passed, few tangible results have so far been achieved and share croppers who do not have any interest in increasing farm productivity are still present in sizable numbers.

In those areas where irrigation facilities are not available the farming is mainly at subsistence level : Sharma (1972) found that the marginal propensity to consume in the unirrigated villages was higher (0.71) than in the irrigated villages (0.61) based on a study of small farmers in Dhenkanal district. This suggests that in the irrigated areas farmers invest more (39% of their total income) than the farmers in the unirrigated areas (29% of their total income) and this increased investment enhances the agricultural productivity leading to commercialisation of agriculture. Although the annual increase in area under crops rose from 1% in the fifties to 1.8% in the sixties, the gain in agricultural production due to this area increase was offset by a drop in productivity from 3.9% to 1.4% per annum during the same period. Extensive areas of arable land, which are currently lying unused, require reclamation but Government policy has not envisaged large scale reclamation of these wasted lands. Therefore structural improvements along with biophysical and economic ones are urgently required. Social forestry can fulfil this gigantic task by involving the increasing labour force (both individuals and communities).

### 1.6 Forest Economy

Official statistics show that nearly 43% of the State is under forests (66,550 $Km^2$) but due to degradation the actual area under forests is not more than 20 % (CSE, 1982. 1985). However, Orissa is more heavily wooded than many other States in India. In addition to a large forest area under shifting cultivation and encroachment nearly 134,800 ha of forests have been deforested during 1951 to 1983, mainly for resettlement, irrigation and power projects (GOI, 1984). Orissan forests are unevenly distributed: coastal Orissa which has 47% of the State's population has only 16% of the total forest area, while in non-coastal Orissa these proportions are 53% and 84% respectively.

**Table 2 Socioeconomic indicators of Orissa (based on 1981 census).**

| District | Density ($pop^n/Km^2$) | Literacy (%) | SC (%) | ST (%) | Agri. labourers* | Forests (%) | Sown area (% of total) |
|---|---|---|---|---|---|---|---|
| Balasore | 357 | 42 | 18 | 7 | 26 | 16 | 68 |
| Bolangir | 164 | 26 | 16 | 19 | 31 | 24 | 45 |
| Cuttack | 415 | 45 | 18 | 3 | 24 | 13 | 55 |
| Denkanal | 146 | 37 | 16 | 12 | 27 | 42 | 37 |
| Ganjam | 213 | 31 | 15 | 9 | 32 | 47 | 39 |
| Kalahandi | 114 | 19 | 16 | 31 | 36 | 46 | 49 |
| Keonjhar | 134 | 30 | 11 | 45 | 23 | 49 | 36 |
| Koraput | 92 | 16 | 14 | 55 | 29 | 52 | 29 |
| Mayur. | 152 | 26 | 7 | 58 | 34 | 45 | 41 |
| Phulbani | 65 | 27 | 19 | 39 | 30 | 75 | 21 |
| Puri | 287 | 45 | 13 | 3 | 23 | 33 | 44 |
| Sambalpur | 130 | 34 | 15 | 27 | 30 | 40 | 35 |
| Sundargarh | 138 | 36 | 9 | 51 | 18 | 56 | 30 |
| Orissa | 169 | 34 | 15 | 22 | 28 | 43 | 39 |

* Percentage to total main workers.
SC = Scheduled castes, ST = Scheduled tribes
Source : Government of Orissa (1985).

#### 1.6.1 Forest productivity

Except for RF, most forests are in a degraded condition. Although forest revenue per $Km^2$ is low (Rs. 6214 in 1980-81) there has been a continuous increase in the total revenue receipts from forestry sector (Rs. 191.4 M or 5.2% of the state's revenue in 1977-78 to 372.6 M or 17% of the state's revenue in 1980-81 and Rs. 600 M in 1983-84), despite a very low forest expenditure (Rs. 95.6 M in 1980-81) a major part of which is spent on administration such as salary and other allowances and only 3.6% on crop improvement measures. Although these revenue figures do not include the forest produce given to villagers under rights and concessions (Orissa Forest Act, 1972 incorporates all the traditional rights and previllages of the villagers), they still represent a substantial part of the State's non-tax revenue. The mean annual increment of the Orissan forests is nearly 0.5 $m^3$ per ha.

### 1.6.2 Forest based Industries

In addition to large scale forest based industries such as pulp and paper mills, extraction plants to produce Sal fat, saw mills, wood product industries and printing industries, there are a large number of cottage and village industries which depend on forests indirectly or directly for raw materials (these are nearly 48000 craftsmen families in Orissa) . Minor forest produce such as Sal seeds, bamboos (*Dendroclamous strictus*) and Kendu leaves (*Dysperous melonxylon*) are a major contributor to the overall forest revenue and provide significant benefits in terms of forest produce and employment to disadvantaged people such as tribals and landless labourers.

### 1.6.3 Forest management

Due to wide variations in climate and topography, a great diversity in forest type has resulted, ranging from coastal and tidal vegetation in the eastern coasts to mixed Sal forests in the hinterland, and moist and dry deciduous forests in other regions. Typically Orissa forms a last zone in south for Sal and teak (*Techtona grandis*) occurs naturally in districts of Koraput, Kalahandi and Bolangir. The main forest types in Orissa are given below (based on the revised classification of forests by Champion and Seth, 1968):

1. Northern Tropical Semi-Evergreen forests.
2. Northern Tropical Moist Deciduous Forests.
3. Littoral Forests.
4. Tidal Swampy Forests.
5. Southern Tropical Dry Deciduous Forests.

Forest management in Orissa (which was earlier a division of Bengal presidency) started in 1936 after its formation as a separate state. After the merger of the erstwhile 26 princely States in 1957, a large areas of forests, which were undemarcated and degraded due to lack of management and inaccessibility, were brought under management. Although a major areas of forests are managed according to the prescriptions of Working Plans under various silvicultural systems, dependence on natural regeneration and non-implementation of Working Plan prescriptions (due mainly to paucity of funds) has resulted in deterioration of forest crops and their productivity. The latter has also been reduced by revenue-oriented improvement felling and illicit removal of trees (Padhi, 1984). Despite low investments and decreasing forest productivity, the overall outturn from the forests has increased continuously and many revised Working Plans contain downward revision of exploitable girth of trees in forests under Selection and Uniform systems, mainly on the false pretext of trees becoming unsound if left to stay for another rotation period.

### 1.6.4 Demand and supply from forests

According to the projection made by NCA (1976), the total timber requirements (roundwood) are 1.2 M $m^3$ in 1985 and 1.89 M $m^3$ in 2000, but the production of timber was only 0.5 M $m^3$ in 1983-84. Similarly the projected requirements for fuelwood are

8 M $m^3$ in 1985 and 9 M $m^3$ in 2000, while its production (stacked volume) in 1983-84 was only 0.7 M $m^3$ . Although some demand for fuelwood must have been met through agricultural residues and trees grown around houses etc., a wide gap still remains between supply and demand. This has resulted in pilferage from forests which is not accounted for. The fodder situation is also no better and the number of animals grazed in forests has increased over the years.

### 1.6.5 Tribal's dependence on forests

Nearly 90% of the total tribal population (who are also mainly forest dwellers) in Orissa depend on agriculture for earning their livelihood, often practising shifting cultivation: 30% of them do not own any land and work as agricultural labourers, sometimes as bonded labourers due to indebtedness to the land owners. The tribals have a community based social structure and own inherited communal lands but of late have been marginalised, mainly due to the onslaught market forces and forest degradation. This has increased their vulnerability to being involved in distress sale of land in cases of socioeconomic contingencies such as loss of oxen, marriage etc. Ties of kinship, which helped them in such crisis, are being broken due to their exposure to the socioeconomic processes generated by the market based economy. The recurrent sale of lands further worsens their situation as the distress sale of land arises due to shortage of income which gets shorter with every such sale of land. Social forestry can help improve their situation by providing them disposable assets in the form of trees which can be sold to raise quite small sums, either by selling trees or by consuming tree products such as edible fruits, flowers etc. In contrast the smallest unit of land a tribal household can sell is his smallest field and this might be worth far more than he needs. In addition , there is a market for fuelwood and timber and tribals know roughly how much they should get by selling a given number of trees. Also, the sale of a tree does not decrease their annual income unlike sale of land .

In the past the social structure of tribals helped in conserving the forests by imposing self restrictions on use of forests. Examples of totem and ancestral worship, protection of certain trees treated as sacred and restrictions about the exploitation of trees in certain seasons are found in Orissa. However, this symbiotic relationship between tribals and forests is changing to one of exploitation, due to changes in their social structure and revenue-oriented forestry practices of the government.

**Table 1.1 Population of India (1901-1981).**

| Year | Pop$^n$.(M) | Decadal Growth(%) | Urban pop$^n$.(% of total pop$^n$.) |
|---|---|---|---|
| 1901 | 238.40 | | 10.84 |
| 1911 | 252.09 | 5.75 | 10.29 |
| 1921 | 251.32 | -0.31 | 11.18 |
| 1931 | 278.98 | 11.00 | 11.99 |
| 1941 | 318.66 | 14.22 | 13.86 |
| 1951 | 361.09 | 13.31 | 17.29 |
| 1961 | 439.23 | 21.51 | 17.97 |
| 1971 | 548.16 | 24.80 | 19.91 |
| 1981 | 685.18 | 25.00 | 23.31 |

Source : Compiled from Govt. of India census reports (1981).

**Table 1.2 Population projections (1986-2001).**

| Year | Projected[1] pop$^n$. ( M ) | Projected[2] pop$^n$. ( M ) |
|---|---|---|
| 1981 | 672.01 | 685.16 |
| 1986 | 735.09 | 758.16 |
| 1991 | 798.96 | 836.45 |
| 1996 | 863.76 | 915.49 |
| 2001 | - | 991.48 |

Source : GOI ( 1984 ). 1-low growth rate; 2-medium growth rate.

**Table 1.3 Percentage of workers to total population.**

| Category | Cultivators | | Agricultural Labourers | | Other workers | |
|---|---|---|---|---|---|---|
| | 1971 | 1981 | 1971 | 1981 | 1971 | 1981 |
| Total | 14.20 | 13.89 | 8.89 | 8.41 | 10.00 | 11.14 |
| Rural | 17.42 | 17.73 | 10.70 | 10.47 | 5.92 | 6.57 |
| Urban | 1.49 | 1.53 | 1.79 | 1.79 | 26.06 | 25.85 |

Sorce : Census reports of Govt. of India, 1981.

**Table 1.4 Land-use pattern.**

| Land use | Area ( M ha ) | Percentage of total area |
|---|---|---|
| Agriculture. | 154.70 | 47.0 |
| Forests. | 75.18 | 22.8 |
| Pasture & grazing land | 12.15 | 3.7 |
| Cultivable tree crops & groves. | 3.91 | 1.3 |
| Cultivable wasteland. | 16.64 | 5.1 |
| Non-agricultural uses. | 17.53 | 5.3 |
| Barren & wasteland. | 24.60 | 7.5 |
| Area for which no returns exist. | 24.09 | 7.5 |
| Total | 328.80 | 100.0% |

**Table 1.5 Land-use trend (1951-1979)** (figures in 'ooo ha)

| Year | Forests | Pastures | Misc. Tree crops | Croopped area |
|---|---|---|---|---|
| 1951 | 40482 | 6675 | 19828 | 131893 |
| 1956 | 51343 | 11473 | 5885 | 147311 |
| 1961 | 54052 | 13966 | 4459 | 152772 |
| 1966 | 61543 | 14810 | 4076 | 155276 |
| 1971 | 63917 | 13262 | 4298 | 165791 |
| 1974 | 65731 | 12781 | 4147 | 169872 |
| 1977 | 67163 | 12529 | 3976 | 167281 |
| 1979 | 67441 | 12155 | 3910 | 175177 |

Source : Statistical Abstracts (various issues), Govt. of India.

**Table 1.6 Pattern of outlay (Public Sector) in Five Year Plans**
(% to total outlay)

| FYP | Agriculture* | Irrigation | Industry |
|---|---|---|---|
| I (1951/52-1955/56) | 14.9 | 19.7 | 7.9 |
| II (1956/57-1960/61) | 11.3 | 9.7 | 21.1 |
| III (1961/62-1965/66) | 14.2 | 8.7 | 23.8 |
| IV (1969/70-1973/74) | 17.2 | 6.8 | 22.8 |
| V (1974/75-1978/79) | 12.1 | 8.7 | 25.9 |
| Annual (1979-80) | 14.4 | 10.0 | 22.5 |
| VI (1980/81-1984/85) | 12.9 | 12.5 | 15.4 |
| VII (1985/86-1989/90) | 12.7 | 9.4 | 12.5 |

* includes allied sectors such as forestry, fishing etc.
Source : Five Year Plans, Govt. of India.

**Table 1.7 Index of State by State variations in agricultural productivity and infrastructure** (All India = 100)

| State | Infrastructure | Income* | Food grain yield** | Value added*** |
|---|---|---|---|---|
| AP | 106 | 98 | 99 | 65 |
| Assam | 96 | 81 | 93 | 48 |
| Bihar | 105 | 60 | 89 | 49 |
| Gujarat | 147 | 129 | 87 | 192 |
| Haryana | 169 | 142 | 139 | 157 |
| Karnataka | 118 | 109 | 89 | 98 |
| Kerala | 148 | 87 | 138 | 83 |
| MP | 72 | 56 | 60 | 53 |
| Maharashtra | 138 | 150 | 60 | 262 |
| Orissa | 94 | 66 | 75 | 53 |
| Punjab | 238 | 200 | 213 | 137 |
| Rajasthan | 85 | 75 | 46 | 61 |
| TN | 168 | 108 | 116 | 139 |
| UP | 113 | 67 | 108 | 40 |
| West Bengal | 144 | 109 | 118 | 132 |

*per capita state income in 1979-80 (at 1970-71 prices)
**per ha yield in 1980-81
***per capita value added in 1979-80
Source : Bardhan, P (1984).

**Table 1.8 Input-output coefficients at factor cost (current prices) for 1968-69 and 1973-74.**

| Sector | Agriculture | | Manufacturing | |
|---|---|---|---|---|
| | 1968-69 | 1973-74 | 1968-69 | 1973-74 |
| Agriculture | 0.188 | 0.167 | 0.175 | 0.181 |
| Manufacturing | 0.033 | 0.039 | 0.274 | 0.379 |

Source : Chakrovorty, S. (1987).

**Table 1.9 Sectoral composition of gross value added at factor cost (VII plan)**

| Sector | 1984-85 | 1989-90 | 1999-2000 |
|---|---|---|---|
| Agriculture | 36.9 | 32.7 | 25.5 |
| Mining | 3.5 | 4.8 | 3.8 |
| Manufacturing | 14.6 | 15.0 | 19.8 |
| Electricity & water supply | 2.0 | 2.3 | 2.9 |
| Construction | 6.2 | 6.2 | 6.1 |
| Transport | 5.6 | 6.2 | 6.4 |

Source: Seventh FYP, Vol. I, Govt. of India (1985)

**Table1.10 Land, labour, capital and output in Indian agriculture (1970-71 prices) from 1950-51 to 1979-80.**

| Description | 1950-51 | 1960-61 | 1970-71 | 1979-80 |
|---|---|---|---|---|
| Agricultural workers (M) | 101.9 | 137.8 | 167.3 | 192.7 |
| Net area sown (M ha) | 118.8 | 133.2 | 140.8 | 141.0 |
| Capital stock (1000M Rs.) | 128.99 | 150.18 | 209.99 | 311.77 |
| Land (per worker in ha) | 1.17 | 0.97 | 0.84 | 0.73 |
| GDP (per ha in Rs.) | 875 | 1023 | 1204 | 1401 |
| Capital stock (per ha in Rs) | 1086 | 1127 | 1492 | 2211 |
| GDP (per worker in Rs.) | 1101 | 9988 | 1013 | 1025 |
| Capital stock (per worker in Rs.) | 1266 | 1090 | 1255 | 1618 |

Source : Raghavan, S.N. ( 1984 ).

**Table 1.11 Saving and investment ratios.**

| Year | Gross domestic saving* | Gross fixed capital formation** |
|---|---|---|
| 151-52 | 9.5 | 12.2 |
| 156-57 | 12.9 | 14.7 |
| 1960-61 | 13.1 | 14.0 |
| 1965-66 | 15.2 | 17.5 |
| 1970-71 | 16.8 | 16.1 |
| 1975-76 | 20.2 | 16.8 |
| 1980-81 | 22.8 | 17.5 |

*% of GDP at current prices
**% of GDP at 1970-71 prices
Source : Compiled from National Account Statistics (various issues).

**Table 1.12 Sectoral shares (in %) in total investment in the economy**

| Sector | 1950-1959 | 1960-1969 | 1970-1979 | 1980-1983 |
|---|---|---|---|---|
| Agriculture | 22.1 | 16.4 | 17.9 | 16.6 |
| Mining | 0.8 | 1.8 | 3.0 | 5.2 |
| Manufacturing | 20.4 | 26.2 | 26.7 | 26.0 |
| Other sectors | 56.7 | 55.6 | 52.4 | 52.2 |

Source : National Account Statistics, Govt. of India.

**Table 1.13 Sectoral contribution to aggregrate growth (%).**

| Sectors | 1950-1959 | 1960-1969 | 1970-1979 | 1980-1983 |
|---|---|---|---|---|
| Agriculture | 54.5 | 48.1 | 41.0 | 39.2 |
| Mining | 0.8 | 1.0 | 1.1 | 1.3 |
| Manufacturing | 11.4 | 13.8 | 15.4 | 15.0 |
| Other sectors | 33.3 | 37.1 | 42.5 | 44.5 |

Source : National Account Statistics, Govt. of India.

**Table 1.14 Sectoral rates of growth of GDP**

| Sector | 1950-1959 | 1960-1969 | 1970-1979 | 1980-1983 |
|---|---|---|---|---|
| Agriculture | 2.61 | 1.37 | 2.31 | 3.96 |
| Mining | 4.81 | 5.24 | 4.33 | 10.53 |
| Manufacturing | 6.11 | 4.77 | 4.75 | 3.25 |
| All sectors | 3.63 | 3.24 | 3.76 | 4.9 |

Source : National Account Statistics, Govt. of India.

**Table 1.15 Percentage of rural people below poverty level of consumption in various states.**

| State | 1960-61 | 1967-68 |
|---|---|---|
| Andhra pradesh ( AP ) | 47 | 44 |
| Assam | 14 | 32-52 |
| Bihar | 38 | 61-71 |
| Gujarat | 25-37 | 48 |
| Harayana | - | 29 |
| Jammu&Kashmir (J&K) | 8 | 21 |
| Kerela | 42 | 67 |
| Madhya Pradesh(MP) | 36-47 | 61 |
| Maharashtra | 40 | 56 |
| Karnataka | 34 | 57 |
| Orissa | 56 | 64 |
| Punjab | 13 | 33 |
| Rajasthan | 33 | 37 |
| Tamil Nadu (TN) | 51 | 61 |
| Uttar Pradesh (UP) | 39 | 60 |
| West Bengal (WB) | 22-42 | 74 |
| All India | 38 | 53 |

Source : Bardhan, P. (1973).

**Table 1.16 Trends in percentage of people below poverty consumption level.**

| Population | 1977-78 | 1983-84 | 1989-90 |
|---|---|---|---|
| Rural | 51.2 | 40.4 | 28.2 |
| Urban | 38.2 | 28.1 | 19.3 |
| Total | 48.3 | 37.4 | 25.8 |

Source : Seventh Five Year Plan (1985-90), Govt. of India.

**Table 1.17 Unemployment rates (based on daily status) in different expenditure groups of households (1977-78).**

| Mothly per capita expenditure group (Rs.) | Rural | Urban |
|---|---|---|
| 0.00-9.99 | 14.71 | 17.60 |
| 10.00-19.99 | 15.70 | 26.89 |
| 20.00-29.99 | 12.35 | 16.91 |
| 30.00-39.99 | 9.54 | 14.23 |
| 40.00-49.99 | 8.85 | 13.01 |
| 50.00-69.99 | 7.05 | 11.07 |
| 70.00-99.99 | 6.15 | 10.10 |
| 100.00-149.99 | 5.25 | 9.18 |
| 150.00-199.99 | 5.53 | 6.88 |
| 200.00 and above | 3.95 | 5.83 |
| All | 7.70 | 10.34 |

Source : Bardhan, P. (1984).

**Table 1.18 Forest area based on various sources.**(in 000 $Km^2$)

| State | Forest Department | NRSA | FSI |
|---|---|---|---|
| Andhra Pradesh | 63.77 | 40.44 | 50.19 |
| Arunachal Pradesh | 51.54 | 52.10 | 60.50 |
| Assam | 30.71 | 19.79 | 26.39 |
| Bihar | 29.23 | 20.14 | 28.75 |
| Goa, Daman&Diu | 1.05 | 1.14 | 1.29 |
| Gujarat | 18.78 | 13.16 | 13.57 |
| Haryana | 1.69 | 0.40 | 0.64 |
| Himachal Pradesh | 21.33 | 9.13 | 12.88 |
| Jammu&Kashmir | 20.89 | 14.36 | 20.88 |
| Karnataka | 38.64 | 31.403 | 2.26 |
| Kerela | 11.22 | 7.38 | 10.40 |
| Madhya Pradesh | 155.41 | 90.22 | 127.75 |
| Maharashtra | 64.06 | 30.35 | 47.42 |
| Manipur | 15.16 | 13.57 | 17.68 |
| Meghalaya | 8.51 | 12.46 | 16.51 |
| Mizoram | 15.94 | 11.97 | 19.09 |
| Nagaland | 8.63 | 39.43 | 53.16 |
| Orissa | 59.56 | 39.43 | 53.16 |
| Punjab | 2.80 | 0.50 | 0.77 |
| Rajasthan | 31.15 | 5.97 | 12.48 |
| Sikkim | 2.65 | 2.88 | 2.84 |
| Tamil Nadu | 22.32 | 15.88 | 18.38 |
| Tripura | 6.28 | 5.14 | 5.74 |
| Uttar Pradesh | 51.27 | 27.78 | 31.44 |
| West Bengal | 11.88 | 9.05 | 8.81 |
| Andaman&Nicobar | 8.29 | 7.65 | 7.60 |
| Chandigarh | 0.11 | - | 0.002 |
| Dadra&Nagar Haveli | 0.49 | 0.13 | 0.24 |
| Delhi | 0.15 | 0.01 | 0.02 |
| Lakshadweep | 0.03 | -- | -- |
| Pondichery | 0.50 | -- | 0.01 |
| TOTAL | 3287.80 | 490.52 | 642.04 |
| % to geographical area | 22.8 | 14.9 | 19.52 |

Source : Compiled from FSI (1987) and NRSA (1983).

**Table 1.19 Forest area under different forest types.**

| Forest type | Percentage of total forest area |
|---|---|
| Tropical wet evergreen forests | 6.0 |
| Tropical semi-evergreen forests | 2.5 |
| Tropical moist deciduous forests | 30.9 |
| Littoral and swamp forests | 0.9 |
| Tropical dry deciduous forests | 38.7 |
| Tropical thorn forests | 6.9 |
| Tropical dry evergreen forests | 0.1 |
| Subtropical broad leaved forests | 0.4 |
| Subtropical pine forests | 5.0 |
| Subtropical dry evergreen forests | 0.2 |
| Montane wet temperate forests | 2.1 |
| Himalayan moist temperate forests | 0.3 |
| Sub-alpine forests | |
| Moist alpine scrub forests | |
| Dry alpine scrub forests | 2.4 |

Source : Kaul and Sharma (1971).

**Table 1.20 Forest area under different silvicultural systems in some States** (in 000 ha).

| State | Selection | Uniform & Shelterwood | Coppice | Clear felling |
|---|---|---|---|---|
| Assam | 866.56 | 76.18 | --- | 94.97 |
| Gujarat | 565.14 | --- | 398..34 | 1.70 |
| Uttar Pradesh | 258.83 | 108.54 | 43.71 | 60.42 |
| Orissa | 1181.05 | 119.40 | 775.71 | 0.44 |

Source: GOI (1961).

**Table 1.21 Temporal trend in forest area.**

| Year | Forest area ( in M ha ) |
|---|---|
| 1950-51 | 40.48 |
| 1955-56 | 51.34 |
| 1960-61 | 68.06 |
| 1965-66 | 75.31 |
| 1972-73 | 74.57 |
| 1979-80 | 74.61 |
| 1983-84 | 74.87 |
| 1986-87 | 75.18 |

Source : FSI (1987).

**Table 1.22 Annual production of wood**

(in '000 $m^3$)

| Year | Roundwood | | Fuelwood & Charcoal |
|---|---|---|---|
| | Coniferous | Non-coniferous | |
| 1975 | 7004 | 182333 | 181375 |
| 1976 | 7227 | 186716 | 185434 |
| 1977 | 7397 | 190972 | 189514 |
| 1978 | 7592 | 195293 | 193618 |
| 1979 | 7799 | 199696 | 197753 |
| 1980 | 8012 | 204176 | 201929 |
| 1981 | 8134 | 208122 | 206137 |
| 1982 | 8257 | 212092 | 210370 |
| 1983 | 8380 | 216075 | 214622 |
| 1984 | 8503 | 220056 | 218866 |

Source : FAO (1986).

**Table 1.23 Forest area by density classes and encroached forests.**

| State | Dense forests[1] | Open forests[2] | Encroached forests[3] |
|---|---|---|---|
| AP | 28580 | 21119 | 76166 |
| Arunachal | 51096 | 9404 | 34226 |
| Assam | 18415 | 7971 | 131196 |
| Bihar | 13490 | 15258 | 9944 |
| Goa & Daman | 763 | 522 | 6638 |
| Gujarat | 7850 | 5293 | 17266 |
| Harayana | 43 | 601 | 287 |
| HP | 9908 | 2974 | 16668 |
| J & K | 12978 | 7902 | 5370 |
| Karanataka | 16394 | 15870 | 12395 |
| Kerela | 8569 | 1833 | 20800 |
| MP | 72174 | 55575 | 246189 |
| Maharashtra | 27244 | 20032 | 22758 |
| Manipur | 4670 | 13009 | 57 |
| Meghalaya | 5749 | 10762 | 11216 |
| Mizoram | 2938 | 16154 | ---- |
| Nagaland | 6379 | 7972 | 990 |
| Orissa | 28573 | 24391 | 8596 |
| Punjab | 96 | 670 | 3177 |
| Rajasthan | 3048 | 9430 | 22000 |
| Sikkim | 1867 | 972 | ---- |
| TN | 10866 | 7491 | 20900 |
| Tripura | 340 | 5403 | 1522 |
| UP | 18876 | 12567 | 14493 |
| WB | 3512 | 3223 | 14275 |
| A & N | 6807 | 110 | 2847 |
| Chandigarh | ---- | 2 | 3 |
| Dadar * Nagar | 187 | 50 | 698 |
| Delhi | ---- | 15 | ---- |

1. in $Km^2$ ( crown density above 40% )
2. in $Km^2$ ( crown density 10 to 40% )
3. in ha

Source : FSI (1987)

**Table 1.24 Potential productivity of forests in various regions.**

| Region | Annual productivity ($m^3$/ha) |
|---|---|
| Western Himalayas | 2.21 |
| North eastern | 1.66 |
| Evergreen forests of western coasts and Andamans | 3.85 |
| Dry forests of Rajasthan & Gujarat | 0.41 |
| Dry deciduous forests of Central India | 1.05 |

Source : FSI (1987).

**Table 1.25 Temporal variations in forest area (in % of total geographical area)**

| Forests | NRSA (1972-75) | NRSA (1980-82) | FSI (1981-83) |
|---|---|---|---|
| Dense | 14.12 | 10.96 | 10.9 |
| Open | 2.67 | 3.06 | 8.6 |
| Mangrove | 0.10 | 0.08 | 0.1 |
| Coffee plantations | --- | --- | 0.1 |
| Total forests | 16.89 | 14.10 | 19.7 |

Source : FSI (1987 ) and NRSA (1983).

**Table 1.26 Forest land diverted for non-forestry purposes (by category).**

| Purpose | Area (M ha) |
|---|---|
| Agriculture | 2.62 |
| River valley projects | 0.50 |
| Industries and townships | 0.13 |
| Transmission lines and roads | 0.06 |
| Miscelleneous | 1.01 |

Source : GOI (1984).

**Table 1.27 Area ($Km^2$) under shifting cultivation.**

| State | Annual area | Fellow period (year) | Minimum area (one time or other) |
|---|---|---|---|
| AP | 500 | 3 | 1500 |
| Arunachal | 1700 | 3-10 | 2100 |
| Assam | 696 | 2-10 | 1392 |
| Bihar | 162 | 5-8 | 810 |
| MP | 125 | 10-15 | 1250 |
| Manipur | 900 | 4-7 | 3600 |
| Meghalaya | 530 | 5-7 | 2650 |
| Mizoram | 630 | 3-4 | 1890 |
| Nagaland | 192 | 4-9 | 768 |
| Orissa | 5298 | 5-14 | 26490 |
| Tripura | 223 | 5-9 | 1115 |
| Total | 9956 | ---- | 43565 |

Source : FSI (1987).

**Table 1.28 Income of tribals from sale of Minor Forest Produce.**

| State | Income ( % of total income ) |
|---|---|
| AP | 10-55 |
| Orissa | 5-13 |
| Bihar | 7-40 |
| MP | 13-38 |

Source : FSI (1987).

**Table 1.29 Trend in consumption and production of fuelwood**

(in Million tonnes)

| Year | Consumption | Production from forests |
|---|---|---|
| 1953-54 | 86.3 | 6.49 |
| 1960-61 | 99.6 | 8.15 |
| 1965-66 | 109.3 | 9.16 |
| 1970-71 | 117.9 | 11.62 |

Source : FSI (1987).

**Table 1.30 Estimates of the commercial & non-commercial energy use in 1999-2000.**

| Energy | Household | Industry | Transport | Agriculture | Others |
|---|---|---|---|---|---|
| Electricity[1] | 82 | 216 | 8 | 41 | 46 |
| Coal[2] | 14 | 161 | 8 | -- | 5 |
| Oil[2] | 18 | 12 | 30 | 8 | 5 |
| Fuelwood[2] | 192 | - | - | - | - |
| Dungcake[2] | 105 | - | - | - | - |
| Vegetable waste[2] | 59 | - | - | - | - |

1 Billion KWH
2 Million tonnes
Source : GOI ( 1985).

**Table 1.31 Fuelwood requirements** (in M $m^3$)

| Year | Fuelwood |
|---|---|
| 1970 | 150 |
| 1980 | 184 |
| 1985 | 202 |
| 2000 | 225 |

Source : NCA (1976).

