CHAPTER II

REVIEW OF LITERATURE

This chapter is devoted to the review of relevant research work carried out by the other investigators. Review of literature provides guidelines in formulating the framework of the study, deciding and methods of approach to the problem and analyzing the data collected. It helps to compare the results of such studies and reasoning for them. However, very few investigators have tried to study the Economics of production of artificially regenerated teak plantation on farmer’s field. Some of the relevant work published in the forestry journals, periodicals, reports, etc is presented in this chapter.

The findings of previous studies related to tree plantation/ farming are presented under the following heads.

2.1 Age

Nimje et al. (1991) reported that a large number of farmers above 30 years of age were inclined to adopt the social forestry programme.

Singh (1991) revealed that majority of the respondents adopting social forestry programme were middle age.

2.2 Education

Dove (1988) noted that majority of the farmers were interested in planting tress and hence were potentiality receptive to farm forest development efforts by the Forest Department. The interest was highest among farmers with higher education and was quite low among uneducated farmers.

Bodiger et al. (1991) observed that there was no significant relationship between education of farm women and knowledge about forestry.

Joshi and Sharma (1991) indicated that education of the individual farmer influenced the success of social forestry programme (farm forestry) at individual level.
Nimje et al. (1991) and Singh (1991) also revealed that majority of the respondents in the social forestry programme were literates.

2.3 Land holding

Malla and Fisher (1987) indicated that in recent years, there had been increasing interest in planting trees on private land in Nepal, but this had primarily benefited land-wealthy people. Tree density was not related to land holding size, although the average number of trees per farmer increased with land holding size.

Dove (1988) noted that interest of farmers to take up a farm forestry programme was found to be the highest having large irrigated holding. It was also quite high among the farmers with rainfed holdings.

Sandhu (1990) stated that eucalyptus plantation gained popularity and was preferred by increasing number of farmers irrespective of their holdings.

Joshi and Sharma (1991) indicated that size of land holding influenced the success of social forestry programme (farm forestry) at individual level.

Nimje et al. (1991) and Roy (1991) observed that majority (84.3%) of the farmers who had adopted social forestry programme possessed less than 5 ha of land holding.

Singh (1991) noted that majority of the respondents adopting social forestry programme had medium size land holding.

Mercer (1992) stated that both theoretical and empirical work suggest that innovation requiring large fixed implementation cost reduce and delay adoption of agro-forestry by small holders.

2.4 Family annual income

Vartak (1982) stated that the farmers of low and medium income group from Western India adopting farm forestry claimed that some additional income had accrued to them from farm forestry.
Prahasto (1988) in a survey of 124 forest farmers in the Blora and Randublatung forest unit in Indonesia reported that average income of the farmers from forestry was Rs. 159000 p.a.

Bodiger et al. (1991) revealed that there was non significant relation between annual income of farm men and their knowledge of forestry.

Roy (1991) noted that 67 per cent of the beneficiaries of farm forestry had annual income of less than Rs. 6000/-.

Singh (1991) observed that respondents adopting social forestry programme belonged to medium category of annual income.

2.5 Socio-economic status

Joshi and Sharma (1991) indicated that socio-economic position of an individual farmers in a village social system may influence his knowledge on adoption of social forestry.

Nimje et al. (1991) reported that about 56 percent of farmers put their land between 5 to 12 acres under tree plantation followed by 44 per cent of farmers putting the land upto 2.5 acres under tree plantation.

Singh (1991) reported that majority of the respondents adopting social forestry programme had medium level of socio-economic status.

Bhople et al. (1995) reported that the proportion of the respondents having area upto 0.50 ha under agro-forestry was relatively higher (45.63%) than the respondents (22.92%) having more than 2.00 ha of agro-forestry. The average size under agro-forestry of the respondents was found to be 1.35 ha.

2.6 Infrastructural facilities

Buck (1980) stated that farmers decisions are affected by two sets of factors viz, environmental (agroclimatic) and socio-economic. These factors include income, capital stocks, needs and preferences, labour availability and access of material and services. A useful assessment of the potential for adoption of agro-forestry should focus on these sets of factors simultaneously.
Tewari (1991) stated that now people have become aware of the importance of plantation of trees. The technical, biological, socio-economic and policy research could grow useful in making afforestation programme successful.

2.7 Economic motivation

Das and Sarkar (1970) revealed that higher was the economic motivation more the favorable attitude towards improved farming practices.

Garg (1983) stated that in a programme such as social forestry, the involvement of people is of vital importance its success. People’s participation can only be observed by assuring them that the benefits from planting the trees will accrue to them and that the economic profitability in choosing the alternative of growing trees is superior to the other uses of land.

Joshi and Sharma (1989) indicated the economic motivation of the respondents adopting social forestry was medium.

2.8 Land use pattern

Powar (2006) studied the land utilization in Amravati division. The average size of holding in the division was 3.76 hectare, net cropped area 3.52 hectare, grossed cropped area 4.85 hectare with relatively higher cropping intensity i.e. 138.0 per cent and hike in irrigation facilities.

Ingale (2007) studied economic stability of farms in Akola district. The pattern of land utilization fallowed by farmers in Akola district was also studied. The average size of land holding was 2.92 hectare with net sown area 2.72 hectare and gross cropped area 3.13 hectare resulting cropping intensity 114.65 per cent indicating the percent of irrigation as 12.77 per cent. Major area 74.44 per cent is rainfed, however a some land is fallow i.e. 6.07 per cent.

2.9 Cropping pattern

Venkataraman and Prahaladachan (1980) examined the cropping pattern changes in Maharashtra. The study concluded that during last 25 years the grossed cropped area in the state has increased by 9.30 lakh hectare. The major contributors to
area are sorghum, cotton, rice, wheat and sugarcane. The cropping pattern in the state remained stable during 70’s and 80’s.

Thorve and Galgalikar (1985) conducted a study on economics of diversification in Akola district. The study suggested that sorghum and cotton are the major crops grown in the district fallowed by green gram. Wheat is preferred as rabi crop by the farmers in the district.

Bandgar (1997) studied the cropping pattern of Akola district in the state. The study revealed that soyabean is replacing cotton, sugarcane and pigeon pea because of high yields.

