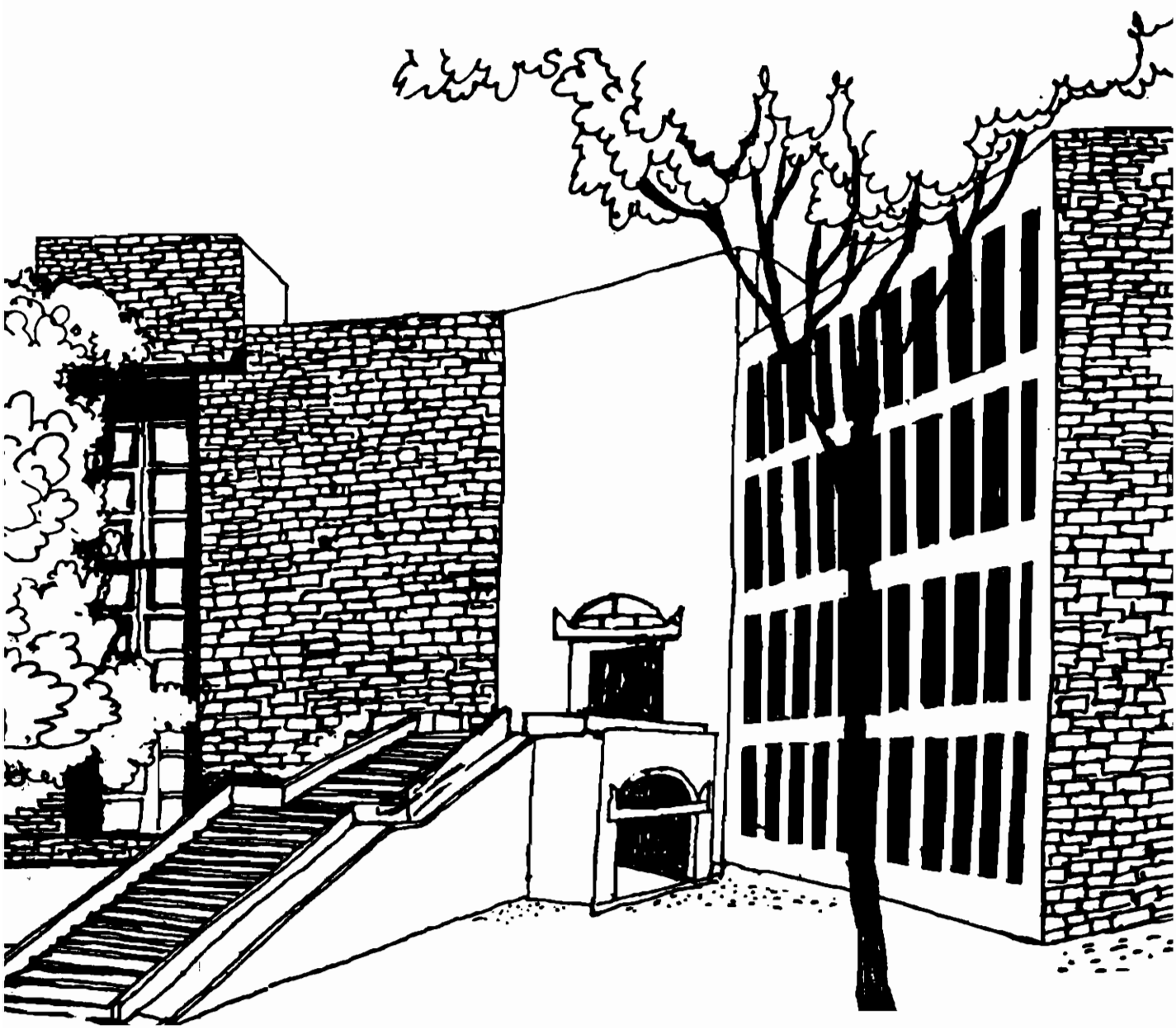
विद्याविनियोगाद्विकासः
IIM
AHMEDABAD

Working Paper

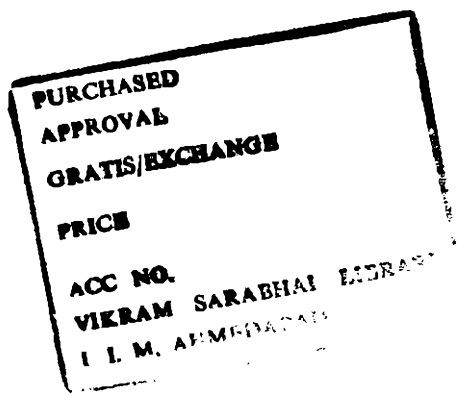


ECONOMIC ANALYSIS OF INDUSTRIAL AGROFORESTRY: POPLAR (*POPULUS DELTOIDES*) IN UTTAR PRADESH (INDIA)

By
Sudhir Kumar Jain
(Trainee as Academic Associate)

W.P. No. 1397
September 1997

INDIAN INSTITUTE OF MANAGEMENT
AHMEDABAD-380 015
INDIA



Economic Analysis of Industrial Agroforestry: Poplar (*Populus deltoides*) in Uttar Pradesh (India)

Sudhir Kumar Jain*

Key Words: Commercial Plantation, Farm Forestry, Land-use System, Silvo-agriculture

ABSTRACT

To meet raw material requirements. Wimco.the biggest match industry in India. has been promoting poplar based agroforestry through agroforestry projects approved by National Bank for Agricultural and Rural Development (NABARD) in the northern region of India since 1984. This study aims at evaluating the performance of poplar based agroforestry in terms of income. employment and environmental impact. Poplar based agroforestry is economically viable and relatively more profitable in comparison to many of the crop rotations followed in the study area. Poplar plantations with intercrops are more remunerative in a plantation of seven years instead of eight years. This land use system is capable of providing employment opportunities on farms and the preserving ecological system as well. The cost charged by Wimco for technical advice. however. reduces the income from poplar plantation substaintially. With farmers gaining experiences. farmers can expect high dividends in subsequent rotations.