**Table 1.32 Wastelands available in various States (in M ha).**

| State | Saline& Alkaline | Wind eroded | Water eroded | Non-forest degraded | Forest degraded |
|---|---|---|---|---|---|
| AP | 0.24 | -- | 7.44 | 7.68 | 3.73 |
| Assam | -- | -- | 0.94 | 0.94 | 0.80 |
| Bihar | 0.004 | -- | 3.89 | 3.90 | 1.56 |
| Gujarat | 1.21 | 0.70 | 5.24 | 7.15 | 0.68 |
| Harayana | 0.53 | 1.60 | 0.28 | 2.40 | 0.08 |
| HP | -- | -- | 1.42 | 1.42 | 0.53 |
| J&K | -- | -- | 0.53 | 0.53 | 1.03 |
| Kranataka | 0.40 | -- | 6.72 | 7.12 | 2.04 |
| Kerela | 0.02 | -- | 1.04 | 1.05 | 0.23 |
| MP | 0.24 | -- | 12.71 | 12.9 | 57.20 |
| Maharashtra | 0.53 | -- | 11.03 | 11.56 | 2.84 |
| Manipur | -- | -- | 0.01 | 0.01 | 1.42 |
| Meghalaya | -- | -- | 0.82 | 0.82 | 1.10 |
| Nagaland | -- | -- | 0.51 | 0.51 | 0.88 |
| Orissa | 0.40 | -- | 2.75 | 3.16 | 3.23 |
| Punjab | 0.69 | -- | 0.46 | 1.15 | 0.08 |
| Rajasthan | 0.73 | 10.62 | 6.66 | 18.00 | 1.93 |
| Sikkim | -- | -- | 0.13 | 0.13 | 0.15 |
| TN | 0.004 | -- | 3.39 | 3.39 | 1.01 |
| Tripura | -- | -- | 0.11 | 0.11 | 0.87 |
| UP | 1.30 | -- | 5.34 | 6.64 | 1.43 |
| WB | 0.85 | -- | 1.33 | 2.18 | 0.36 |
| Union Terr. | 0.02 | -- | 0.87 | 0.89 | 2.72 |

Source : GOI (1987).

## Appendix 1.1

Main recommendations of the National Commission on Agriculture (1973) which have been accepted by the Government of India (GOI).

1. Farm forestry should be so organised that a substantial programme of planting of trees on bunds and bounderies of the fields of farmers is taken up by the farmers themselves. Conditions differ from state to state. It is, therefore, necessary to choose the tree species for farm forestry with great care, taking into account the acceptability of the farmers in the local area.
2. A pilot scheme for development of farm forestry should be taken up in 100 selected districts in the country during fifth FYP in the central sector.
3. The Forest Departments should organise extension units in the districts, to propagate directly and through the agricultural extension staff the advantages of the programme and the methods of tree plantation.
4. Where irrigation facilities do not exist in drought prone areas, the approach to the solution of the problem should include adoption of such land use patterns as would essentially result in reducing the areas of arable cropping and increasing the area under permanent vegetation.
5. With a view to preparing a land use plan based on a village or a group of villages as a unit, a survey of waste land and village Panchayat lands, including areas around village ponds and community wells outside the village, should be organised in areas where the occurrence of waste lands is sufficiently high. A certain area should be available (in a compact block) for development of mixed forestry, comprising the raising of grass and leaf fodder, fruit and fuelwood trees.
6. Development of fodder and grass should be made an important component of mixed forestry to be taken up with optimum input and technology.
7. The funds from central sector should be allotted to various States, provided that adequate waste lands are available and demand for fuelwood and small timber exists in the nearby areas.
8. Degraded forests should be rehabilitated.
9. Forest Department should take up afforestation on lands along with railway lines, canals, roads etc.
10. To begin with, the selection of degraded forests for reafforestation should be integrated with proposed survey of waste lands. The state government should identify areas of degraded forests, linking this with consuming population.
11. Supply of fuelwood and small timber (for agricultural implements including ploughs) at fair rates in the rural and semi-urban areas is a necessary part of the programme of refforestation in degraded forests.
12. During fifth FYP , refforestation with 50% central assisstence should be taken up on at least 300,000 ha of degraded forests in the country.
13. State governments should take up agri-silviculture, giving additional wage earning to the landless labourers.
14. Since a major financial support for social forestry programme will come from the central government, a cell in the centre should be created to watch the progress of work and to do frequent appraisal work. State governments should also create extension organisations.
15. The strategy for popularising social forestry should include the establishment of a large number of field demonstrations. For the participation of local Panchayats and cooperatives, state government should take up necessary action.
16. All social forestry programmes should be executed by engaging local labour and no contract system should be introduced.
17. Planning Commission have approved a sum of Rs. 200.5 M for various programmes of social forestry during the fifth FYP. State governments should be asked to provide matching grants where the schemes are to be implemented on a 50% central grant basis.

**Table 2.1 Toal forest land diverted to non-forestry purposes in India.**

| Year | Forest land diverted (ha) |
|---|---|
| 1951 to 1980 | 4,328,000 |
| 1981 | 2673 |
| 1982 | 3247 |
| 1983 | 5702 |
| 1984 | 7838 |
| 1985 | 30608 |
| 1986 | 11963 |
| 1987 | 4823 |

Source : FSI (1987).

**Table 2.2 Category to which forest area (in India) was diverted during 1951 to 1980.**

| Purpose | Area ('000 ha) |
|---|---|
| Agriculture | 2623 |
| River valley projects | 502 |
| Industries and townships | 134 |
| Transmission lines and roads | 61 |
| Miscellaneous | 1008 |

Sourec : FSI (1987).

**Table 2.3 Financial outlays for the main schemes in Five Year Plans**
(million Rs.)

| Scheme | I | II | III | Annual | IV | V |
|---|---|---|---|---|---|---|
| Economic plantations | 11.19 | 48.69 | 116.32 | 93.40 | 201.50 | 225.00 |
| Rehabilatation of degraded forests | 1.64 | 19.92 | 38.06 | 22.98 | 32.22 | 150.00 |
| Farm forestry | _ _ | _ _ | 10.95 | 15.19 | 36.12 | 20.00 |
| MFP Development | — | — | 15.17 | 14.81 | 10.74 | 20.00 |
| Consolidation | 1.46 | 6.18 | 19.93 | 19.42 | 36.78 | 50.00 |
| Development of pasture & grazing | — | — | 5.29 | 4.71 | 7.78 | 10.00 |
| Working plans | — | — | 12.12 | 10.09 | 13.29 | 30.00 |
| Intensification of management | — | — | — | 2.06 | 2.94 | 30.00 |
| Cultural operations | — | — | — | 4.29 | 7.13 | — |
| Planatation of quick growing species | — | — | 40.65 | 93.94 | 168.94 | 240.00 |
| Environmental forestry | — | — | — | — | — | 10.00 |
| Amenities to staff & labour | — | — | 4.80 | 1.46 3. | 11 9.37 | 10.00 |

Source : NCA (1976).

**Table 2.4 Physical achivements/targets of the main schemes under Five Year Plans ('000 ha)**

| Scheme | I | II | III | Annual | IV | V(targets) |
|---|---|---|---|---|---|---|
| Plantations of quick growing species | — | — | 86.64 | 166.98 | 232.80 | 350.00 |
| Economic plantations | 39.96 | 163.95 | 236.41 | 156.41 | 291.20 | 760.00 |
| Farm forestry | — | — | 33.32 | 39.52 | 63.00 | 180.00 |
| Rehabilatation of degraded forests | 15.13 | 147.21 | 226.99 | 88.29 | 127.30 | — |

Source : NCA (1976)

**Table 2.5 Forestry sector outlay in Five Year Plans** (ten million Rs.).

| Five Year Plan/Period | Total Public Sector Outlay | Forestry Sector Outlay |
|---|---|---|
| First (1951-56) | 1960 | 7.64 |
| Second (1956-61) | 4600 | 21.21 |
| Third (1961-66) | 8576 | 45.85 |
| Annual plans (1966-69) | 6000 | 42.1 |
| Fourth (1969-74) | 40650 | 208.84 |
| Fifth (1974-79) | 40650 | 208.84 |
| Annual (1979-80) | 12550 | 68.33 |
| Sixth (1980-85) | 97500 | 692.49 |
| Seventh (1985-90) | 180000 | 1859.10 |

Source : FSI (1987)

**Table 2.6 Forest area covered under Working Plans.** ($Km^2$)

| State/UT | Forest area covered under Working Plans | Percentage of total forest area covered by Working Plans |
|---|---|---|
| Andhra Pradesh | 63771 | 100 |
| Arunachal | 5220 | 10 |
| Assam | 16500 | 54 |
| Bihar | 29230 | 100 |
| Goa, Daman | 1460 | 91 |
| Gujarat | 13880 | 74 |
| Haryana | 693 | 41 |
| Himachal | 21325 | 100 |
| Jammu&Kashmir | 20892 | 100 |
| Karnataka | 38408 | 99 |
| Kerela | 11222 | 100 |
| Madhya Pradesh | 122910 | 79 |
| Maharashtra | 50540 | 79 |
| Manipur | 390 | 3 |
| Meghalaya | 722 | 9 |
| Mizoram | — | — |
| Nagaland | 180 | 2 |
| Orissa | 59555 | 100 |
| Punjab | 2803 | 100 |
| Rajasthan | 31151 | 100 |
| Sikkim | 2650 | 100 |
| Tripura | 6280 | 100 |
| Tami Nadu | 21120 | 95 |
| Uttar Pradesh | 51269 | 100 |

| | | |
|---|---|---|
| West Bengal | 11879 | 100 |
| Andamans | 4790 | 74 |
| Chandigarh | — | — |
| Dadar&Nagar Haveli | 203 | 100 |
| Delhi, Laksdweep and Pondichery | — | — |
| Total | 589043 | 78 |

Source : FSI (1987)

**Table 2.7 Natural regeneration in forests in various States of India.**

| State | Surveyed forest area(Km$^2$) | Natural regeneration (%) Profuse | Adequate | Inadequate | Absent |
|---|---|---|---|---|---|
| Assam | 2354 | 2 | 9 | 23 | 66 |
| Arunachal | 11599 | 5 | 18 | 35 | 42 |
| Andamans | 5124 | 32 | 37 | 29 | 2 |
| Bihar | 11120 | 20 | 26 | 38 | 16 |
| Gujarat | 5816 | 5 | 9 | 54 | 32 |
| Goa | 1056 | 4 | 26 | 47 | 23 |
| Himachal | 16766 | 18 | 13 | 31 | 38 |
| J & K | 3191 | — | 1 | 8 | 91 |
| Karnataka | 6761 | — | 2 | 22 | 76 |
| M P | 38378 | 7 | 43 | 48 | 2 |
| Manipur | 15154 | 22 | 69 | 8 | 1 |
| Meghalaya | 12867 | 16 | 27 | 49 | 8 |
| Nagaland | 6149 | 3 | 8 | 33 | 56 |
| Orissa | 14925 | 3 | 11 | 54 | 32 |
| Rajasthan | 4548 | 1 | 7 | 41 | 51 |
| Sikkim | 835 | 3 | 13 | 32 | 52 |
| U P | 22607 | 12 | 7 | 11 | 70 |
| West Bengal | 5399 | 13 | 16 | 35 | 36 |

Source : FSI (1987)

## Appendix 4.1

### Notes about the species

### 1. *Eucalyptus hybrid* (*Eucalyptus tereticornis*)

Eucalyptus are important in social forestry due mainly to their fast growth rate, coppicing power, little shade, few branches, good fuelwood and small timber such as poles, low susceptibility to grazing and browsing, etc. They are good raw material for the paper and pulp industry and are also used in the match industry. Bark and leaves of Eucalyptus are used for producing oxalic acid and oil for medicinal purposes respectively.

Although the *Eucalyptus hybrid* is exotic, it is widely grown in many parts of India. Lohani (1978) and Chaturvedi (1983) have reported extensively about the silvicultural and management aspects of Eucalyptus. The air dried wood of Eucalyptus burns well (calorific value = 4800 ca./gm) and leaves little ash. The wood is heavy and burns slowly and so provides a good fuelwood for domestic cooking. Trees of higher age burn better than those of younger age due to higher density.

Although many species of the Eucalyptus such as *Eucaluptus nilotica, Eucalyptus occidentales, Eucalyptus robusta* and *Eucalyptus globulus* are being increasingly grown, *Eucalyptus hybrid* has been grown extensively in varying climatic zones of the country. It is estimated that by 1974 about 415 thousand ha plantations of Eucalyptus have been raised throughout India.

### 2. *Acacia nilotica*

*Acacia nilotica*, which provides very good fuelwood and small timber, has a very wide distribution ranging from semi-arid regions of Rajasthan in the north to southern and eastern parts such as Orissa and Bihar. It also provides gum (gum arabic), bark for tanning and is an execllent fodder for goats and sheep. Although well suited to black cotton soils of semi-arid regions, it grows well even on the saline soils having adequate moisture.

The tree belongs to family Leguminosae and there are at least three varieties found in India. It is a moderate sized and spiny evergreen tree which grows up to 20 m in height. Flowers are yellow and sweet scented, and paired whitish spines occur at the base of each leaf. The wood is heavy (specific gravity = 0.80) and makes good quality of fuelwood and charcoal (the calorific value of heartwood is 4950 K calories/Kg). The bark and leaves are widely used as fodder and crude protein content in pods is about 15%.

The natural forests of *Acacia nilotica* are usually found on black cotton soils and riverain alluvium subject to inundation. Natural sporadic trees, which are protected by farmers, can be found in agricultural fields in Orissa, Uttar Pradesh and Madhya Pradesh. Although mainly a lowland species, it sometimes comes up to an elevation of 500 m in the Himalayas. The annual rainfall in areas where it is indigeneous ranges from 7 cm. to 125 cm.

It is a frost tender species but can tolerate extremes of temperature (upto 40-45 $^{0}$C) in its natural areas. The species is not a coppicer and can be propagated by nursery raised plants or by direct sowing (the fresh seeds can be planted directly after immersing in boiling water and soaking in sun).

3. ***Dalbergia sissoo***

It is a fairly fast growing species and has vigorous coppicing potential. Although ideally suited for well drained alluvial soils it is being widely grown in many parts of the country such as Orissa, Harayan, Uttar Pradesh, Andhra Pradesh, Tamil Nadu, Maharashtra, Gujarat etc. The species is suitable for fuelwood, fodder, charcoal, small timber (agricultural implements and cottage industries) and timber (furniture and musical instruments).

Nursery raised plants (even up to a height of 2-3 m) can be transplanted at closer spacings. Since the species is vulnerable to grazing and browsing, it needs protection especially in early years of planting. It is a light demanding species and in many areas the old plantations are managed under coppice system.

4. ***Casuarina equisitifolia***

It is a large evergreen tree with a straight stem and brown bark. Since the wood is very hard and liable to crack and split, it is mainly used for fuelwood. The tree is not long lived and in less favourable areas it hardly reaches 25 years, before becoming hollow stem and badly shaped.

Although the species is being widely planted, it is particularly suitable for coastal sandy areas (where it thrives well on loose sand with roots in the sea) and is therefore planted for arresting shifting sand dunes. In Orissa, plantations have been raised along coasts (mainly in Puri, Ganjam and Balasore) where it is gregarious and forms pure stands with almost no undergrowth.

The seedlings are very sensitive to drought and execessive moisture, and its growth is rapid in nursery beds (nursery raised seedlings are transplanted). Since it is a fast-growing and light-demanding species thinnings are necessary, or it should be raised at a wider spacing to avoid the costs necessary for intermittent thinnings. The species is managed under a clear-felling system with of artificial regeneration

## Appendix 4.2

## Program for computing (in FORTRAN 77) PNW, LEV AND ALR

```
      PROGRAM VALUE
C     This program computes values of PNW, LEV and ALR
      INTEGER T, N
C     N refers to the rotation length (in years) of species
C     T is a variable which takes values from 0 to N
      REAL B(0:40), C(0:40), R
C     B refers (in real numbers) to the benefits accrued
C     C refers (in real numbers) to the costs incurred
C     R is the interest rate expressed in decimals
      READ (5, *) R
C     This enables reading a value of R directly from the key board
       READ (5, *) N
C     This enables reading a value of N directly from the key board
      READ (5, *) (B(T), T=0, N)
C     This enables reading a range (from 0 to N) of values for B
      READ (5, *) (C(T), T=0, N)
C     This enables reading a range (from 0 to N) of values for C
      X = 1. + R
      Y = X**N
      SUM = 0
      DO 10 T = 0, N
      Z = B(T) - C(T)
      D = X**T
      SUM = SUM + Z / D
   10 CONTINUE
C     The SUM gives the value for PNW
      WRITE(6, 100) SUM
  100 FORMAT(F11.3)
C     Value of SUM is displayed up to three decimal places
      ALEV = SUM *Y / (Y - 1.)
C     The ALEV gives the value of LEV
      WRITE(6, 200) ALEV
  200 FORMAT(F12.3)
C     Value of ALEV is displayed up to three decimal places
      ALR = R*ALEV
C     The ALR gives the value of ALR
      WRITE(6, 300) ALR
  300 FORMAT(F11.3)
C     Value of ALR is displayed up to three decimal places
      STOP
      END
```

**Note:** No attempt was made to create input data files because input data was different for computing PNW, LEV AND ALR for each individual rotations. It was found easy to read the input data from the key board rather than creating a new file in order to compute the analysis for each individual rotations. Similar was true for output files.

## Appendix 4.3

### Program for computing (in FORTRAN 77) PNW (based on discounting from the initial year)

```
      PROGRAM WORTH
C     This program computes PNW
      INTEGER T, N
C     N refers to the rotation length (in years) of species
C     T is a variable which takes values from 0 to N
      REAL B(0:40), C(0:40), R
C     B refers (in real numbers) to the benefits accrued
C     C refers (in real numbers) to the costs incurred
C     R is the interest rate expressed in decimals
      READ (5, *) R
C     This enables reading a value of R directly from the key board
       READ (5, *) N
C     This enables reading a value of N directly from the key board
      READ (5, *) (B(T), T=0, N)
C     This enables reading a range (from 0 to N) of values for B
      READ (5, *) (C(T), T=0, N)
C     This enables reading a range (from 0 to N) of values for C
      X = 1. + R
      Y = X
      SUM = 0
      DO 10 T = 0, N
      Z = B(T) - C(T)
      X = X*Y
      SUM = SUM + Z / X
   10 CONTINUE
C     The SUM gives the value for PNW
      WRITE(6, 100) SUM
  100 FORMAT(F11.3)
C     Value of SUM is displayed up to three decimal places
      STOP
      END
```

**Note:** No attempt was made to create input data files because input data was different for computing PNW for each individual rotations. It was found easy to read the input data from the key board rather than creating a new file in order to compute the analysis for each individual rotations. Similar was true for output files.

## Appendix 4.4

### Program for computing (in FORTRAN 77) BCR

```
      PROGRAM RATIO
C     This program computes BCR
      INTEGER T, N
C     N refers to the rotation length (in years) of species
C     T is a variable which takes values from 0 to N
      REAL B(0:40), C(0:40), R
C     B refers (in real numbers) to the benefits accrued
C     C refers (in real numbers) to the costs incurred
C     R is the interest rate expressed in decimals
      READ (5, *) R
C     This enables reading a value of R directly from the key board
       READ (5, *) N
C     This enables reading a value of N directly from the key board
      READ (5, *) (B(T), T=0, N)
C     This enables reading a range (from 0 to N) of values for B
      READ (5, *) (C(T), T=0, N)
C     This enables reading a range (from 0 to N) of values for C
      X = 1. + R
      SUM1 = 0
      SUM2 = 0
      DO 10 T = 0, N
      Y = B(T)
      Z = C(T)
      D = X**T
      SUM1 = SUM1 + Y / D
C     SUM1 gives the discounted value of the benefit stream
      SUM2 = SUM2 + Z / D
C     SUM2 gives the discounted value of the cost stream
      RATIO = SUM1 / SUM2
   10 CONTINUE
C     The RATIO gives the value for BCR
      WRITE(6, 100) SUM
  100 FORMAT(F11.3)
C     Value of RATIO is displayed up to three decimal places
      STOP
      END
```

**Note:** No attempt was made to create input data files because input data was different for computing BCR for each individual rotations. It was found easy to read the input data from the key board rather than creating a new file in order to compute the analysis for each individual rotations. Similar was true for output files.

## Appendix 5.1

## Program for computing (in FORTRAN 77) economic PNW, LEV AND ALR

```
      PROGRAM EVALUE
C     This program computes values of PNW, LEV and ALR
      INTEGER T, N
C     N refers to the rotation length (in years) of species
C     T is a variable which takes values from 0 to N
      REAL B(0:40), C(0:40)
C     B refers (in real numbers) to the benefits accrued
C     C refers (in real numbers) to the costs incurred
       READ (5, *) N
C     This enables reading a value of N directly from the key board
      READ (5, *) (B(T), T=0, N)
C     This enables reading a range (from 0 to N) of values for B
      READ (5, *) (C(T), T=0, N)
C     This enables reading a range (from 0 to N) of values for C
      X = 1. + 0.142
      Y = X**N
      SUM = 0
      DO 10 T = 0, N
      Z = B(T) - C(T)
      D = X**T
      SUM = SUM + Z / D
   10 CONTINUE
C     The SUM gives the value for PNW
      WRITE(6, 100) SUM
  100 FORMAT(F11.3)
C     Value of SUM is displayed up to three decimal places
      ALEV = SUM *Y / (Y - 1.)
C     The ALEV gives the value of LEV
      WRITE(6, 200) ALEV
  200 FORMAT(F12.3)
C     Value of ALEV is displayed up to three decimal places
      ALR = R*ALEV
C     The ALR gives the value of ALR
      WRITE(6, 300) ALR
  300 FORMAT(F11.3)
C     Value of ALR is displayed up to three decimal places
      STOP
      END
```

**Note:** No attempt was made to create input data files because input data was different for computing PNW, LEV AND ALR for each individual rotations. It was found easy to read the input data from the key board rather than creating a new file in order to compute the analysis for each individual rotations. Similar was true for output files.

## Appendix 7.1

## Program for computing (in FORTRAN 77) socioeconomic PNW, LEV AND ALR

```
      PROGRAM SEVALUE
C     This program computes values of PNW, LEV and ALR
      INTEGER T, N
C     N refers to the rotation length (in years) of species
C     T is a variable which takes values from 0 to N
      REAL B(0:40), C(0:40)
C     B refers (in real numbers) to the benefits accrued
C     C refers (in real numbers) to the costs incurred
       READ (5, *) N
C     This enables reading a value of N directly from the key board
      READ (5, *) (B(T), T=0, N)
C     This enables reading a range (from 0 to N) of values for B
      READ (5, *) (C(T), T=0, N)
C     This enables reading a range (from 0 to N) of values for C
      X = 1. + 0.0205
      Y = X**N
      SUM = 0
      DO 10 T = 0, N
      Z = B(T) - C(T)
      D = X**T
      SUM = SUM + Z / D
   10 CONTINUE
C     The SUM gives the value for PNW
      WRITE(6, 100) SUM
  100 FORMAT(F11.3)
C     Value of SUM is displayed up to three decimal places
      ALEV = SUM *Y / (Y - 1.)
C     The ALEV gives the value of LEV
      WRITE(6, 200) ALEV
  200 FORMAT(F12.3)
C     Value of ALEV is displayed up to three decimal places
      ALR = R*ALEV
C     The ALR gives the value of ALR
      WRITE(6, 300) ALR
  300 FORMAT(F11.3)
C     Value of ALR is displayed up to three decimal places
      STOP
      END
```

**Note:** No attempt was made to create input data files because input data was different for computing PNW, LEV AND ALR for each individual rotations. It was found easy to read the input data from the key board rather than creating a new file in order to compute the analysis for each individual rotations. Similar was true for output files.

**Table 4.1 Cost estimate (per ha) for agroforestry (at market wage = Rs. 10).**

| Operations & items | Unit No. | Total cost (Rs.) |
|---|---|---|
| **Preplanting year** | | |
| Survey & demarcation | 2 W D* | 20.00 |
| Clearance of site | " " | " |
| Debris burning | " " | " |
| Alignment & stacking | 4 " | 40.00 |
| Cost of stacks & ropes | _ _ | 5.00 |
| Cost of implements | _ _ | 45.00 |
| Pit digging (45cm cubes during Feb. - May) | 200 W D | 2000.00 |
| Labour required for agricultural operations | 168 " | 1680.00 |
| Materials for agricculture component | _ _ | 720.00 |
| Subtotal | | 4550.00 |
| **First year activities (Plantation year)** | | |
| Carriage of seedlings from nursery to planting site | 12 W D | 120.00 |
| Pit scooping & application of fertiliser and insecticide | 16 " | 160.00 |
| Planting of seedlings (June - July) | 40 " | 400.00 |
| Soil working, casuality replacement & fertiliser | 80 " | 800.00 |
| Cost of fertiliser & insecticides | (200+20) Kg | 750.00 |
| Weeding, fire tracing & grass cutting | 5 W D | 50.00 |
| Labour required for agricultural operations | 112 " | 1120.00 |
| Materials for agricculture component | _ _ | 480.00 |
| Subtotal | | 3880.00 |
| **Second year activities (Post plantation)** | | |
| Casuality replacement | 40 W D | 400.00 |
| Soil working, casuality replacement & fertiliser | 48 " | 480.00 |
| Cost of fertiliser & insecticides | (120+4) Kg | 340.00 |
| Labour required for agricultural operations | 84 " | 840.00 |
| Materials for agricculture component | _ _ | 360.00 |
| Subtotal | | 2420.00 |
| **Third year activities (Post plantation)** | | |
| Weeding, soil working and pruning | 40 W D | 400.00 |
| Total | | 11250.00 |

* W D = Workers Days
Source : Orissa Forest Department (1987).

**Table 4.2 Regression coefficients and constants of the Eucalyptus yield model.**

| Description | SQ | C0 | C1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|
| Crop diameter | I | -0.918143 | 0.805833 | 0.302152 | 2414.88 | _ |
| | II | -2.802035 | 0.521374 | 0.307638 | 5180.77 | _ |
| | III | -4.63179 | 0.618086 | 0.611193 | 667.75 | - |
| Stand volume | I | 3.087538 | -7.517484 | 0.022068 | 0.609979 | -44.43637 |
| | II | -2.340403 | -10.936540 | 0.264775 | 0.216846 | 31.00776 |
| | III | 3.506935 | -14.93375 | -0.04531 | 0.6224 | 29.53161 |

Source : Sharma (1978)

**Table 4.3 Timber auction rates of the Orissa Forest Department.**

| Year | Species | Prices (Rs. per $m^3$) |
|---|---|---|
| 1983 | Teak | 3135.47 |
| | Sal | 1235.51 |
| | Others | 861.01 |
| 1984 | Teak | 3227.10 |
| | Sal | 1682.11 |
| | Others | 1014.65 |
| 1985 | Teak | 3526.40 |
| | Sal | 2140.66 |
| | Others | 1383.68 |
| 1986 | Teak | 4424.19 |
| | Sal | 2204.51 |
| | Others | 1549.69 |
| 1987 | Teak | 3717.02 |
| | Sal | 1537.56 |
| | Sissoo | 1913.23 |
| | Miscelleneous | 558.97 |

Source : Orissa Forest Department (1987).

**Table 4.4 Agricultural yield** (Rs./ha)

| Year | SQ I | SQ II | SQ III |
|---|---|---|---|
| Preplanting | 6650 | 5000 | 3350 |
| First | 4655 | 3500 | 2345 |
| Second | 3325 | 2500 | 1775 |

Note : Less benefits in first and second year are due to less sapce available for agricultural crops (due to increased space occupied by the seedlings).

Source : Mohapatra (1988).

**Table 4.5 Estimated yield table for *Eucalysptus hybrid*** (4000 seedlings/ha).

| Rot$^n$ | Crop diameter | | | Yield (m3) | | | Money value (Rs.) | | |
|---|---|---|---|---|---|---|---|---|---|
| | SQI | SQII | SQII | SQI | SQII | SQII | SQI | SQII | SQII |
| 5 | 10.06 | 5.71 | 4.31 | 147.03 | 27.46 | 7.34 | 42639.28 | 2677.06 | 716.65 |
| 6 | 10.87 | 6.24 | 4.74 | 188.90 | 36.54 | 12.08 | 54781.58 | 3562.16 | 1177.31 |
| 7 | 11.67 | 6.76 | 5.36 | 225.93 | 51.29 | 17.23 | 65519.12 | 5001.17 | 1679.92 |
| 8 | 12.48 | 7.28 | 5.98 | 258.39 | 62.36 | 22.50 | 74932.23 | 6079.81 | 2193.36 |
| 9 | 13.28 | 7.80 | 6.60 | 286.82 | 72.78 | 27.68 | 83183.60 | 7096.25 | 2698.99 |
| 10 | 14.09 | 8.32 | 7.22 | 311.81 | 81.96 | 32.68 | 90425.19 | 7991.52 | 3186.10 |
| 11 | 14.89 | 8.84 | 7.83 | 333.87 | 90.53 | 37.43 | 96820.85 | 8826.87 | 3649.33 |
| 12 | 15.70 | 9.36 | 8.45 | 353.43 | 98.35 | 41.93 | 102494.99 | 28522.37 | 4086.52 |
| 13 | 16.51 | 9.89 | 9.07 | 370.88 | 105.50 | 46.12 | 107554.91 | 30593.55 | 13375.67 |
| 14 | 17.31 | 10.41 | 9.69 | 386.52 | 112.03 | 50.07 | 112090.51 | 32488.41 | 14519.72 |
| 15 | 18.12 | 10.93 | 10.31 | 400.61 | 118.02 | 53.76 | 116175.74 | 34225.22 | 15590.11 |
| 16 | 18.92 | 11.45 | 10.93 | 413.35 | 123.52 | 57.21 | 119872.37 | 35820.80 | 16590.61 |
| 17 | 19.73 | 11.97 | 11.54 | 424.94 | 128.59 | 60.44 | 123231.44 | 37290.52 | 17527.02 |
| 18 | 20.54 | 12.49 | 12.16 | 435.51 | 133.27 | 63.46 | 221658.98 | 38647.43 | 18403.69 |
| 19 | 21.34 | 13.01 | 12.78 | 445.18 | 137.60 | 66.29 | 226585.30 | 39903.13 | 19224.97 |
| 20 | 22.15 | 13.53 | 13.40 | 454.08 | 141.62 | 68.95 | 231112.08 | 41068.35 | 19995.50 |

Note : Stumpage rate for timber (crop dia. ≥ 20 cm.) = Rs. 508.97 / $m^3$

Stumpage rate for small timber and poles (9< crop dia.<20 cm) = Rs. 290.00.

Stumpage rate for fuelwood (crop dia ≤ 9 cm) = Rs. 97.50.