Tingre (2005) studied the cropping pattern behaviour in Vidarbha. The cropping pattern of Akola district was dominated by cotton 30.72 per cent, kharif sorghum 14.08 per cent, soyabean 10.21 per cent, pigeonpea 8.11 per cent. Gram and safflower are emerging as rabi crops. The grossed cropped area during 2001-02 was 10,85,732 hectare. As regards the cropping pattern of Yavatmal district the grossed cropped area was 10,28,982 hectare. The major contributors during kharif are cotton 30.04 per cent and soyabean 17.52 per cent, kharif sorghum 11.54 per cent, pigeonpea 9.68 per cent. During rabi gram and wheat are taken up by Yavatmal farmer which contributes 3.56 per cent and 1.30 per cent to the grossed cropped area. It is revealed from the above data that the cropping pattern of Akola and Yavatmal district is kharif dominated. Cotton, soyabean, pigeonpea are important crops grown during kharif while gram and wheat are preferred during rabi season.

Powar (2006) studied the per farm cropping pattern of Amravati Division. Cotton, soyabean and pigeonpea, covered 61 per cent of grossed cropped area. Sorghum, green gram and black gram are another important kharif crops grown in the division. During rabi more than 20 per cent of grossed cropped area is covered by wheat and gram. It is observed from the above that cropping pattern of the division is kharif dominated as 79 per cent of the grossed cropped area is covered during kharif season.

Ingale (2007) studied the cropping pattern behavior in Akola district. It was observed from the study that cotton is the predominant crop grown in the district
covering 42.17 per cent of grossed cropped area. Gross cropped area 87.22 per cent is sown during kharif while 12.78 per cent is under rabi crops.

2.10 Fixed capital investment

Powar (2006) studied the fixed capital investment by farmers in Amravati Division. The total investment was Rs. 1,76,019 with the share of land 43.25 per cent, farm building 47.77 per cent, livestock 6.63 per cent and implements 2.95 per cent. The average farm size reported in the division was 3.76 hectare.

Dixit (2007) in his paper on private natural forest management in Madhya Pradesh stated that private forest management is the only hope of achieving 33 percent of forest cover in the state.

Ingale (2007) studied the per farm fixed capital investment in Akola district. The study revealed that per farm total investment is Rs. 2,63,264 for a farm size of 2.93 hectare. The share of land was 63.32 percent, building 30.38 per cent, livestock, implements and machinery, store and shed and other amenities contributed 6.30 per cent indicating land and building are the items of fixed capital investment.

2.11 Management

Sono (1975) presented two growth curves for natural Tectona grandis in Thailand, based on data from different sources, and gave sociological, economic and technological reasons for concluding that the present girth limit of 213 cm should be reduced to 150 cm.

Samanta and Roy (1981) reported that the adoption behavior of the farmers in the high management orientation was appreciably superior to that of farmers with land management orientation.

Pangavhane (1982) concluded that the farmers with more management orientation had better knowledge and experience related to farming.

Adegbeihn (1982) studied the effect of spacing on grown and yield of Tectona grandis. The study revealed that spacing affected mean height and top height. However, the total volume of yield produced remained unchanged.

Crofts (1984) studied the integration between forests and farmland on Scandinavian farms. Where most farms were 66 per cent under forest, existing in
conjunction with arable crops. Most farmers are employed part time off the farm. Every holding is classified and the owner is taxed on the estimated annual growth of the forest. It is accepted that under poor management the owner was paying tax on income that had not been earned, but under good management the farmer could make extra income without paying tax on it. It is further highlighted that government is trying to increase yields from forestry.

Singh (1987) observed that in Indian sub-continent the actual number of trees planted however vary and depend on agro-ecological conditions and on farmer’s perception of opportunity costs for farming inputs.

Totej et al. (1988) studied effect of NPK on the growth of teak seedlings in nursery. It is revealed that, teak seedlings may become transplantable size within 4 months duration. A four months old seedling produced shoot and root of about 116.72 g and 42.33 g respectively. Shoot length of this seedling was 41.84 cm while as root length was 48.13 cm. Girth size at collar was 4.75 cm. shoot/ root ratios of fresh weight and also of length of teak seedlings tended to approach one in September and October (Sixth and Seventh month after sowing) in heavy texture soil.

Patel (1988) carried out a study on high density tree planting technique in a semi-arid area of Gujarat. The technique has been advocated as a strategy for farm forestry and is aimed to produce timber, fuelwood, rayon and paper pulp form multipurpose trees planted at densities as high as 25000 ha$^{-1}$. Particularly promising species were Eucalyptus hybrid, E. tereticornis, Leucaena leucocephala, Prosopis juliflora and Acacia tortilis, with two other species also promising (Tectona grandis and Melia azedarach). It has been submitted that the plantations are usually labour intensive (depending on the spacing) but with proper care, and with fertilizer and insecticide application, can provide 112.5 t ha$^{-1}$ of biomass per annum to be cost effective.

Negi et al. (1990) studied biomass production and distribution of nutrients in 20 years old teak and gamar plantation in Teliamura Forest Division in Tripura state during January, 1987. The results of the study indicated that the productivity for teak comes out to be 69 t ha$^{-1}$ year$^{-1}$ and 8.2 t ha$^{-1}$ year$^{-1}$ for gamar.

Chacko et al. (1991) conducted a study in which teak was raised in a second rotation plantation with rice and gingerly as the first year taungya crops. The site was
at Mundakadavu, Karulai Range, Nilambur Forest Division, Kerala. Taungya yields and teak survival and growth were non significantly affected by the different treatments (which involved removal and burning of different sized slash) and teak survival and growth was not affected by the practice of taungya. Treatment effects on soil chemistry and weed growth were transitory. Salvaging slash for fuelwood increased revenue.

Reddy (1995) found that planting of teak under irrigated condition yields more timber than unirrigated condition in 20 years.

Gogate and Joshi (1996) in their study on growth response to irrigation revealed that use of sewage water in teak plantation as a source of irrigation. Sewage water is rich in NPK and S. The use of sewage water will not only decrease cost of plantation but will reduce the pollution as well.