Introduction

Cultivation of field crops and cultivation of forest crops are two different practices of land use in India. Forest crops are grown mainly in forest land and field crops on farmers' land. Although, farmers have been growing trees on their fields and community land to meet fuel wood and wood requirements since long, there was no commercial tree plantation on farmers' land for production of timber and fuel-wood. The requirements of wood-based industries were met mainly by forests. Therefore, there was a great burden on forests for meeting the continuous growing demand for timber, fuel-wood and fodder. Sensing the danger to the ecosystem because of heavy deforestation caused by indiscriminate and injudicious cutting of trees, the government has restricted the easy access of wood-based industries to forests for their raw materials since the late seventies. Through the new forest policy of 1988, the government has advised these industries that they should meet their raw material needs by establishing a direct relationship with farmers

* Trainee as Academic Associate at Indian Institute of Management, Ahmedabad.

who can grow trees on their farms. These industries should also provide inputs including credit, technical advice, harvesting, and transportation services.

Therefore, functional allocation of land for agriculture and forest needs a fresh look in order to make the present land use system more productive, remunerative, cost effective, and capable of meeting multifarious demands of the growing population.

Industrial Agroforestry in India: Wimco Sponsored Agroforestry Programme

Western India Match Company Ltd. now known as Wimco Ltd., the biggest manufacturer of matches in India, contributes about one-fifth of the match production in the country through its five factories located in Ambarnath (Mumbai, Maharashtra), Calcutta (West Bengal), Dhubri (Assam), Chennai (Tamil Nadu), and Bareilly (Uttar Pradesh). Wimco's interest in agroforestry emanated from an acute shortage of raw material, it faced for its match production. Wimco set up its Agro and Farm Forestry Division in 1979 to meet the raw material requirements through direct interaction with farmers. Since then, Wimco has been successfully promoting and popularizing the concept of agroforestry in the northern belt. In the early stage of its agroforestry programme, it organized farmers to grow poplar tree which was identified an ideal forest crop for use as raw material and agroforestry, through extension activities and technical assistance in the northern region particularly in the Terai region on an experimental basis. After National Bank for Agriculture and Rural Development (NABARD) approved refinancing the agroforestry project in 1984, Wimco has covered a large area and a large number of farmers in several districts of Uttar Pradesh (UP), Punjab, and Haryana. Under this project, Wimco provides technical assistance to farmers, good quality planting materials developed at its nurseries, ties up institutional finance, and guarantees to purchase woods at remunerative prices.

Agroforestry in Uttar Pradesh

The most prevalent practices of silvoagriculture system in UP are scattered trees, boundary and block plantation. The system of planting scattered trees on farm land is most common in unirrigated areas. In irrigated areas, the most common species are ***eucalyptus, dalbergia sissoo, acacia nilotica, populus deltoides, artocarpus heterophyllus, syzygium cumini, albizia lebbeck,*** etc. Of late, ***bombax ceiba, tectona grandis, morus alba, grevilea robusta, meila azedarach,*** etc. have also been planted on farms. Among all species, ***eucalyptus sp.*** is most widely planted in the Gangetic plain areas, whereas ***populus deltoids is*** the most common forest crop in the Tarai and some parts of the Gangetic plain. ***Eucalyptus*** trees are commonly planted along field boundaries, whereas ***populus deltoides*** is planted in blocks, rows and on farm boundaries. The most commonly planted tree species in the boundaries of fruit orchards are ***eucalyptus hybrid, dalbergia sissoo, syzygium cumini, acacia nilotica,*** etc.

Poplar Based Agroforestry: An Alternative Land Use System

Poplar, a fast growing and short duration forest crop, is an important raw material for a number of softwood-based industries. This wood can be put to a variety of purposes in different forms. Poplar can be grown in different orientations along with agricultural and horticultural crops. Poplar is widely cultivated on highly fertile and irrigated land for the production of wood and fuelwood in the block plantation It is grown along with agricultural crops with the spacing of 5 x 4 square metres which provides sufficient space between plants for the cultivation of intercrops in block plantations. It can also be grown on uncultivated land. As a result of comprehensive research, a large number of exotic species/clones have been tested, screened and recommended for raising large scale commercial plantations in different regions of India. With the advent of exotic species of poplar particularly 'G-3' and 'G-48' suitable to the northern regions and harvestable in six to eight years, its utility on farms has enhanced.

Objectives

By dint of its merits agroforestry has proved to be an integral element of not only the farming system but also as one of the important components of sustainable agriculture. Evaluation of economic performance of agroforestry becomes imperative in order to analyse its implications for agricultural crops and existing land use system and its socio-economic and environmental impact in the area. Research endeavour in this area has more relevance because large chunks of irrigated and fertile crop lands are being brought under agroforestry.