**Table 4.6 Cost estimates for the cultural operations in coppice crops.**

| | Age | Opeartion | costs | Remark |
|---|---|---|---|---|
| Ist | 3 | Singling of coppice shoots | 7..00 | 7 WD are required @ Rs. 10 |
| Coppice | 3 | Weeding and soil working around coppice shoots | 266.67 | One worker does weeding and soil working around 150 shoots. |
| | 4 | Singling of coppice shoots | 40.00 | 4 WD are required |
| 2nd | 3 | Singling of coppice shoots | 70.00 | |
| coppice | 3 | Weeding and soil working around coppice shoots | 266.7 | |
| | 4 | 40.00 | | |

**Table 4.7 PNW and LEV (Rs.) for agroforestry (maiden crop) when varying tree rotations (years) and discount rates (%).**

| \DR Rot$^n$ | SQ | | 2 | 3 | 5 | 7 | 10 | 12 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | I | PNW | 41973 | 40121 | 36723 | 33690 | 29728 | 27423 | 25352 | 24395 |
| | | LEV | 445241 | 292016 | 169640 | 117379 | 78421 | 63396 | 52747 | 48515 |
| | II | PNW | 2202 | 2100 | 1913 | 1747 | 1532 | 1459 | 1349 | 1298 |
| | | LEV | 23360 | 15282 | 8836 | 6087 | 4042 | 3372 | 2806 | 2581 |
| | III | PNW | -3100 | -3091 | -3072 | -3052 | -3017 | -2993 | -2968 | -2955 |
| | | LEV | -32882 | -22500 | -14193 | -10632 | -7960 | -6919 | -6175 | -5877 |
| 6 | I | PNW | 51997 | 49218 | 44192 | 39792 | 34175 | 30983 | 28164 | 26879 |
| | | LEV | 464144 | 302852 | 174134 | 119259 | 78468 | 62798 | 51733 | 47349 |
| | II | PNW | 2941 | 2774 | 2473 | 2212 | 1881 | 1694 | 1531 | 1457 |
| | | LEV | 26248 | 17067 | 9746 | 6629 | 4319 | 3435 | 2812 | 2567 |
| | III | PNW | -2752 | -2773 | -2805 | -2827 | -2847 | -2853 | -2853 | -2852 |
| | | LEV | -24569 | -17061 | -11051 | -8474 | -6537 | -5782 | -5241 | -5024 |
| 7 | I | PNW | 60391 | 56613 | 49877 | 44090 | 36874 | 32866 | 29390 | 27826 |
| | | LEV | 466559 | 266852 | 172394 | 116873 | 75741 | 60013 | 48954 | 44589 |
| | II | PNW | 4131 | 3857 | 3369 | 2953 | 2437 | 2152 | 1907 | 1797 |
| | | LEV | 31916 | 20635 | 11646 | 7827 | 5005 | 3927 | 3176 | 2880 |
| | III | PNW | -2335 | -2393 | -2489 | -2566 | -2650 | -2689 | -2718 | -2730 |
| | | LEV | -18043 | -12801 | -8604 | -6599 | -5442 | -4911 | -4528 | -4374 |
| 8 | I | PNW | 67307 | 62492 | 54031 | 46900 | 38209 | 33493 | 29474 | 27691 |
| | | LEV | 459403 | 296745 | 167195 | 112202 | 71620 | 56185 | 45384 | 41139 |
| | II | PNW | 4966 | 4590 | 3930 | 3377 | 2706 | 2345 | 2040 | 1905 |
| | | LEV | 33899 | 21795 | 12162 | 8078 | 5073 | 3934 | 3141 | 2830 |
| | III | PNW | -1926 | -2027 | -2199 | -2335 | -2488 | -2563 | -2621 | -2644 |
| | | LEV | -11512 | -9626 | -6803 | -5587 | -4664 | -4300 | -4036 | -3928 |
| 9 | I | PNW | 72957 | 67093 | 56935 | 48535 | 38530 | 33226 | 28786 | 26841 |
| | | LEV | 44920 | 287233 | 160202 | 106420 | 66904 | 51965 | 41569 | 37502 |
| | II | PNW | 5715 | 5229 | 4389 | 3698 | 2880 | 2449 | 2090 | 1934 |
| | | LEV | 35010 | 22387 | 12351 | 8109 | 5000 | 3830 | 3019 | 2702 |
| | III | PNW | -1540 | -1690 | -1943 | -2144 | -2367 | -2476 | -2560 | -2594 |
| | | LEV | -9430 | -7235 | -5468 | -4700 | -4110 | -3872 | -3696 | -3624 |
| 10 | I | PNW | 77533 | 70624 | 58827 | 49256 | 38115 | 32343 | 27598 | 25547 |
| | | LEV | 431575 | 275977 | 152367 | 100185 | 60683 | 47702 | 37792 | 33935 |
| | II | PNW | 6333 | 5737 | 4721 | 3901 | 2951 | 2463 | 2064 | 1892 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | LEV | 35253 | 22418 | 12228 | 7934 | 4803 | 3632 | 2826 | 2514 |
| | III | PNW | -1184 | -1388 | -1727 | -1992 | -2283 | -2423 | -2530 | -2574 |
| | | LEV | -6592 | -5423 | -4474 | -4052 | -3716 | -3574 | -3465 | -3419 |
| 11 | I | PNW | 81223 | 73285 | 59923 | 49287 | 37187 | 31062 | 26116 | 24006 |
| | | LEV | 414958 | 264015 | 144281 | 93897 | 57255 | 43595 | 34211 | 30579 |
| | II | PNW | 6877 | 6167 | 4976 | 4032 | 2964 | 2427 | 1997 | 1814 |
| | | LEV | 35132 | 22218 | 11981 | 7681 | 4563 | 3407 | 2616 | 2311 |
| | III | PNW | -863 | -1122 | -1549 | -1878 | -2233 | -2400 | -2526 | -2577 |
| | | LEV | -4408 | -4043 | -3731 | -3578 | -3437 | -3368 | -3309 | -3282 |
| 12 | I | PNW | 84170 | 75228 | 60387 | 48797 | 35910 | 29537 | 24480 | 22352 |
| | | LEV | 397953 | 251917 | 136264 | 87767 | 52703 | 39736 | 30892 | 27491 |
| | II | PNW | 22267 | 19796 | 15698 | 12503 | 8958 | 7211 | 5828 | 5248 |
| | | LEV | 105279 | 66290 | 35422 | 22487 | 13147 | 9701 | 7355 | 6454 |
| | III | PNW | -576 | -892 | -1408 | -1797 | -2210 | -2400 | -2542 | -2597 |
| | | LEV | -2722 | -2988 | -3176 | -3233 | -3243 | -3229 | -3207 | -3194 |
| 13 | I | PNW | 86497 | 76579 | 60353 | 47920 | 34407 | 27878 | 22789 | 20676 |
| | | LEV | 488770 | 271108 | 128498 | 81909 | 48438 | 36166 | 27862 | 24689 |
| | II | PNW | 23427 | 20623 | 16040 | 12534 | 8732 | 6901 | 5478 | 4889 |
| | | LEV | 103219 | 64640 | 34150 | 21423 | 12293 | 8953 | 6698 | 5838 |
| | III | PNW | 6542 | 5350 | 3410 | 1939 | 363 | -384 | -954 | -1187 |
| | | LEV | 28823 | 16767 | 7261 | 3314 | 511 | -498 | -1167 | -1418 |
| 14 | I | PNW | 88304 | 77445 | 59927 | 46759 | 32769 | 26165 | 21108 | 19037 |
| | | LEV | 364704 | 228530 | 121082 | 76381 | 44483 | 32896 | 25120 | 22170 |
| | II | PNW | 24400 | 21269 | 16224 | 12438 | 8425 | 6538 | 5097 | 4509 |
| | | LEV | 100773 | 62763 | 32781 | 20317 | 11437 | 8219 | 6066 | 5251 |
| | III | PNW | 7206 | 5841 | 3650 | 2019 | 312 | -478 | -171 | -1309 |
| | | LEV | 29763 | 17235 | 7375 | 3298 | 423 | -601 | -1274 | -1525 |
| 15 | I | PNW | 89674 | 77617 | 58911 | 45115 | 30791 | 24186 | 19219 | 17212 |
| | | LEV | 348952 | 216726 | 113513 | 70764 | 40482 | 29592 | 22350 | 19623 |
| | II | PNW | 25207 | 21758 | 16278 | 12243 | 8063 | 6143 | 4703 | 4123 |
| | | LEV | 98098 | 60754 | 31366 | 19203 | 10601 | 7516 | 5469 | 4701 |
| | III | PNW | 7786 | 6248 | 3816 | 2039 | 220 | -601 | -1206 | -1445 |
| | | LEV | 30297 | 17446 | 7353 | 3198 | 290 | -735 | -1402 | -1648 |
| 16 | I | PNW | 90674 | 78040 | 58229 | 43893 | 29340 | 22783 | 17938 | 16005 |
| | | LEV | 33914 | 207096 | 107457 | 66378 | 37501 | 27223 | 20451 | 17920 |
| | II | PNW | 25871 | 22113 | 16225 | 11972 | 7666 | 5733 | 4310 | 3745 |
| | | LEV | 95271 | 58681 | 29942 | 18105 | 9798 | 6850 | 4914 | 4193 |
| | III | PNW | 8288 | 6580 | 3917 | 2008 | 99 | -743 | -1351 | -1588 |
| | | LEV | 30519 | 17462 | 7229 | 3037 | 126 | -888 | -1540 | -1778 |
| 17 | I | PNW | 91361 | 77897 | 57080 | 42300 | 27633 | 21177 | 16491 | 14647 |
| | | LEV | 319631 | 197216 | 101259 | 61985 | 34448 | 24787 | 18483 | 16147 |
| | II | PNW | 26409 | 22352 | 16085 | 11643 | 7248 | 5321 | 3928 | 3382 |
| | | LEV | 92392 | 56589 | 28535 | 17037 | 9036 | 6228 | 4403 | 3729 |
| | III | PNW | 8719 | 6846 | 3964 | 1937 | -44 | -896 | -1500 | -1732 |
| | | LEV | 30505 | 17331 | 7032 | 2834 | -55 | -1049 | -1682 | -1910 |
| 18 | I | PNW | 158551 | 133541 | 95418 | 68869 | 43120 | 32053 | 24167 | 21107 |
| | | LEV | 528793 | 323656 | 163255 | 97807 | 52576 | 36884 | 26691 | 22962 |
| | II | PNW | 26837 | 22492 | 15874 | 11273 | 6821 | 4915 | 3563 | 3040 |
| | | LEV | 89504 | 54512 | 27160 | 16009 | 8317 | 5650 | 3940 | 3307 |
| | III | PNW | 9088 | 7052 | 3964 | 1833 | -202 | -1056 | -1649 | -1874 |
| | | LEV | 30309 | 17091 | 6782 | 2603 | -246 | -1214 | -1822 | -2039 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 19 | I | PNW | 158889 | 132558 | 92982 | 65941 | 40301 | 29537 | 22001 | 19116 |
| | | LEV | 506722 | 308483 | 153877 | 91143 | 48178 | 33417 | 23991 | 20561 |
| | II | PNW | 27168 | 22470 | 15606 | 10872 | 6395 | 4523 | 3218 | 2721 |
| | | LEV | 86644 | 52470 | 25827 | 15027 | 7645 | 5117 | 3509 | 2927 |
| | III | PNW | 9399 | 7205 | 3925 | 1704 | -368 | -1217 | -1795 | -2010 |
| | | LEV | 29974 | 16768 | 6495 | 2355 | -440 | -1377 | -1957 | -2162 |
| 20 | I | PNW | 158886 | _ | _ | _ | _ | _ | _ | _ |
| | | LEV | 485857 | _ | _ | _ | _ | _ | _ | _ |
| | II | PNW | 27416 | 22529 | 15294 | 10451 | 5975 | 4147 | 2896 | 2426 |
| | | LEV | 83834 | 50477 | 24544 | 14093 | 7018 | 4627 | 3124 | 2584 |
| | III | PNW | 9659 | 7312 | 3853 | 1555 | -539 | -1376 | -1935 | -2139 |
| | | LEV | 29535 | 16384 | 6184 | 2097 | -633 | -1535 | -2087 | -2279 |

Note : Figures have been rounded.

**Table 4.8 PNW and LEV (Rs.) for agroforestry (maiden and first coppice crop) when varying tree rotations (years) and discount rates (%).**

| Rot$^n$ | SQ | \DR | 3 | 5 | 7 | 10 | 12 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|
| 5+5 | I | PNW | 71552 | 36968 | 33458 | 28965 | 26403 | 24135 | 23099 |
| | | LEV | 279604 | 95753 | 68053 | 47139 | 38941 | 33050 | 30684 |
| | II | PNW | 3795 | 3303 | 2890 | 2390 | 2120 | 1890 | 1788 |
| | | LEV | 14931 | 8554 | 5878 | 3890 | 3127 | 2589 | 2376 |
| | III | PNW | -2905 | -2937 | -2955 | -2965 | -2963 | -2955 | -2950 |
| | | LEV | -11353 | -7607 | -6011 | -4826 | -4370 | -4047 | -3918 |
| 6+6 | I | PNW | 87353 | 74456 | 63912 | 51472 | 44910 | 39420 | 37012 |
| | | LEV | 292525 | 168011 | 114952 | 75542 | 60417 | 49745 | 45521 |
| | II | PNW | 4984 | 4215 | 3590 | 2858 | 2475 | 2156 | 2017 |
| | | LEV | 11691 | 9512 | 6457 | 4194 | 3329 | 2721 | 2481 |
| | III | PNW | -2235 | -2391 | -2508 | -2630 | -2685 | -2723 | 2738 |
| | | LEV | -7483 | -5395 | -4511 | -3860 | -3612 | -3437 | -3367 |
| 7+7 | I | PNW | 99649 | 82739 | 69310 | 53983 | 46153 | 39754 | 36994 |
| | | LEV | 294054 | 167173 | 113218 | 73280 | 58026 | 47310 | 43083 |
| | II | PNW | 6884 | 5665 | 4702 | 3610 | 3056 | 2605 | 2412 |
| | | LEV | 20313 | 11447 | 7681 | 4900 | 3842 | 3101 | 2809 |
| | III | PNW | -1561 | -1871 | -2104 | -2351 | -2465 | -2550 | -2584 |
| | | LEV | -4607 | -3780 | -3437 | -3191 | -3100 | -3035 | -3009 |
| 8+8 | I | PNW | 108916 | 88139 | 72104 | 54385 | 45609 | 38595 | 35619 |
| | | LEV | 289032 | 162654 | 109040 | 69514 | 54499 | 44003 | 39880 |
| | II | PNW | 8107 | 6496 | 5258 | 3899 | 3230 | 2699 | 2474 |
| | | LEV | 21515 | 11988 | 7952 | 4983 | 3860 | 3077 | 2771 |
| | III | PNW | -932 | -1413 | -1770 | -2142 | -2313 | -2439 | -2490 |
| | | LEV | -2472 | -2607 | -2677 | -2738 | -2763 | -2781 | -2787 |
| 9+9 | I | PNW | 115691 | 91291 | 72980 | 53373 | 43947 | 36575 | 33494 |
| | | LEV | 280394 | 156193 | 103645 | 65078 | 50516 | 40395 | 36438 |
| | II | PNW | 9134 | 7129 | 5632 | 4037 | 3276 | 2684 | 2438 |
| | | LEV | 22138 | 12198 | 7998 | 4922 | 3766 | 2965 | 2653 |
| | III | PNW | -368 | -1031 | -1511 | -2000 | -2220 | -2382 | -2445 |
| | | LEV | -892 | -1763 | -2146 | -2439 | -2552 | -2630 | -2660 |
| 10+10 | I | PNW | 120435 | 92709 | 72468 | 51448 | 41632 | 34110 | 31012 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | LEV | 269839 | 148786 | 97722 | 60431 | 46447 | 36787 | 33030 |
| II | PNW | 9906 | 7534 | 5811 | 4031 | 3206 | 2578 | 2320 |
| | LEV | 22195 | 12092 | 7836 | 4738 | 3577 | 2780 | 2471 |
| III | PNW | 121 | -725 | -1324 | -1918 | -2178 | -2366 | -2440 |
| | LEV | 270 | -1164 | -1785 | -2253 | -2430 | -2552 | -2598 |

Note : 5+5 rotation means that main crop is harvested at 5 years followedd by coppice crop at 10 th year (i.e. both main and coppice crop have 5 years rotation).

**Table 4.9 PNW and LEV (Rs.) for agroforestry (maiden, first and second coppice crops) when varying tree rotations (years) and discount rates.**

| \DR Rot$^n$ | \|SQ | | 3 | 5 | 7 | 10 | 12 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|
| 5+5+5 | I | PNW | 91822 | 77830 | 66583 | 53541 | 46759 | 41136 | 38683 |
| | | LEV | 256390 | 149968 | 104436 | 70392 | 57211 | 47838 | 44103 |
| | II | PNW | 4828 | 4070 | 3509 | 2809 | 2402 | 2104 | 1975 |
| | | LEV | 13482 | 7841 | 5504 | 3693 | 2939 | 2447 | 2251 |
| | III | PNW | -2816 | -2877 | -2916 | -2945 | -2950 | -2948 | -2944 |
| | | LEV | -7864 | -5544 | -4574 | -388 | -3610 | -3428 | -3357 |
| 6+6+6 | I | PNW | 111246 | 91347 | 75932 | 58772 | 50184 | 43253 | 40287 |
| | | LEV | 269620 | 156290 | 107838 | 71661 | 57686 | 47771 | 43828 |
| | II | PNW | 6313 | 5145 | 4245 | 3249 | 2754 | 2357 | 2188 |
| | | LEV | 15299 | 8803 | 6026 | 3961 | 3166 | 2603 | 2380 |
| | III | PNW | -1957 | -2204 | -2382 | -2561 | -2638 | -2692 | -2712 |
| | | LEV | -4743 | -3371 | -3383 | -3122 | -3032 | -2973 | -2950 |
| 7+7+7 | I | PNW | 125837 | 100214 | 81059 | 60550 | 50647 | 42850 | 39575 |
| | | LEV | 272110 | 156327 | 106870 | 70010 | 55813 | 45772 | 41796 |
| | II | PNW | 8673 | 6848 | 5490 | 4043 | 3348 | 2805 | 2577 |
| | | LEV | 18754 | 10683 | 7238 | 4674 | 3690 | 2996 | 2721 |
| | III | PNW | -1111 | -1582 | -1918 | -2255 | -2403 | -2510 | -2552 |
| | | LEV | -2403 | -2468 | -2529 | -2607 | -2648 | -2681 | -2695 |
| 8+8+8 | I | PNW | 136348 | 105417 | 83080 | 60030 | 49268 | 40985 | 37556 |
| | | LEV | 268369 | 152794 | 103481 | 66813 | 52743 | 42831 | 38915 |
| | II | PNW | 10136 | 7762 | 6054 | 4301 | 3487 | 2864 | 2608 |
| | | LEV | 19951 | 11250 | 7541 | 4786 | 3733 | 2993 | 2702 |
| | III | PNW | -336 | -1042 | -1543 | -2033 | -2245 | -2398 | -2457 |
| | | LEV | -662 | -1510 | -1922 | -2263 | -2404 | -2506 | -2546 |
| 9+9+9 | I | PNW | 143576 | 107867 | 82984 | 58081 | 46838 | 38365 | 34907 |
| | | LEV | 261138 | 147330 | 98900 | 62877 | 49143 | 39514 | 35727 |
| | II | PNW | 11328 | 8420 | 6398 | 4393 | 3491 | 2815 | 2541 |
| | | LEV | 20604 | 11501 | 7625 | 4755 | 3663 | 2900 | 2600 |
| | III | PNW | 341 | -623 | -1276 | -1896 | -2160 | -2347 | -2418 |
| | | LEV | 621 | -851 | -1521 | -2053 | -2266 | -2417 | -2475 |
| 10+10 +10 | I | PNW | 148185 | 108279 | 81299 | 55293 | 46868 | 35423 | 32021 |
| | | LEV | 252012 | 140875 | 93594 | 58655 | 45383 | 36132 | 32512 |
| | II | PNW | 12185 | 8799 | 6519 | 4333 | 3379 | 2677 | 2396 |
| | | LEV | 20722 | 11448 | 7505 | 4596 | 3495 | 2731 | 2433 |
| | III | PNW | 915 | -294 | -1089 | -1822 | -2126 | -2338 | -2418 |
| | | LEV | 1556 | -383 | -1254 | -1933 | -2200 | -2384 | -2455 |

Note : 5+5+5 rotation means that main crop is harvested at 5 years followed by coppice crops at 10 th and 15 th year (i.e. both main and coppice crops have 5 years rotation).

**Table 4.10 Estimated yield table for the first generation coppice crops of *Eucalyptus hybrid.***

| Age | SQ | Basal area ($m^2$/ha) | Crop dia (cm.) | Yield ($m^3$) | Money value (Rs.) |
|---|---|---|---|---|---|
| 5 | I | 24.64 | 8.85 | 102.9626 | 29859.15 |
| | II | 10.89 | 5.89 | 20.9611 | 2043.71 |
| 6 | I | 28.69 | 9.56 | 123.0534 | 35685.49 |
| | II | 12.32 | 6.26 | 25.9994 | 2534.94 |
| 7 | I | 32.58 | 10.18 | 139.7621 | 40531.01 |
| | II | 13.46 | 6.54 | 30.3239 | 2956.58 |
| 8 | I | 36.31 | 10.75 | 153.7662 | 44592.20 |
| | II | 14.33 | 6.75 | 34.0331 | 3318.23 |
| 9 | I | 39.91 | 11.27 | 165.6215 | 48030.24 |
| | II | 14.96 | 6.90 | 37.2289 | 3629.82 |
| 10 | I | 43.37 | 11.75 | 175.7606 | 50970.57 |
| | II | 15.39 | 7.00 | 40.0004 | 3900.04 |

**Table 4.11 PNW and LEV (Rs.) for agroforestry (maiden and first coppice crops-yield estimated from the model) when varying tree rotations (years) and discount rates (%).**

| Rot$^n$ | SQ \DR | | 3 | 5 | 7 | 10 | 12 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|
| 5+5 | I | PNW | 62042 | 54800 | 48651 | 41066 | 36887 | 33276 | 31654 |
| | | LEV | 242443 | 141938 | 98954 | 66833 | 54403 | 45567 | 42047 |
| | II | PNW | 3324 | 2914 | 2568 | 2146 | 1916 | 1720 | 1632 |
| | | LEV | 12980 | 7547 | 5224 | 3493 | 2826 | 2355 | 2168 |
| 6+6 | I | PNW | 73960 | 63822 | 55433 | 45387 | 40008 | 35457 | 33443 |
| | | LEV | 247673 | 144017 | 99702 | 66612 | 53823 | 44744 | 41131 |
| | II | PNW | 4264 | 3643 | 3134 | 2530 | 2211 | 1943 | 1825 |
| | | LEV | 14279 | 8221 | 5637 | 3714 | 2974 | 2452 | 2245 |
| 7+7 | I | PNW | 83129 | 70118 | 59619 | 47403 | 41040 | 35763 | 33971 |
| | | LEV | 245305 | 141673 | 97388 | 64348 | 51598 | 42561 | 38970 |
| | II | PNW | 5532 | 4633 | 3909 | 3071 | 2637 | 2279 | 2123 |
| | | LEV | 16325 | 9360 | 6386 | 4169 | 3316 | 2712 | 2473 |
| 8+8 | I | PNW | 90009 | 74240 | 61827 | 47782 | 40660 | 34867 | 32376 |
| | | LEV | 238858 | 137004 | 93498 | 61074 | 48584 | 39752 | 36250 |
| | II | PNW | 6387 | 5231 | 4323 | 3298 | 2780 | 2359 | 2179 |
| | | LEV | 16948 | 9654 | 6538 | 4215 | 3321 | 2690 | 2440 |
| 9+9 | I | PNW | 95042 | 76684 | 62579 | 47050 | 39376 | 33251 | 30653 |
| | | LEV | 230348 | 131201 | 88874 | 57368 | 45262 | 36723 | 33348 |
| | II | PNW | 7098 | 5689 | 4606 | 3414 | 2825 | 2356 | 2158 |
| | | LEV | 17203 | 9734 | 6541 | 4162 | 3248 | 2603 | 2348 |
| 10+10 | I | PNW | 98590 | 77839 | 62273 | 45583 | 37542 | 31239 | 28601 |
| | | LEV | 220894 | 124921 | 83971 | 53542 | 41884 | 33690 | 30462 |
| | II | PNW | 7641 | 5992 | 4753 | 3423 | 2782 | 2280 | 2070 |
| | | LEV | 17119 | 9617 | 6410 | 4021 | 3104 | 2459 | 2205 |

Note : 5+5 rotation means that main crop is harvested at 5 years followed by coppice crop at 10 th year (i.e. both main and coppice crop have 5 years rotation).

**Table 4.12 PNW and LEV (Rs.) for dense plantations (maiden crop) when varying tree rotations (years) and discount rates (%).**

| \DR Rot$^n$ | SQ | | 3 | 5 | 7 | 10 | 12 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|
| 5 | I | PNW | 30901 | 27636 | 24728 | 20944 | 18752 | 16787 | 15881 |
| | | LEV | 224918 | 127664 | 86158 | 55250 | 43349 | 34927 | 31584 |
| | II | PNW | -3570 | -3676 | -3764 | -3869 | -3924 | -3968 | -3987 |
| | | LEV | -25987 | -16981 | -13115 | -10207 | -9071 | -8257 | -7929 |
| | III | PNW | -5262 | -5213 | -5163 | -5087 | -5037 | -4987 | -4962 |
| | | LEV | -38302 | -24081 | -17988 | -13420 | -11644 | -10376 | -9869 |
| 6 | I | PNW | 39999 | 35106 | 30830 | 25391 | 22311 | 19599 | 18366 |
| | | LEV | 246126 | 138330 | 92402 | 58301 | 45222 | 36000 | 32352 |
| | II | PNW | -2896 | -3115 | -3299 | -3521 | -3638 | -3736 | -3778 |
| | | LEV | -17822 | -12276 | -9888 | -8084 | -7374 | -6862 | -6655 |
| | III | PNW | -4894 | -4895 | -4888 | -4867 | -4847 | -4822 | -4809 |
| | | LEV | -30112 | -19288 | -14651 | -11175 | -9823 | -8858 | -8472 |
| 7 | I | PNW | 47394 | 40790 | 35129 | 28090 | 24195 | 20825 | 19313 |
| | | LEV | 253567 | 140988 | 93119 | 57699 | 44179 | 34688 | 30947 |
| | II | PNW | -1813 | -2219 | -2558 | -2965 | -3181 | -3360 | -3438 |
| | | LEV | -9701 | -7671 | -6782 | -6091 | -5808 | -5597 | -5509 |
| | III | PNW | -4514 | -4580 | -4627 | -4669 | -4683 | -4687 | -4687 |
| | | LEV | -24149 | -15829 | -12265 | -9591 | -8551 | -7808 | -7510 |
| 8 | I | PNW | 53273 | 44944 | 37938 | 29425 | 24821 | 20910 | 19177 |
| | | LEV | 252970 | 139078 | 90764 | 55156 | 41638 | 32196 | 28491 |
| | II | PNW | -1080 | -1658 | -2134 | -2695 | -2987 | -3227 | -3331 |
| | | LEV | -5129 | -5132 | -5106 | -5052 | -5012 | -4970 | -4948 |
| | III | PNW | 4148 | -4289 | -4396 | -4508 | -4557 | -4590 | -4601 |
| | | LEV | -19698 | -13272 | -10518 | -8451 | -7645 | -7067 | -6836 |
| 9 | I | PNW | 57874 | 47848 | 39574 | 29747 | 24554 | 20221 | 18328 |
| | | LEV | 247767 | 134636 | 86772 | 51652 | 38402 | 29200 | 25607 |
| | II | PNW | -441 | -1199 | -1813 | -2522 | -2884 | -3177 | -3301 |
| | | LEV | -1888 | -3374 | -3975 | -4379 | -4511 | -4587 | -4612 |
| | III | PNW | -3811 | -4034 | -4205 | -4387 | -4470 | -4529 | -4551 |
| | | LEV | -16316 | -11350 | -9220 | -7617 | -6991 | -6540 | -6358 |
| 10 | I | PNW | 61405 | 49740 | 40295 | 29331 | -23672 | 19033 | 17034 |
| | | LEV | 239954 | 128833 | 81958 | 47736 | 34912 | 26064 | 22627 |
| | II | PNW | 67 | -867 | -1610 | -2450 | -2870 | -3203 | -3343 |
| | | LEV | 261 | -2247 | -3276 | -3988 | -4233 | -4386 | -4440 |
| | III | PNW | -3509 | -3818 | -4053 | -4303 | -4417 | -4499 | -4531 |
| | | LEV | -13712 | -9888 | -8244 | -7003 | -6515 | -6161 | -6081 |
| 11 | I | PNW | 64066 | 50836 | 40326 | 28404 | 22391 | 17551 | 15493 |
| | | LEV | 230805 | 122403 | 76825 | 43732 | 31425 | 22991 | 19735 |
| | II | PNW | 497 | -613 | -1479 | -2438 | -2905 | -3270 | -3421 |
| | | LEV | 1791 | -1475 | -2818 | -3753 | -4078 | -4284 | -4357 |
| | III | PNW | -3243 | -3640 | -3939 | -4252 | -4393 | -4495 | -4534 |
| | | LEV | -11685 | -8764 | -7504 | -6547 | -6167 | -5889 | -5775 |
| 12 | I | PNW | 66009 | 51300 | 39836 | 27127 | 20865 | 15915 | 13839 |
| | | LEV | 221047 | 115760 | 71650 | 39812 | 28070 | 20084 | 17020 |
| | II | PNW | 14125 | 10109 | 6991 | 3557 | 1878 | 561 | 13 |
| | | LEV | 47303 | 22811 | 12575 | 5220 | 2526 | 708 | 16 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | III | PNW | -3031 | -3498 | -3858 | -4229 | -4394 | -4511 | -4554 |
| | | LEV | -10091 | -7893 | -6940 | 6207 | -5911 | -5692 | -5601 |
| 13 | I | PNW | 67360 | 51266 | 38959 | 25624 | 19206 | 14224 | 12163 |
| | | LEV | 211130 | 109152 | 66592 | 36073 | 24916 | 17390 | 14523 |
| | II | PNW | 14953 | 10451 | 7022 | 3330 | 1568 | 211 | -346 |
| | | LEV | 46868 | 22252 | 12003 | 4689 | 2035 | 259 | -413 |
| | III | PNW | 3229 | 1320 | -123 | -1657 | -2378 | -2923 | -3144 |
| | | LEV | 10120 | 2810 | -209 | -2333 | -3085 | -3574 | -3754 |
| 14 | I | PNW | 68226 | 50840 | 37798 | 23986 | 17493 | 12543 | 10524 |
| | | LEV | 201327 | 102723 | 61743 | 32560 | 21993 | 14927 | 12256 |
| | II | PNW | 15599 | 10635 | 6927 | 3024 | 1205 | -170 | -727 |
| | | LEV | 46031 | 21489 | 11315 | 4105 | 1515 | -202 | -846 |
| | III | PNW | 3720 | 1560 | -42 | -1708 | -2472 | -3040 | -3266 |
| | | LEV | 10976 | 3152 | -68 | 2319 | -3108 | -3618 | -3804 |
| 15 | I | PNW | 68689 | 50110 | 36435 | 22280 | 15782 | 10917 | 8959 |
| | | LEV | 191797 | 96554 | 57148 | 29293 | 19310 | 12696 | 10215 |
| | II | PNW | 16088 | 10690 | 6732 | 2662 | 810 | -564 | -1112 |
| | | LEV | 44922 | 20597 | 10559 | 3500 | 991 | -656 | -1264 |
| | III | PNW | 4127 | 1726 | -22 | 1799 | -2595 | -3175 | -3402 |
| | | LEV | 11524 | 3325 | -35 | -2366 | -3175 | -3692 | -3879 |
| 16 | I | PNW | 68821 | 49142 | 34932 | 20556 | 14111 | 9373 | 7492 |
| | | LEV | 182631 | 90687 | 52826 | 26275 | 16861 | 10686 | 8389 |
| | II | PNW | 16443 | 10637 | 6461 | 2264 | 400 | -957 | -1490 |
| | | LEV | 43635 | 19629 | 9770 | 2894 | 478 | -1091 | -1668 |
| | III | PNW | 4459 | 1827 | -53 | -1921 | -2737 | -3320 | -3545 |
| | | LEV | 11833 | 3371 | -80 | -2455 | -3270 | -3785 | -3969 |
| 17 | I | PNW | 68678 | 47993 | 33339 | 18849 | 12505 | 7926 | 6133 |
| | | LEV | 173876 | 85139 | 48783 | 23498 | 14637 | 8883 | 6762 |
| | II | PNW | 16682 | 10496 | 6132 | 1846 | -12 | -1339 | -1853 |
| | | LEV | 42235 | 18621 | 8973 | 2302 | -14 | -1501 | -2043 |
| | III | PNW | 4725 | 1874 | -124 | -2064 | -2890 | -3469 | -3689 |
| | | LEV | 11962 | 3324 | -182 | -2573 | -3383 | -3889 | -4067 |
| 18 | I | PNW | 124322 | 86332 | 59908 | 34336 | 23382 | 15602 | 12593 |
| | | LEV | 301312 | 147708 | 85081 | 41866 | 26877 | 17231 | 13700 |
| | II | PNW | 16822 | 10285 | 5761 | 1420 | -417 | -1704 | -2195 |
| | | LEV | 40770 | 17598 | 8182 | 1731 | -480 | -1882 | -2388 |
| | III | PNW | 4931 | 1874 | -228 | -2221 | -3050 | -3618 | -3831 |
| | | LEV | 11950 | 3206 | -324 | -2709 | -3506 | 3996 | -4168 |
| 19 | I | PNW | 123339 | 83895 | 56980 | 31517 | 20865 | 13436 | 10603 |
| | | LEV | 287029 | 138839 | 78757 | 37678 | 23606 | 14652 | 11404 |
| | II | PNW | 16877 | 10018 | 5361 | 993 | -810 | -2049 | -2514 |
| | | LEV | 39275 | 16578 | 7409 | 1187 | -916 | -2234 | -2704 |
| | III | PNW | 5084 | 1835 | -357 | -2388 | -3211 | -3764 | -3967 |
| | | LEV | 11832 | 3036 | -494 | -2855 | -3633 | -4105 | -4267 |
| 20 | I | PNW | 122082 | 81331 | 54051 | 28822 | 18516 | 11458 | 8803 |
| | | LEV | 273530 | 130526 | 72886 | 33854 | 20657 | 12357 | 9376 |
| | II | PNW | 16859 | 9705 | 4940 | 573 | -1186 | 2371 | -2809 |
| | | LEV | 37773 | 15575 | 6661 | 673 | -1323 | -2557 | -2992 |
| | III | PNW | 5191 | 1763 | -506 | -2559 | -3370 | -3904 | -4097 |
| | | LEV | 11632 | 2829 | -682 | -3006 | -3760 | -4210 | -4363 |