Haque (1996) discussed the technical feasibility and financial viability of intensive, irrigated teak plantations, based on observations made in Periyar District, Tamil Nadu, in plantations financed both by banks and farmers' own resources, and of various ages (1.5-11 yr). It is suggested that intensive, irrigated teak plantations may not produce wood with the qualities for which teak is famous, but that such wood has a ready use in an otherwise wood starved market. However, such schemes are viewed not only as technically feasible but also financially viable, and are eligible for institutional finance, if raised for the development of waste lands. The IRR of such schemes exceeds 30 per cent.

Murugesh et al. (1997) study was carried out at the Forest College and Research Institute (Tamil Nadu) to elicit information on the growth and yield of teak (*Tectona grandis* L.F.) under irrigated condition. The oldest (11 years) available irrigated teak had a mean volume of 0.109m$^3$ (3.85 ft$^3$) tree with a mean annual volume increment (MAI) of 0.0099 m tree. Based on this, the volume at 20 years was extrapolated to be 0.199 m (7.00 ft) tree. Based on the diameter class of 11 years wood lot, only the diameter class of 15.1 – 25.0 cm was expected to attain a girth of 90 cm in 20 years and trunk with a GBH of 90 cm and above alone was considered as a log. This class of trees accounted for only 13.7 per cent in 11 years wood lot raised.

Shende *et al.* (1998) conducted study of 80 farmers in 31 villages of Akola District, Maharashtra, India, of whom 34 grew teak, 31 eucalyptus, and 15 grew
bamboo. The data was used to examine the productivity and efficiency of inputs used in production by applying a Cobb-Douglas production function equation. Variables examined are: tree crop yield; area under the crop in hectares; human labour days; bullock labour days; value of seedlings; expenditure incurred on manures and fertilizers; irrigation on plantation; expenditure on plant protection.

Krishnapillay et al. (1999) the potential of planting Teak (*Tectona grandis*) and Sentang (*Azadirachta excelsa*) in Malaysia on a plantation basis for commercial timber production is discussed. Properties of these species, their suitability for growth in Malaysia and the financial return on investment are considered.

Mohan Jha and Jha (1999) made a comparative study at 3 years 3 months old of the performance of a conventional rainfed Teak plantation of the Maharashtra Forest Department (India) and an irrigated private (farmer's) teak plantation on an adjacent site. Both plantations were weeded and insecticides applied for the first 3 years, and both were at 2x2 m spacing. Data collected on girth and height growth of the 2 plantations showed that irrigation in the early phase had positive effects on growth. An economic analysis of the plantations gave the benefit cost ratio in the irrigated plantation as 1.48, and that in the non-irrigated plantation as 1.15. The net profit in the irrigated plantation was 2.28 times more than that in the non-irrigated plantation. It is concluded that teak can be used profitably as a farm forestry species.

Maessen (2001) described the development of teak plantations, with special attention to predictions of average annual increment, teak quality and prices. The establishment and management of plantations is outlined, and damage by forest fires, pests and plant diseases is described. The need for certification and monitoring of growth, as well as future trends and opportunities for investments are discussed.

### 2.12 Agroforestry

Mutanal et al. (2001) reported that an experiment involving arable crops (*Oryza sativa, Zea mays*) and (*Crotalaria juncea*), silvicultural trees (*Eucalyptus tereticornis, Casuarina equisetifolia, Albizia moluccana, Falcataaria moluccana* and *Dalbergia sissoo*) horticultural crop sapota (*Achras sapota* [*Manilkara sapota*] and *pasture grass (Panicum maximum)*, in black clayey soils in Dharwad, Karnataka, India during 1976, for economic evaluation. Results showed that fruit yield was higher with sapota + field
crops. A lowest fruit yield was observed in sapota + field crops + *E. tereticornis* and sapota + field crops + *T. grandis*. Among the tree species, *E. tereticornis* recorded the highest timber volume. Income from trees was higher in field crops + sapota with inclusion of teak and *E. tereticornis* trees. Higher income from *A. sapota* was in sole crop and with *F. moluccana*. Total average income from field crop + sapota + teak was higher by 46% than with field crops + sapota. Net pay back benefit: cost ratios were highest in sapota + teak.

**Mutanal et al.** (2002) In an experiment consisting of teak (Silvi), field crops (Agri) and grass/ subabul (Pastoral) during 1984 on red gravelly soils, MRS, UAS, Dharwad, Karnataka, India, under rainfed conditions. Teak was planted at 10 or 20 m apart with 2 m between plants. Pasture crops (Guinea grass (*Panicum maximum*)) and subabul (*Leucaena leucocephala*) were planted on either side of teak row. Marketable timber volume was higher in groundnut + teak (25.3 m$^3$ ha$^{-1}$) and sorghum + teak (23.147 m$^3$ ha$^{-1}$) and was reduced with inclusion of grass or subabul with teak alley. Fodder yield was significantly higher in grass than subabul. Grain/pod yields were lower in agroforestry systems than their solecroppings. Net return was higher in groundnut + teak (Rs.26585 ha$^{-1}$ year$^{-1}$) sorghum + teak (Rs.25259 per ha$^{-1}$ year$^{-1}$) and sorghum + teak + subabul (Rs.21475 ha$^{-1}$ year$^{-1}$) as compared to sole crops. Benefit : Cost ratio was higher (2.37) in sorghum + teak followed by groundnut (2.32) as compared to sole crops. Inclusion of sorghum or groundnut with teak was economically viable agroforestry system as compared to inclusion of pastures along teak or sole cropping.

**Yadav et al.** (2003) conducted a study in sandy loam experimental field in Jhansi, Uttar Pradesh, India. Black gram and wheat were grown every year during kharif and rabi season intercropped between teak (*Tectona grandis*), neem (*Azadirachta indica*) and safed siris (*Albizia procera*). The mean crop yield of both black gram and wheat was maximum in the no-tree plots while the minimum was obtained under safed siris. Wheat production under safed siris was lowest in all years of study. Maximum pruned biomass was obtained from safed siris in all the years of study except during 2000 where teak gave more biomass. Maximum mean height and diameter was obtained from crops under safed siris. The cost of cultivation was higher under the safed siris based agrosilviculture system. The average annual net returns from teak,
neem and safed siris based agrosilvicultural systems were Rs 70121, 25621 and 5919, respectively, while the traditional cropping system had a net return of Rs 5261.