This study aims at

- examining the socio-economic profiles of agroforestry adopters
- examining the costs and returns and employment potential of agroforestry on farms
- making a comparative analysis of the agroforestry system with the existing land use system
- examining the environmental perspective of the agroforestry system

Sources, Data and Methodology

The study is based on primary cross-sectional data. For the collection of data stratified sampling technique was used. Shahjahanpur district of U.P. was selected considering the number of poplar based agroforestry adopters and the area under poplar plantation. In this district a NABARD-sponsored poplar based agroforestry project has been under implementation since 1986. In the next step, three tahsils- Shajahanpur, Puwayan, and Tilher were also selected considering the number of agroforestry adopters and area under poplar plantation. Out of eleven administrative blocks from the three tahsils, six blocks-Bhavalkhera, Daddrail, Kant, Puwayan, Tilher and Nigohi were selected following the aforesaid criteria. In the final stage, out of total agroforestry adopters (1986 to 1993, one coppice period) in the selected blocks, 176 farmers (approximately 40 per cent of the agroforestry adopters in the selected blocks and 25 per cent of the total agroforestry adopters in the district) were selected randomly. Since in poplar plantation, activities involved

from establishment to harvest stretch over eight years, farmers in the harvest stage (eighth year) could not be expected to recall the details pertaining to the establishment stage (first year). A reasonable approach would be to select eight strata of group of farmers, each group representing particular age of the plant in the current year. On the basis of this logic, eight strata of the group of agroforestry adopters were made. Each stratum comprised 22 adopters. Data were collected through a pre-tested schedule in the agricultural year 1993-94. Since it is difficult to get data/information for complete life cycle of poplar tree from the individual farmer under the above stated grouping of the sample, a life-time matrix was constructed for each sample unit on all parameters through interpolation techniques[1]

Poplar is supposed to attain physical maturity for harvesting in eight years, however, its growth can be advanced. If the farmer wishes, he can sell the timber after six years. Furthermore, farmers can take all crops except paddy as intercrops in interspaces between poplar in its early age and rabi crops and shade loving crops could be grown as intercrops till the harvest time. Therefore, costs and returns of poplar plantation with agricultural crops were worked out for six, seven and eight years of plantation. For the computation of costs and returns of poplar with agricultural crops, conventional cost measures, i.e. Cost A_1, Cost C_2 and income measures, i.e. farm business income and net return, were used. Financial viability of poplar based agroforestry was examined with the help of conventional discounted cash flow measures of project worth, namely, Benefit-Cost ratio (B-C ratio), Net Present Worth (NPV) and Financial Internal Rate of Return (FIRR). In the case of field crops, returns come in a season or year whereas in the case of poplar, returns come after the eight year (if harvested early, they may come after six or seven years). Therefore, for making a comparison of profitability accrued from sole crops and poplar with intercrops, yearly income generated per hectare from different crop rotations was worked out in the case of field crop and in the case of poplar with intercrops, annuity value was calculated. To capture the impact of poplar plantation on farmers' fields, an opinion survey was conducted and analysed through tabulation method.

Data

Input and Output Data

For poplar plantation and intercrops, information regarding inputs employed for different ages of poplar plants were collected from respective groups of farmers. Output of poplar is timber and pruned wood is used as fuelwood. Volume of timber of plants planted in one hectare of land was determined by the number of trees under a particular range of the girth at breast height, height and taper of the tree. Data regarding girth at breast height, height, and incremental growth of the poplar tree were collected from Wimco, Agroforestry Division in Shahajahanpur district. Timber volume was calculated using the quarter girth formula.

Pricing of Outputs and Inputs

For pricing inputs like bullock labour, tractor hours and irrigation, opportunity costs were considered equivalent to their hiring charges prevailing in the study area during the survey year. For the remaining inputs, then prices prevailing in the market in the survey year were considered. For the pricing of seedling, price charged by Wimco's Agroforestry Division in the survey year was considered. Market prices of field crops were taken into consideration for arriving at income from field crops To arrive at tree income, price offered by Wimco according to the girth at breast height on volume basis in the survey year was taken into account For the pruned wood, the price prevailing in the study area was considered.

Study Area

Shahjahanpur district is situated in the mid-western region of Uttar Pradesh. About 80 per cent of the population of this district depends on agriculture for livelihood. However, agriculture is very backward. Paddy, wheat and sugarcane together account for about 75 per cent of the cropped area. The district has just 2.45 per cent of the under forest area. Before 1986, there were only stray plants on the fields and very few fruit orchards Thanks to the initiative of Wimco under the NABARD sponsored agroforesty project from 1986 to 1994, 610 farmers had planted 4,39438 poplar trees (ETPs) in 878 87 hectares.

Results and Discussions

A probe into the socio-economic profiles of the farmers reflects the capability of farmers to bring about changes in farming practice and land use system on their farms. The results showed that the major adopters of poplar based agroforestry were large farmers (55.68 per cent) followed by medium (32.95 per cent) and small (11.36 per cent) farmers (Table 1).

Table 1. : Socio-economic Characteristics of the Agroforestry Adopters

Categories of Agroforestry Adopters	Size of the farms (in hectares)	Family Labourers			Educational Status (in per cent)				
		In Agri culture (in per cent)	In Non-Agricultu re (in per cent)	Number of working persons per farm	Illiter ate	Primary	Secon dary	Graduat e and Above	Number of Adopters
Small	1.45	76.47	23.53	3.4	25	35	25	15	20
Medium	3.13	83.33	16.67	3.6	18.97	39.65	34.48	6.89	58
Large	7.35	61.63	38.37	3.86	9.28	33.67	36.75	20.26	98
Average	5.29	70.0	30.0	3.72	14.27	35.66	34.69	15.37	176

Note: Small : Less than 2 hectares
Medium : 2-4 hectares
Large : More than 4 hectares

For bringing about changes in the economic activity on the farm, size of the operational holding is one of the most important determining factors as availability of land for purposes other than agriculture is assured. The results revealed that the average size of the holdings of sample farmers was 5.29 hectares and 7.35 hectares for the large farmers. Farmers can not afford to bring the larger areas under agroforestry if the returns accrued from the tree are not assured come in short period. Hence, only fast growing exotic species of the tree like poplar can be grown along agricultural crops. Another important aspect is the family labour occupation which greatly influences the land use pattern on farms The results showed that sample farmers had on average 70 per cent family labour involved in agriculture. About 50 per cent of the agroforestry adopters had prmary education This indicated that besides educational background, awareness and aptitude to follow up new practices on farms also played an important role in the adoption of new land-use systems.