**Table 4.13 PNW and LEV (Rs.) for dense plantations (maiden and first coppice crops) when varying tree rotations (years) and discount rates (%).**

| \DR Rot$^n$ | \|SQ | | 3 | 5 | 7 | 10 | 12 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|
| 5+5 | I | PNW | 52823 | 45713 | 39690 | 32282 | 28215 | 24711 | 23141 |
| | | LEV | 206417 | 118402 | 80727 | 52538 | 41614 | 33839 | 30739 |
| | II | PNW | -2346 | -2675 | -2943 | -3255 | -3416 | -3547 | -3603 |
| | | LEV | -9168 | -6929 | -5986 | -5298 | -5039 | -4858 | -4787 |
| 6+6 | I | PNW | 64741 | 54735 | 46472 | 36604 | 31336 | 26892 | 24930 |
| | | LEV | 216800 | 123512 | 83584 | 53721 | 42157 | 33935 | 30661 |
| | II | PNW | -2346 | -2675 | -2943 | -3255 | -3416 | -3547 | -3603 |
| | | LEV | -4709 | -4390 | -4276 | -4214 | -4200 | -4195 | -4194 |
| 7+7 | I | PNW | 73910 | 61031 | 50658 | 38620 | 32368 | 27198 | 24949 |
| | | LEV | 218101 | 123313 | 82749 | 52425 | 40695 | 32368 | 29056 |
| | II | PNW | -138 | -956 | -1602 | -2330 | -2696 | -2988 | -3112 |
| | | LEV | -407 | -1932 | -2617 | -3163 | -3389 | -3556 | -3624 |
| 8+8 | I | PNW | 80790 | 65153 | 52866 | 38999 | 31988 | 26302 | 23863 |
| | | LEV | 214393 | 120235 | 79946 | 49847 | 38223 | 29987 | 26718 |
| | II | PNW | 716 | -357 | -1188 | -2104 | -2553 | -2908 | -3056 |
| | | LEV | 1901 | -660 | -1797 | -2689 | -3051 | -3315 | -3421 |
| 9+9 | I | PNW | 85823 | 67597 | 53618 | 38267 | 30704 | 24686 | 22140 |
| | | LEV | 208005 | 115654 | 76147 | 46659 | 35294 | 27264 | 24086 |
| | II | PNW | 1428 | 100 | -905 | -1988 | -2508 | -2910 | -3077 |
| | | LEV | 3461 | 172 | -1286 | -2424 | -2882 | -3214 | -3348 |
| 10+10 | I | PNW | 89371 | 68752 | 53311 | 36800 | 28870 | 22674 | 20088 |
| | | LEV | 200239 | 110338 | 71889 | 43225 | 32209 | 24453 | 21395 |
| | II | PNW | 1971 | 404 | -758 | -1979 | 2551 | -2987 | -3165 |
| | | LEV | 4415 | 648 | -1022 | -2324 | -2846 | -3221 | -3371 |

Note : 5+5 rotation means that main crop is harvested at 5 years followedd by coppice crop at 10 th year (i.e. both main and coppice crop have 5 years rotation).

**Table 4.14 Cost estimate (per ha) for the institutional plantations of *Acacia nilotica*** at sapcing 2.5 m x 2.5 m (at market wage Rs. 10).

| Operations & items | Unit No. | Total cost (Rs.) |
|---|---|---|
| **Preplanting year** | | |
| Survey & demarcation | 2 W D* | 20.00 |
| Clearance of site | " " | " |
| Debris burning | " " | " |
| Alignment & stacking | 3 " | 30.00 |
| Cost of stacks & ropes | _ _ | 5.00 |
| Cost of implements | _ _ | 45.00 |
| Pit digging (45cm cubes during Feb. - May) | 80 W D | 800.00 |
| Subtotal | | 940.00 |
| **First year activities (Plantation year)** | | |
| Carriage of seedlings from nursery to planting site | 14 W D | 140.00 |
| Pit scooping & application of fertiliser and insecticide | 6 " | 60.00 |
| Planting of seedlings (June - July) | 23 " | 230.00 |

| | | |
|---|---|---|
| Soil working, casuality replacement & fertiliser | 32 " | 320.00 |
| Cost of fertiliser & insecticides | (125+12.5) Kg | 470.00 |
| Weeding, fire tracing & grass cutting | 5 W D | 50.00 |
| Subtotal | | 1270.00 |
| **Second year activities (Post plantation)** | | |
| Casuality replacement | 16 W D | 160.00 |
| Soil working, casuality replacement & fertiliser | 20 " | 200.00 |
| Cost of fertiliser & insecticides | (75+2.5) Kg | 230.00 |
| Subtotal | | 590.00 |
| **Third year activities (Post plantation)** | | |
| Weeding, soil working and pruning | 20 W D | 200.00 |
| Total | | 3000.00 |

* W D = Workers Days
Source : Orissa Forest Department (1987).

**Table 4.15 Yield table for *Acacia nilotica*** (fuelwood with dia. < 15 cm and small timber with dia ≥ 15 cm.)

| Management option | Age (year) | Yield ($m^3$) SQ I | SQ II | SQ III | Money value (Rs.) SQ I | SQ II | SQ III |
|---|---|---|---|---|---|---|---|
| Fell _ 5 yr | 5 | 36.63 | 20.83 | 9.18 | 3571.43 | 2030.93 | 895.00 |
| Fell - 10 yr | 5 | 6.83 | 4.17 | 1.13 | 665.93 | 406.58 | 110.18 |
| Thin - 5 yr | 10 | 88.42 | 55.40 | 28.79 | 25641.80 | 5401.50 | 2807.03 |
| Fell - 15 yr | 5 | 6.83 | 4.17 | 1.13 | 665.93 | 406.58 | 110.18 |
| Thin - 5 | 10 | 12.82 | 6.91 | 2.72 | 3717.80 | 673.73 | 265.20 |
| & 10 yrs | 15 | 120.75 | 77.36 | 41.83 | 35017.50 | 22434.40 | 4078.43 |
| Fell - 20 yr | 5 | 6.83 | 4017 | 1.13 | 665.93 | 406.58 | 110.18 |
| Thin - 5, 10 | 10 | 12.82 | 6.91 | 2.72 | 3717.80 | 673.73 | 265.20 |
| & 15 yrs | 15 | 13.88 | 7.72 | 3.13 | 4025.20 | 2238.80 | 305.18 |
| | 20 | 143.94 | 92.83 | 50.92 | 41742.60 | 26920.70 | 4964.70 |
| Fell - 25 yr | 5 | 6.83 | 4.17 | 1.13 | 665.93 | 406.58 | 110.18 |
| Thin - 5, 10, | 10 | 12.82 | 6.91 | 2.72 | 3717.80 | 673.73 | 265.20 |
| 15 & 20 yrs | 15 | 13.88 | 7.72 | 3.13 | 4025.20 | 2238.80 | 305.18 |
| | 20 | 15.38 | 7.86 | 3.21 | 4460.20 | 2279.40 | 312.98 |
| | 25 | 162.61 | 104.35 | 57.60 | 47156.90 | 30261.50 | 16704.00 |

Note : Yield figures compiled from Singh (1982).

**Table 4.16 Cost estimates (Rs.) for thinnings in institutional plantations.**

| Age | No of trees thinned | | | Thinning rate (Rs. per 1000) | | | Total cost | | |
|---|---|---|---|---|---|---|---|---|---|
| | SQ I | SQ II | SQ III | SQ I | SQ II | SQ III | SQ I | SQ II | SQ III |
| 5 | 404 | 127 | 113 | 5 | 5 | 5 | 20.20 | 6.35 | 5.65 |
| 10 | 505 | 601 | 428 | 7 | 5 | 5 | 35.35 | 30.05 | 21.50 |
| 15 | 177 | 212 | 204 | 8 | 6 | 6 | 14.16 | 12.72 | 12.24 |
| 20 | 97 | 119 | 129 | 9 | 7 | 7 | 8.73 | 8.33 | 9.03 |

Source : Orissa Forest Department

**Table 4.17 PNW and LEV (Rs.) for the institutional plantations of *Acacia nilotica* when varying tree rotations (years) and discount rates (%).**

| Man[t] option | SQ | \DR | 3 | 5 | 7 | 10 | 12 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|
| Fell 5 | I | PNW | 169 | -59 | 259 | 515 | -660 | -788 | -846 |
| | | LEV | 1227 | -273 | -903 | -1358 | -1526 | -1640 | -1683 |
| | II | PNW | -1160 | -1266 | -1357 | -1471 | -1534 | -1588 | -1612 |
| | | LEV | 8445 | -5849 | -4730 | -3881 | -3547 | -3304 | -3206 |
| | III | PNW | -2140 | -2156 | -2167 | -2177 | -2179 | -2178 | -2177 |
| | | LEV | -15577 | -9960 | -7551 | -5742 | -5037 | -4532 | -4330 |
| Fel 10 & Thin 5 | I | PNW | 16725 | 13390 | 10690 | 7555 | 5936 | 4609 | 4037 |
| | | LEV | 65356 | 34683 | 21743 | 12295 | 8754 | 6312 | 5363 |
| | II | PNW | 1452 | 772 | 226 | -401 | -720 | -978 | -1079 |
| | | LEV | 5675 | 2000 | 459 | -653 | -1062 | -1339 | 1445 |
| | III | PNW | -733 | -1052 | -1304 | -1587 | -1724 | -1832 | -1876 |
| | | LEV | -2866 | -2725 | -2652 | -2580 | -2542 | -2508 | -2492 |
| Fell 15 & Thin 5 &10 | I | PNW | 22861 | 16753 | 12219 | 7471 | 5263 | 3592 | 2913 |
| | | LEV | 63835 | 32281 | 19165 | 9823 | 6439 | 4177 | 3321 |
| | II | PNW | 12312 | 8643 | 5938 | 3135 | 1846 | 881 | 493 |
| | | LEV | 34378 | 16653 | 9314 | 4122 | 2259 | 1025 | 562 |
| | III | PNW | -23 | -664 | -1129 | -1597 | -1804 | -1952 | -2009 |
| | | LEV | -64 | -1280 | -1771 | -2100 | -2207 | -2270 | -2290 |
| Fell 20 & Thin 5, 10 & 15 | I | PNW | 26071 | 17571 | 11768 | 6253 | 3926 | 2285 | 1653 |
| | | LEV | 58414 | 28199 | 15869 | 7345 | 4380 | 2464 | 1760 |
| | II | PNW | 14246 | 9068 | 5571 | 2299 | 945 | 9 | -345 |
| | | LEV | 31919 | 14554 | 7512 | 2700 | 1055 | 99 | -368 |
| | III | PNW | 296 | -614 | -1218 | -1765 | -1981 | -2121 | -2170 |
| | | LEV | 664 | -985 | -1642 | -2074 | -2210 | -2287 | -2312 |
| Fell 25 & Thin 5, 10, 15 & 20 | I | PNW | 27947 | 17442 | 10820 | 5063 | 2834 | 1354 | 807 |
| | | LEV | 53498 | 24751 | 13263 | 5577 | 3011 | 1407 | 832 |
| | II | PNW | 15051 | 8715 | 4776 | 1428 | 170 | -641 | -930 |
| | | LEV | 28813 | 12366 | 5855 | 1573 | 181 | -666 | -961 |
| | III | PNW | 5694 | 2562 | 655 | -917 | -1481 | -1829 | -1948 |
| | | LEV | 10899 | 3636 | 803 | -1010 | -1574 | -1900 | -200 |

**Table 4.18 Cost estimates (per ha) for village woodlots (community plantations) of *Dalbergia sissoo* at spacing 2 m x 2 m (at market wage Rs. 10).**

| Operations & items | Unit No. | Total cost (Rs.) |
|---|---|---|
| **Preplanting year** | | |
| Survey & demarcation | 2 W D* | 20.00 |
| Clearance of site | " " | " |
| Debris burning | " " | " |
| Alignment & stacking | 4 " | 40.00 |
| Cost of stacks & ropes | _ _ | 5.00 |
| Cost of implements | _ _ | 45.00 |
| Pit digging (45cm cubes during Feb. - May) | 125 W D | 800.00 |
| Subtotal | | 1400.00 |
| **First year activities (Plantation year)** | | |
| Carriage of seedlings from nursery to planting site | 15 W D | 150.00 |
| Pit scooping & application of fertiliser and insecticide | 10 " | 100.00 |
| Planting of seedlings (June - July) | 25 " | 250.00 |
| Soil working, casuality replacement & fertiliser | 50 " | 500.00 |
| Cost of fertiliser & insecticides | (125+12.5) Kg | 470.00 |
| Weeding, fire tracing & grass cutting | 5 W D | 50.00 |
| Subtotal | | 1520.00 |
| **Second year activities (Post plantation)** | | |
| Casuality replacement | 25 W D | 250.00 |
| Soil working, casuality replacement & fertiliser | 30 " | 300.00 |
| Cost of fertiliser & insecticides | (75+2.5) Kg | 230.00 |
| Subtotal | | 780.00 |
| **Third year activities (Post plantation)** | | |
| Weeding, soil working and pruning | 30 W D | 300.00 |
| Total | | 4000.00 |

* W D = Workers Days

Source : Orissa Forest Department (1987).

**Table 4.19 Cost of coppicing in village woodlots** (Rs./ha).

| Operation | Age | Worker days | Cost |
|---|---|---|---|
| Singling of coppice shoots | 3 | 6 | 60.00 |
| | 4 | 3.5 | 35.00 |
| Soil working and weeding around coppice stools | 3 | * | 166.67 |
| | " | " | " |

* One worker does soil working and weeding in around 150 coppice shoots in a day.

**Table 4.20 Cost estimates for thinnings in village woodlots (Rs.).**

| Age | No of trees thinned | Thinning rate (Rs. per 1000) SQ I | SQ II | SQ III | Total cost SQ I | SQ II | SQ III |
|---|---|---|---|---|---|---|---|
| 10 | 1000 | 5 | 5 | 5 | 50 | 50 | 50 |
| 20 | 400 | 7 | 5 | 5 | 28 | 20 | 20 |
| 30 | 300 | 10 | 7 | 7 | 30 | 21 | 21 |
| 40 | 200 | 10 | 7 | 7 | 20 | 14 | 14 |

Source : Orissa Forest Department (1987)

**Table 4.21 Regression coefficients and constants of the yield model of *Dalbergia sissoo.***

| Description | SQ | C0 | C1 | C2 | C3 | C4 |
|---|---|---|---|---|---|---|
| Basal area | I | -5.009249 | 0.509325 | -0.026432 | -0.031157 | 0.726117 |
| of the main | II | -4.292161 | 0.602787 | -0.045261 | -0.018530 | 0.504507 |
| crop (B(M)) | III | -2.390571 | 0.611090 | -0.075681 | -0.049139 | 0.3522 |
| Stand volume | I | 4.161709 | 0.013254 | 1.21661 | -12.201020 | |
| of the main | II | 2.930075 | 0.086725 | 0.980752 | -15.623050 | |
| crop (V(M)) | III | 3.240967 | 0.0806296 | 0.510211 | -12.09748 | |
| Volume of | I | 2.551382 | -0.007553 | 1.060334 | -8.676954 | |
| thinnings | II | 1.522739 | 0.034793 | 1.040331 | -6.84933 | |
| (V(T)) | III | 3.026979 | -0.054664 | 0.910016 | -7.403642 | |

Source : Sharma (1979)

**Table 4.22 Yield table for *Dalbergia sissoo.***

| Management option | Age (year) | Yield ($m^3$) SQ I | SQ II | SQ III | Money value (Rs.) SQ I | SQ II | SQ III |
|---|---|---|---|---|---|---|---|
| Fell _ 10 yr | 10 | 85.05 | 52.09 | 44.31 | 29765.68 | 18230.80 | 4320.13 |
| & coppice | 20 | " | " | " | 23812.54 | 14584.64 | 3456.10 |
| at 20 yr | | | | | | | |
| Fell - 15 yr | 15 | 127.75 | 87.68 | 66.32 | 44710.72 | 30688.35 | 23210.78 |
| & coppice | 30 | " | " | " | 35768.58 | " | " |
| at 30 yr | | | | | | | |
| Fell - 20 yr | 10 | 59.55 | 34.99 | 21.45 | 20842.50 | 12246.78 | 2091.71 |
| Thin - 10 yr | 20 | 209.29 | 142.52 | 97.15 | 73249.99 | 49858.20 | 34002.64 |
| Fell - 30 yr | 10 | 59.55 | 34.99 | 21.45 | 20842.50 | 12246.78 | 2091.71 |
| Thin -10 | 20 | 96.13 | 54.87 | 26.34 | 33644.28 | 19205.20 | 9219.00 |
| 20 yrs | 30 | 270.20 | 183.12 | 112.02 | 422385.06 | 64090.39 | 39206.23 |
| Fell - 40 yr | 10 | 59.55 | 34.99 | 21.45 | 20842.50 | 12246.78 | 2091.71 |
| Thin - 10, | 20 | 96.13 | 54.87 | 26.34 | 33644.28 | 19205.20 | 9219.00 |
| 20 & | 30 | 132.54 | 70.16 | 25.66 | 207185.81 | 24556.00 | 8979.81 |
| 30 yrs | 40 | 280.40 | 192.25 | 114.36 | 438326.72 | 300529.09 | 40026.53 |

Note : Yield figures estimated from Sharma (1979) (when no thinnings are done the value of BA(M)/[BA(M)+BA(T)] is taken as 1). Timber value of Dalbergia, estimated from auction rates of Orissa Forest Department, is Rs. 1563.23/$m^3$.

**Table 4.23 PNW and LEV (Rs.) for the village woodlots of *Dalbergia sissoo* when varying tree rotations (years) and discount rates (%).**

| Man^t option | \DR SQ | | 3 | 5 | 7 | 10 | 12 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|
| Fell | I | PNW | 31270 | 23296 | 17431 | 11289 | 8401 | 6179 | 5262 |
| 10 yr | | LEV | 70062 | 37388 | 23505 | 13260 | 9372 | 6664 | 5604 |
| & | II | PNW | 17578 | 12737 | 9182 | 5470 | 3730 | 2396 | 1847 |
| coppice | | LEV | 39383 | 20441 | 12382 | 6425 | 4162 | 2584 | 1967 |
| at 10 | III | PNW | 1065 | 3 | -765 | -1547 | -1902 | -2166 | -2272 |
| yr | | LEV | 2387 | 4 | -1032 | -1818 | -2122 | -2336 | -2419 |
| Fel | I | PNW | 39396 | 25861 | 17081 | 9055 | 5736 | 3406 | 2505 |
| 15 yr | | LEV | 66999 | 33646 | 19664 | 9605 | 5934 | 3474 | 2544 |
| & | II | PNW | 25774 | 16520 | 10525 | 5055 | 2800 | 1221 | 613 |
| coppice | | LEV | 43832 | 21493 | 12116 | 5363 | 2897 | 1245 | 622 |
| at 15 | III | PNW | 18510 | 11539 | 7029 | 2922 | 1234 | 56 | -397 |
| yr | | LEV | 31478 | 15013 | 8092 | 3100 | 1277 | 57 | -403 |
| Fell | I | PNW | 52143 | 36558 | 25752 | 15253 | 10696 | 7403 | 6106 |
| 20 | | LEV | 116829 | 58671 | 34726 | 17916 | 11933 | 7983 | 6504 |
| & | II | PNW | 32795 | 22465 | 15338 | 8462 | 5503 | 3382 | 2552 |
| Thin | | LEV | 73480 | 36053 | 20683 | 9939 | 6140 | 3647 | 2719 |
| 10 | III | PNW | 16460 | 10255 | 6078 | 2190 | 590 | -511 | -927 |
| | | LEV | 36880 | 16457 | 8196 | 2572 | 658 | -551 | -987 |
| Fell | I | PNW | 204217 | 119353 | 70998 | 33568 | 20685 | 12809 | 10064 |
| 30 | | LEV | 347302 | 155283 | 81736 | 35609 | 21400 | 13065 | 10218 |
| & | II | PNW | 42217 | 25734 | 15831 | 7575 | 4463 | 2408 | 1646 |
| Thin | | LEV | 71797 | 33481 | 18225 | 8036 | 4617 | 2456 | 1672 |
| 10 | III | PNW | 18880 | 9978 | 4819 | 750 | -673 | -1546 | -1850 |
| & 20 | | LEV | 32108 | 12982 | 5548 | 795 | -696 | -1577 | -1878 |
| Fell | I | PNW | 249918 | 131817 | 71996 | 30918 | 18212 | 10925 | 8450 |
| 40 | | LEV | 360404 | 153642 | 77148 | 31617 | 18410 | 10963 | 8482 |
| & | II | PNW | 118051 | 59271 | 30704 | 11949 | 6372 | 3223 | 2171 |
| Thin | | LEV | 170239 | 69085 | 32901 | 12219 | 6441 | 3240 | 2179 |
| 10, | III | PNW | 18688 | 8665 | 3518 | -99 | -1252 | -1928 | -2157 |
| 20 & 30 | | LEV | 26950 | 10100 | 3770 | -102 | -1266 | -1938 | -2165 |

**Table 4.24 Yield table for *Casuarina equisitifolia*** (sapcing 2.74 m X 2.74 m per ha).

| Age | Yield ($m^3$) | Money value (Rs./ha) |
|---|---|---|
| 7 | 37.986 | 3703.64 |
| 12 | 67.950 | 6235.13 |
| 18 | 81.185 | 7915.54 |

Source : Singh *et al* (1983)

**Table 4.25 PNW and LEV (Rs.) for *Casuarina equisitifolia* when varying tree rotations (years) and discount rates (%).**

| Rot$^n$. | Criteria | Discount rate 3 | 5 | 7 | 10 | 12 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|
| 7 | PNW | 99 | -225 | -499 | -832 | -1011 | -1163 | -1230 |
| | LEV | 531 | -779 | -1323 | -1709 | -1847 | -1937 | -1970 |
| 12 | PNW | 1461 | 615 | -37 | -746 | -1086 | -1349 | -1457 |
| | LEV | 4893 | 1387 | -67 | -1094 | -1461 | -1702 | -1791 |
| 18 | PNW | 1737 | 432 | -464 | -1309 | -1657 | -1895 | -1982 |
| | LEV | 4211 | 739 | -658 | -1596 | -1905 | -2092 | -2157 |

**Table 4.26 Structure of interest rates in India (1986-87).**

| Institution | | Interest rate (%) |
|---|---|---|
| **Short term interest rates** | | |
| State Bank of India (SBI)- Demand loan rate | | 17.5 |
| Commercial Bank Rates - | a. Lending rate | 16.5 |
| | b. Lending rate as prescribed by Reserve Bank of India (RBI) | 17.5 |
| Discount rate (SBI) | | 17.00-17.50 |
| Bank rate | | 10.00 |
| **Long term interest rates** | | |
| Prime lending rate of term lending institutions | | |
| | a. IDBI | 14.00 |
| | b. IFCI | 14.00 |
| | c. ICICI | 14.00 |
| | d. IRBI | 12.50 |
| | e. SFCs | 11.5 - 16.5 |
| Ceiling dividend/interest rates fixed by the Controller of capital issues | a. Preference shares | 15.00 |
| | b. Debentures | 15.00 |
| | c. Public sector bonds | 14.00 |
| Unit of UTI | a. Dividend rate | 16.00 |
| | b. Yield rate | 12.27 |

Source : GOI (1988), Report on Currency and Finance 1986-87, Vol. II.

**Table 4.27 Estimation of the rate of inflation in India.**

| Year | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 |
|---|---|---|---|---|---|---|---|---|---|---|
| GDP deflator | 22.2 | 22.8 | 23.7 | 25.9 | 28.2 | 30.9 | 35.0 | 37.8 | 37.9 | 39.4 |

| Year | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 |
|---|---|---|---|---|---|---|---|---|---|---|
| GDP deflator | 40.7 | 42.8 | 47.6 | 56.6 | 66.8 | 64.8 | 69.0 | 71.5 | 72.9 | 84.3 |

| Year | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|---|---|
| GDP deflator | 100.0 | 110.8 | 119.0 | 128.8 | 137.4 | 147.4 | 157.9 |

Source : United Nations (1987) : National Account Statistics.

The best fit model obtained by regression analysis is

$$\log_e Df = -149 + 0.0775\ T$$

(-48.97) (50.30)

SE = 0.062 $R^2 = 99$ %

**Table 5.1 Estimation of the Cobb-Douglas production function.**

| Year | GDP[1] (Y) (Rs.x$10^9$) | GCF[2] (Rs.x$10^9$) | EAP[3] (L) (x$10^6$) | Capital (K) (Rs.x$10^9$) | $MPC_1$ (0.962Y/K) | $MPC_2$ (0.581Y/K) |
|---|---|---|---|---|---|---|
| 1970 | 402.63 | 73.44 | 198.1694 | 2005.44 | 0.1931 | 0.1166 |
| 1971 | 411.96 | 79.59 | 200.6358 | 2085.03 | 0.1900 | 0.1148 |
| 1972 | 409.01 | 74.79 | 207.1574 | 2159.82 | 0.1821 | 0.1100 |
| 1973 | 423.70 | 87.39 | 211.7010 | 2247.21 | 0.1813 | 0.1095 |
| 1974 | 424.37 | 89.47 | 216.2630 | 2336.68 | 0.1747 | 0.1055 |
| 1975 | 468.02 | 94.28 | 220.8434 | 2430.96 | 0.1852 | 0.1119 |
| 1976 | 472.98 | 98.64 | 225.8434 | 2529.60 | 0.1798 | 0.1086 |
| 1977 | 511.64 | 101.29 | 230.0556 | 2630.89 | 0.1870 | 0.1130 |
| 1978 | 545.63 | 116.54 | 234.6764 | 2747.43 | 0.1910 | 0.1154 |
| 1979 | 519.37 | 114.01 | 239.3046 | 2861.44 | 0.1746 | 0.1055 |
| 1980 | 552.91 | 122.20 | 243.9438 | 2983.64 | 0.1782 | 0.1077 |
| 1981 | 585.98 | 125.21 | 248.5830 | 3108.85 | 0.1813 | 0.1095 |
| 1982 | 602.51 | 128.21 | 263.5299 | 3237.06 | 0.1790 | 0.1081 |
| 1983 | 654.93 | 136.06 | 268.7132 | 3373.12 | 0.1867 | 0.1128 |
| 1984 | 679.93 | 142.31 | 273.8707 | 3515.43 | 0.1860 | 0.1124 |
| 1985 | 722.74 | 148.64 | 276.0359 | 3664.07 | 0.1897 | 0.1146 |
| Average | | | | 0.1837 | 0.1110 | |

1 Gross Domestic Product (GDP) at 1970 prices
2 Gross Capital Formation (GCF) at 1970 prices
3 Economically Active Population (EAP)
4 Marinal Productuvity of Capital (MPC)
Columns 2 & 3 are compiled from UN (1988) and population estimates from International Financial Statistics Yearbook (1987). Proportion of EAP has been estimated by making use of statistics from GOI 1981 census reports :
EAP=[Mainworkers(222475000)+Marginalworkers(22089000)]/Total pop$^n$

**Table 5.2 Estimation of marginal propensity to save (s).**
(figures in Rs. billion at current prices)

| Year | GNP (Y) (1) | Govt. consumption (2) | Private consumption (3) | Gross national saving (4)=(1)-{(2)+(3)} | Incremen. saving income ΔY (5) | Incremen. national saving ΔS (6) | s=ΔS/ΔY (7)=(6)/(5) |
|---|---|---|---|---|---|---|---|
| 1960 | 149.5 | 10.9 | 119.7 | 18.9 | _ | _ | _ |
| 1961 | 158.8 | 12.1 | 125.2 | 21.5 | 9.3 | 2.6 | 0.2796 |
| 1962 | 169.9 | 14.6 | 131.8 | 23.5 | 11.1 | 2.0 | 0.1802 |
| 1963 | 195.4 | 18.8 | 147.3 | 29.3 | 25.5 | 5.8 | 0.2274 |
| 1964 | 229.0 | 20.1 | 175.3 | 33.6 | 33.6 | 4.3 | 0.1280 |
| 1965 | 239.5 | 23.0 | 185.3 | 31.2 | 10.5 | -2.4 | -0.2286 |
| 1966 | 274.3 | 25.0 | 217.7 | 31.6 | 34.8 | 0.4 | 0.0115 |
| 1967 | 320.4 | 27.9 | 262.6 | 29.9 | 46.1 | -1.7 | -0.0369 |
| 1968 | 330.2 | 30.5 | 262.4 | 37.3 | 9.8 | 7.4 | 0.7551 |
| 1969 | 365.8 | 34.2 | 285.1 | 46.5 | 35.6 | 9.2 | 0.2584 |
| 1970 | 399.8 | 38.0 | 298.0 | 63.8 | 34.0 | 17.3 | 0.5088 |
| 1971 | 430.7 | 44.6 | 321.0 | 65.1 | 30.9 | 1.3 | 0.0421 |
| 1972 | 475.6 | 47.5 | 351.3 | 76.8 | 44.9 | 11.7 | 0.2606 |
| 1973 | 586.2 | 51.0 | 428.7 | 106.5 | 110.6 | 29.7 | 0.2685 |
| 1974 | 693.0 | 61.4 | 519.1 | 112.5 | 106.8 | 6.0 | 0.0562 |
| 1975 | 738.3 | 73.5 | 527.5 | 137.3 | 45.3 | 24.8 | 0.5475 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1976 | 799.7 | 82.1 | 541.1 | 176.5 | 61.4 | 39.2 | 0.6384 |
| 1977 | 896.2 | 86.7 | 625.3 | 184.2 | 96.5 | 7.7 | 0.0798 |
| 1978 | 975.9 | 96.2 | 692.6 | 187.1 | 79.7 | 2.9 | 0.0364 |
| 1979 | 1077.0 | 110.3 | 752.0 | 214.7 | 101.1 | 27.6 | 0.2730 |
| 1980 | 1277.5 | 130.3 | 909.4 | 237.8 | 200.5 | 23.1 | 0.1152 |
| 1981 | 1476.8 | 152.8 | 1034.6 | 289.4 | 199.3 | 51.6 | 0.2589 |
| 1982 | 1644.6 | 180.2 | 1137.9 | 326.5 | 167.8 | 37.1 | 0.2211 |
| 1983 | 1930.7 | 207.9 | 1355.4 | 367.4 | 286.1 | 40.9 | 0.1429 |
| 1984 | 2129.1 | 240.6 | 1459.6 | 428.9 | 198.4 | 61.5 | 0.3100 |
| 1985 | 2420.8 | 282.7 | 1635.1 | 503.0 | 291.7 | 74.1 | 0.2540 |
| Average | | | | | | | 0.2235 |

Source : Statistics compiled from UN (1988) and IFS (1988).