2.13 Economics

Rahman (1973) in the light of studies made in Bangladesh and other countries highlighted the economics of the present practice of clear felling the Bamboos and replacing them with Teak plantations concluded that exclusive Bamboo management in area is likely to be more profitable than raising Teak.

Mangundikoro (1974) described an improved cost accounting system for the Indonesian state forest enterprise Perhutani in the Tectona grandis forests in E. and central Java, based on an investigation in 1972. The system enables the unit product cost of the separate products (logs, squares, and fuelwood) to be determined by means of conversion factors based on the product value, transport cost, and harvesting cost.

Goswami and Singh (1976) studied investment in afforestation of deep ravines with Bamboo, Sissoo and Teak as additional sources of income for farmers. Data were obtained from experiments covering 15 years for Teak and Sissoo and 10 years for Bamboo. Costs and returns were estimated from average prices during the past 3 years and were discounted at 12 per cent. The economic rotation was taken as 30 years. Financial analysis showed that Sissoo had the highest benefit/cost ratio of 2.9, the highest internal rate of return of 20 per cent and the shortest pay-back period of 10 years. Bamboo had the next shortest pay-back period but the internal rate of return of 12.45 per cent was little higher than the computed discount rate.

Rahman (1977) in his study on profitability of teak reported that the assessment was based on a 60-year rotation of Tectona grandis plantations, and prices for 1975-76. The capital value was calculated for plantations of site quality (SQ) I-III. A net profit was indicated for all SQ's at an interest rate of 8% (the government borrowing rate), but only for SQ's I and II at an interest rate of 13%. When the internal rate of return was calculated for SQ's I-V, a net profit was indicated for SQ's I and II, and a net loss for SQ's IV and V. The teak plantations in the Chittagong, Cox's Bazar and Sylhet forest divisions all fall below SQ III, and it is suggested that in order to improve their profitability, it will be necessary to improve their management, or perhaps grow species other than teak on such sites.
Rahman (1981) reported that two regression equations were tested to explain price changes in response to size variation in teak logs, using data from randomly selected teak merchants in Chittagong. A logarithmic equation (log $Y = a + b \log X$, where $Y = \text{price}$, $X = \text{mid girth of logs}$, and $a$ and $b$ are const.) best explained the variation. This equation was used with average cost/acre values for plantation operations and yield tables to calculate internal rates of return for teak plantations of site indices 15-40 under 30 per cent and 50 per cent yield reductions. Social rates of return (which include opportunity costs and other related social costs and linkage effects over the economy) are also considered. On many sites these are lower than internal rates of return or even negative.

Sangal (1981) stressed that fuel and fodder have to be made available at little or no cost to the rural communities. While planning individual agro forestry projects, the actual needs of the community should get priority rather than economics of the project, at least to begin with. This approach will help in enlisting the cooperation of the people without which no plans and programme can be successfully implemented. Without willing cooperation of the people the protection of forests, which is vital, will become impossible.

A report by (Anon 1984) of economic research division of the Birla Institute of Scientific Research highlighted incentives to be provided to farmers and departmental staff for good work in planting. In case of farmers, survivals during the second and third year should form the main basis. The sharing of benefits of the programme between the state, which makes the initial investment and the residents of the adjoining villages, should be on an ambiguous basis, declared in advance.

Keith (1986) stressed on economic and non commercial incentives in persuading farmers to grow trees despite risks and difficulties based on field interviews in India. It was highlighted that formal and non formal education via school, media and organizations encourage people to grow trees. But people need economic support for long term benefits. Economic support may stimulate large farmers but smaller farmers may require additional market support and credit schemes for financial security before tree harvesting.
Peele and Piearce (1986) in their study on the main teak (*Baikiaea plurijuga*) products produced in Zambia are railway sleepers for local consumption, mining timber for local consumption and for export, and parquet flooring for export. Local consumption accounts for about 80 per cent of the total production. The main export market has been South Africa, but prices for Zambian products are not competitive.

Chambers *et al.* (1987) observed that the trees have rarely been regarded as a means of savings for the poor. It is further pointed out that trees and their products have become more valuable and easier to market. Consequently, the trees have increased importance, since they provide savings and security for the poor, for savings and security, trees compare quite well with jewellery, stock, land and bank deposits. Disadvantages of trees can include insecure rights, restrictions on cutting, and problems with marketing. Advantages include cheap and easy establishment, rapid appreciation in value, divisibility and regeneration. It has been stressed that the policy implications on the present evidence and analysis should include tree reform, improved marketing and prices, with rights to harvest, cut and sell similar to the withdrawal rights of depositors in savings banks.

Mishra *et al.* (1987) studied price trends of teak in Orissa and concluded that, the annual growth rate in prices is higher in the larger girth classes, there was comparatively steep rise in teak prices after 1974, and the trend remains almost the same up to 1981. Rise in teak prices indices is much higher than the general indices, and after 1974 this gap has been widened which may be due to economic causes.

Mizra *et al.* (1987) analysed the price data from the Forest Research Institute Timber Price Bulletins for 1968-81. They were available for 4 girth classes (0-90, 90-120, 120-150 and >150 cm) for logs >3 m long. A linear regression equation fitted to the price trend over the period explained 95.3-97.9 per cent of the variation for each girth class. The average annual growth rate of prices was highest for the larger girth classes; rates were generally higher for 1974-81 than for 1968-81. A comparison of trends in teak and general price indices (based on 1970=100) showed that they were similar up to 1973 but that teak indices rose faster after 1974. A comparison of the average annual growth rate of teak and general price indices showed that they were similar.
Prahasto (1987) analyzed the data collected from limited locations in Blora and Randublatung areas of Indonesia and concluded that the labour force required in traditional and 'mass intensification' taungya systems was 1146 and 1535 h/ha p.a. respectively. Corresponding average incomes per ha were Rs. 138700 and Rs. 228300 p.a. and average forest farmer (household) incomes were Rs. 54100 and Rs. 68500 p.a.