Land Utilisation Pattern

The results revealed that agroforestry adopters had a high percentage of their land under irrigation (92.50 per cent). Only a very small fraction of land (2.47 per cent) was uncultivable and barren (Table 2). Therefore, ample scope existed for introducing new practices on their farms. Out of the total 930.83 hectares of land owned by sample farmers,

Table 2. : Land Utilisation Pattern on the Sample Farms

Categories of Agroforestry Adopters	Total Land Holdings			Categories of Land							
				Under Agricultural Crops			Under Tree Plantation				Waste land
	Irrigated In per cent	Unirrigated in per cent	Total in hectares	Irrigated in per cent	Unirrigated in per cent	Total in ha	Irrigated		Unirrigated in per cent	Total in hectares	
							Poplar in per cent	Other Tree in per cent			
Small	100	0	29.05	100	0	52.6	100	0	0	47.43	0
Medium	89.85	10.15	181.23	0.93	7	61.26	84.85	10.60	4.55	38.50	4.36
Large	92.86	7.14	720.46	0.97	3	71.04	62.49	30.40	7.10	38.74	2.00
All	92.50	7.50	930.83	0.96	4	68.56	68.23	25.43	6.34	38.94	2.39

land under crop cultivation and tree plantation formed 68.56 and 38.94 per cent respectively. A sizable chunk of land under total tree plantations (68.23 per cent) was under poplar based agroforestry practice. Poplar was grown only on irrigated cultivable land because for its profuse growth irrigation is essential.

Cropping Pattern

Cropping pattern within a homogenous agro-climatic area is considered to be influenced by soil type, size of holding, source of irrigation, level of investment, availability of resources, and enterpreneurship of farmers. Paddy in kharif and wheat in rabi were important

Table 3: Cropping Pattern on the Sample Farms

Crops	Percentage of Total Cropped Area	Percentage of Total Cropped Area (Intercrops Included)
Paddy	19.02	16.61
Wheat	23.58	28.28
Sugarcane	14.70	14.48
Poplar	19.06	16.65
Others (Kharif)	12.77	11.64
Others(Rabi)	10.87	12.33
Total Cropped Area[1]	1297.63	1485.44
Net Sown Area[1]	885.46	885.46
Cropping Intensity	146.55	167.76

Note: 1. Unit is in hectares

foodgrain crops cultivated by agroforestry adopters (Table 3). These two crops were followed by poplar in terms of percentage of the cropped area (19.06 per cent). Sugarcane was an other important crop. These four crops accounted for 76.37 per cent of the cropped area. The major loss of cropped area was witnessed in the case of paddy owing to the adverse impact on poplar. There was a substantial increase in the cropped area under wheat as wheat could be grown with poplar till harvest time. Cropped area under sugarcane remained more or less same as sugarcane could be grown along with poplar during the first three years. With the introduction of poplar (agroforestry) on the farms, land could be utilised more intensively, the cropping intensity of sample farms increasing from 146.55 to 167.76 per cent.

Performance of Agroforestry

The performance of poplar-based agrofroestry was examined from physical and economic aspects.

Physical Aspects

Poplars in block plantation (5 x 4 sq. metres) could attain 76.97 cm of average girth at breast height in eight years which was less than the expected girth of 90 cm. As a result of low girth, average volume of timber per tree was also lower than expected. It was also observed that till the fourth year, girth at breast height increased at an increasing rate and, thereafter, increased at a decreasing rate (Table 4). Incremental increase in the girth of poplar was recorded as 6.3, 5, and 3.395 cm during the sixth, seventh and eightth year respectively. The incremental increase in the volume was 0.05, 0.04 and 0.035 cubic meter per tree during the sixth, seventh and eightth year respectively. However, some farmers in the sample reported a girth of more than 90 cm at breast

Table 4 : Physical Output of Poplar on the Sample Farms			
Year	Girth (in Cm)	Total VUB (200 Trees) in m^3	Increment VUB (200 Trees) in m^3
1 st	22.13	-	-
2nd	30.45	-	-
3rd	39.72	-	-
4th	51.02	12.31	-
5th	62.28	26.26	13.95
6th	68 58	36 16	09.90
7th	73.58	43.90	07.74
8th	76.98	51.06	07.16

Note Coppice Period is 1986 (Jan- Feb) to 1993 (Dec.- Jan).
VUB = Volume Under Bark

height in eight years. The differences in the physical performance of poplar across the farms arose from differences in the frequencies and timing of irrigation, fertilisers and cultural operations. Unlike eucalyptus, poplar is highly sensitive to input application and other cultural operations which farmers did not consider seriously owing to inexperience in growing forest crops. The average growth performance of poplar can not be ascribed to the non-suitability of poplar in the study area. In the first year, the growth was good. This may be because of the strict supervision and persuasion of Wimco.