**Table 5.3 Estimation of marginal productivity of capital (q).**
(figures in Rs. billion)

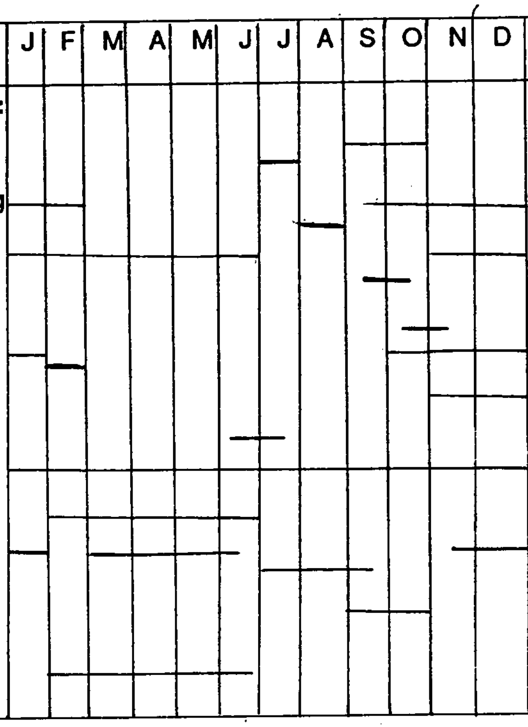
| Year | CFC[1] (1) | GDP[2] (2) | PCE[3] (3) | NDP[4] (4) | ΔPCE[5] (5) | NDP[6] for constant labour (1980prices) |
|---|---|---|---|---|---|---|
| 1965 | 12.3 | 241.1 | 184.4 | 695.441 | _ | 695.441 |
| 1966 | 14.0 | 276.6 | 216.5 | 704.021 | 19.943 | 684.078 |
| 1967 | 15.6 | 322.9 | 261.5 | 762.531 | 88.397 | 674.134 |
| 1968 | 16.8 | 332.8 | 261.9 | 784.119 | 89.390 | 694.729 |
| 1969 | 19.1 | 368.5 | 284.7 | 831.905 | 117.371 | 714.534 |
| 1970 | 22.2 | 402.6 | 298.03 | 876.498 | 126.219 | 750.279 |
| 1971 | 24.0 | 433.6 | 320.61 | 896.280 | 141.068 | 755.212 |
| 1972 | 26.7 | 478.7 | 350.84 | 889.764 | 130.144 | 759.620 |
| 1973 | 30.3 | 589.4 | 428.65 | 927.197 | 150.376 | 776.821 |
| 1974 | 35.2 | 696.0 | 519.05 | 929.395 | 169.542 | 759.853 |
| 1975 | 40.5 | 740.8 | 528.33 | 1014.927 | 205.210 | 809.717 |
| 1976 | 45.1 | 802.0 | 542.20 | 1028.397 | 736.685 | 176.199 |
| 1977 | 50.0 | 898.5 | 626.31 | 1113.517 | 261.443 | 852.074 |
| 1978 | 57.4 | 977.5 | 686.71 | 1184.170 | 323.311 | 860.859 |
| 1979 | 67.0 | 1075.4 | 742.88 | 1122.940 | 266.775 | 856.165 |
| 1980 | 81.0 | 1274.5 | 897.75 | 1193.500 | 337.264 | 856.236 |
| 1981 | 98.0 | 1476.8 | 1024.04 | 1261.482 | 376.422 | 885.060 |
| 1982 | 114.8 | 1651.4 | 1127.30 | 1303.308 | 395.663 | 907.645 |
| 1983 | 134.5 | 1940.6 | 1346.09 | 1405.525 | 487.055 | 918.470 |
| 1984 | 153.9 | 2143.9 | 1453.27 | 1454.678 | 501.846 | 952.832 |

1 Consumption of fixed capital (CFC) at current prices
2 Gross domestic product (GDP) at current prices
3 Private consumption expenditure at current prices
4 National domestic product (NDP) at 1980 prices. NDP (=GDP-CFC)at 1980 prices is calculated by using GDP deflators.
5 Difference in Private consumption expenditure (PCE at 1980 prices is calculated from PCE at current prices by using deflators ) at 1980 prices over the base year 1965.
6 Difference between (4) and (5).
Data for PCE is compiled from UN (1988) and remaining from IMF (1987).

**Table 5.4 Calender of the operations in forestry and agriculture.**

Forestry

**Harvesting:**
-demarcation of coupes
-tree marking
-depot operations
**Tending:**
-climber cutting
-thinnings
**Planting:**
-nursery operations
-preplanting
-casuality replacement
-weeding
Fire protection




Agriculture

**Peak season:**
-sowing & trans-planting
-tending & protect-ion
-harvesting of kha-rif crop
-sowing of Rabi crop
-harvesting of Rabi
**Average season:**
-sowing of Kharif crop
**Lean season:**
-harvesting and soil working

**Table 5.5 Distribution of workers in rural Orissa ('000).**

| Main | Marginal | All workers | Non-workers | Total pop$^n$ |
|---|---|---|---|---|
| 7699 (33.1) | 1348 (5.8) | 9047 (38.9) | 14213 (61.1) | 23260 |

Source : General Economic Tables, GOI (1987)
figures in parenthese are the percentage to total rural population.

**Tables 5.6 Distribution of persons (age 5 and above) by employment status.**

| Workers | Working days in the week | Male workers ('00) | Unemployed days | Female workers ('00) | Unemployed days workers | Unemployed days for total workers |
|---|---|---|---|---|---|---|
| Subsidiary workers | 0.0 | 48928 | 6.9 | 24390 | 6.7 | - |
| | 0.5 | 53100 | 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 | 1036 | 2.6 | 2113 | 0.5 | - |
| | 3.0 | 24689 | 2.7 | 22680 | 1.7 | - |
| | 3.5 | 9399 | 1.4 | 59444 | 0.1 | - |
| Average | 1.944 | 111989 | 4.653 | 134137 | 1.9896 | 3.2015 |
| Main workers | 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 | 238. | 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 | - |
| Average | 6.726 | 1259137 | 0.113 | 456004 | 0.1563 | 0.1246 |
| Total | 6.1262 | 1371126 | 0.4839 | 590141 | 0.5730 | 0.5107 |

Source : Estimated from NSSO (1981), Sarvekshna : A journal of National Sample Survey Organisation, Govt. of India. 5(1&2), July - Oct.

**Table 5.7 Occupation profile of workers.**

| \Type of workers | Subsidiary | Main | All |
|---|---|---|---|
| 1 Average no. of days worked in the week | 1.94399 | 6.726366 | 6.1262 |
| 2 Average no. of days unemployed " " | 3.201465 | 0.124577 | 0.51071 |
| 3 " " " " " in work force " " | 5.145455 | 6.850937 | 6.63691 |
| 4 " " neither working nor unemployed" " | 1.854545 | 0.149063 | 0.36309 |

Worked from Table 5.6. Row 3 = 1 + 2. Row 4 = 7 - Row 3.

**Table 5.8 Marginal productivity of labour.**

| Year | Y/L | (dY/dL) = {(1 - 0.581)Y}/L |
|---|---|---|
| 1970 | 2.0317 | 0.8513 |
| 1971 | 2.0330 | 0.8518 |
| 1972 | 1.9744 | 0.8273 |
| 1973 | 2.0014 | 0.8386 |
| 1974 | 1.9623 | 0.8222 |
| 1975 | 2.1192 | 0.8880 |
| 1976 | 2.0980 | 0.8791 |
| 1977 | 2.2240 | 0.9318 |
| 1978 | 2.3250 | 0.9742 |
| 1979 | 2.1703 | 0.9094 |
| 1980 | 2.2665 | 0.9497 |
| 1981 | 2.3573 | 0.9877 |
| 1982 | 2.2863 | 0.9579 |
| 1983 | 2.4373 | 1.0212 |
| 1984 | 2.4827 | 1.0402 |
| 1985 | 2.6183 | 1.0971 |
| Average | | 0.9267 |

**Table 5.9 Estimation of Shadow Exchange Rate (SER).**
(figures in Rs. billion)

| Year | Border prices | | Domestic prices | | SER |
|---|---|---|---|---|---|
| | Export (fob) (1) | Import (cif) (2) | Export (3) | Import (4) | |
| 1965 | 8.032 | 13.516 | 9.3 | 14.6 | 1.109152 |
| 1966 | 11.714 | 20.373 | 13.3 | 21.2 | 1.075202 |
| 1967 | 12.097 | 20.796 | 15.1 | 22.0 | 1.127899 |
| 1968 | 13.209 | 19.273 | 16.0 | 19.0 | 1.077520 |
| 1969 | 13.763 | 16.589 | 16.3 | 17.5 | 1.113600 |
| 1970 | 15.189 | 15.933 | 17.7 | 18.2 | 1.153191 |
| 1971 | 15.256 | 18.155 | 17.9 | 21.8 | 1.188231 |
| 1972 | 18.568 | 16.844 | 22.3 | 20.5 | 1.208630 |
| 1973 | 22.591 | 24.893 | 28.3 | 31.8 | 1.265689 |
| 1974 | 31.786 | 41.596 | 38.4 | 47.8 | 1.174675 |
| 1975 | 36.412 | 53.388 | 48.1 | 56.6 | 1.165924 |
| 1976 | 49.702 | 50.738 | 61.4 | 56.1 | 1.169853 |
| 1977 | 55.734 | 57.937 | 66.4 | 65.2 | 1.157727 |
| 1978 | 54.564 | 64.387 | 71.2 | 74.2 | 1.222352 |
| 1979 | 63.445 | 79.820 | 83.4 | 100.9 | 1.286427 |
| 1980 | 67.517 | 116.771 | 90.3 | 136.0 | 1.227993 |
| 1981 | 71.780 | 133.379 | 102.6 | 148.2 | 1.222466 |
| 1982 | 88.416 | 139.691 | 116.7 | 158.1 | 1.204698 |
| 1983 | 92.430 | 142.012 | 132.4 | 176.1 | 1.315890 |
| 1984 | 112.744 | 163.035 | 159.6 | 198.3 | 1.286900 |
| 1985 | 114.098 | 198.587 | Not available | Not available | |
| Average | | | | 1.1877 | |

SER = {(3) + (4)}/{(1) + (2)}
Source : Statistics compiled from IMF (1988).

**Table 5.10 Economic PNW and LEV for agroforestry (maiden crop).** (in Rs)

| Rot$^n$ | SQ | PNW | | LEV | |
|---|---|---|---|---|---|
| | | EWR=0.33w | EWR=0.91w | EWR=0.33w | EWR=0.91w |
| 5 | I | 30300 | 25848 | 62452 | 53278 |
| | II | 6431 | 1980 | 13256 | 4081 |
| | III | 2128 | -2324 | 4386 | -4789 |
| 6 | I | 33044 | 28593 | 60170 | 52064 |
| | II | 6659 | 2208 | 12126 | 4020 |
| | III | 2290 | -2161 | 4170 | -3935 |
| 7 | I | 34212 | 29761 | 56527 | 49172 |
| | II | 7028 | 2576 | 11611 | 4257 |
| | III | 2422 | -2029 | 4002 | -3352 |
| 8 | I | 34250 | 29798 | 52344 | 45541 |
| | II | 7155 | 2703 | 10935 | 4132 |
| | III | 2517 | -1934 | 3847 | -2956 |
| 9 | I | 33527 | 29075 | 48080 | 41697 |
| | II | 7201 | 2750 | 10327 | 3944 |
| | III | 2576 | -1875 | 3695 | -2689 |
| 10 | I | 32315 | 27864 | 43970 | 37913 |
| | II | 7171 | 2720 | 9758 | 3701 |
| | III | 2604 | -1848 | 3543 | -2514 |
| 11 | I | 30819 | 26368 | 40135 | 34338 |
| | II | 7102 | 2651 | 9249 | 3452 |
| | III | 2606 | -1845 | 3394 | -2403 |
| 12 | I | 29178 | 24727 | 36621 | 31034 |
| | II | 10850 | 6399 | 13618 | 8031 |
| | III | 2590 | -1862 | 3250 | -2336 |
| 13 | I | 27489 | 23037 | 33440 | 28025 |
| | II | 10498 | 6047 | 12771 | 7356 |
| | III | 4140 | -312 | 5036 | -379 |
| 14 | I | 25815 | 21364 | 30581 | 25308 |
| | II | 10116 | 5665 | 11984 | 6711 |
| | III | 4022 | -429 | 4765 | -509 |
| 15 | I | 24201 | 19750 | 28025 | 22870 |
| | II | 9724 | 5272 | 11260 | 6106 |
| | III | 3887 | -565 | 4501 | -654 |

**Table 5.11 Economic PNW and LEV for agroforestry (maiden and first coppice crop).** (figures in Rs.)

| Rot$^n$ | SQ | PNW | | LEV | |
|---|---|---|---|---|---|
| | | EWR=0.33w | EWR=0.91w | EWR=0.33w | EWR=0.91w |
| 5+5 | I | 38171 | 33646 | 51938 | 45780 |
| | II | 6931 | 2405 | 9430 | 3272 |
| 6+6 | I | 40259 | 35743 | 50529 | 44860 |
| | II | 7137 | 2621 | 8958 | 3289 |
| 7+7 | I | 40496 | 35987 | 47971 | 42631 |
| | II | 7456 | 2947 | 8832 | 3491 |
| 8+8 | I | 39550 | 35048 | 44917 | 39805 |
| | II | 7523 | 3022 | 8544 | 3432 |
| 9+9 | I | 37902 | 33407 | 41725 | 36777 |
| | II | 7509 | 3014 | 8266 | 3318 |
| 10+10 | I | 35874 | 31385 | 38585 | 33756 |
| | II | 7424 | 2934 | 7985 | 3156 |

**Table 5.12 Economic PNW and LEV for dense plantations of *Eucalyptus hybrid* (maiden crop) .** (figures in Rs.)

| Rot$^n$ | SQ | PNW | | LEV | |
|---|---|---|---|---|---|
| | | EWR=0.33w | EWR=0.91w | EWR=0.33w | EWR=0.91w |
| 5 | I | 19534 | 17033 | 40263 | 35107 |
| | II | -1040 | -3541 | -2144 | -7299 |
| | III | -2050 | -4551 | -4225 | -9381 |
| 6 | I | 22278 | 19777 | <u>40567</u> | <u>36012</u> |
| | II | -812 | -3314 | -1479 | -6034 |
| | III | -1887 | -4389 | -3437 | -7992 |
| 7 | I | 23446 | 20945 | 38739 | 34606 |
| | II | -444 | -2945 | -734 | -4866 |
| | III | -1755 | -4256 | -2900 | -7033 |
| 8 | I | <u>23484</u> | <u>20983</u> | 35891 | 32068 |
| | II | -317 | -2818 | -484 | -4307 |
| | III | -1660 | -4161 | -2537 | -6360 |
| 9 | I | 22761 | 20260 | 32642 | 29054 |
| | II | -270 | -2772 | -388 | -3975 |
| | III | -1601 | -4103 | -2296 | -5884 |
| 10 | I | 21550 | 19048 | 29322 | 25918 |
| | II | -300 | -2801 | -408 | -3812 |
| | III | -1574 | -4075 | -2141 | -5545 |
| 11 | I | 20054 | 17553 | 26115 | 22858 |
| | II | -370 | -2871 | -481 | -3739 |
| | III | -1571 | -4073 | -2046 | -5304 |
| 12 | I | 18413 | 15911 | 23110 | 19970 |
| | II | <u>3379</u> | <u>877</u> | <u>4240</u> | <u>1101</u> |
| | III | -1588 | -4089 | -1993 | -5132 |
| 13 | I | 16723 | 14222 | 20344 | 17301 |
| | II | 3204 | 525 | 3898 | 639 |
| | III | -38 | -2539 | -46 | -3089 |

**Table 5.13 Economic PNW and LEV for Dense plantations of *Eucalyptus hybrid* (maiden and first coppice crop) .** (figures in Rs.)

| Rot$^n$ | SQ | PNW | | LEV | |
|---|---|---|---|---|---|
| | | EWR=0.33w | EWR=0.91W | EWR=0.33w | EWR=0.91w |
| 5+5 | I | 27406 | 24830 | <u>37290</u> | 33785 |
| | II | -541 | -3117 | -736 | -4241 |
| 6+6 | I | 29494 | 26927 | 37017 | <u>33796</u> |
| | II | -334 | -2901 | -420 | -3641 |
| 7+7 | I | <u>29730</u> | <u>27172</u> | 35219 | 32188 |
| | II | -16 | -2574 | -19 | -3050 |
| 8+8 | I | 28784 | 26233 | 32691 | 29793 |
| | II | <u>52</u> | -2500 | <u>58</u> | -2839 |
| 9+9 | I | 27137 | 24592 | 29874 | 27072 |
| | II | 37 | -2508 | 41 | -2761 |
| 10+10 | I | 25109 | 22569 | 27006 | 24275 |
| | II | -48 | -2588 | -52 | -2783 |

**Table 5.14 Economic PNW and LEV for the institutional plantations of *Acacia nilotica*.** (figures in Rs.)

| Management option | SQ | PNW EWR=0.33w | PNW EWR=0.91w | LEV EWR=0.33w | LEV EWR=0.91w |
|---|---|---|---|---|---|
| Felling at 5 yr | I | 539 | -620 | 1110 | -1278 |
| | II | -255 | -1413 | -525 | -2913 |
| | III | -839 | -1998 | -1730 | -4118 |
| Felling at 10 yr | I | 5836 | 4671 | 7940 | 6356 |
| & thin at 5 yr | II | 340 | -821 | 462 | -1117 |
| | III | -500 | -1661 | -681 | -2259 |
| Felling at 15 yr | I | 4800 | 3630 | 5559 | 4204 |
| & thin at 5 & | II | 2145 | 980 | 2484 | 1135 |
| 10 yr | III | -619 | -1783 | -717 | -2065 |
| Felling at 20 yr | I | 3503 | 2332 | 3768 | 2508 |
| & thin at 5, 10 | II | 1280 | 114 | 1377 | 123 |
| & 15 yr | III | -786 | -1951 | -846 | -2098 |
| Felling at 25 yr | I | 2589 | 1418 | 2686 | 1471 |
| & thin at 5, 10, | II | 643 | -523 | 668 | -543 |
| 15 & 20 yr | III | -509 | -1674 | -528 | -1737 |

**Table 5.15 Economic PNW and LEV for the village woodlots of *Dalbergia sissoo*.** (figures in Rs.)

| Management option | SQ | PNW EWR=0.33w | PNW EWR=0.91w | LEV EWR=0.33w | LEV EWR=0.91w |
|---|---|---|---|---|---|
| Felling at 10 yr | I | 7952 | 6251 | 8553 | 6723 |
| & coppice at | II | 4246 | 2573 | 4567 | 2770 |
| 20 yr | III | -223 | -1924 | -239 | -2069 |
| Felling at 15 yr | I | 5164 | 3476 | 5262 | 3542 |
| & coppice at | II | 3042 | 1353 | 3100 | 1379 |
| 30 yr | III | 1910 | 222 | 1946 | 226 |
| Felling at 20 yr | I | 9071 | 7388 | 9756 | 7947 |
| & thin at 10 yr | II | 5149 | 3467 | 5538 | 3730 |
| | III | 1344 | -339 | 1445 | -365 |
| Felling at 30 yr | I | 14153 | 12470 | 14422 | 12706 |
| & thin at 10 | II | 4189 | 2505 | 4268 | 2553 |
| and 20 yr | III | 332 | -1351 | 338 | -1377 |
| Felling at 40 yr | I | 12309 | 10625 | 12370 | 10678 |
| & thin at 10, | II | 4936 | 3252 | 4960 | 3268 |
| 20 and 30 yr | III | -33 | -1717 | -34 | -1725 |

**Table 5.16 Economic PNW and LEV for *Casuarina equisitifolia*.** (Rs)

| Rot$^{n}$ | PNW EWR=0.33w | PNW EWR=0.91w | LEV EWR=0.33w | LEV EWR=0.91w |
|---|---|---|---|---|
| 7 | 162 | -997 | 267 | -1647 |
| 12 | -33 | -1191 | -41 | -1495 |
| 18 | -575 | -1733 | -633 | -1908 |

**Table 7.1 Estimation of the elasticity of marginal social utility of consumption ($e_u$).** (figures for population are mid-year estimates in millions and remaining in Rs. billions at 1970 prices)

| Year | Pop$^n$ | GNP | Total PCE | PCE on food | Price indices P1 | Pa | P1/P2 |
|---|---|---|---|---|---|---|---|
| 1970 | 539.08 | 399.79 | 298.38 | 187.79 | 100.0 | 100.0 | 1.0000000 |
| 1971 | 551.23 | 409.05 | 307.04 | 187.03 | 101.0 | 105.0 | 0.9465975 |
| 1972 | 563.53 | 405.99 | 300.70 | 178.77 | 107.9 | 113.0 | 0.9369178 |
| 1973 | 575.89 | 420.45 | 308.80 | 182.78 | 128.6 | 131.5 | 0.9688777 |
| 1974 | 588.30 | 421.46 | 311.43 | 486.35 | 165.3 | 169.2 | 0.9674850 |
| 1975 | 600.76 | 465.47 | 335.30 | 203.55 | 170.2 | 175.8 | 0.9552300 |
| 1976 | 613.27 | 470.65 | 334.77 | 190.74 | 152.2 | 172.4 | 0.8410025 |
| 1977 | 625.82 | 509.31 | 369.88 | 216.61 | 170.8 | 185.4 | 0.8914526 |
| 1978 | 638.39 | 544.07 | 387.72 | 222.55 | 173.3 | 185.0 | 0.9122664 |
| 1979 | 650.98 | 520.90 | 368.95 | 202.19 | 181.3 | 185.9 | 0.9651187 |
| 1980 | 663.60 | 555.89 | 410.88 | 239.03 | 200.7 | 248.1 | 0.7482655 |
| 1981 | 676.22 | 585.91 | 424.50 | 241.46 | 230.3 | 278.4 | 0.7707044 |
| 1982 | 716.88 | 600.70 | 439.60 | 239.98 | 244.7 | 285.3 | 0.8088353 |
| 1983 | 730.98 | 645.02 | 474.77 | 267.75 | 275.6 | 308.5 | 0.8546652 |
| 1984 | 745.01 | 665.22 | 483.66 | 265.39 | 294.6 | 334.0 | 0.8399751 |
| 1985 | 750.90 | 708.03 | 497.56 | 268.86 | 312.4 | 353.3 | 06428179 |

**Table 7.2 Distributional impact weights (rural Orissa) for marginal increases in consumption** (poverty line, $C_{pl}$ = Rs. 31.27 based on a per capita calorie intake of 2800).

| % of rural pop$^n$. | Monthly per capita consumption exp. (1970 prices)* | Monthly per capita consumption exp. (1970 prices)** | Weights $d_i=(C_i/C_{pl})^{-1.4}$ * | ** |
|---|---|---|---|---|
| 4.44 | 10.42 | 13.76 | 4.6555 | 3.1558 |
| 13.66 | 15.32 | 20.22 | 2.7148 | 1.8411 |
| 10.17 | 19.06 | 25.16 | 1.9993 | 1.3558 |
| 12.33 | 22.23 | 29.34 | 1.6126 | 1.0933 |
| | | ----- | | |
| 14.45 | 26.48 | 34.96 | 1.2618 | 0.8554 |
| 11.90 | 31.03 | 40.96 | 1.0109 | 0.6853 |
| | ------ | | | |
| 8.80 | 35.11 | 46.34 | 0.8504 | 0.5765 |
| 8.24 | 41.42 | 54.64 | 0.6747 | 0.4574 |
| 8.06 | 48.41 | 63.90 | 0.5424 | 0.3677 |
| 4.41 | 61.05 | 80.58 | 0.3920 | 0.2657 |
| 1.80 | 80.01 | 105.62 | 0.2684 | 0.1819 |
| 1.29 | 95.37 | 125.89 | 0.2099 | 0.1423 |
| 0.45 | 143.53 | 189.46 | 0.1184 | 0.0803 |
| Weighted average | | | 1.482 | 1.005 |

* Base year = 1961
** Base year = 1963
Source : Consumtion data is compiled from NSSO (1968).

**Table 7.3 Consumption of the workers with and without Social Forestry.**

| Description | Subsidiary workers | Main workers | All workers |
|---|---|---|---|
| **Without social forestry** | | | |
| 1 Average weekly wages per worker | 1.944w | 6.726w | 6.126w |
| 2 Average weekly wages per capita (1/2.57) | 0.756w | 2.616w | 2.383w |
| 3 Average annual wages per capita (2x52) | 39.312w | 136.032w | 123.916w |
| **With social forestry** | | | |
| 4 Average weekly wages per worker | 5.145w | 6.851w | 6.637w |
| 5 Average weekly wages per capita (4/2.571) | 2.001w | 2.665w | 2.581w |
| 6 Average annual wages per capita (5x52) | 104.068w | 138.564w | 134.233w |
| Average increase in weekly wages per worker | 3.2015w | 0.1246w | 0.5107w |

**Table 7.4 Combined distributional impact weights per unit of expenditure in social forestry.**

| Descrip$^n$ | Consumption losses to the society | | | Consumption gains to the workers | | |
|---|---|---|---|---|---|---|
| | Savings weight (v) | consum$^n$ weight ($d_i$) | Combined weight ($v.d_i$) | Savings weight (v) | consum$^n$ weight ($d_i$) | Combined weight ($v.d_i$) |
| | | | **Case I** | | | |
| Goods | 6.77 | 1.005 | 6.804 | – | – | – |
| Main workers | 6.77 | 1.005 | 6.804 | 1.00 | 0.5731 | 0.5731 |
| Subsidiary workers | 6.77 | 1.005 | 6.804 | 1.00 | 2.2014 | 2.2014 |
| | | | **Case II** | | | |
| Goods | 1.00 | 1.005 | 1.005 | – | – | – |
| Main workers | 1.00 | 1.005 | 1.005 | 1.00 | 0.5731 | 0.5731 |
| Subsidiary workers | 1.00 | 1.005 | 1.005 | 1.00 | 2.2014 | 2.2014 |

**Table 7.5 Socioeconomic benefits of agroforestry (maiden crop).** (figures in Rupees worth, Rsw)

| Year/ Rot$^{n}$ | Version I* | | | Version II** | | |
|---|---|---|---|---|---|---|
| | SQ I | SQ II | SQ III | SQ I | SQ II | SQ III |
| 0 | 14640 | 11007 | 7375 | 23822 | 17911 | 12000 |
| 1 | 10248 | 7705 | 5162 | 16675 | 12538 | 8400 |
| 2 | 7320 | 5504 | 3687 | 11911 | 8956 | 6000 |
| 3 | – | – | – | – | – | – |
| 4 | – | – | – | – | – | – |
| 5 | 93868 | 5893 | 1575 | 152743 | 9590 | 2564 |
| 6 | 116195 | 7842 | 2592 | 196239 | 12760 | 4217 |
| 7 | 144236 | 11010 | 3698 | 234703 | 17915 | 6018 |
| 8 | 164959 | 13384 | 4829 | 268423 | 21779 | 7857 |
| 9 | 183124 | 15622 | 5942 | 297981 | 25420 | 9668 |
| 10 | 199066 | 17593 | 7014 | 323922 | 28627 | 11413 |
| 11 | 213145 | 19432 | 8034 | 346832 | 31620 | 13073 |
| 12 | 225637 | 62790 | 8996 | 367158 | 102173 | 14639 |
| 13 | 236776 | 67350 | 29446 | 385284 | 109592 | 47914 |
| 14 | 246761 | 71521 | 31964 | 401532 | 116380 | 52013 |
| 15 | 255754 | 75345 | 34321 | 416166 | 122602 | 55847 |
| 16 | 263892 | 78857 | 36523 | 429408 | 128318 | 59431 |
| 17 | 271287 | 82093 | 38585 | 441441 | 133582 | 62785 |
| 18 | 487969 | 85080 | 40515 | 794029 | 138443 | 65926 |
| 19 | 498814 | 87844 | 42323 | 811676 | 142941 | 68868 |
| 20 | 508779 | 90410 | 44019 | 827892 | 147115 | 71628 |

* Combined distributional weight = 2.2014

** Combined distributional weight is 6.804 for 30% of the benefits and 2.2014 for the remaining.

**Table 7.6 Socioeconomic benefits for agroforestry (maiden and first coppice crops).** (socioeconomic benefits in Rsw for the main tree crop and agricultural crop are same as in Table 7.5 and this Table is for the coppice crop only).

| Rot$^{n}$ | Version I* | | Version II** | |
|---|---|---|---|---|
| | SQ I | SQ II | SQ I | SQII |
| 5+5 | 65733 | 4499 | 106962 | 7321 |
| 6+6 | 78559 | 5581 | 127833 | 9081 |
| 7+7 | 89227 | 6509 | 145191 | 10591 |
| 8+8 | 98167 | 7305 | 159739 | 11887 |
| 9+9 | 105736 | 7991 | 172054 | 13003 |
| 10+10 | 112209 | 8586 | 182587 | 13971 |

* Combined distributional weight = 2.2014

** Combined distributional weight is 6.804 for 30% of the benefits and 2.2014 for the remaining.

**Table 7.7 Socioeconomic costs of agroforestry (maiden crop).**
(figures in Rsw and EWR = 0.33w)

| Yr (1) | Descr$^n$ (2) | Financial cost (3) | Economic cost (4) | Combined wt. (5) | SE[1] cost of cons$^n$ loss to society (6)=(4) X(5) | SE[2] cost of cons$^n$ loss to society (7)=(5)X {(3)-(4)} | Total SE cost (8)= (6)+(7) | Combined wt. (9) | Total SE benefits (10)= (9)X{(3) -(4)} | Net SE cost-to society (11)= {(8)- (10)} |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Goods | 770 | 770 | 6.8 | 5239 | _ | 5239 | _ | _ | 5239 |
| | Main workers | 295 | 98 | 6.8 | 664 | 1342 | 2006 | 0.57 | 239 | 1767 |
| | Subsidiary workers | 3485 | 1154 | 6.8 | 7849 | 15864 | 23713 | 2.20 | 5133 | 18580 |
| 1 | Goods | 1230 | 1230 | 6.8 | 8369 | _ | 8369 | _ | _ | 8369 |
| | Main workers | 207 | 68 | 6.8 | 466 | 941 | 1406 | 0.57 | 79 | 1327 |
| | Subsidiary workers | 2443 | 809 | 6.8 | 5503 | 11122 | 16624 | 2.20 | 3598 | 13026 |
| 2 | Goods | 700 | 700 | 6.8 | 4763 | _ | 4763 | _ | _ | 4763 |
| | Main workers | 134 | 44 | 6.8 | 302 | 611 | 913 | 0.57 | 51 | 862 |
| | Subsidiary workers | 1586 | 525 | 6.8 | 3571 | 7219 | 10790 | 2.20 | 2336 | 8454 |
| 3 | Goods | _ | _ | _ | _ | _ | _ | _ | _ | _ |
| | Main workers | 31 | 10 | 6.8 | 70 | 142 | 212 | 0.57 | 12 | 200 |
| | Subsidiary workers | 369 | 122 | 6.8 | 831 | 1679 | 2509 | 2.20 | 543 | 1966 |

1 Socioeconomic cost of consumption loss to society due to the economic cost of the Agroforestry.
2 Socioeconomic cost of the consumption loss to society due to extra commitment to the economy (due to the increased consumption by the workers).
Note : See Tables 12.1 and 12.2 for the sensitivity analysis with respect to **v**.