Rahman (1987) studied the socio economic impact of community forestry project launched in 1980 in the protected forest land in Bangladesh. The cropping patterns developed, input/output ratio, land expectation value and employment levels were studied on the basis of a survey of 24 of the families. The activities include growing of plantation crops. It has been concluded that in general there is increase in living standard and socio economic status of the families.

Islam (1988) in his studies on commercial volume tables derived for teak based on data collected during 1977 from plantations established at Kaptai, in the Chittagong Hill tracts (South) Division, in 1874-79. Thirteen models of the variation of volume with d.b.h. and with d.b.h. and height were compared; these had been derived by computer using data from 635 and 616 trees respectively. One- and two-way equations were selected using Furnival's Index and other statistical tests. Equations are also given for the relations between d.b.h. and height. One- and two-way volume tables were prepared.

Singh et al. (1988) examined the linkage with particular reference to the dependence of rural households, on forests and forest products by selecting 184 respondents from five villages in Cuttak district. The finding of the study shows that of the total population, 4.37 per cent of the households accepted forestry as their main economic activity while 43.75 per cent as a secondary source. When the linkage was viewed from the angle of economic dependence, as high as 75.72 per cent of the households were found to be dependent on forests for fire wood and for construction materials.

USAID (1988) Bureau for Science and Technology for six countries in its report stated that smaller landholders may risk tree farming when good prices and profits have been demonstrated, but usually cannot demand the same high prices. It has been further
concluded that tree planting and management decisions are based mainly on the cash value of the crop even by farmers who consume much more of their crop than they sell.

Kumar (1989) examined the economics of the principle of sustained yield forestry management, which gives priority to raising successor crops, rather than to exploitation of existing resources. The main points made are that: (1) economic criteria ascribe a real cost to delay in recovering investment resources but ignore historic costs; and (2) the response to changes in market conditions in supply decisions from a single acre of plantation may not be as expected from rational producer behavior, while supply from an expanding land base may be more in consonance with economic theory.

Gajaseni and Jordan (1990) reported that Teak harvest in northern Thailand in 1985 was only one-tenth of that in 1971. The dramatic decrease has been attributed by some authors to loss of trees for shifting cultivation and intensive agriculture. Forested areas, however, decreased only 26 per cent during 1973-85. Stand structure and biomass were measured in September 1986 in a mature mixed deciduous forest with teak about 40 km from Lampang. Data from stump measurements were used to estimate volume and biomass before logging. Most of the remaining trees were smaller than 50 cm d.b.h., while most stumps were larger than this. It is concluded that the reduction in teak production to the point where sustainable, profitable yield is no longer possible may have resulted from over-intensive harvest of large trees. At present rates of diameter increment, it is estimated that trees 35-40 cm diameter will take more than 14 year to reach marketable size (60 cm diameter).

Gasson and Hill (1990) presented the results of the socio economic evaluation of the UK Farm Woodland Scheme. The main objectives of the evaluation were to estimate the overall impact in terms of forgone production, total costs or savings to the exchequer, effects on farm incomes and employment and to investigate attitudes towards the scheme. It has been revealed that the consumption motive takes precedence over the production motive in the way farmers approach the scheme. It has been further concluded that the scheme does not attract the small scale farmers struggling to make a living who have neither means nor inclination to grow trees.

Hiltunen (1990) presented results of a questionnaire survey conducted to assess the profitability of raising forest tree seedlings on private farms in Finland. In 1989
there were 62 such farms producing planting stock of high enough quality to satisfy local forestry associations. It was concluded that profitability was good in comparison with conventional agricultural production.

Kumar (1990 a) examined the economics of teak (*Tectona grandis*) plantations as part of the regeneration programme in Karnataka Forest Department, using data from North Kanara district. The study revealed the impact of economic criterion on sustained yield.

Kumar (1990 b) studied the theoretical economic framework for analyzing (sustainable) management decisions in forestry was presented. In the paper, a financial analysis of teak plantations in North Kanara district, Karnataka, was undertaken. study covered include: Silvicultural requirements; growth and yield under teak monoculture; yield tables and standing crop; costs; net benefit flows; the role of market prices; the economics of teak plantations under constant prices; optimal rotations under sustained yield; optimal rotations with positive discount rates under 2 site qualities (SQ III and IV); economics of teak plantations under variable market conditions; optimal rotations and increase in output prices; optimal rotations and uneven price increases; optimal rotations with inflation in output price; optimal rotations and administrative charges were studied.

The Monitoring and Evaluation Cell, West Bengal, (1992) observed that, the marginal farmer’s holdings mostly were unproductive lands and they took to planting trees on a large scale as the inputs were obtained either free of cost or at a subsidized rate. They were motivated to adopt an alternative land use plan. Most of the farmers planted trees for their fuelwood need and cash income. It was an encouraging trend that the farmers were trying to meet their fuelwood demand for their own land, which indirectly reduced the pressure on Government forests.

Godoy (1992) highlighted determinants of smallholder commercial tree cultivation in developing countries. It was found that donor organizations have tried to arrest deforestation and rural poverty by promoting tree cultivation. It was pointed out that output prices play the key role in smallholder commercial tree cultivation, even in the face of insecure tenure. Output prices, however, a necessary but not a sufficient condition to induce smallholders to undertake commercial fuelwood cultivation. It was
therefore concluded that smallholders, on their own, have taken up commercial tree cultivation by adopting and fitting new technology into their established farming practices, for reasons other than output prices.

Marawar et al. (1993) performed socio economic analysis of farm forestry in Vidarbha region of Maharashtra. Data were collected from 25 Eucalyptus growers in 16 villages who had raised plantations under a farm forestry programme and harvested the trees in 1990-91. The information given included socio economic profile (most of the growers were graduates and had agriculture as a secondary occupation), farmers’ attitudes, farmers knowledge of the technical aspects of farm forestry (almost 50% had very poor knowledge), farm size and cropping intensity, labour used (man/bullock), inputs (fertilizers), cost and returns and constraints (lack of lack of knowledge, non availability of quality plants, lack of irrigation facilities, lack of proper markets, lack of credit facilities). The results showed that investment in Eucalyptus was financially justified, but that the profit was low. The low returns were primarily due to poor marketing structure. It was suggested that planting of Eucalyptus (and other species) should, nevertheless, be encouraged in order to meet the farmers’ own requirements for fuel, fodder and small timber, in addition to the indirect benefits resulting from tree planting. Creation of proper timber markets with a strong extension infrastructure was also suggested.