Economic Aspects

The economic profitability of poplar with intercrops was examined under two settings with and without Wimco assistance. Costs of agroforestry comprise expenses incurred on poplar plantation and cultivation of intercrops. Intercrops taken into account were wheat, barley, lentil, pea, gram, mustard, potato, mung, urd, til and sugarcane. Costs incurred in the plantation of poplar in the first year comprised establishment and maintenance costs. Cost incurred in the cultivation of poplar then onwards was mainly maintenance cost Harvesting cost was not included as cost of the harvesting of poplar was borne by the buyer. The returns from agroforestry included income accrued from poplar logs, fuelwood, and intercrops grown with poplar .

The results showed that farmers incurred approximately 27 per cent of the discounted total variable cost (Cost A_1) on the establishment and maintenance of poplar in the first year in the plantation of eight years Rest of the discounted total variable cost was incurred on maintenance, with interest constituting a major share. The results also showed that the total cost (Cost C_2) increased faster than the variable cost (Cost A_1) with increase in the age of the plant (Table 5). Farmers could earn on an average gross income of Rs. 99400, Rs. 63059, and Rs. 5621 per hectare from logs, intercrops, and fuelwood, respectively. Gross income accrued from intercrops was higher in the first three years owing to income from growing sugarcane along with poplar.

However, the gross income from intercrops declined over the years. On comparing the returns accrued from poplar and intercrops in the sixth, seventh, and eightth year of plantation, it was observed that farm business income was maximum in eight years whereas net income was maximum in seven years However, there was not much difference in farm business income of poplar and intercrops in the plantation of seven and eight years. Furthermore, the annuity value also remained higher in the case of farm business and net income in the plantation of seven years. Therefore, it can be inferred that holding of poplar for eight years is not a profitable proposition.

Table 5: Discounted Costs and Returns of Poplar Based Agroforestry
(Rupees Per Hectare)

Year	Cost A_1	Cost C_2	Gross Income From Logs	Gross Income From Fuel wood	Gross Income From Crops	Total Gross Income	Farm Business Income	Net Income
1st	22169	30204	-	-	16630	16630	-5539	-13574
2nd	36000	51604	-	797	30505	31302	-4698	-20302
3rd	47325	69520	-	1723	39373	41096	-6229	-28424
4th	56523	85192	-	2677	45542	48219	-8304	-36973
5th	64502	99193	-	3726	51311	55037	9465	-44156
6th	71534	111842	85922 *	4740	55729	146391	74857 (18208)	34549 (8404)
7th	77648	123119	85448 **	5621	59762	160831	83183 (18225)	37712 (8262)
8th	82463	132675	99400 ***	5621	63059	168080	85617 (17234)	35405 (7126)

Note: 1. Figures in the parenthesis are annuity values
2 prices of poplar timber used in the valuation of logs are given below

* Rs. 1850/ m^3
** Rs. 1950/ m^3
*** Rs. 2000/ m^3

Costs and Returns of Poplar with Wimco Assistance

As mentioned earlier, poplar- based agroforestry in the study area has been promoted by Wimco under its NABARD sponsored agroforestry project. Since this was the first rotation, poplar growers without Wimco assistance could not be found in the study area. However, an effort was made in this study to capture the differences in the costs and returns of poplar plantation owing to the involvement of Wimco. Since Wimco charged Rs. 25 per tree for technical advice and Rs. 8 per tree as an insurance premium during eight years, agroforestry adopters had to bear an extra cost of Rs. 33 per tree in eight years, Besides this, farmers had to bear stamp duty charges of Rs. 62 per Rs. 1000 for taking loan. These extra costs enhanced Cost A_1 and Cost C_2 and reduced farm business and net income. Although, the gross income from poplar plantation with and without Wimco remained same, the intention of comparing the costs and returns with and without assistance is to ascertain the profitability from poplar based agroforestry if farmers continue this

practice on their farms in the second rotation when Wimco's technical assistance would be not essential. Therefore, the costs and returns of poplar plantation with Wimco assistance were worked out separately. The results revealed that Cost A_1 and Cost C_2 of poplar and intercrops with Wimco assistance had increased 33.14 and 20.59 per cent, respectively during eight years in comparison to these costs without Wimco assistance (Table 6). Cost

Table 6: Discounted Costs and Returns of Poplar Based Agroforestry with Wimco Assistance @ 12 Per cent Discount Rate (Rupees per Hectare)

Year	Cost $_{A1}$	Cost C_2	Gross Income From Logs	Gross Income From Fuel wood	Gross Income From Crops	Total Gross Income	Farm Business Income	Net Income
1st	32297	40329	-	-	16630	16630	-15667	-23699
2nd	50348	65949	-	797	30505	31302	-19046	-34647
3rd	65326	87517	-	1723	39373	41096	-24230	-46421
4th	77645	106309	-	2677	45542	48219	-29426	-58090
5th	87922	122611	-	3726	51311	55037	-32885	-67547
6th	96807	137112	85922	4740	55729	146391	49584 (12061)	9279 (2257)
7th	104071	149539	95448	5621	59762	160831	56760 (12436)	11292 (2474)
8th	109793	160000	99400	5621	63059	168080	58287 (11732)	8080 (1626)

Note: Figures in the parenthesis are annuity values

A_1 and CostC_2 of poplar and intercrops with Wimco assistance in the first year increased by 45.68 and 33.52 per cent respectively in comparison to those without Wimco assistance. Farm business income and net income accrued from poplar and intercrops with Wimco assistance declined by 31.92 and 77.18 per cent respectively in the plantation of eight years. In the case of seven and six years of plantation, farm business incomes were 31.76 and 33.76 per cent respectively lower than those of without Wimco assistance and reductions in net income were 70.05 and 73.14 per cent. The results showed that the discounted farm business income of poplar and intercrops with Wimco assistance was maximum in the plantation of eight years and net return was maximum in the plantation of seven years. Both average annual farm business and net income per hectare were maximum in the plantation of seven years. Therefore, it can be concluded that poplar plantation with Wimco assistance is more profitable in the plantation of seven years instead of eight years.