**Table 7.7.1 Socioeconomic costs of agroforestry (maiden crop), when investment funds are drawn from Rural Development Department.**
(figures in Rsw and EWR = 0.33w)

| Yr (1) | Descr$^{n}$ (2) | Financial cost (3) | Economic cost (4) | Combined wt. (5) | SE$^{1}$cost of cons$^{n}$ loss to society (6)=(4) X(5) | SE $^{2}$ cost of cons$^{n}$ loss to society (7)=(5)X {(3)-(4)} | Total SE cost (8)= (6)+(7) | Combined wt. (9) | Total SE benefits (10)= (9)X{(3) -(4)} | Net SE cost-to society (11)= {(8)- (10)} |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Goods | 770 | 770 | 1.005 | 774 | _ | 774 | _ | _ | 774 |
| | Main workers | 295 | 98 | " | 98 | 198 | 296 | 0.57 | 239 | 57 |
| | Subsidiary workers | 3485 | 1154 | " | 1159 | 2343 | 3503 | 2.20 | 5133 | -1630 |
| 1 | Goods | 1230 | 1230 | 1.005 | 1236 | _ | 1236 | _ | _ | 1236 |
| | Main workers | 207 | 68 | " | 69 | 139 | 208 | 0.57 | 79 | 128 |
| | Subsidiary workers | 2443 | 809 | " | 813 | 1643 | 2456 | 2.20 | 3598 | -1143 |
| 2 | Goods | 700 | 700 | 1.005 | 704 | _ | 704 | _ | _ | 704 |
| | Main workers | 134 | 44 | " | 45 | 90 | 135 | 0.57 | 51 | 84 |
| | Subsidiary workers | 1586 | 525 | " | 528 | 1066 | 1594 | 2.20 | 2336 | -742 |
| 3 | Goods | _ | _ | _ | _ | _ | _ | _ | _ | _ |
| | Main workers | 31 | 10 | 1.005 | 10 | 21 | 31 | 0.57 | 12 | 19 |
| | Subsidiary workers | 369 | 122 | " | 123 | 248 | 371 | 2.20 | 543 | -173 |

**Table 7.8 Socioeconomic costs of coppicing and cultural operations in agroforestry (maiden and first coppice crops).** (figures in Rsw and EWR = 0.33w)

| Yr (1) | Descr$^{n}$ (2) | Financial cost (3) | Economic cost (4) | Combined wt. (5) | SE$^{1}$cost of cons$^{n}$ loss to society (6)=(4) X(5) | SE $^{2}$ cost of cons$^{n}$ loss to society (7)=(5)X {(3)-(4)} | Total SE cost (8)= (6)+(7) | Combined wt. (9) | Total SE benefits (10)= (9)X{(3) -(4)} | Net SE cost-to society (11)= {(8)- (10)} |
|---|---|---|---|---|---|---|---|---|---|---|
| 3 | Main workers | 26 | 9 | 6.8 | 59 | 120 | 179 | 0.57 | 10 | 169 |
| | Subsidiary workers | 310 | 103 | 6.8 | 699 | 1413 | 2112 | 2.20 | 457 | 1655 |
| 4 | Main workers | 3 | 1 | 6.8 | 701 | 14 | 21 | 0.57 | 1 | 20 |
| | Subsidiary workers | 37 | 12 | 6.8 | 83 | 168 | 251 | 2.20 | 54 | 197 |

**Table 7.9 Socioeconomic PNW and LEV for agroforestry (maiden crop) when varying tree rotations and site quality. (in Rsw)**

| Rot$^n$ | Criteria | Version I SQ I | SQ II | SQIII | Version II SQ I | SQII | SQIII |
|---|---|---|---|---|---|---|---|
| 5 | PNW | 53111 | -34243 | -46012 | 126195 | -15949 | -35100 |
| | LEV | 620909 | -35491 | -476893 | 1307952 | -165304 | -363795 |
| 6 | PNW | 71176 | -32625 | -45141 | 161933 | -13316 | -33682 |
| | LEV | 620909 | -284603 | -393789 | 1412634 | -116162 | -293830 |
| 7 | PNW | 93437 | -30016 | -44227 | 191814 | -9071 | -32195 |
| | LEV | 705632 | -226676 | -333998 | 1448562 | -68500 | -243136 |
| 8 | PNW | 108541 | -28189 | -43330 | 216390 | -6098 | -30737 |
| | LEV | 724358 | -188120 | -289170 | 1444100 | -40964 | -205123 |
| 9 | PNW | 120857 | -26553 | -42486 | 236431 | -3436 | -29362 |
| | LEV | 724033 | -159076 | -254524 | 1416419 | -20587 | -175902 |
| 10 | PNW | 130806 | -25206 | -41710 | 252621 | -1244 | -28099 |
| | LEV | 712236 | -137244 | -227108 | 1371511 | -6772 | -152999 |
| 11 | PNW | 138805 | -24037 | -41009 | 265636 | 681 | -26959 |
| | LEV | 693836 | -120083 | -204989 | 1327820 | 3402 | -134758 |
| 12 | PNW | 145172 | 9652 | -40384 | 275996 | 55478 | -25941 |
| | LEV | 671706 | 44661 | -186854 | 177029 | 256694 | -120030 |
| 13 | PNW | 150175 | 12166 | -24817 | 284138 | 59568 | -612 |
| | LEV | 647671 | 52469 | -107032 | 1225422 | 256903 | -2638 |
| 14 | PNW | 154077 | 14267 | -23376 | 290422 | 62986 | 1734 |
| | LEV | 622879 | 57690 | -94525 | 1174378 | 254696 | 7011 |
| 15 | PNW | 156940 | 16005 | -22121 | 295145 | 65815 | 3775 |
| | LEV | 598049 | 60991 | -84297 | 1124708 | 250802 | 14387 |
| 16 | PNW | 159032 | 17428 | -21038 | 298550 | 68130 | 5538 |
| | LEV | 573636 | 62863 | -75884 | 1076884 | 245748 | 19977 |
| 17 | PNW | 160438 | 18574 | -20108 | 300838 | 69996 | 7051 |
| | LEV | 549910 | 63665 | -68921 | 1031138 | 239914 | 24169 |
| 18 | PNW | 306960 | 19480 | -19318 | 539261 | 71469 | 8338 |
| | LEV | 1003202 | 63663 | -63133 | 1762401 | 233573 | 27249 |
| 19 | PNW | 307533 | _ | -18653 | 540193 | _ | 9419 |
| | LEV | 1961277 | _ | -58304 | 1688517 | _ | 29443 |
| 20 | PNW | _ | _ | -18101 | _ | _ | 10318 |
| | LEV | _ | _ | -54261 | _ | _ | 30931 |

**Table 7.9.1 Socioeconomic PNW and LEV for agroforestry (maiden crop) when varying tree rotations and site quality (when investment funds are drawn from the Rural Develeopment Department). (in Rsw)**

| Rot$^n$ | | Version I | | |
|---|---|---|---|---|
| | Criteria | SQ I | SQ II | SQIII |
| 5 | PNW | 117203 | 29849 | 18080 |
| | LEV | 1214756 | 309370 | 187387 |
| 6 | PNW | 135268 | 31467 | 18951 |
| | LEV | 1180018 | 274505 | 165319 |
| 7 | PNW | 157529 | 34076 | 19865 |
| | LEV | 1189647 | 257339 | 150017 |
| 8 | PNW | 172633 | 35903 | 20761 |
| | LEV | 1152079 | 239601 | 138552 |
| 9 | PNW | 184948 | 37538 | 21606 |
| | LEV | 1107996 | 224887 | 129438 |
| 10 | PNW | 194898 | 38886 | 22382 |
| | LEV | 1061212 | 211732 | 121869 |
| 11 | PNW | 202897 | 40068 | 23083 |
| | LEV | 1014208 | 200288 | 118382 |
| 12 | PNW | 209263 | 73744 | 23708 |
| | LEV | 968258 | 341212 | 109697 |
| 13 | PNW | 214267 | 76258 | 39274 |
| | LEV | 924084 | 328882 | 169381 |
| 14 | PNW | 218129 | 78358 | 40716 |
| | LEV | 882046 | 316856 | 164642 |
| 15 | PNW | 221031 | 80097 | 41970 |
| | LEV | 842283 | 305225 | 159937 |
| 16 | PNW | 223124 | 81519 | 43054 |
| | LEV | 804818 | 294044 | 155297 |
| 17 | PNW | 224530 | 82666 | 43984 |
| | LEV | 769587 | 283342 | 150756 |
| 18 | PNW | _ | 83571 | 44774 |
| | LEV | _ | 273126 | 146330 |
| 19 | PNW | _ | 84265 | 45439 |
| | LEV | _ | 263393 | 142031 |
| 20 | PNW | _ | 84775 | 45991 |
| | LEV | _ | 254134 | 137870 |

**Table 7.10 Socioeconomic PNW and LEV for agroforestry (maiden and first coppice crops) when varying tree rotations and site quality**

| Rot$^n$ | | Version I | | Version II | |
|---|---|---|---|---|---|
| | Criteria | SQ I | SQ II | SQI | SQII |
| 5+5 | PNW | 105042 | -32301 | 211782 | -11703 |
| | LEV | 571947 | -175876 | 1153143 | -63724 |
| 6+6 | PNW | 131061 | -29946 | 260442 | -7894 |
| | LEV | 606417 | -138560 | 1205062 | -36524 |
| 7+7 | PNW | 158936 | -26778 | 299737 | -2761 |
| | LEV | <u>642690</u> | -108284 | <u>1210830</u> | -11163 |
| 8+8 | PNW | 177864 | -24538 | 330215 | 865 |
| | LEV | 641564 | -88508 | 1191102 | 3120 |
| 9+9 | PNW | 192643 | -22603 | 354244 | 3992 |
| | LEV | 629594 | -73872 | 1157733 | 13046 |
| 10+10 | PNW | <u>204020</u> | -21048 | <u>372736</u> | 6503 |
| | LEV | 611604 | -63096 | 1117373 | 1949 |

**Table 7.11 Socioeconomic costs of the dense plantations of *Eucalyptus hybrid* (maiden crop).** (figures in Rsw and EWR = 0.33w)

| Yr (1) | Descrn (2) | Financial cost (3) | Economic cost (4) | Combined wt. (5) | SE[1] cost of consn loss to society (6)=(4) X(5) | SE[2] cost of consn loss to society (7)=(5)X {(3)-(4)} | Total SE cost (8)= (6)+(7) | Combined wt. (9) | Total SE benefits (10)= (9)X{(3) -(4)} | Net SE cost-to society (11)= {(8)-(10)} |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Goods | 50 | 50 | 6.8 | 340 | _ | 340 | _ | _ | 340 |
| | Main workers | 164 | 54 | 6.8 | 369 | 746 | 1114 | 0.57 | 63 | 1052 |
| | Subsidiary workers | 1936 | 641 | 6.8 | 4361 | 8813 | 13174 | 2.20 | 2852 | 10322 |
| 1 | Goods | 750 | 750 | 6.8 | 5103 | _ | 5103 | _ | _ | 5103 |
| | Main workers | 119 | 40 | 6.8 | 269 | 543 | 812 | 0.57 | 46 | 766 |
| | Subsidiary workers | 1411 | 467 | 6.8 | 3177 | 6421 | 9598 | 2.20 | 2078 | 7521 |
| 2 | Goods | 340 | 340 | 6.8 | 2313 | _ | 2313 | _ | _ | 2313 |
| | Main workers | 69 | 23 | 6.8 | 155 | 312 | 467 | 0.57 | 26 | 441 |
| | Subsidiary workers | 811 | 269 | 6.8 | 1827 | 3693 | 5520 | 2.20 | 1195 | 4326 |
| 3 | Goods | _ | _ | _ | _ | _ | _ | _ | _ | _ |
| | Main workers | 31 | 10 | 6.8 | 70 | 142 | 212 | 0.57 | 12 | 200 |
| | Subsidiary workers | 369 | 122 | 6.8 | 831 | 1679 | 2509 | 2.20 | 543 | 1966 |

1 Socioeconomic cost of consumption loss to society due to the economic cost of the Agroforestry.
2 Socioeconomic cost of the consumption loss to society due to extra commitment to the economy (due to the increased consumption by the workers).

**Table 7.12 Socioeconomic PNW and LEV for the dense plantations of *Eucalyptus hybrid* (maiden crop) when varying tree rotations and site quality.** (in Rsw)

| Rot$^n$ | Criteria | Version I SQ I | SQ II | SQIII | Version II SQ I | SQII | SQIII |
|---|---|---|---|---|---|---|---|
| 5 | PNW | 51140 | -28347 | -32248 | 104334 | -25007 | -31355 |
| | LEV | 530038 | -293802 | -334238 | 1081374 | -259187 | -324984 |
| 6 | PNW | 69204 | -26729 | -31377 | 140072 | -22374 | -29938 |
| | LEV | 603707 | -233170 | -273719 | 1221929 | -195181 | -261164 |
| 7 | PNW | 91465 | -24120 | -30463 | 169953 | -18129 | -28451 |
| | LEV | 690740 | -182150 | -230055 | 1283470 | -136906 | -214857 |
| 8 | PNW | 106569 | -22293 | -29567 | 194529 | -15156 | -26992 |
| | LEV | 711197 | -14773 | -197315 | 1298209 | -101145 | -180133 |
| 9 | PNW | 118885 | -20657 | -28722 | 214570 | -12495 | -25617 |
| | LEV | 712219 | -123755 | -172068 | 1285453 | -74853 | -153468 |
| 10 | PNW | 128834 | -19310 | -27946 | 230760 | -10302 | -24354 |
| | LEV | 701498 | -105141 | -152164 | 1256479 | -56094 | -132609 |
| 11 | PNW | 136833 | -18127 | -27245 | 243775 | -8378 | -23214 |
| | LEV | 683979 | -90612 | -136188 | 1218545 | -41877 | -116040 |
| 12 | PNW | 143200 | 15548 | -26620 | 254135 | 46419 | -22197 |
| | LEV | 662582 | 71941 | -123169 | 1175879 | 214782 | -102704 |
| 13 | PNW | 148203 | 18062 | -11053 | 262277 | 50510 | 3133 |
| | LEV | 639166 | 77897 | -47671 | 1131140 | 217837 | 13512 |
| 14 | PNW | 152065 | 20163 | -9612 | 268562 | 53928 | 5478 |
| | LEV | 614905 | 81531 | -38868 | 1085979 | 218068 | 22153 |
| 15 | PNW | 154968 | 21901 | -8357 | 273284 | 56757 | 7520 |
| | LEV | 590534 | 83459 | -31847 | 1041403 | 216284 | 28657 |
| 16 | PNW | 157060 | 23324 | -7274 | 276689 | 59072 | 9283 |
| | LEV | 566523 | 84130 | -26237 | 998031 | 213075 | 33484 |
| 17 | PNW | 158466 | 24470 | -6344 | 278977 | 60938 | 10796 |
| | LEV | 543151 | 83873 | -21745 | 956208 | 208867 | 37004 |
| 18 | PNW | 304988 | 25376 | -5554 | 517400 | 62411 | 12082 |
| | LEV | 996757 | 82932 | -18150 | 1690955 | 203969 | 39487 |
| 19 | PNW | 305561 | 26069 | -4889 | 518332 | 63540 | 13164 |
| | LEV | 955113 | 81487 | -15282 | 1620185 | 198610 | 41147 |
| 20 | PNW | 305388 | 26579 | -4337 | 518050 | 64369 | 14063 |
| | LEV | 915479 | 79677 | -13000 | 1552988 | 192962 | 42156 |

**Table 7.13 Socioeconomic PNW and LEV for the dense plantations of *Eucalyptus hybrid* (maiden and first coppice crops) when varying tree rotations and site quality.** (in Rsw)

| Rot$^n$ | Criteria | Version I SQ I | SQ II | Version II SQI | SQII |
|---|---|---|---|---|---|
| 5+5 | PNW | 103070 | -26405 | 189921 | -20761 |
| | LEV | 561210 | -143773 | 1034112 | -113045 |
| 6+6 | PNW | 129089 | -24050 | 238581 | -16952 |
| | LEV | 597293 | -111280 | 1103911 | -78436 |
| 7+7 | PNW | 156964 | -20883 | 277576 | -11819 |
| | LEV | 634716 | -84442 | 1122431 | -47791 |
| 8+8 | PNW | 175892 | -18642 | 308354 | -8193 |
| | LEV | 634451 | -67241 | 1112248 | -29554 |
| 9+9 | PNW | 190671 | -16707 | 332384 | -5066 |
| | LEV | 623149 | -54603 | 1086287 | -16557 |
| 10+10 | PNW | 202048 | -15152 | 350875 | -2555 |
| | LEV | 605692 | -45422 | 1051839 | -7660 |

**Table 7.14 Socioeconomic costs of the institutional plantations of *Acacia nilotica*.** (figures in Rsw and EWR = 0.33w)

| Yr (1) | Descr$^n$ (2) | Financial cost (3) | Economic cost (4) | Combined wt. (5) | SE[1] cost of cons$^n$ loss to society (6)=(4) X(5) | SE[2] cost of cons$^n$ loss to society (7)=(5)X {(3)-(4)} | Total SE cost (8)= (6)+(7) | Combined wt. (9) | Total SE benefits (10)= (9)X{(3) -(4)} | Net SE cost-to society (11)= {(8)-(10)} |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Goods | 50 | 50 | 6.8 | 340 | _ | 340 | _ | _ | 340 |
| | Main workers | 69 | 23 | 6.8 | 156 | 316 | 472 | 0.57 | 27 | 446 |
| | Subsidiary workers | 821 | 272 | 6.8 | 1848 | 3735 | 5583 | 2.20 | 1209 | 4375 |
| 1 | Goods | 470 | 470 | 6.8 | 3198 | _ | 3198 | _ | _ | 3198 |
| | Main workers | 62 | 21 | 6.8 | 141 | 284 | 425 | 0.57 | 24 | 401 |
| | Subsidiary workers | 738 | 244 | 6.8 | 1661 | 3357 | 5019 | 2.20 | 1086 | 3932 |
| 2 | Goods | 230 | 230 | 6.8 | 1565 | _ | 1565 | _ | _ | 1565 |
| | Main workers | 28 | 9 | 6.8 | 63 | 128 | 191 | 0.57 | 11 | 180 |
| | Subsidiary workers | 332 | 110 | 6.8 | 748 | 1511 | 2258 | 2.20 | 409 | 1850 |
| 3 | Goods | _ | _ | _ | _ | _ | _ | _ | _ | _ |
| | Main workers | 16 | 5 | 6.8 | 35 | 71 | 106 | 0.57 | 6 | 100 |
| | Subsidiary workers | 184 | 61 | 6.8 | 415 | 839 | 1255 | 2.20 | 272 | 983 |

1 Socioeconomic cost of consumption loss to society due to the economic cost of the Agroforestry.
2 Socioeconomic cost of the consumption loss to society due to extra commitment to the economy (due to the increased consumption by the workers).

**Table 7.15 Socioeconomic costs of thinnings in the institutional plantations of *Acacia nilotica* (first coppice crop). (figures in Rsw and EWR = 0.33w)**

| Yr | Descr$^{n}$ | Fina-ncial cost | Eco-nom-oic cost | Com-bined wt. | SE[1]cost of cons$^{n}$ loss to society | SE [2] cost of cons$^{n}$ loss to society | Total SE cost | Com-bined wt. | Total SE bene-fits | Net SE cost-to society |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6)=(4) X(5) | (7)=(5)X {(3)-(4)} | (8)= (6)+(7) | (9) | (10)= (9)X{(3) -(4)} | (11)= {(8)-(10)} |
| 5 | Main workers | | | | | | | | | |
| | I | 1.58 | 0.52 | 6.8 | 3.54 | 7.21 | 10.75 | 0.57 | 0.61 | 10.14 |
| | II | 0.50 | 0.17 | 6.8 | 1.16 | 2.24 | 3.40 | 0.57 | 0.19 | 3.21 |
| | III | 0.44 | 0.15 | 6.8 | 1.02 | 1.97 | 2.99 | 0.57 | 0.17 | 2.82 |
| | Subsidiary workers | | | | | | | | | |
| | I | 18.62 | 6.16 | 6.8 | 41.91 | 84.78 | 126.69 | 2.2 | 27.43 | 99.26 |
| | II | 5.85 | 1.84 | " | 13.20 | 26.60 | 39.80 | " | 8.61 | 31.19 |
| | III | 5.21 | 2.04 | " | 13.88 | 21.57 | 35.45 | " | 6.98 | 28.47 |
| 10 | Main workers | | | | | | | | | |
| | I | 2.76 | 0.91 | " | 6.19 | 12.59 | 18.78 | " | 1.06 | 17.72 |
| | II | 2.34 | 0.77 | " | 5.24 | 10.68 | 15.92 | " | 0.90 | 15.02 |
| | III | 1.68 | 0.56 | " | 3.81 | 7.62 | 11.43 | " | 0.64 | 10.79 |
| | Subsidiary workers | | | | | | | | | |
| | I | 32.59 | 10.79 | " | 73.42 | 148.33 | 221.75 | " | 47.99 | 173.76 |
| | II | 27.71 | 9.17 | " | 62.39 | 126.15 | 188.54 | " | 40.81 | 147.73 |
| | III | 19.82 | 6.56 | " | 44.63 | 90.22 | 134.85 | " | 29.19 | 105.66 |
| 15 | Main workers | | | | | | | | | |
| | I | 1.10 | 0.36 | " | 2.45 | 5.03 | 7.48 | " | 0.42 | 6.04 |
| | II | 0.99 | 0.33 | " | 2.25 | 4.49 | 6.74 | " | 0.38 | 6.36 |
| | III | 0.95 | 0.31 | " | 2.11 | 4.35 | 6.46 | " | 0.37 | 6.09 |
| | Subsidiary workers | | | | | | | | | |
| | I | 13.06 | 4.32 | " | 29.39 | 59.47 | 88.86 | " | 19.24 | 69.62 |
| | II | 11.73 | 3.88 | " | 26.40 | 53.41 | 79.81 | " | 17.28 | 62.53 |
| | III | 11.29 | 3.74 | " | 25.45 | 51.37 | 76.82 | " | 16.62 | 60.20 |
| 20 | Main workers | | | | | | | | | |
| | I | 0.68 | 0.23 | " | 1.56 | 3.06 | 4.62 | " | 0.26 | 4.36 |
| | II | 0.65 | 0.22 | " | 1.50 | 2.92 | 4.42 | " | 0.25 | 4.17 |
| | III | 0.70 | 0.23 | " | 1.56 | 3.20 | 4.76 | " | 0.27 | 4.49 |
| | Subsidiary workers | | | | | | | | | |
| | I | 8.05 | 2.66 | " | 18.10 | 36.67 | 54.77 | " | 11.86 | 42.91 |
| | II | 7.68 | 2.54 | " | 17.28 | 34.97 | 52.25 | " | 11.32 | 40.93 |
| | III | 8.33 | 5.76 | " | 18.78 | 37.90 | 56.68 | " | 12.26 | 44.42 |

1 Socioeconomic cost of consumption loss to society due to the economic cost of the Agroforestry.

2 Socioeconomic cost of the consumption loss to society due to extra commitment to the economy (due to the increased consumption by the workers).

**Table 7.16 Socioeconomic benefits from the institutional plantations of *Acacia nilotica*.** (Rsw)

| Management option | Age | Version I* | | | Version II** | | |
|---|---|---|---|---|---|---|---|
| | | SQ I | SQ II | SQ III | SQ I | SQ II | SQ III |
| Felling_5 yr | 5 | 7862 | 4471 | 1970 | 12794 | 7275 | 3206 |
| Felling_10 yr | 5 | 1466 | 895 | 243 | 2386 | 1456 | 395 |
| Thinnings_5 yr | 10 | 56449 | 11891 | 6180 | 91854 | 19349 | 10055 |
| Felling_15 yr | 5 | 1466 | 895 | 243 | 2386 | 1456 | 395 |
| Thinnings_5, | 10 | 8185 | 1483 | 584 | 13318 | 2413 | 950 |
| & 10 yr | 15 | 77089 | 49388 | 8978 | 125440 | 80365 | 14610 |
| Felling_20 yr | 5 | 1466 | 895 | 243 | 2386 | 1456 | 395 |
| Thinnings_5, | 10 | 1466 | 895 | 243 | 2386 | 1456 | 395 |
| 10 & 15 yr | 15 | 8861 | 4929 | 672 | 13892 | 8020 | 1093 |
| | 20 | 91894 | 59264 | 10929 | 149531 | 96436 | 17785 |
| Felling_25 yr | 5 | 1466 | 895 | 243 | 2386 | 1456 | 395 |
| Thinnings_5, | 10 | 8185 | 1483 | 584 | 13318 | 2413 | 950 |
| 10, 15 & | 15 | 8861 | 4929 | 672 | 13892 | 8020 | 1093 |
| 20 yr | 20 | 9819 | 5018 | 689 | 15977 | 8165 | 1121 |
| | 25 | 103813 | 66619 | 36773 | 168926 | 108403 | 59837 |

* Combined distributional weight = 2.2

** Combined distributional weight is 6.8 for 30% & 2.2 for remaining 70% of the socioeconomic benefits.

**Table 7.17 Socioeconomic PNW and LEV for the institutional plantations of *Acacia nilotica*.** (in Rsw)

| Management option | | Version I | | | Version II | | |
|---|---|---|---|---|---|---|---|
| | | SQ I | SQ II | SQ III | SQ I | SQ II | SQ III |
| Fell - 5 yr | PNW | -9908 | -12972 | -15231 | -5452 | -10438 | -14114 |
| | LEV | -102687 | -134445 | -157862 | -56508 | -108185 | -146289 |
| Fell -10 yr | PNW | 30296 | -6526 | -11776 | 60030 | 69 | -8474 |
| Thin _5 yr | LEV | 164961 | -35536 | -64119 | 326860 | 377 | -46142 |
| Fell -15 yr | PNW | 47599 | 21272 | -9817 | 88283 | 45386 | -5227 |
| Thin -5 & 10 yr | LEV | 181385 | 81061 | -37408 | 336420 | 172954 | -19917 |
| Fell -20 yr | PNW | 58459 | 27923 | -8709 | 105601 | 56242 | -3393 |
| Thin - 5, 10 & 15 yr | LEV | 175247 | 83708 | -26106 | 316568 | 168599 | -10172 |
| Fell -25 yr | PNW | 66239 | 31855 | 6576 | 118281 | 62658 | 21499 |
| Thin - 5, 10, 15 & 20 yr | LEV | 166481 | 80062 | 16528 | 297279 | 157481 | 54033 |

**Table 7.18 Socioeconomic costs of the village woodlots of *Dalbergia sissoo*.** (figures in Rsw and EWR = 0.33w)

| Yr (1) | Descr$^n$ (2) | Financial cost (3) | Economoic cost (4) | Combined wt. (5) | SE[1] cost of cons$^n$ loss to society (6)=(4)X(5) | SE[2] cost of cons$^n$ loss to society (7)=(5)X{(3)-(4)} | Total SE cost (8)=(6)+(7) | Combined wt. (9) | Total SE benefits (10)=(9)X{(3)-(4)} | Net SE cost-to society (11)={(8)-(10)} |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Goods | 50 | 50 | 6.8 | 340 | _ | 340 | _ | _ | 340 |
| | Main workers | 105 | 35 | 6.8 | 237 | 479 | 716 | 0.57 | 40 | 676 |
| | Subsidiary workers | 1245 | 412 | 6.8 | 2803 | 5666 | 8469 | 2.20 | 1833 | 6636 |
| 1 | Goods | 470 | 470 | 6.8 | 3198 | _ | 3198 | _ | _ | 3198 |
| | Main workers | 82 | 27 | 6.8 | 184 | 373 | 557 | 0.57 | 31 | 526 |
| | Subsidiary workers | 968 | 320 | 6.8 | 2180 | 4407 | 6587 | 2.20 | 1426 | 5161 |
| 2 | Goods | 230 | 230 | 6.8 | 1565 | _ | 1565 | _ | _ | 1565 |
| | Main workers | 43 | 14 | 6.8 | 97 | 195 | 292 | 0.57 | 16 | 275 |
| | Subsidiary workers | 507 | 168 | 6.8 | 1142 | 2308 | 3450 | 2.20 | 747 | 2703 |
| 3 | Goods | _ | _ | _ | _ | _ | _ | _ | _ | _ |
| | Main workers | 23 | 8 | 6.8 | 53 | 106 | 159 | 0.57 | 9 | 150 |
| | Subsidiary workers | 277 | 92 | 6.8 | 623 | 1259 | 1882 | 2.20 | 407 | 1475 |

**Table 7.19 Socioeconomic costs of coppicing and cultural operations in the village woodlots of *Dalbergia sissoo*.** (figures in Rsw and EWR = 0.33w)

| Yr (1) | Descr$^n$ (2) | Financial cost (3) | Economoic cost (4) | Combined wt. (5) | SE[1] cost of cons$^n$ loss to society (6)=(4)X(5) | SE[2] cost of cons$^n$ loss to society (7)=(5)X{(3)-(4)} | Total SE cost (8)=(6)+(7) | Combined wt. (9) | Total SE benefits (10)=(9)X{(3)-(4)} | Net SE cost-to society (11)={(8)-(10)} |
|---|---|---|---|---|---|---|---|---|---|---|
| 3 | Main workers | 18 | 6 | 6.8 | 40 | 80 | 120 | 0.57 | 7 | 114 |
| | Subsidiary workers | 209 | 69 | 6.8 | 471 | 951 | 1422 | 2.20 | 308 | 1114 |
| 4 | Main workers | 3 | 1 | 6.8 | 7 | 12 | 19 | 0.57 | 1 | 18 |
| | Subsidiary workers | 32 | 11 | 6.8 | 73 | 147 | 220 | 2.20 | 48 | 172 |

**Table 7.20 Socioeconomic costs of thinnings in the village woodlots of *Dalbergia sissoo*.** (figures in Rsw and EWR = 0.33w)

| Yr | Descr$^n$ | Financial cost | Economic cost | Combined wt. | SE[1]cost of cons$^n$ loss to society | SE [2] cost of cons$^n$ loss to society | Total SE cost | Combined wt. | Total SE benefits | Net SE cost-to society |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6)=(4) X(5) | (7)=(5)X {(3)-(4)} | (8)= (6)+(7) | (9) | (10)= (9)X{(3) -(4)} | (11)= {(8)- (10)} |
| 10 | Main workers | | | | | | | | | |
| | I | 3.90 | 1.29 | 6.8 | 8.78 | 17.76 | 26.54 | 0.57 | 1.50 | 25.04 |
| | II | 3.90 | 1.29 | 6.8 | 8.78 | 17.76 | 26.54 | 0.57 | 1.50 | 25.04 |
| | III | 3.90 | 1.29 | 6.8 | 8.78 | 17.76 | 26.54 | 0.57 | 1.50 | 25.04 |
| | Subsidiary workers | | | | | | | | | |
| | I | 46.10 | 15.26 | 6.8 | 103.83 | 209.84 | 313.67 | 2.2 | 67.89 | 247.78 |
| | II | 46.10 | 15.26 | " | 103.83 | 209.84 | 313.67 | " | 67.89 | 245.78 |
| | III | 46.10 | 15.26 | " | 103.83 | 209.84 | 313.67 | " | 67.89 | 245.78 |
| 20 | Main workers | | | | | | | | | |
| | I | 2.18 | 0.72 | " | 4.90 | 9.93 | 14.83 | " | 0.84 | 13.99 |
| | II | 1.56 | 0.52 | " | 3.54 | 7.08 | 10.62 | " | 0.60 | 10.02 |
| | III | 1.56 | 0.52 | " | 3.54 | 7.08 | 10.62 | " | 0.60 | 10.02 |
| | Subsidiary workers | | | | | | | | | |
| | I | 25.82 | 8.55 | " | 58.17 | 117.51 | 175.68 | " | 38.02 | 137.66 |
| | II | 18.44 | 6.10 | " | 41.50 | 83.96 | 125.46 | " | 27.17 | 98.29 |
| | III | 18.44 | 6.10 | " | 41.50 | 83.96 | 125.46 | " | 27.17 | 98.29 |
| 30 | Main workers | | | | | | | | | |
| | I | 2.34 | 0.77 | " | 5.24 | 10.68 | 15.92 | " | 0.90 | 15.02 |
| | II | 1.64 | 0.54 | " | 3.67 | 7.48 | 11.15 | " | 0.63 | 10.52 |
| | III | 1.64 | 0.54 | " | 3.67 | 7.48 | 11.15 | " | 0.63 | 10.52 |
| | Subsidiary workers | | | | | | | | | |
| | I | 27.66 | 9.16 | " | 62.32 | 125.87 | 188.1 | " | 40.73 | 147.46 |
| | II | 19.36 | 6.41 | " | 43.61 | 88.11 | 131.72 | " | 28.51 | 103.21 |
| | III | 19.36 | 6.41 | " | 43.61 | 88.11 | 131.72 | " | 28.51 | 103.21 |

**Table 7.21 Socioeconomic benefits from the village woodlots of *Dalbergia sissoo*.** (Rsw)

| Management option | Age | Version I* | | | Version II** | | |
|---|---|---|---|---|---|---|---|
| | | SQ I | SQ II | SQ III | SQ I | SQ II | SQ III |
| Felling_10 yr | 10 | 65527 | 40134 | 9511 | 106627 | 65307 | 15476 |
| Coppice at 20 yr | 20 | 52422 | 32107 | 7608 | 85301 | 52245 | 12380 |
| Felling_15 yr | 15 | 98428 | 67559 | 51097 | 160163 | 109932 | 83146 |
| Coppice at 30 | 30 | 78742 | 54047 | 40878 | 128130 | 87946 | 66517 |
| Felling_20 yr | 10 | 45884 | 26961 | 4605 | 74662 | 43871 | 7493 |
| Thinnings_10 yr | 20 | 161255 | 109760 | 74855 | 262397 | 178602 | 121805 |
| Felling_30 yr | 10 | 45884 | 26961 | 4605 | 74662 | 43871 | 7493 |
| Thinnings_10 & | 20 | 74066 | 42279 | 20295 | 120521 | 68797 | 33024 |
| 20 yr | 30 | 929855 | 141091 | 86310 | 1513071 | 229585 | 140445 |
| Felling_40 yr | 10 | 45884 | 26961 | 4605 | 74662 | 43871 | 7493 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Thinnings_10, | 20 | 74066 | 42279 | 20295 | 120521 | 68797 | 33024 |
| 20 & | 30 | 456107 | 54059 | 19769 | 742183 | 87965 | 32168 |
| 30 yr | 40 | 964950 | 661597 | 88116 | 1570177 | 1076558 | 143383 |

* Combined distributional weight = 2.2
** Combined distributional weight is 6.8 for 30% & 2.2 for remaining 70% of the socioeconomic benefits.