Niskanen et al. (1993) investigated the profitability of fast-growing trees in the northeastern and eastern provinces of Thailand. The financial, economic, and tentative environmental-economic profitability was determined separately for three fast-growing plantation tree species (Eucalyptus camaldulensis, Acacia mangium and Melia azedarach) Fast-growing tree crops were also compared with teak (Tectona grandis), a traditional medium- or long-rotation species, and rubber (Hevea brasiliensis) which is the most commonly cultivated tree in Thailand. Eucalyptus camaldulensis was the most profitable species for pulpwood production, and the optimum rotation was eight years. The profitability of tree growing was sensitive to plantation yields and labour cost changes and especially to wood prices. There is an urgent need to improve the growth and yield data and to study the environmental impacts of tree plantations for all species and plantation types.
Subhash et al. (1994) in their study revealed that for optimal returns from forest plantations, it is necessary to follow a management plan which is developed after consideration of the implications of demand pattern, rate of tree growth, and economic return in terms of sustainable utilization. It is also essential to have a rational basis for pricing of the final product (i.e. timber).

Jayaraman et al. (1994) studied a glimpse on the status of teak plantations in Kerela and it was found that around 75 per cent of the area below 35 years of age structure of teak plantations. A survey on the status of the teak plantations in the state revealed that nearly 20 per cent of the plantations were fully stocked, 40 per cent under stocked and 40 per cent overstocked. However, considering the presence of miscellaneous species growing in teak plantations which were more in older plantations the degree of under stocking reduced to 20 per cent with a corresponding increase in the per cent of over stockaged plantations. The mean expected yield at 60 year which was the sum of final yield and accumulated yield of thinning worked out to 336.496 m³/ha for plantations maintained under full stocking for a full period under the assumption of constancy of site productivity over time.

Kinhal (1995) in the study concentrated on the upcoming corporate sector in plantation forestry by way of either company investment or investment from the public, looking in particular at plantations on owned land using funds raised from the market by way of shares/equities/debentures. An analysis of proposals presently being floated by various companies is done in terms of technical feasibility and financial viability, ways of subsidies or incentives.

Joshi (1995) briefly discusses the advantages of calculating the internal rate of return by computer and explains, with an abbreviated flow diagram, the use of an internal halving programme for the calculation. The internal rate of return for Teak plantations in Thana calculated by computer are compared with the interest rates (not strictly internal rates of return) as calculated in the working plan for the reserved forests of Thana.

Parameswarappa (1995) in his studies on Teak growth and its returns pointed out that the initial fast rate of growth being obtained with fertilizer application and irrigations bound to come down considerably after few years. There is need for caution
about the over optimism regarding predicted high yields from Teak plantations. At the best we may expect a tree to produce a maximum of 0.60 m$^3$ of timber in 20 years under best conditions of intensive management and there could be a maximum of 100 trees per hectare.

Rawat (1995) in his study on value of a 20 year old irrigated teak plantation observed that the highest value of average teak tree obtained from density of 250 trees/ha and anticipated price escalation of 15 per cent per annum was Rs.40,000. At a reasonable rate of price escalation, the value of average tree will be below Rs.25,000.

Gogate and Joshi (1996) in their case study reported the economic basis for projecting physical and financial returns from teak (Tectona grandis) plantations in India, including yield tables, local volume tables, stand density, site quality, yield variations, expected timber and small wood, timber specifications, and prices and changes in these over the years.

Gupta (1996) in his study on plantation scheme guaranteeing high quality and returns from teak (Tectona grandis) plantations after 20 years. However, despite the uncertainties expressed over such schemes, and the need for some form of governmental control non-governmental efforts need to be encouraged if the necessary tree planting is to be achieved in India.

Haque (1996) in his study on teak wood plantations in 20 hectare of wastelands in Anthiyur block with a plant population of 10,000 trees ha$^{-1}$ by using 1 x 1 m espacement. The per hectare unit cost up to 5 years was estimated at Rs.60,000. Taking into the survival rate at 80 per cent about 8000 trees were to be available for harvesting about 50 per cent of the standing trees were to be cut in 5th year and the remaining trees were to be cut in 9th and 14th year. The returns of more than Rs.50,000 per tree in 20 years with investment of 1000 were worked.

Ganapathy (1997) in his report on Asia Pacific Forestry Sector Outlook worked out the industrial wood requirement (million Cu.m) of India for the year 2000, 2005 and 2010 for Sawn wood (housing, furniture, implements, sports goods, packaging.) 47.00, 50.00 and 54.00 respectively. For Pulp (paper, newsprint) 23.60, 28.50 and 35.00 respectively. For Plywood 1.45, 1.69 and 1.92 respectively. For plywood 1.45, 1.69 and 1.92 respectively. For particle board 0.34, 0.49 and 0.65 respectively. For
Fiberboard 0.22, 0.32 and 0.41 respectively and 0.40, 0.67 and 0.95 respectively for MDF.

Oluwalana (1997) in the economic assessment studies of Teak (*Tectona grandis*) and Gmelina (*Gmelina arborea*) in Ogun State, Nigeria concluded that plantations shows that huge economic losses are sustained from the poor conversion of the woods in the sawmills in the state. It is suggested that urgent steps are required to reduce wood waste in sawmills, and to avoid crisis of wood supply in next century; plantation establishment of Teak should especially be improved.