Financial Analysis

The financial feasibility of poplar based agroforestry with and without Wimco assistance was examined at the discounting rate of 10, 12 and 15 per cent for six, seven and eight years of plantation. For the financial analysis of perennial crop, time series data for incremental cash flow are required. Since this study was based on primary data, incremental cash flow data of each year

were obtained from respective groups of sample farmers representing a particular age of the poplar tree. The results revealed that poplar based agroforestry without Wimco assistance was financially viable at the discounting rate of 10, 12 and 15 per cent in terms of both NPV and B-C ratio measures in all years of plantation (Table 7). NPV and average annual income of poplar

Table 7: Financial Analysis of Poplar Based Agroforestry With and Without Wimco Assistance

Rotational Age/Year	Discount Rate (in per cent)	Without Wimco Assistance			With Wimco Assistance		
		NPW (in Rupees)	B-C Ratio	Annuity Value (in Rupees)	NPW (in Rupees)	B-C Ratio	Annuity Value (in Rupees)
6	10	40528	1.34	9306	14064	1.10	3229
	12	33982	1.30	8266	8711	1.06	2120
	15	25469	1.25	6549	1824	1.01	469
IRR (Per cent)	32.40 = 32				16.02 =16		
7	10	46056	1.35	9461	18284	1.12	3756
	12	37147	1.30	8139	10724	1.07	2349
	15	26364	1.23	6140	1762	1.01	411
IRR (Per cent)	31.30 = 31				15.76 = 16		
8	10	46016	1.32	8625	17197	1.10	3224
	12	35410	1.27	7128	8081	1.05	1627
	15	22853	1.19	5093	-2483	-	-
IRR (Per cent)	24.45 = 24				14.29=14		

plantation with intercrops were maximum in seven years of plantation at the discounting rate of 12 per cent. Poplar based agroforestry with Wimco assistance was also financially viable at the discounting rate of 10, 12, and 15 per cent in six and seven years of plantation. But with Wimco assistance, poplar plantation with intercrops for eight years was financially viable at the discounting rate of only 10 and 12 per cent. The net present and annuity values of poplar plantation and intercrops with Wimco assistance were also maximum in seven year of plantation. Financial Internal Rate of Return (FIRR) of poplar plantation with intercrops without Wimco assistance was maximum in the six year of plantation (32.40 per cent); thereafter, it declined. FIRRs were 31.30 and 24 per cent, respectively in the seven and eight year of plantation. These FIRRs were substantially higher than the market rate of interest. Although FIRRs of poplar with intercrops with Wimco assistance were lower than those without Wimco assistance, they were higher than the market rate of intrest FIRR of poplar plantation with intercrops with Wimco assistance also remained maximum in the six year of plantation (16 per cent); thereafter, it declined.

Employment Absorption

Operations required for the establishment and maintenance of poplar are different from those of agricultural crops. Besides this, poplar remains in the field for a longer period whereas, agricultural crops stand in the field for a season or at most a year. Therefore, intensity of labour requirement also varies with the type of crops. In the case of poplar, labour requirement declines with age. However, in the establishment and harvesting years, labour requirements remain high Farmers usually hire casual labour during sowing, harvesting and peak season for agricultural crops whereas, in the case of tree plantation, more strenuous jobs are performed by hired labourers and lighter works are performed by family labourers Therefore, hired and family labour uses were also worked out separately In the case of poplar plantation, planting operations including digging and preparation of pits were done by Wimco. Since sample farmers purchased ETPs (one year old entire transplants) of poplar from the Wimco nursery, labour employed in the production of ETPs was not considered in the total labour absorption in poplar plantation. It was estimated that poplar plantation provided a total of 710 man days employment per hectare during eight years. In the first year employment of 130 labour mandays including labour employed by

Table 8: Human Labour Employment under Poplar and Intercrops
(Man-days per Hectare)

	Poplar			Poplar-wheat	Poplar-Sugarcane-Wheat
Rotation Age/Year	Hired Labourers	Family Labourers	Total Labourers	Total Labourers	Total Labourers
1st	35 (30)	65	130	189	349
2nd	20	50	70	128	274
3rd	27	63	90	145	291
4th	22	60	82	136	136
5th	20	53	73	131	131
6th	17	51	68	122	122
7th	14	46	60	112	112
8th	3 (122)	12	137	187	187
Total	158 (152) = 310	400	710	1150	1602
Average	39	50	89	144	200

Note : Fingures in the parenthesis are the number of labouerers employed by Wimco

Wimco was created while, of 137 labour mandays employment was created during the harvest year. During maintenance years, labour employment varied between 60 and 90 mandays per hectare per year (Table 8). During the later stages of the plant, labourrequirement was low. In the

planting operations like planting of seedlings, digging, and filling of pits, Wimco employed about 30 workers per hectare. It was observed that the practice of employing hired labour on permanent basis was quite limited. In poplar plantation, casual labour did strenuous works like pruning, leader training, weeding. In total labour, 43.66 per cent was casual and the rest was provided by family. If labourers employed by contractor or Wimco in the planting of seedlings and harvesting were excluded, total hired labour employed by farmers in poplar plantations during eight years was 28.28 per cent of the total labourers. The percentage of hired labour declined with increase in the age of poplar. Since wheat and sugarcane were found to be major intercrops grown with poplar in this study area, labour absorption in poplar-wheat and poplar-sugarcane-wheat combinations were examined The results revealed that on an average poplar and wheat combination generated 146 labourer employment per hectare per annum and poplar, sugarcane, and wheat combination generated 184 labourer employment per hectare per annum. Employment generation in case of poplar, sugarcane and wheat remained substantially high in the first three years owing to high demand for labour in sugarcane cultivation.