**Table 7.22 Socioeconomic PNW and LEV for the village woodlots of *Dalberia sissoo.*** (in Rsw)

| Management option | | Version I SQ I | SQ II | SQ III | Version II SQ I | SQ II | SQ III |
|---|---|---|---|---|---|---|---|
| Fell - 10yr | PNW | 65092 | 30824 | -10512 | 120554 | 64784 | -2462 |
| Coppice at 20 yr | LEV | 195129 | 92402 | -31511 | 361393 | 194207 | -7380 |
| Fell -15 yr | PNW | 92195 | 55992 | 36686 | 164598 | 105687 | 74272 |
| Coppice at 30 yr | LEV | 202194 | 122796 | 80456 | 360982 | 231784 | 162887 |
| Fell -20 yr | PNW | 122439 | 72674 | 31162 | 213334 | 132356 | 64808 |
| Thin 10 yr | LEV | 367043 | 217858 | 93417 | 639526 | 396771 | 194280 |
| Fell -30 yr | PNW | 570099 | 104388 | 41686 | 941835 | 184008 | 81977 |
| Thin - 10, & 20 yr | LEV | 1250286 | 228935 | 91421 | 2065543 | 403549 | 179784 |
| Fell -40 yr | PNW | 740825 | 350811 | 44566 | 1219707 | 585023 | 86698 |
| Thin - 10, 20 & 30 yr | LEV | 1332687 | 631083 | 80172 | 2194159 | 1052411 | 155962 |

**Table 7.23 Socioeconomic benefits of the *Casuarina equisitifolia* plantations.** (Rsw)

| Rotation | Version I* | Version II** |
|---|---|---|
| 7 | 8153 | 13267 |
| 12 | 13726 | 22336 |
| 18 | 17425 | 28355 |

* Combined distributional weight = 2.2
** Combined distributional weight is 6.8 for 30% & 2.2 for remaining 70% of the socioeconomic benefits.

**Table 7.24 Socioeconomic PNW and LEV for *Casuarina equisitifolia* plantations.** (in Rsw)

| Rotation | PNW Version I* | PNW Version II* | LEV Version I* | LEV Version II* |
|---|---|---|---|---|
| 7 | -9938 | -5501 | -75049 | -41542 |
| 12 | -6252 | 497 | -28927 | 2300 |
| 18 | -4918 | 2668 | -16072 | 8719 |

**Table 9.1 Distribution of the main workers by occupation.**

| Occupation | District | Male ('000) | % | Female ('000) | % | Total ('000) | % |
|---|---|---|---|---|---|---|---|
| Cultivators | Puri | 378 | 48 | 6 | 9 | 384 | 45 |
| | Ganjam | 321 | 48 | 68 | 27 | 389.5 | 42 |
| Agricultural labourers | Puri | 157 | 20 | 32 | 49 | 189 | 22 |
| | Ganjam | 157 | 23 | 143 | 57 | 300 | 32 |
| Household industries | Puri | 23 | 3 | 6 | 9 | 29 | 3.4 |
| | Ganjam | 23 | 3.4 | 9 | 4 | 32 | 3.4 |
| Other workers | Puri | 225 | 29 | 21 | 32 | 246 | 29 |
| | Ganjam | 174 | 26 | 29 | 12 | 203 | 22 |
| Total workers | Puri | 783 | 100 | 65 | 100 | 848 | 100 |
| | Ganjam | 675 | 100 | 249 | 100 | 924 | 100 |

Source : Compiled from Government of India (1981) population census reports.

**Table 9.2 Underemployment in Puri and Ganjam.**

| Underemployment | District | Male | Female | Total |
|---|---|---|---|---|
| % of persons reporting available for work. | Puri | 40.9 | 17.04 | 36.28 |
| | Ganjam | 13.1 | 11.0 | 12.6 |
| Average no. of days seeking for work | Puri | 109 | 119 | 110 |
| | Ganjam | 119 | 101 | 114 |

Source : ORG (1982a, 1982b).

**Table 9.3 Matrix for goal programming model for multiple objective planning in social forestry.**

| Goals & constraints | X1 | X2 | X3 | X4 | X5 | X6 |
|---|---|---|---|---|---|---|
| Socio-economic benefits | 712219 | 84130 | 724357 | 63664 | 1332687 | 631083 |
| Employment | 491 | 491 | 855 | 855 | 335.8 | 334.1 |
| Budget | 6050 | 6050 | 11250 | 11250 | 4108 | 4091 |
| Fuelwood | 0 | 0 | 0 | 0 | 0 | 0 |
| Small-timber | 286.82 | 123.52 | 258.39 | 128.59 | 155.68 | 89.86 |
| Timber | 0 | 0 | 0 | 0 | 412.94 | 262.41 |
| Agricultural produce | 0 | 0 | 41.8 | 31.44 | 0 | 0 |
| Land area(SQ I) | 1 | _ | 1 | _ | 1 | _ |
| Land area(SQ II) | _ | 1 | _ | 1 | _ | 1 |
| Land area(SQ III) | _ | _ | _ | _ | _ | _ |
| Total land area | 1 | 1 | 1 | 1 | 1 | 1 |

continued

| Goals & constraints | X7 | X8 | X9 | X10 | X11 | Goal-level |
|---|---|---|---|---|---|---|
| Socio-economic benefits | 93417 | 181385 | 83708 | 16528 | 8718.61 | 61690000 |
| Employment | 330 | 230.56 | 229.92 | 229.85 | 225 | 898900 |
| Budget | 4050 | 3055.55 | 3049.12 | 3048.42 | 3000 | 11940000 |
| Fuelwood | 21.45 | 6.83 | 11.08 | 10.19 | 81.19 | 250000 |
| Small-timber | 97.15 | 133.57 | 100.55 | 57.6 | 0 | 420000 |
| Timber | 0 | 0 | 0 | 0 | 0 | 8000 |
| Agricultural produce | 0 | 0 | 0 | 0 | 0 | 4500 |
| Land area(SQ I) | _ | 1 | _ | _ | _ | 50 |
| Land area(SQ II) | _ | _ | 1 | _ | 1 | 3300 |
| Land area(SQ III) | 1 | _ | _ | 1 | _ | 350 |
| Total land area | 1 | 1 | 1 | 1 | 1 | 3700 |

**Table 9.4 Results of the model with different type of inequalities (detailed below).**

| Socio-economic benefits | Employment | Budget | Fuelwood | Small timber | Timber | Agricultural produce |
|---|---|---|---|---|---|---|
| | Specified and achieved (underlined) goal levels | | | | | |
| 62000000 | 898900 | 11940000 | 250000 | 42000 | 8000 | 4500 |
| 62002243 | 898902 | 11940023 | 250000 | 42001 | 8001 | 4506 |
| 62000000 | 898900 | 11930000 | 250000 | 42000 | 8000 | 4500 |
| 61997962 | 898900 | 11930008 | 250000 | 41999 | 7731 | 4367 |
| 62000000 | 898900 | 11920000 | 250000 | 42000 | 8000 | 4500 |
| 61999208 | 898904 | 11920050 | 250000 | 42000 | 7248 | 4262 |
| 62000000 | 898900 | 11940000 | 250000 | 42000 | 8000 | 4500 |
| 62000207 | 893258 | 11814930 | 250000 | 42000 | 1995 | 4506 |
| 62000000 | 898900 | 11940000 | 250000 | 42000 | 8000 | 4500 |
| 6200596 | 874506 | 11632019 | 250000 | 41999 | 4782 | 3644 |
| 62000000 | 898900 | 11940000 | 250000 | 42000 | 8000 | 4500 |
| 58615280 | 851798 | 11296074 | 247912 | 30189 | 6712 | 4506 |

Notes
Row 1- afforestation budget has equality type.
Row2- " " " "
Row 3- " " " "
Row 4_afforestation budget and land area under SQ I have equality type.
Row 5- afforestation budget and land area under SQ I and III have equality type.
Row 6- afforestation budget and land area under SQ II have equality type.

**Table 9.5 Management options: land area (ha) to be afforested when social welfare is given priority over production goals.**

| X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 |
|---|---|---|---|---|---|---|---|---|---|---|
| _ | 15.00 | 0.7 | 142.38 | _ | 30.49 | _ | 0.08 | _ | 328.26 | 3037.99 |
| _ | 38.37 | _ | 138.91 | _ | 29.46 | _ | _ | _ | 298.81 | 3042.70 |
| _ | 62.20 | _ | 135.55 | _ | 27.62 | _ | _ | _ | 250.09 | 3047.81 |
| _ | 135.90 | _ | 143.31 | 4.83 | _ | _ | 45.17 | _ | _ | 3075.40 |
| _ | _ | _ | 115.91 | 11.58 | _ | _ | 38.42 | _ | 350.00 | 3032.04 |
| _ | 60.61 | _ | 143.31 | _ | 25.58 | _ | _ | 19.72 | _ | 3050.79 |

**Table 9.6 Results of the model with varying goal levels (when social welfare is given priority over production goals).**

| | Specified and achieved (underlined) goal levels | | | | | |
|---|---|---|---|---|---|---|
| Socio-economic benefits | Employment | Budget | Fuelwood | Small timber | Timber | Agricultural produce |
| 62000000 | 898900 | 11940000 | 250000 | 42000 | 8000 | 4500 |
| 62002243 | 898902 | 11940023 | 250000 | 42001 | 8001 | 4506 |
| *61690000* | 898900 | 11940000 | 250000 | 42000 | 8000 | 4500 |
| 61691294 | 898897 | 11940000 | 250000 | 41999 | 8001 | 4506 |
| 61690000 | *900000* | 11940000 | 250000 | 42000 | 8000 | 4500 |
| 61691838 | 900000 | 11949488 | 250000 | 42000 | 7801 | 4506 |
| *61680000* | 898900 | 11940000 | 250000 | 42000 | 8000 | 4500 |
| 61682299 | 898899 | 11939990 | 250000 | 42000 | 8001 | 4506 |
| *61672384* | 898900 | 11940000 | 250000 | 42000 | 8000 | 4500 |
| 61673601 | 898897 | 11939970 | 250000 | 42035 | 8001 | 4506 |
| 61690000 | *899000* | 11940000 | 250000 | 42000 | 8000 | 4500 |
| 61691992 | 898998 | 11940940 | 249999 | 42000 | 8001 | 4506 |
| 61690000 | 898900 | *11940500* | 250000 | 42000 | 8000 | 4500 |
| 61691384 | 898898 | 11940470 | 250000 | 41999 | 8001 | 4506 |
| 61690000 | 898900 | *11941000* | 250000 | 42000 | 8000 | 4500 |
| 61695322 | 898904 | 11940540 | 250000 | 42001 | 8001 | 4506 |
| 61690000 | 898900 | 11940000 | *260000* | 42000 | 8000 | 4500 |
| 61691940 | 898898 | 11953760 | 260000 | 42000 | 8001 | 2708 |
| 61690000 | 898900 | 11940000 | 250000 | *42840* | 8000 | 4500 |
| 61692103 | 898902 | 11947000 | 250000 | 42840 | 8001 | 4464 |
| 61690000 | 898900 | 11940000 | 250000 | 42000 | *8160* | 4500 |
| 61690532 | 898901 | 11942652 | 250000 | 42000 | 8161 | 4506 |
| 61690000 | 898900 | 11940000 | 250000 | 42000 | *8250* | 4500 |
| 61690136 | 898898 | 11943172 | 250000 | 42000 | 8227 | 4506 |
| 61690000 | 898900 | 11940000 | 250000 | 42000 | 8000 | *4590* |
| 61692552 | 898905 | 11942285 | 250000 | 42001 | 8001 | 4596 |
| 61690000 | 898900 | 11940000 | 250000 | 42000 | 8000 | *4650* |
| 61692147 | 898902 | 11946479 | 250000 | 42000 | 8001 | 4656 |
| 62000000 | 898900 | 11940000 | 250000 | 42000 | 8000 | *4590* |
| 62002153 | 898903 | 11940120 | 250000 | 42000 | 8001 | 4596 |
| 62000000 | 898900 | 11940000 | 250000 | *42840* | 8000 | 4500 |
| 62001093 | 898897 | 11946786 | 250000 | 42839 | 8001 | 4506 |
| 62000000 | 898900 | 11940000 | 250000 | 42000 | *8160* | 4500 |
| 62002357 | 898902 | 11940075 | 250000 | 42000 | 8161 | 4506 |

**Table 9.7 Management options: land area (ha) to be afforested when production goals are given priority over social welfare.**

| X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 |
|---|---|---|---|---|---|---|---|---|---|---|
| _ | 12.72 | _ | 143.31 | _ | 30.49 | 3.11 | 0.32 | _ | 328.39 | 3037.13 |
| _ | 15.00 | 0.7 | 142.38 | _ | 30.49 | _ | 0.08 | _ | 328.26 | 3037.99 |
| _ | 26.64 | _ | 143.31 | _ | 29.73 | _ | _ | _ | 305.73 | 3040.82 |
| _ | 12.51 | _ | 143.31 | _ | 30.49 | 3.40 | 0.2 | _ | 328.64 | 3037.04 |
| _ | 12.36 | _ | 143.31 | _ | 30.49 | 3.61 | 0.1 | _ | 328.83 | 3036.96 |
| _ | 13.32 | _ | 143.31 | _ | 30. 49 | 3.36 | _ | _ | 327.44 | 3037.20 |
| _ | 13.53 | _ | 143.31 | _ | 30.49 | 0.45 | 1.23 | _ | 329.03 | 3037.68 |
| _ | 12.78 | 0.27 | 142.96 | _ | 30.49 | _ | 0.57 | _ | 332.53 | 3037.41 |
| _ | _ | _ | 86.12 | _ | 30.49 | _ | _ | 26.9 | 442.38 | 3143.17 |
| _ | _ | _ | 141.99 | _ | 30.49 | _ | _ | 12.8 | 356.84 | 3032.66 |
| _ | 8.75 | 0.13 | 143.14 | _ | 31.10 | _ | _ | _ | 341.74 | 3036.31 |
| _ | 7.34 | _ | 143.31 | _ | 31.35 | _ | _ | _ | 344.58 | 3035.95 |
| _ | 1.39 | _ | 146.18 | _ | 30.49 | 11.43 | _ | _ | 333.02 | 3034.38 |
| _ | _ | _ | 148.09 | _ | 30.49 | _ | 4.21 | 2.68 | 336.56 | 3036.24 |
| _ | 4.31 | _ | 146.18 | _ | 30.49 | 13.90 | _ | _ | 322.58 | 3035.04 |
| _ | _ | _ | 143.31 | _ | 31.10 | 3.66 | _ | _ | 329.33 | 3036.90 |
| _ | 11.76 | _ | 143.31 | _ | 31.10 | 3.66 | _ | _ | 329.33 | 3036.90 |

**Table 9.8 Results of the model with varying goal levels (when production goals are given priority over social welfare).**

| | Specified and achieved (underlined) goal levels | | | | | |
|---|---|---|---|---|---|---|
| Fuel-wood | Small timber | Timber | Agricul. produce | Employment | Budget | Socio-economic benefits |
| 250000 | 42000 | 8000 | 4500 | 898900 | 11940000 | 61672384 |
| 250000 | 42000 | 8001 | 4500 | 898900 | 11940003 | 61674689 |
| 250000 | 42000 | 8000 | 4500 | 898900 | 11940000 | *61690000* |
| 250000 | 41994 | 8001 | 4499 | 898880 | 11939732 | 61676427 |
| 250000 | 42000 | 8000 | 4500 | 898900 | 11940000 | *61670000* |
| 250000 | 41999 | 8001 | 4500 | 898897 | 11939959 | 61671217 |
| 250000 | 42000 | 8000 | 4500 | 898900 | 11940000 | *61680000* |
| 250000 | 42000 | 8001 | 4500 | 898901 | 11940013 | 61682230 |
| 250000 | 42000 | 8000 | 4500 | *900000* | 11940000 | *61672384* |
| 250000 | 42000 | 8001 | 4500 | 899398 | 11945514 | 61674287 |
| 250000 | 42000 | 8000 | 4500 | *899000* | 11940000 | *61680000* |
| 250000 | 42000 | 8001 | 4500 | 898999 | 11940925 | 61673985 |
| 250000 | 42840 | 8000 | 4500 | 898900 | 11940000 | *62000000* |
| 250000 | 42840 | 8001 | 4500 | 898902 | 11946757 | 62001255 |
| 250000 | 42000 | *8160* | 4500 | 898900 | 11940000 | 62000000 |
| 250000 | 42001 | 8161 | 4500 | 898903 | 11940039 | 62002726 |
| 250000 | 42000 | 8000 | *4590* | 898900 | 11940000 | 62000000 |
| 250000 | 41614 | 8001 | 4496 | 896332 | 11906205 | 61810173 |
| 250000 | 42000 | 8000 | 4500 | *916878* | 11940000 | 62000000 |
| 250000 | 42000 | 8001 | 4500 | 899772 | 11947538 | 62001808 |
| 250000 | 42000 | 8000 | 4500 | 898900 | *12178800* | 62000000 |
| 250000 | 42000 | 8001 | 4500 | 898902 | 11942820 | 61242142 |
| 250000 | 42000 | 8000 | 4500 | 898900 | *11701200* | 62000000 |
| 250000 | 42000 | 8002 | 4500 | 898903 | 11940477 | 62005591 |
| 250000 | 42000 | 8000 | 4500 | 898900 | *11820600* | 62000000 |
| 250000 | 42000 | 8002 | 4500 | 898903 | 11940477 | 62005591 |
| 250000 | 42000 | 8000 | 4500 | 898900 | 11940000 | *61367600* |
| 250000 | 42000 | 8001 | 4500 | 898901 | 11937782 | 61369667 |
| 250000 | 42000 | 8000 | 4500 | 898900 | 11940000 | *61700000* |
| 250000 | 41989 | 8001 | 4498 | 898863 | 11939516 | 61669132 |
| 250000 | 42000 | 8000 | 4500 | 898900 | 11940000 | *62000000* |
| 250000 | 41999 | 7998 | 4483 | 898897 | 11939957 | 61993444 |
| *255000* | 42000 | 8000 | 4500 | 898900 | 11940000 | 62200000 |
| 255000 | 42001 | 8001 | 3756 | 898903 | 11949912 | 62002400 |

Note: Equalities are same as in section 9.5.

**Table 9.9 Management options: land area (ha) to be afforested (when production goals are given priority over social welfare).**

| X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 |
|---|---|---|---|---|---|---|---|---|---|---|
| _ | 14.45 | _ | 143.31 | _ | 30.49 | 0.75 | _ | 1.80 | 326.68 | 3037.75 |
| _ | 14.99 | _ | 143.10 | _ | 30.49 | _ | _ | 2.26 | 325.94 | 3037.98 |
| _ | 14.31 | _ | 143.13 | _ | 30.49 | 0.94 | _ | 1.75 | 326.90 | 3037.69 |
| _ | 14.90 | _ | 143.13 | _ | 30.49 | 0.12 | _ | 2.26 | 325.97 | 3037.95 |
| _ | 17.36 | _ | 143.13 | _ | 30.49 | _ | _ | _ | 324.84 | 3038.43 |
| _ | 13.85 | _ | 143.13 | _ | 30. 49 | 2.75 | _ | _ | 327.72 | 3037.34 |
| 0.24 | _ | _ | 143.13 | _ | 30.49 | _ | _ | 15.0 | 349.22 | 3033.32 |
| _ | 13.16 | | 143.13 | _ | 31.10 | 1.93 | _ | 0.84 | 328.19 | 3037.38 |
| _ | 5.62 | _ | 142.99 | _ | 30.49 | 12.34 | _ | 0.72 | 321.55 | 3035.48 |
| _ | 23.78 | _ | 143.13 | _ | 30.49 | _ | _ | | 311.07 | 3040.15 |
| _ | 8.89 | | 143.13 | _ | 31.10 | _ | _ | _ | 343.01 | 3036.15 |
| _ | 14.60 | _ | 143.13 | 1.4 | 28.29 | _ | _ | _ | 330.42 | 3037.73 |
| _ | 14.60 | _ | 143.13 | 1.4 | 28.29 | _ | _ | _ | 330.42 | 3037.73 |
| _ | 10.09 | _ | 143.13 | _ | 30.49 | 1.02 | _ | _ | 338.71 | 3036.42 |
| _ | 14.99 | _ | 143.07 | _ | 30.49 | _ | _ | 2.17 | 326.07 | 3037.98 |
| _ | 15.24 | 0.41 | 142.58 | 0.5 | 29.63 | _ | _ | _ | 328.64 | 3037.95 |
| _ | _ | _ | 119.48 | _ | 30.49 | _ | _ | 24.61 | 371.92 | 3090.74 |

**Appendix 9.1 A sample computer print out of the outputs from the goal programming model for social forestry**

```
End
SOLV
REINVERSION BECAUSE OF TIME AT ITERATION 16
THESE ARE THE NUMBERS OF THE COLUMNS IN SOLUTION
   2  4  6  10  11  15  18  20  22  24  26
THESE ARE THE NUMBERS OF THE ROWS WITH ARTIFICIALS IN SOLUTION.
```

**CONSTRAINT SUMMARY**

| ROW NO. | ROW RIGHT HAND-SIDE VALUE | ROW DESCRIPTION | ROW TYPE | NEGATIVE DEVIATIONS PRIORITY | WEIGHT | POSITIVE DEVIATIONS PRIORITY | WEIGHT |
|---|---|---|---|---|---|---|---|
| R001 | 61690000 | SOCIOEC. BENEFITS G1 | L | 1 | 1.00 | 0 | 0.00 |
| R002 | 900000 | EMPLOYMENT G2 | L | 2 | 1.00 | 0 | 0.00 |
| R003 | 11940000 | BUDGET G3 | B | 3 | 1.00 | 0 | 0.00 |
| R004 | 250000 | FUELWOOD DEMAND G4 | L | 4 | 1.00 | 0 | 0.00 |
| R005 | 42000 | SMALL TIMBER " G5 | L | 5 | 1.00 | 0 | 0.00 |
| R006 | 8000 | TIMBER DEMAND G6 | L | 6 | 1.00 | 0 | 0.00 |
| R007 | 4500 | STAPLE FOOD " G7 | L | 7 | 1.00 | 0 | 0.00 |
| R008 | 50 | SITE QUALITY I | B | 0 | 0.00 | 0 | 0.00 |
| R009 | 3300 | SITE QUALITY II | B | 0 | 0.00 | 0 | 0.00 |
| R010 | 350 | SITE QUALITY III | B | 0 | 0.00 | 0 | 0.00 |
| R011 | 3700 | TOTAL AREA | B | 0 | 0.00 | 0 | 0.00 |

**SUMMARY OF INPUT INFORMATION**

| | |
|---|---|
| NUMBER OF CONSTRAINT ROWS........................ | 11 |
| NUMBER OF NON-ZERO MATRIX ENTRIES................ | 90 |
| NUMBER OF VARIABLES INCLUDING SLACK............. | 27 |
| NUMBER OF PRIORITIES........................................ | 7 |
| NUMBER OF DECISION VARIABLES......................... | 11 |
| NUMBER OF POSITIVE DEVIATIONAL VARIABLES...... | 5 |
| NUMBER OF NEGATIVE DEVIATIONAL VARIABLES..... | 11 |
| NUMBER OF ARTIFICIAL VARIABLES...................... | 0 |
| NUMBER OF ITERATIONS TO FIND THE SOLUTION..... | 16 |

**OPTIMAL VALUE OF DECISION VARIABLES**

| VARIABLE | DESCRIPTION | AMOUNT |
|---|---|---|
| X002 | MANAGEMENT UNIT 2 | 26.64 |
| X004 | MANAGEMENT UNIT 4 | 143.31 |
| X006 | MANAGEMENT UNIT 6 | 29.73 |
| X010 | MANAGEMENT UNIT 10 | 305.73 |
| X011 | MANAGEMENT UNIT 11 | 3040.82 |

**GOAL ACHIEVEMENT**

```
GOAL LEVEL      1 SOCIOECONOMIC BENEFITS G1       COMPLETELY ACHIEVED
GOAL LEVEL      2 EMPLOYMENT G2                   COMPLETELY ACHIEVED
GOAL LEVEL      3 BUDGET G3                       COMPLETELY ACHIEVED
GOAL LEVEL      4 FUELWOOD DEMAND G4              COMPLETELY ACHIEVED
GOAL LEVEL      5 SMALL TIMBER DEMAND G5          COMPLETELY ACHIEVED
GOAL LEVEL      6 IS NOT ACHIEVED IN THE FOLLOWING CONSTRAINTS-
          *       R006, TIMBER DEMAND G6 ,
                  IS UNDERACHIEVED BY              199.25 WGTUNITS.
          * SUMMARY -
            GOAL  6 IS NOT ACHIEVED BY             199.25 WGTUNITS.
GOAL LEVEL      7 STAPLE FOOD G7                  COMPLETELY ACHIEVED
```

## GOAL SLACK ANALYSIS

THIS SECTION ANALYZES GOAL CONSTRAINTS WITH -B- TYPE INEQUALITIES WHERE EITHER A NEGATIVE OR POSITIVE DEVIATION IS NOT GIVEN A PRIORITY LEVEL. THE VALUE WILL THEN REFLECT THE AMOUNT BY WHICH THE EXACT GOAL WAS NOT ACHIEVED, EVEN THOUGH THE MINIMUM OR MAXIMUM GOAL LEVEL WAS ACHIEVED.

| ROW NO. | GOAL DESCRIPTION | EXACT GOAL LEVEL | NEGATIVE SLACK | POSITIVE SLACK |
|---|---|---|---|---|
| R003 | BUDGET G3 | 11940000 | 0.00 | 9495.38 |
| R008 | SITE QUALITY I | 50 | 50.00 | 0.00 |
| R009 | SITE QUALITY II | 3300 | 59.50 | 0.00 |
| R010 | SITE QUALITY III | 350 | 44.27 | 0.00 |
| R011 | TOTAL AREA | 3700 | 153.77 | 0.00 |

## RESOURCE UTILISATION ANALYSIS

*** ALL RESOURCES, AS EXPRESSED IN CONSTRAINTS, WERE USED***

STOP

**Table 10.1 Temporal trend (% increase over the decade 1971-1981) in economic activities of workers in Orissa.**

| District | Main workers | Cultivators | Agricultural labourers | Household industry workers | Non-workers | Total Rural $pop^n$ |
|---|---|---|---|---|---|---|
| Sambalpur | 24 | 15 | 35 | 15 | 5 | 19 |
| Sundargarh | 27 | 17 | 45 | 12 | -2.5 | 17 |
| Keonjhar | 19 | 16 | 25 | 10 | -4 | 11 |
| Mayurbhanj | 24 | 28 | 12 | 40 | -2 | 7 |
| Baleswar | 21 | 16 | 11 | 27 | 16 | 19 |
| Cuttack | 18 | 13 | 8 | 4 | 15 | 18 |
| Dhenkanal | 22 | 15 | 26 | 13 | 6 | 17 |
| Phulbani | 26 | 22 | 29 | 20 | -1 | 13 |
| Bolangir | 18 | 11 | 31 | 3 | -1 | 13 |
| Kalahandi | 26 | 20 | 39 | 14 | -3 | 14 |
| Koraput | 31 | 39 | 27 | 17 | -9 | 17 |
| Ganjam | 22 | 26 | 24 | -3 | -6 | 13 |
| Puri | 18 | 18 | 12 | 4 | 14 | 18 |

Source : Calculated from GOI (1986).