Mammen and Chundamannil (1998) analyzed the productivity and profitability of teak (*Tectona grandis*) plantations in Nilambur North and South Divisions, Kerala, India. Yield data were collected for the period 1967-94 from an area of 12500 ha. The mean yield in a rotation of 53 yr was 151 m$^3$ ha$^{-1}$ and mean annual increment (MAI) 2.85 m$^3$ ha$^{-1}$. The profitability analysis was done using prices and costs for 1995. When no land rent was considered, the net benefit in a rotation of 53 yr was Rs 23 lakhs. Net present value (NPV) and benefit cost ratio (BCR) were calculated using different discount rates. At 12 per cent rate of discount the NPV for one hectare of teak plantation with mean yield was Rs 40 000 and the BCR was 3.2. The internal rate of return (IRR) was 31.3 per cent. The maximum land rent possible was calculated as an indication of the surplus available from teak plantations. At 12 per cent rate of discount, for mean yield, the maximum land rent possible was Rs 4500 ha$^{-1}$. It is recommended that a more regular assessment of the productivity of teak plantations be made to monitor the situation and collect data for optimizing the rotation age and management inputs.

Muraleedharan and Anitha (2000) conducted an experiment to examine the economic impact of *Mikania micrantha* infestation, especially in terms of income, on teak (*Tectona grandis*) plantations in Kerala, India. Results showed *M. micrantha* has increased the cost of planting and has adversely affected the profitability of the plantations and that there was a significant difference in the cost of maintenance of teak plantations with and without *M. micrantha*. Infestation was severe in younger plantations where Mikania completely covered the teak plants, which affects their growth and productivity. Results also showed that weeding is the most efficient method to reduce the effect of Mikania on the productivity of forest plantations.
Steber et al. (2000) discussed from the point of supplies of plantation teak (*Tectona grandis*) from South East Asia, including financial aspects of the marketing of teak plantations as investments, as well as harvested teak timber.

Krishnankutty (2001a) examined the long term trend in prices of teak in five girth classes (E (logs with mid-girth 185 cm and above) 1 (150-184 cm), 2 (100-149 cm), 3 (75-99 cm), and 4 (60-74 cm)) in Kerala, India and compared the price trend of teak with those of other timbers. Among the different trend models estimated, the linear model spline model with three knots $k_1$ (1968-69), $k_2$ (1976-77) and $k_3$ (1983-84) was found to be the best for prices of teak in girth-classes 1, 2 and 4. For girth-class E, quadratic spline model having 3 knots was the best. The analysis showed that the real prices of teak and other timber declined moderately during the period from 1956-57 to 1968-69 thereafter, the price of all timbers showed an increasing behavior until 1983-84. The rate of increase was moderate during the period from 1968-70 to 1976-77, whereas the rate of increase was drastic during the period from 1977-78 to 1993-94. Since then, while price of teak continued to increase, the prices of other timbers declined.

Krishnankutty (2001b) in his studies predicted the future prices of teak in three girth classes (based on mid-girth, under bark and of logs) in Kerala, India using the autoregressive integrated moving average (ARIMA) models. The data used for price forecasting was based on the average annual current prices of teak.

Bhat (2006) reported that India is one of International Timber Trade Organization’s (ITTO) 4th largest log producer and consumer with requirements of 13.50 million m$^3$ and 17.00 million m$^3$ respectively. India stood 2nd in log import valuing more than 3 million m$^3$ in 2005. Sawn wood production and consumption of about 6 million m$^3$ is 2nd in ITTO. Sawn wood import is very marginal. Indian veneer consumption is 0.25 million m$^3$ 4th in rank with almost equal production values. In recent past plywood consumption and production has rapidly increased quantifying 1.90 million m$^3$ among the top 4 in ITTO countries.
2.14 Adoption

Jeelani and Prasad (1985) reported that the rich and well to do farmers adopted tree plantation with the hope of getting more income and avoiding labour problems. Cultivated lands were diverted to plantation with hope of getting more income.

Arnold (1987) stated that farmers would be adopting agroforestry if the benefits they received out weighed the cost (which might include such things as the sacrifice of leisure) they incurred but the benefits must such things as the farmer himself valued.

Sandhu (1990) stated that farmers are adopting eucalyptus plantation because it has come up as a reliable insurance against agricultural crops failure. The farmers can cut eucalyptus trees to meet financial astringencies and hence most of the farmers are adopting this plantation.

Mercer (1992) stated that high adoption rate increased with the increases in information (awareness), thereby reducing the subjective risk. The livelihood of adoption was also related to the farmer's ability to decipher and analyze the available information. Less educated generally poorer farmers with small holdings were unlikely to be the first to adopt new agro-forestry practices.

2.15 Constraints

Burley (1980) while studying obstacles of tree planting for woodfuel with particular reference to India and Kenya, observed that environmental factors and practical afforestation techniques are not the major constraints to the tree planting in arid and semi-arid lands. More important are social features including land use and tenure, community organization and economic constraints such as the lack of a monetarized economy, poor transport and marketing system and poor understanding of long-term cost-benefit appraisal. It was suggested that there is a great need to devise incentives and encourage participation in tree planting schemes by local populations. Hence professional and non-professional training in extension techniques for arid zones is also required.

Keita (1982) reported that forestry activities in West Africa provided the farmer with food, fodder, fertilizer, energy and raw material. The constraints to implement the
programme were land tenure system, demographic pressures on land and the viability of collective institutions. It was suggested that long term ownership of trees planted should be guaranteed for the farmers. Farm subsidy should give priority to nurseries, setting up of market and processing activities.

Smaller and Meister (1983) studied farmers’ knowledge, experience, attitudes and intentions regarding farm forestry in New Zealand and compared the possible financial return of woodlot growing with alternative activities. The data were based on a questionnaire survey of a sample of woodlot owners. It has been observed that woodlot plantings with a dual purpose (shelter, weed control and diversification) are more likely to be made than single purpose planting. It has been further observed that government assistance for woodlot operators appears to be a bonus.

Mulch (1985) found that UK farmers’ new interest in forestry arose partly from the need to spare the land from agriculture and recognition that wood production may be a useful new enterprise as a response to conservation pressures. Until recently many farmers had never given to the forestry a serious thought as a farm activity. It was further highlighted that the capital cost of afforestation dominated forest economics and for many farmers the retirement of land from agriculture production raises the problem of how to maintain the flow of income. The provision of professional advice also deserved close attention. Duplication of effort or conflict of advice to farmers on trees, however, might be only a symptom of over enthusiasm of concerned organizations.