Comparative Analysis: Poplar based Agroforestry Vs Agricultural crops

Costs and Returns

Changes in land use will take place only when they offer better returns. It observed that sugarcane was the most remunerative enterprise on the sample farms. Net returns accrued from sugarcane was Rs. 17,285 per hectare per annum. The net returns from sugarcane was the highest among all agricultural crops except vegetable crops. However, it terms of acreage, wheat and paddy had higher share in the cropping pattern. Paddy-wheat rotation provided an income of Rs. 7136 per hectare per annum on the sample farms. Next to these crop rotations, groundnut-wheat crop rotation provided the highest net return. Other important crop rotations were paddy-pea, paddy-mustard which provided net returns of Rs. 5669 and Rs. 5728 per hectare per annum respectively. Net returns accruing from other crop rotations were either near or less than Rs. 5000 per hectare per annum. Vegetable crops based crop rotations were also highly remunerative on the sample farms.

The net return per hectare per annum from poplar and intercrops without Wimco assistance at 12 per cent discount rate appeared to be higher than that of all crop rotations except sugarcane and vegetable based crop rotations in the plantation of six and seven years. In the case of a plantation of eight years, it was more or less equal to the annual net income generated from paddy-wheat rotation and higher than that of other rotations except sugarcane and vegetable based crop rotations (Tables 5 and 9). Annual income per hectare from poplar and intercrops with Wimco assistance was lower than the annual income generated from major crop rotations in the plantation of six, seven and eight years at 12 per cent discounting rate. Besides this, the benefit-cost ratio of poplar and intercrops without Wimco assistance was higher than those of many crop rotations including sugarcane and paddy- wheat in the case of six and seven year plantations.

Table 9: Costs and Returns of Different Crop Rotations
(Rupees per Hectare)

Crop Rotations	Cost A_1	Cost C_2	Gross Income	Farm Business income	Net Income	B-C Ratio
Paddy-Wheat	15153	24396	30979	16379	7136	1.27
Paddy-Barley	13733	22475	25740	12007	3265	1.15
Paddy-Gram	12686	21447	26209	13523	4762	1.22
Paddy-Pea	12476	21146	26814	14338	5669	1.27
Paddy-Mustard	12940	21963	27691	14751	5728	1.26
Paddy-Potato	21914	32767	42101	20187	9334	1.29
Paddy-Tomato	21661	32965	77128	55466	44164	2.34
Paddy-Lentil	11004	19849	25029	14025	5180	1.26
Groundnut-Wheat	12446	21173	27160	15267	6541	1.28
Groundnut-Barley	11026	19251	21921	10895	2670	1.14
Groundnut-Gram	9979	18224	21391	12412	4157	1.17
Groundnut-Pea	9769	17922	22996	13227	5073	1.28
Groundnut-Mustard	10233	18740	23873	13639	5133	1.27
Groundnut-Lentil	8297	16626	21210	12913	4584	1.28
Groundnut-Potato	19207	29544	38283	19076	8739	1.30
Groundnut-Tomato	18955	29741	73309	54355	43568	2.47
Sugarcane	12851	21743	39028	26177	17285	1.80

Employment

Labour employment generation from poplar-wheat was on an average 144 labour mandays which were either almost equal to or higher than labour absorption in groundnut based crop rotations but lower than that in paddy and vegetable based crop rotations and sugarcane (Tables 8 and 10). However, in the case of poplar-sugarcane-wheat combination, labour absorption was higher in almost all crop rotations except paddy-potato and paddy-tomato rotations till the third year. From the third year onwards, sugarcane could not be grown as intercrop with poplar, and employment declined till the penultimate year of harvest. Labour absorption during this period was in the range of 112 to 136 labour mandays per hectare per annum, high in comparison to a few crop rotations. In the harvest year, approximately 187 labour mandays of employment was created which was also high in comparison to many crop rotations. Besides this, labour employed in the raising of entire transplants (ETPs) was not taken into account. If the labour mandays employed in the raising of ETPs were considered, employment generation under poplar based agroforestry would have been substantially higher in comparison to many crop rotations. Furthermore, poplar plantation also creates considerable indirect employment. Over and above, it provides a livelihood to a large number of workers who are involved in this enterprise directly or indirectly.

Environmental Aspects

Maintenance of the fragile eco-system and quality of land are major concerns for the sustainability of any new land-use system. For assessing the impact of any new land use-system on the quality of land requires research which is biological in nature. However, effort has been made to capture

this issue from the experiences of the farmers through all opinion surveys. As poplar plantation generates substaitial amount of fuelwood on the farm which influences the consumption and saving of dung, production, consumption and saving of dung before and after poplar plantation were also examined.