**Table 10.2 Average annual rates of growth in output, area and productivity of agriculture (1960-71).**

| Districts | Output | Area | Productivity |
|---|---|---|---|
| | **High output growth districts** | | |
| Ganjam | 7.1 | 6.9 | 0.1 |
| Phulbani | 6.2 | 0.9 | 5.1 |
| Cuttack | 5.7 | 2.6 | 3.1 |
| Balasore | 4.0 | 1.9 | 2.1 |
| Sambalpur | 3.7 | 0.9 | 2.7 |
| | **Low output growth districts** | | |
| Puri | 3.1 | 0.5 | 2.6 |
| Mayurbhanj | 2.6 | 1.8 | 0.8 |
| Koraput | 2.2 | 2.6 | -0.4 |
| Keonjhar | 0.9 | 0.5 | 0.4 |
| Bolangir | 0.8 | 0.4 | 0.4 |
| Kalahandi | 1.1 | 0.5 | -1.6 |
| Sundargarh | -4.3 | -2.5 | -1.9 |
| All Orissa | 3.2 | 1.8 | 1.4 |

Source : Annual issues of Government of Orissa reports on Season and Crops.

**Table 10.3 Distribution of the responses by the staff of social forestry based on open questions.**

| Reason | Weighted frequency for social forestry uptake | | |
|---|---|---|---|
| | High | Moderate | Low |
| Co-operation of the villagers | 60 | 18 | |
| Motivation of the villagers | 24 | 10 | |
| Participation by the villagers | 54 | 32 | |
| Suitable edaphic conditions | 57 | 24 | |
| Appropriate time of planting | 36 | 40 | |
| Less grazing incidence | 54 | 32 | |
| Supervision by staff | 36 | 40 | |
| Acute felt needs of villagers | 51 | 36 | |
| Good relations between staff & villagers | 33 | 34 | |
| Availability of land for plantations | 51 | 24 | |
| Unemployment/underemployment among the villagers | 54 | 38 | |
| Adequate training of staff | 21 | 30 | |
| Involvement of VFC members | 30 | 36 | |
| Motivation of the staff | 33 | 34 | |
| Declaration of plantations as village forests | 33 | 34 | |
| Amendment of the village forest rules | 48 | 24 | |
| Plantation's handover to VFCs | 39 | 40 | |
| Ownership documents | 60 | 32 | |
| Incentives to villagers | 45 | 14 | |
| Incentives to staff | 33 | 34 | |
| Publicity | 36 | 38 | |
| Villager's receptiveness | 45 | 16 | |
| High grazing incidence | | | 20 |
| Illicit felling | | | 9 |
| Less felt needs for forest produce | | | 18 |
| Unsuitable edaphic conditions | | | 16 |
| Lack of proper supervision | | | 14 |
| Lack of protection for plantations | | | 19 |
| Less number of VFC meetings | | | 10 |
| Conflict among the villagers | | | 16 |
| Malfunctioning of VFC | | | 20 |
| Lack of good staff | | | 12 |

**Table 10.4 Distribution of the responses by the staff of social forestry based on the closed questions.**

| Reason | Weighted frequency High | Moderate | Low |
|---|---|---|---|
| | **High uptake** | | |
| Enterpreunership and rationality of viilagers | 6 | 42 | 8 |
| Co-operation of villagers | 30 | 42 | - |
| Sincere, receptive and well trained staff | 36 | 38 | - |
| Employment to villagers | 9 | 32 | 12 |
| Additional income to villagers | 6 | 38 | 10 |
| Need for forest produce | 60 | 20 | 1 |
| Presence of active Panchayat | 6 | 18 | 20 |
| Presence of co-operative societies | 6 | 10 | 24 |
| Presence of local leadership | 9 | 40 | 8 |
| Land availability for plantations | 27 | 40 | 2 |
| NGOs participation | 36 | 30 | 4 |
| | **Low uptake** | | |
| Malfunctioning of VFCs | 20 | 22 | - |
| Poor JMP | 3 | 20 | 20 |
| Absence of village Panchayat | 3 | 20 | 20 |
| Absence of village co-operatives | 33 | 20 | 20 |
| Lack of good staff | 27 | 20 | 3 |
| No ownership documents | 33 | 30 | 5 |
| Poor communication between staff & villagers | 15 | 42 | 5 |
| Lack of labour supply from a village | 3 | 2 | 29 |
| Inadequate land availability | 33 | 30 | 5 |
| Lack of seedlings | 3 | 10 | 25 |
| Lack of preferred species | 6 | 38 | 10 |
| Fatalistic attitude among the villagers | 15 | 42 | 5 |

**Suggestions for a high uptake in future**

| **Provision** | **Number** |
|---|---|
| Provision of supplementary income during the period when trees mature | 15 |
| Adequate market facilities | 12 |
| Support prices for forest produce | 21 |
| Amendment to village forest rules | 15 |
| Involvement of women | 11 |
| Appointment of women staff | 2 |

**Table 10.5** **Data base to estimate consumption functions for the rural Orissa** (figures in Rs. millions and in millions for population).

| Year | Savings * | Savings ** | Income * | Income ** | Consumption * | Consumption ** | Population (rural) |
|---|---|---|---|---|---|---|---|
| 1950-51 | 1663 | 2925 | 70886 | 124685 | 69223 | 121759 | 294.5 |
| 1951-52 | 1707 | 2927 | 74079 | 127010 | 72372 | 124083 | 299.3 |
| 1952-53 | 1635 | 2949 | 73064 | 131805 | 71429 | 128855 | 305.1 |
| 1953-54 | 1805 | 3252 | 76363 | 137584 | 74558 | 134332 | 310.9 |
| 1954-55 | 1479 | 2978 | 66728 | 134364 | 65249 | 131386 | 316.6 |
| 1955-56 | 1537 | 3075 | 69930 | 139923 | 68393 | 136847 | 322.3 |
| 1956-57 | 1877 | 3497 | 77639 | 144644 | 75762 | 141147 | 328.9 |
| 1957-58 | 1795 | 3248 | 88438 | 160003 | 86643 | 156756 | 335.5 |
| 1958-59 | 2122 | 3763 | 88707 | 157318 | 86585 | 153555 | 342.8 |
| 1959-60 | 2125 | 3727 | 89600 | 157166 | 87475 | 153438 | 349.4 |
| 1960-61 | 2253 | 4059 | 94221 | 169765 | 91968 | 165706 | 351.9 |
| 1961-62 | 1958 | 3422 | 97120 | 169747 | 95162 | 166325 | 360.1 |
| 1962-63 | 2488 | 4163 | 101954 | 170587 | 99466 | 166425 | 369.0 |
| 1963-64 | 2843 | 4328 | 113149 | 172257 | 110306 | 167929 | 377.2 |
| 1964-65 | 3268 | 4611 | 136681 | 192869 | 133413 | 188257 | 384.5 |
| 1965-66 | 4678 | 6023 | 147066 | 189357 | 142388 | 183333 | 392.2 |
| 1966-67 | 6495 | 7330 | 171707 | 193770 | 165212 | 186440 | 399.9 |
| 1967-68 | 6285 | 6687 | 205009 | 218121 | 198724 | 211434 | 407.8 |
| 1968-69 | 6030 | 6430 | 207910 | 221712 | 201880 | 215281 | 415.9 |
| 1969-70 | 8343 | 8556 | 218511 | 224097 | 210168 | 215542 | 424.3 |
| 1970-71 | 8648 | 8648 | 231311 | 231311 | 222663 | 222663 | 432.8 |
| 1971-72 | 8685 | 8307 | 248926 | 238085 | 240241 | 229778 | 441.5 |
| 1972-73 | 11250 | 9567 | 274000 | 233007 | 262750 | 223440 | 449.4 |
| 1973-74 | 12793 | 9126 | 336324 | 239925 | 323532 | 230799 | 457.3 |
| 1974-75 | 16128 | 9853 | 402421 | 245864 | 386294 | 236010 | 465.2 |
| 1975-76 | 20038 | 12862 | 418182 | 268429 | 398144 | 255567 | 473.0 |
| 1976-77 | 24383 | 14693 | 449685 | 270983 | 425303 | 256290 | 480.7 |
| 1977-78 | 27228 | 15784 | 506030 | 293355 | 478802 | 277571 | 488.5 |
| 1978-79 | 35365 | 20125 | 539695 | 307123 | 504330 | 286998 | 502.0 |
| 1979-80 | 33623 | 16630 | 588672 | 291162 | 555049 | 274532 | 510.6 |
| 1980-81 | 42888 | 19276 | 697937 | 313683 | 655050 | 294408 | 519.9 |
| 1981-82 | 46375 | 18215 | 798445 | 313615 | 752070 | 295400 | 529.2 |
| 1982-83 | 50565 | 19344 | 883419 | 337955 | 832854 | 318612 | 538.3 |
| 1983-84 | 63248 | 22055 | 1041729 | 363255 | 978482 | 341201 | 547.3 |
| 1984-85 | 71685 | 23576 | 1140684 | 375155 | 1068999 | 351579 | 556.9 |

* current prices
** 1970/71 prices
Source : as explained in the text.

## Appendix 10.1

### Social forestry questionnaire (for villagers)

| | | |
|---|---|---|
| 1 Are you a: | Absentee landlord (please tick) | -- |
| | Big farmer | -- |
| | Small farmer | -- |
| | Marginal farmer | -- |
| | Landless labourer/artisan | -- |

(marginal farmer ≤ 2.0 ha, 2.0 < small farmer ≤ 4.0 ha, big farmer > 4.0 ha)

| | | |
|---|---|---|
| 2 Agricultural production: | Surplus | -- |
| | Meets household needs | -- |
| | Less than household needs | -- |
| 3 Are you a: | Full time worker | -- |
| | Part time worker | -- |
| | Casual worker | -- |
| | Seasonal worker | -- |
| 4 Quality of land: | Fully productuve | -- |
| | Less productive | -- |
| | Unproductive | -- |
| 5 Irrigation status | Fully irrigated | -- |
| | Partially irrigated | -- |
| | Rainfed | -- |
| 6 Do you have trees on village common/private lands | | Yes/No |
| If yes, what purpose do they serve presently: | Income | -- |
| | Household needs | -- |
| | Use of poorerland | -- |

7 Why do you participate in social forestry:-----------------------------------
-----------------------------------------------------------------------------------------------

| | | |
|---|---|---|
| a Basic needs for: | Fuelwood | -- |
| | Staple food and fruits | -- |
| | Small timber and poles | -- |
| | Timber | -- |
| | Fodder | -- |
| b Contingency needs for: | Medical purposes | -- |
| | Marriage | -- |
| | Natural calamities | -- |
| c Additional source of income: | Selling trees as cash crops | -- |
| | Wage income | |
| d Additional source of employment: | Yes/No | |
| e Checking environmental degradation: | Shifting cultivation | -- |
| | Forest degradation | -- |
| | Wasteland reclamation | -- |
| | Declining agricultural productivity | -- |
| f Tree planting is linked with religious sentiments: | | Yes/No |
| g Creating assets for future benefits: | | Yes/No |
| h Ease of labour management, less operating cost and time: | | Yes/No |
| 8 Do you get sufficient dung manure for your agricultural fields: | | Yes/No |
| If no do you envisage raising fuelwood plantations in order to divert dung: | | Yes/No |
| 9 Do you get adequate forest produce from the village forests for your domestic needs: | | Yes/No |
| If no, why? | No village forests in proximity | -- |
| | Not adequate trees in village forests | -- |
| 10 Do you get adequate forest produce from PF and RF: | | Yes/No |
| If no, why? | No village forests in proximity | -- |
| | Not adequate trees in village forests | -- |

11 Labour availability: Adequate --
Inadeaute --
Timely available --
Not available during peak season --

12 Cropping intensity: Once in a year --
Twice in a year --

13 Availability of seedlings: Adequate --
Inadequate --
Preferred species available --
Preferred species not available --

14 Location of nurseries: In proximity to planting site Yes/No

15 Survival of seedlings: Low (< 30%) --
Medium (30 to 60%) --
Good ( > 60%) --

If survival is low, mention reasons for this: Grazing & browsing --
Lack of technical knowhow --
Lack of inputs --
Refactory terrain --
Desease/pest attack --
Drought/flood --

16 Availability of technical advice from the Forest Department staff------------------------------------------------------------------------------------

| | | | |
|---|---|---|---|
| Planting techniques: | low | medium | good |
| Choice of tree species: | " | " | " |
| Rotation: | " | " | " |
| Cultural operations | " | " | " |

17 Channel of contact and the degree of response:

| | | | |
|---|---|---|---|
| Village Forest Worker: | low | medium | good |
| Social Forestry Supervisor: | " | " | " |
| Assistant Conservator of Forests | " | " | " |
| Deputy Director | " | " | " |

18 Marketing facilities for the forest produce: Adequate --
Inadequate --

19 Are village Panchayats actively associated with VFCs: Yes/No
If yes, state the degree of association: low medium high

20 Are NGOs actively involved in social forestry: Yes/No
If yes, state the degree of involvement: low medium high

21 Does the village has a co-operative society: Yes/No
(such as tree-grower society, etc.)

22 Are you aware of social forestry policy: Not aware --
(rights, responsibilities & legal aspects) Aware but do not have adequate details --
Aware of some details only --
Fully aware --

23 Do you possess ownership documents: Yes/No

24 Women involvement: low medium good

25 What types of issues cause conflicts in VFC decision-making----------------------------------------------------------------------------------------

Who helps in conflict resolution: Forest Department --
Panchayat --
Local leadership --
Majority opinion --

26 Are you aware of the provisions of the Joint Management Plan (JMP): Yes/No
If no, mention the reasons: No JMP exists --
VFC has informed --

27 Do you envisage reinvesting a part of income, obtained from the current social forestry plantations, in raising plantations in future: Yes/No
If yes, how? Through Panchayats --

| | | |
|---|---|---|
| | Private | -- |
| If no, what are reasons for not planting? | No time | -- |
| | No capital | -- |
| | No labour | -- |
| | Lack of knowledge | -- |
| | Others | -- |

28 What might encourage you to actively participate in social forestry activities------
---------------------------------------------------------------------------------

29 Do you have successors to take over social forestry plantations: Yes/No

30 Do you have inter-generational conflicts in social forestry decision-making: Yes/No

31 What disadvantages/disincentives do you see in participating in social forestry-----
---------------------------------------------------------------------------------

32 Household and village size-----------------------------------------------------

Number of earning members in household-------------------------------------

Education of respondent: Literate/illiterate

## Appendix 10.2

### Social forestry questionnaire for the staff of Forest Department

1 In which villages/ranges, has the uptake of social forestry been high-----------

------------------------------------------------------------------------

What is your understanding or measure of high/good uptake----------------------

2 What are the contributory factors for this high/good uptake--------------------

------------------------------------------------------------------------

| | | low | medium | high |
|---|---|---|---|---|
| a | Villagers are enterprising/rational: | | | |
| b | Villagers are cooperative: | " | " | " |
| c | Sincere, receptive and well trained staff: | " | " | " |
| d | Villagers get employment: | " | " | " |
| e | Villagers get additional income: | " | " | " |
| f | Need for forest produce: | " | " | " |
| g | Presence of active Panchayat: | " | " | " |
| h | Presence of active cooperative society: | " | " | " |
| I | Presence of local leadership: | " | " | " |
| j | Availability of land for plantations: | " | " | " |

k Mention if others-------------------------------------------------------

3 In which villages/ranges, has the uptake of social forestry been low---------------

------------------------------------------------------------------------

What is your understanding or measure of this low uptake------------------------

4 What are the contributory factors for this low uptake--------------------------

------------------------------------------------------------------------

| | | low | medium | high |
|---|---|---|---|---|
| a | Malfunctioning/absence of VFC: | | | |
| b | Poor/no JMP: | " | " | " |
| c | Inactive village Panchayat: | " | " | " |
| d | Absence of village cooperatives: | " | " | " |
| e | No good staff: | " | " | " |
| f | No ownership documents: | " | " | " |
| g | Communication gap between the staff and villagers: | " | " | " |
| h | Poor labour supply: | " | " | " |
| i | Inadequate land: | " | " | " |
| j | Inadequate stock of seedlings: | " | " | " |
| k | No preferred tree species: | " | " | " |
| l | Fatalistic attitudes of villagers: | " | " | " |
| m | Adequate village and protected forests: | " | " | " |
| n | Fragmentation of land holdings: | " | " | " |
| o | No economic rationality among the villagers: | | " | " |
| p | Poor peasant type qualities: | " | " | " |
| q | High productive paddy areas: | " | " | " |
| r | Cumbersome rules for tree cutting: | " | " | " |
| s | Inadequate timber transit rules: | " | " | " |

t Mention if others-------------------------------------------------------

5 Please suggest the contributory factors for a normal uptake of social forestry-------

------------------------------------------------------------------------

6 State your experiences about temporal trend of social forestry uptake-------------

------------------------------------------------------------------------

a Initially only big farmers joined:

b Small and marginal farmers, and labourers also joined later, although they were apprehensive initially:

c Which component of social forestry has become more successfull and acceptable over the period:

What is the evidence of this success:

i Area under the component increased:

ii More villagers joined:

7 Suggest main measures which if implemented will result in a high uptake of social forestry------------------------------------------------------------

a Provision of supplementary income during the period when tree mature:
b Adequate market facilities:
c Support prices:
d Amendment to the village forest rules:
e Involvement of women:
f More women staff:
g Subsidies:
h Mention if others--------------------------------------------------------

8 What problems do you face to get enough land for the village woodlots and FFRP------
---------------------------------------------------------------------------

9 Are selection and allocation of the land under FFRP scheme done in consultation of the beneficiaries Yes/No

10 Do you encounter labour shortages: a Normal agricultural season Yes/No
b Peak agricultural season Yes/No

11 State main constraints in successful implementation of social forestry in your area-
---------------------------------------------------------------------------

12 State main problems and improvements in constituting a representative VFC and drafting a good JMP---------------------------------------------------

13 How could social forestry be made more accepatble to villagers------------------
---------------------------------------------------------------------------

14 Do you think that rewarding the staff for their good work will improve their performance and involvement--------------------------------------

## Appendix 11.1

## I Rules at regional level (Orissa)

IF NOT Land is declared as village forest before planting
AND NOT Good rapport between the villagers and staff of the Forest Department
AND NOT The Forest Department staff is receptive towards the needs of villagers
AND NOT Staff of the Forest Department is competent and well trained
* AND NOT Staff is motivated
AND NOT Staff is committed to the basic philisiphy of social forestry
AND NOT Ownership documents are given to the villagers
AND NOT Social forestry activities are compatible to the social behaviour and agricultural cycle
AND NOT Developmental goals are clearly defined
AND NOT Resources required are timely available
AND NOT Decision-making is consistent and well thought
AND NOT Tree cutting rules are simple and adequate
AND NOT Optimal rotations for the species for different components are determined
AND NOT Present village forest rules are amended suitably
AND NOT Timber transit rules are simple and adequate
AND NOT Villagers are aware of tree and land tenures
THEN **Socioeconomic uptake of social forestry is low**

IF NOT Land is declared as the village forest before planting
AND NOT Good rapport between the villagers and staff of the Forest Department
AND NOT The Forest Department staff is receptive towards the needs of villagers
AND NOT Staff of the Forest Department is competent and well trained
* AND NOT Staff is motivated
AND NOT Staff is committed to the basic philisiphy of social forestry
AND NOT Ownership documents are given to the villagers
AND NOT Social forestry activities are compatible to the social behaviour and agricultural cycle
AND Developmental goals are clearly defined
AND NOT Resources required are timely available
AND NOT Decision-making is consistent and well thought
AND NOT Tree cutting rules are simple and adequate
AND Optimal rotations for the species for different components are determined
AND NOT Present village forest rules are amended suitably
AND NOT Timber transit rules are simple and adequate
AND NOT Villagers are aware of tree and land tenures
THEN **Socioeconomic uptake of social forestry is low**

IF NOT Land is declared as village forest before planting
AND Good rapport between the villagers and staff of the Forest Department
AND The Forest Department staff is receptive towards the needs of villagers
AND Staff of the Forest Department is competent and well trained
* AND NOT Staff is motivated
AND NOT Staff is committed to the basic philosiphy of social forestry
AND NOT Ownership documents are given to the villagers
AND Social forestry activities are compatible to the social behaviour and agricultural cycle

AND NOT Developmental goals are clearly define
AND Resources required are timely available
AND NOT Decision-making is consistent and well thought
THEN **Socioeconomic uptake of social forestry is moderate**

IF Tree cutting rules are simple and adequate
AND Timber transit rules are simple and adequate
AND Ownership documents are given to the villagers
AND Present village forest rules are amended suitably
AND Villagers are aware of tree and land tenures
AND Optimal rotations for the tree species for different components are determined
IF NOT Land is declared as village forest before planting
* AND NOT Staff is motivated
AND NOT Social forestry activities are compatible to the social behaviour and agricultural cycle
AND NOT Good rapport between the villagers and staff of the Forest Department
AND NOT Staff of the Forest Department adopts a participatory approach
THEN **Socioeconomic uptake of social forestry is moderate**

IF Good coordination between the Forest Department and Rural Development Agencies
AND The land is compatible with the social forestry component to be established
AND Village community agrees to raise social forestry plantations
AND The Forest Department staff is receptive towards the needs of villagers
AND Staff of the Forest Department adopts a participatory approach
AND NOT Optimal rotations for the species for different components are determined
AND NOT Ownership documents are given to the villagers
AND NOT Present village forest rules are amended suitably
* AND NOT Staff is motivated
AND Staff is committed to the basic philisophy of social forestry
AND Tree cutting rules are simple and adequate
AND Timber transit rules are simple and adequate
AND Staff is committed to the basic philisophy of social forestry
THEN **Socioeconomic uptake of social forestry is moderate**

IF NOT Good coordination between the Forest Department and Rural Development Agencies
AND Staff of the Forest Department is competent and well trained
AND Good rapport between the villagers and staff of the Forest Department
AND Staff of the Forest Department adopts a participatory approach
AND Staff is committed to the basic philisophy of social forestry
AND Villagers are aware of tree and land tenures
AND Adequate community or unused governement land exists in proximity
AND Adequate market facilities for the forest produce exist
AND Tree cutting rules are simple and adequate
AND Timber transit rules are simple and adequate
THEN **Socioeconomic uptake of social forestry is moderate**

## II Rules at the village level (Orissa)

* IF NOT Participation of the villagers is adequate
AND NOT Local NGOs are actively involved in social forestry activities
* AND NOT Representative village leadership exists
* AND NOT Satisfactory functioning of VFC
* AND NOT Adequate prices for the villagers' forest produce
AND NOT Need for additional income
AND NOT Adequate community or unused governement land exists in proximity
AND NOT Nurseries are in proximity of the village
* AND NOT Plantations are well protected
* AND NOT Surplus labour is available in the village
AND NOT Adequate stock for tree seedlings is available
AND NOT Planting techniques and other necessary knowhow is dessiminated to the villagers
AND NOT Villagers are generally risk takers
* AND NOT Villagers have felt needs for forest produce
THEN **Socioeconomic uptake of social forestry is low**

IF High illeteracy in the village
AND high factionalism in the village
AND Ignorence about the provisions of the Joint Management Plan
AND NOT Provisions for sharing the produce are worked out
AND NOT Watering facilities for nurseries are adequate
AND NOT Adequate community or unused governement land exists in proximity
AND NOT Nurseries are in proximity of the village
* AND NOT Plantations are well protected
* AND NOT Villagers have felt needs for forest produce
THEN **Socioeconomic uptake of social forestry is low**

* IF NOT Plantations are well protected
* AND NOT Villagers have felt needs for forest produce
AND Pest attack in plantations
THEN **Socioeconomic uptake of social forestry is low**

IF High grazing pressure
* AND NOT Adequate prices for the villagers' forest produce
* AND NOT Villagers have felt needs for forest produce
* AND NOT Adequate marketing facilities for the forest produce
* AND NOT Participation of villagers is adequate
AND NOT Planting techniques and knowhow is dessiminated
* AND NOT Satisfactory functioning of VFCs
AND Fatalistic attitude of villagers
THEN **Socioeconomic uptake of social forestry is low**

IF Cooperative and receptive villagers
AND Economically rationale and enterprising villagers
AND NOT Local NGOs are actively involved
AND Leadership advocates the interests of the rural poor
* AND Leadership is based on all socio-political groups
AND Members of VFC are actively involved in decision-making
* AND All socio-cultural groups are represented in VFC
AND Meetings of VFCs are conducted regularly
AND VFC maintains good relations with Panchayats
AND Social organisations are involved in decision-making
AND Power structure of the village is considered

AND Caste heirarchy is considered
AND Social and intergenerational mobility is accounted for
AND Value system of the viilagers is respected
AND NOT Tree grower societies exist
AND Need for additional income
AND Adequate community or governement unused land exists in proximity
AND NOT Nurseries are in proximity of the village
AND Protection is provided by the Forest Department through watchers
THEN **Socioeconomic uptake of social forestry is moderate**

IF NOT Economic opportunities are available
* AND Representative village leadership exists
* AND Satisfactory functioning of VFCs
AND Adequate community or unused governement land exists in proximity
* AND Adequate prices for the villagers' forest produce
* AND Surplus labour is available
* AND Plantations are well protected
AND Villagers get seedlings of preffered tree species
AND Trees have religious connotations or sanctity
THEN **Socioeconomic uptake of social forestry is moderate**

IF Cooperative and receptive villagers
AND NOT Economically rationale and enterprising villagers
AND NOT Local NGOs are actively involved
* AND NOT Leadership is based on all the socio-political groups
AND Community centres exist in the village
AND Management of community centres is proper
AND Members of VFC are actively involved in decision-making
AND Members of VFC are properly elected
AND NOT Women are adequately represented in VFC
AND NOT SCs and STs are adequately represented
AND Meetings of VFC are conducted regularly
AND Inadequate PF and RF in proximity
AND Social organisations are involved in decision-making
AND Power structure of village is considered
AND Villager need additional income
AND Adequate community or unused governement land exists in proximity
AND Nurseries are in proximity of the village
AND Protection is provided by the Forest Department through watchers
THEN **Socioeconomic uptake of social forestry is moderate**

IF Local NGOs are actively involved
AND Leadership advocates the interests of the rural poor
* AND All socio-cultural groups are represented in VFC
AND VFC maintains good relations with Panchayats
AND Members of VFC are actively involved in decision-making
* AND Plantations are well protected
AND NOT Community centres exist in the village
AND Women are adequately represented in VFC
AND Meetings of VFC are conducted regularly
* AND Adequate prices for the villagers' forest produce
AND Adequate stock of seedlings is available
AND NOT Adequate forests in proximity
THEN **Socioeconomic uptake of social forestry is moderate**

**Table 12.1 Socioeconomic costs of agroforestry (maiden crop), when v = 3.** (figures in Rsw and EWR = 0.33w)

| Yr | Descr^n | Financial cost | Economoic cost | Combined wt. | SE[1] cost of cons^n loss to society | SE[2] cost of cons^n loss to society | Total SE cost | Combined wt. | Total SE benefits | Net SE cost-to society |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6)=(4) X(5) | (7)=(5)X {(3)-(4)} | (8)= (6)+(7) | (9) | (10)= (9)X{(3) -(4)} | (11)= {(8)-(10)} |
| 0 | Goods | 770 | 770 | 3.02 | 2325 | _ | 2325 | _ | _ | 2325 |
| | Main workers | 295 | 98 | " | 295 | 96 | 890 | 0.57 | 239 | 652 |
| | Subsidiary workers | 3485 | 1154 | " | 3484 | 7041 | 10525 | 2.20 | 5133 | 5392 |
| 1 | Goods | 1230 | 1230 | 3.02 | 3715 | _ | 3715 | _ | _ | 3715 |
| | Main workers | 207 | 68 | " | 207 | 418 | 624 | 0.57 | 79 | 545 |
| | Subsidiary workers | 2443 | 809 | " | 2442 | 4936 | 7379 | 2.20 | 3598 | 3780 |
| 2 | Goods | 700 | 700 | 3.02 | 2114 | _ | 2114 | _ | _ | 2114 |
| | Main workers | 134 | 44 | " | 134 | 271 | 405 | 0.57 | 51 | 354 |
| | Subsidiary workers | 1586 | 525 | " | 1585 | 3204 | 4789 | 2.20 | 2336 | 2454 |
| 3 | Goods | _ | _ | _ | _ | _ | _ | _ | _ | _ |
| | Main workers | 31 | 10 | 3.02 | 31 | 63 | 94 | 0.57 | 12 | 82 |
| | Subsidiary workers | 369 | 122 | " | 369 | 745 | 1114 | 2.20 | 543 | 571 |

1 Socioeconomic cost of consumption loss to society due to the economic cost of the Agroforestry.

2 Socioeconomic cost of the consumption loss to society due to extra commitment to the economy (due to the increased consumption by the workers).

**Table 12.2 Socioeconomic PNW and LEV for agroforestry (maiden crop) with varying tree rotations and site quality (when v = 3). (in Rsw)**

| Rot$^n$ | Criteria | Version I | | |
|---|---|---|---|---|
| | | SQ I | SQ II | SQIII |
| 5 | PNW | 94933 | 7579 | -4191 |
| | LEV | 983936 | 78550 | -43433 |
| 6 | PNW | 112998 | 9197 | -3319 |
| | LEV | 985743 | 80230 | -28956 |
| 7 | PNW | 135259 | 11806 | -446 |
| | LEV | 1021465 | 89157 | -3366 |
| 8 | PNW | 150362 | 13633 | 451 |
| | LEV | 1003457 | 90979 | 3009 |
| 9 | PNW | 162678 | 15268 | 1296 |
| | LEV | 974579 | 91470 | 7762 |
| 10 | PNW | 172628 | 16616 | 2072 |
| | LEV | 939952 | 90472 | 11280 |
| 11 | PNW | 180626 | 17798 | 2772 |
| | LEV | 902887 | 88967 | 13858 |
| 12 | PNW | 186993 | 51474 | 3398 |
| | LEV | 865212 | 238168 | 15721 |
| 13 | PNW | 191996 | 53987 | 18964 |
| | LEV | 828037 | 232835 | 81787 |
| 14 | PNW | 195859 | 56088 | 20405 |
| | LEV | 791992 | 226803 | 82513 |
| 15 | PNW | 198761 | 57827 | 21660 |
| | LEV | 757418 | 220360 | 82540 |
| 16 | PNW | 200854 | 59249 | 22744 |
| | LEV | 724489 | 213715 | 82037 |
| 17 | PNW | 202260 | 60396 | 23673 |
| | LEV | 693255 | 207010 | 81141 |
| 18 | PNW | _ | 61301 | 24464 |
| | LEV | _ | 200343 | 79952 |
| 19 | PNW | _ | 61995 | 25129 |
| | LEV | _ | 193782 | 78546 |
| 20 | PNW | _ | 62504 | 25681 |
| | LEV | _ | 187373 | 76985 |