Banerjee (1987) suggested that in farm forestry, farmers have to be motivated to plant trees on their own land at their own cost. This mean using land lying waste, switching over from the present land use to tree farming, allocating a part of one’s labour to an activity which is not immediately rewarding. The aim of all these activities is for better economic returns to the farmer and for production of fuelwood, fodder and small timber for direct use at home creating a general awareness of tree economics, availability of incentives for farmers, importance of trees at homestead, its effect on agriculture etc. It was suggested to conduct survey every year of demand for different species of trees by the would be beneficiaries at least 3-6 months in advance of planting time and transfer of technology and skills through regular field visits.
Poel et al. (1987) studied the household economy and tree growing in two upland areas Bunder and Merden in central Java. Twenty-two households were interviewed in Bunder and 50 in Merden. Fields were surveyed and other general information was collected. The study reported that households with little land, used it more intensively with respect to crop, livestock and tree production, as did those with access to market opportunities. It was suggested that interventions in the tree production system would only be successful if they could be integrated into the farming system by the farmer.

Dove (1988) revealed that the major constraints perceived by farmers in farm forestry were difficult nature of plant protection. Lack of planting stock, feared impact on food crop production, lack of interest and experience and inadequacy of Governmental assistance.

Chauhan and Dhyani (1989) identified the constraints in adoption of agroforestry as lack of knowledge and experience, inadequacy of capital, security of tenure of land in many areas and traditional methods of cultivation.

Everett (1989) found that many farm woodlands in UK were in a neglected state and offered few benefits to the farmers. Reasons for the neglect of farm woodlands included the small scale of operations, the financial implements for the farmer and lack of management knowledge. These problems could be partially solved by the formation of cooperatives to purchase forestry equipments, possibly linked to training schemes. Grant of incentives for the establishment of farm woodlands were also available as part of the encouragement of alternative use of agricultural land.

Muir and Casey (1989) concluded that the lack of appropriate technologies was a major constraint to the success of social forestry.

Eld (1990) revealed that long investment period and large time interval between planting and wood harvest were the constraints in adoption of farm forestry.

Saxena (1991) highlighted that during the early 1980s farmers in India planted eucalyptus on a massive scale for sale as poles and pulpwood. However, since 1986 farmers had almost stopped growing eucalyptus because of marketing problems. The pole market became saturated, paper mills did not pay a remunerative price and
fuelwood prices were low and uneconomical. More importantly, because of legal restrictions on the transport and sale of wood and other institutional factors, the gap between the farm gate price and the consumer price remained very wide. Wood markets had on the whole, exploited the farmers, rather than helped them.

Nimje et al. (1991) stated the difficulties faced by the farmers in adoption of social forestry in managing for the expenditures up to receipt of any earning from plantation is the difficulty expressed by 92 percent cultivators. About 60 percent farmers experienced that there was very little help from departmental officers. Information needed and guidance for sale were the major difficulty expressed by farmers. In addition less technical knowledge and non availability of loan were also the other difficulties faced by farmers.

Singh (1991) noted that majority of the farmers were of the opinion that income and subsidies should be given through co-operative bank. The visits by concerned officials have to be suggested for the development of social forestry.

Tewari (1991) noted the constraints such as lack of people’s participation, lack of information about various production systems which can generate income to the farmer, lack of suitable infrastructure to market the forestry products, lack of appropriate legislation for growing, felling and marketing of trees and lack of good research on trees breeding protection and intensive forestry.

Saxena (1992) in his study found that many farmers who had a high ratio of owned land to male members in the family, resorted to tree farming. Conversely, farmers in eastern Uttar Pradesh, with small holdings, subsistence orientation and cheap labour, showed little enthusiasm for planting. Based on field investigations in six villages (4 in western and 2 in eastern Uttar Pradesh), it was described that woodlot planting emerged as an attractive option for landowners facing management and labour problems in western Uttar Pradesh, as tree farming allowed saving in family labour time and permitted greater flexibility in the timing of operations.

Marawar et al. (1993) worked on socio-economic analysis of farm forestry in Vidarbha by selecting 25 farmers from 16 villages of seven districts in Vidarbha. The study examined the economics of eucalyptus grown under farm forestry and constraint faced by farmers in growing tree crop. Lack of adequate knowledge about cultivation of
forest trees, non availability of quality plants, difficulty in marketing, remuneration prices and lack of credit facilities were the main constraints faced by the farmers during cultivation of eucalyptus. The study suggest that a strong and effective extension infrastructure is necessary to educate and motivate the farmers for farm forestry and proper timber market be created in the area.

Conroy (1993) in his study an eucalyptus in Gujrat discussed that in India, small farmers have generally found growing Eucalyptus as a cash crop. Farm-gate prices have been much lower than retail prices, due to the existence of middlemen, and retail prices have fallen to lower levels than expected as markets have become saturated. Farmers sold their Eucalyptus directly to buyers at prices close to those in organized wood markets. An important reason for this unusual situation was the absence of controls on Eucalyptus sales in Gujarat, which has helped producers to avoid dependence on rent-seeking intermediaries. The study showed that growing Eucalyptus can be a profitable activity for small farmers, if given the right circumstances.

Bhople et al. (1999) noted the important difficulties in adoption of agroforestry by farmers were the incomplete knowledge of recommended practices of agroforestry, uncertainty of market, no provision of subsidy, non availability of seedlings in time, lack of irrigation facilities, stunted growth of trees and uncertainty regarding for felling of the trees.

Bhople et al. (1999) studied the constraints faced by farmers in Akola District, Maharashtra (India). Farmers have been planting commercial teak on their land as part of a social forestry programme. The recommended cultivation practices for teak were identified and passed on for use by the farmers. A survey of the extent of adoption of these practices by 92 of the farmers showed that they have planted the recommended species (teak) at appropriate times and distances. The adoption of intercropping, cultural operations, manures and fertilizers, and plant protection measures were poor. The farmers need to be convinced about the usefulness of these practices for healthier plant growth. Constraints faced by the farmers in adopting teak planting were credit/loan, inputs, labour, information, technology.