Table 10: Human Labour Employment under Different Rotations
(Mandays per hectare)

Crop Rotations	Hired Labourers	Family Labourers	Total Labourers
Paddy- Wheat	73.81	140.18	214.01
Paddy- Barley	73.90	132.96	206.87
Paddy-Gram	61.13	126.37	187.50
Paddy-Pea	68.59	144.79	213.39
Paddy-Mustard	71.74	137.90	209.65
Paddy-Potato	130.09	215.71	345.81
Paddy-Tomato	102.92	234.23	337.16
Paddy-Lentil	60.93	133.45	194.39
Groundnut-Wheat	47.67	99.31	146.99
Groundnut-Barley	47.76	92.09	139.85
Groundnut-Gram	34.99	85.50	120.48
Groundnut-Pea	42.45	103.92	146.37
Groundnut-Mustard	45.60	97.03	142.63
Groundnut-Lentil	34.79	92.58	127.37
Groundnut-Potato	103.95	174.85	278.79
Groundnut-Tomato	76.78	193.36	270.14
Sugarcane	87.94	142.91	230.86

Opinions of 110 farmers were sought about the quality of the land. It was found that 50 per cent of them could not find any change in the quality of their land. They experienced that whatever amount of nutrients was taken by poplar was refurbished through its leaves and twigs and application of fertilisers. About 45 per cent of poplar growers felt that poplar enriched the soil by furnishing organic matter content which made the soil more compact. Only less than five per cent reported that poplar plantation did harmed the quality of the soil because of higher uptake of nutrients from the soil. They also added that at the time of harvesting, surface soil which was highly fertile was lost while taking out the roots of poplar. Not one farmer experienced a decline in the water table owing to poplar plantation, whereas 56 per cent felt that poplar plantation did not affect the water table.

Dung is a major source of fuel in rural areas. A large amount of dung is burnt for cooking because of scarcity of fuelwood. Pruning of poplar produces a substantial amount of fuelwood which reduces dung consumption for fuel purposes. Dung consumption for fuel purpose is estimated to decline from 46 to 9.5 per cent of the total outflow of dung on large farms. Whereas, it had declined from 73 per cent to 16.5 per cent on medium farmers and from 84 to 19.64 per cent on small farms. Thist had resulted in saving of about 7 quintals of dung in a month

on the sample farms which is equivalent to saving of 0.02 quintal N, 0.01 quintal P. and 0.01 quintal K in a month (Table 11).

Table 11: Production, Consumption and Saving of Dung on Various Sizes of Farms

Size of Farms	Total Outturn of Dung (Quintal per Month)	Consumption of Dung (in per cent)		Saving of Dung (in per cent)	Saving of Nutrients (Quintal per month)		
		without Agroforestry	with Agroforestry		N	P_2O_5	K_2O
Large	1656.33 (16.90)	46 (7.78)	9.50 (1.61)	79.36 (6.18)	2.12 (0.02)	0.91 (0.02)	1.21 (0.01)
Medium	740.25 (12.76)	73 (9.32)	16.5 (2.10)	77.39 (7.21)	1.46 (0.03)	0.63 (0.01)	0.836 (0.01)
Small	304 79 (15.24)	84 (12.80)	19.64 (2.89)	76.61 (9.80)	0.69 (0.04)	0.29 (0.02)	0.40 (0.02)
Total	2701.38	1558.87*	337.40*	1219.51*	4.28	1.83	2.44
Average	15.35	57.71	12.48	6.92	0.02	0.01	0.01

Note: Figures in the Parenthesis indicate per farm in quintal per month
* Unit is in quintal per month

Conclusions

or preventing the current rate of loss of forest cover and meeting the growing demand for timber, fuelwood and fodder, ecologically and economically sustainable changes in land use is urgently needed. Promotion of agroforestry by wood-based industries to reduce the dependence on forests is a right step in this direction. This has shown that poplar-based agroforestry is economically viable and relatively more profitable to many of the crop rotations. Cost-benefit analysis shows that poplar plantations with intercrops with and without Wimco assistance are more remunerative in seven years. It is capable of providing continuous employment on farms and preserving ecological system as well. However, income realized from poplar-based agroforestry is not up to the expected level because of inappropriate application of inputs, cultural operations, and selection of intercrops. There exists plenty of scope for improving the output of poplar tree and income from agroforestry. The results of the study reveal that the cost charged by Wimco for technical advice reduces the income substaintially. Since farmers were growing poplar on their farms for the first time, technical assistance provided by Wimco was necessary. In subsequent rotations, farmers can expect high dividends. However, for attracting new agroforestry adopters, ways should be found to reduce the cost of technical assistance.

For sustaining and popularizing this new land use system, resolute act and some corrective measures are required on the part of both government and Wimco. Findings of this study would be valuable for wood-based industries for the adoption of such approaches on a large scale for meeting their raw material needs.

Note

1. For constructing the life time matrix for the variable (x_i), the index is computed by the formula: $K_h = Xj_h / Sj$ Where. K_h is index for the value of variable under consideration. 'h' is an unit of sub-ample in jth age year and X_{jh} is the value of variable at h sample unit which belongs to j^{th} year. S_j is the average of the sub-sample in j^{th} age of the tree. K_h indicates that the value of variable, say X_1 for the h^{th} unit is K_h times the sample average. Based on this the missing values of the variable for the h^{th} unit in the past and future ware obtained by multiplying the average value of each sub-sample by K_h.

Acknowledgement

The author is grateful to Professor Gopal Naik for his Comments on this paper.

References

Bhalla BK (1988) Industrial oriented farm forestry-a case study from India. *Forest News*,2 (3): 1-4.

Bhalla BK (1989) Agroforestry for meeting the industrial requirements Wimco Ltd., Bombay.

Chand Ramesh (1994) Economics of perennial crops: some methodological issues. *Indian Journal of Agricultural Economics* 49 (2): 246-249.

Gittinger J Price (1982) Economic Analysis of Agricultural Projects. The Hopkins University Press, Baltimore London, U.K.

Jain SK (1996) An Economic Analysis of Agroforestry in Shahjahanpur District in Uttar Pradesh,Ph. D. Thesis (unpublished), submitted to PG School, IARI, New Delhi.

Tejwani KG (1994) Agroforestry in India. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Tiwari DN (1994) Poplar. Surya Publication, Dehra Dun.