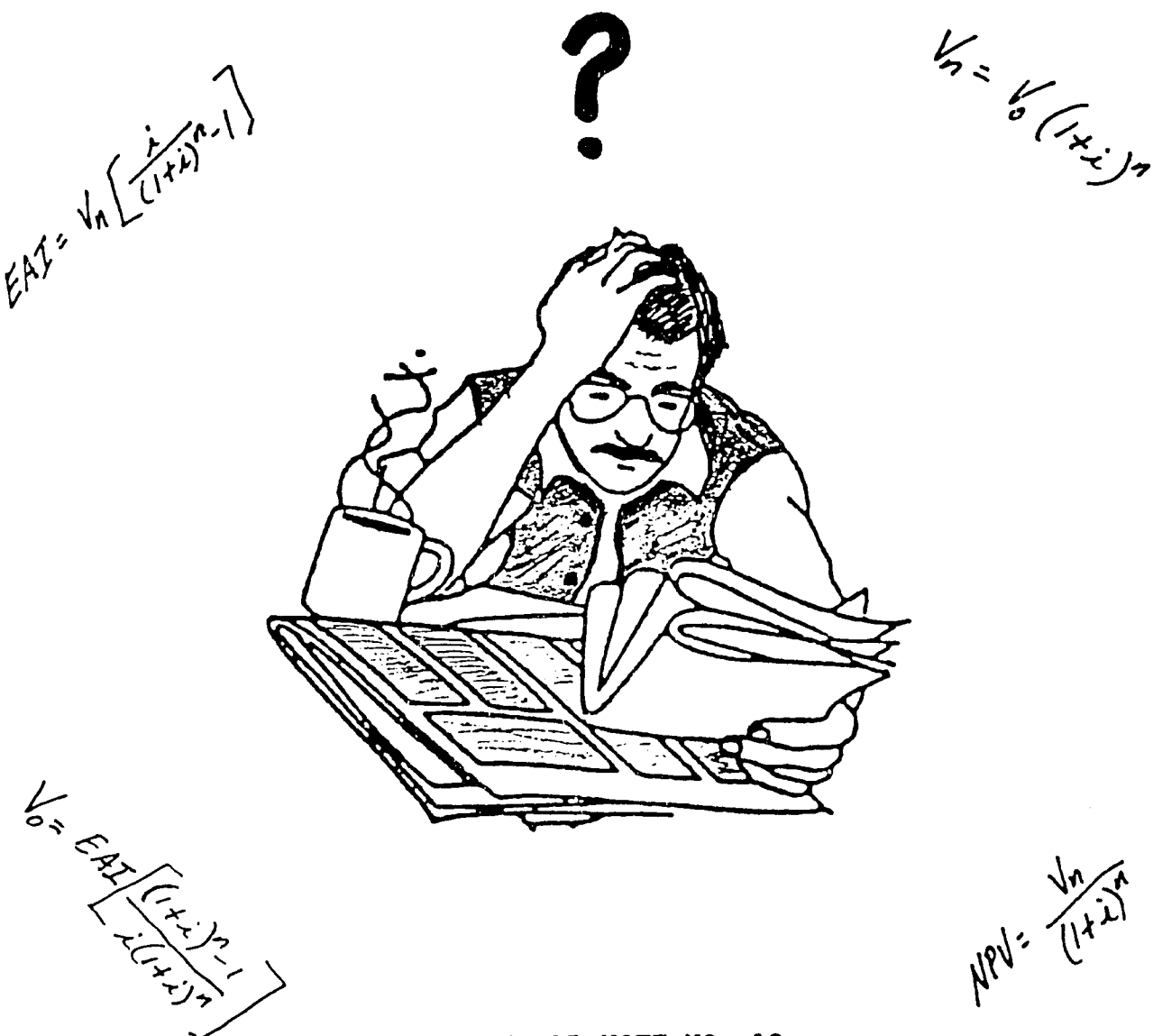
FORESTRY PLANNING & DEVELOPMENT PROJECT
Government of Pakistan-USAID

ECONOMIC OPPORTUNITIES FROM TREE FARMING



TECHNICAL NOTE NO. 12

March 1993

Winrock International

Technical Assistance Team

58, Margalla Road, F-7/2, Islamabad, Pakistan. Tel : 813262 - 813272 Fax : 824519

ECONOMIC OPPORTUNITIES FROM TREE FARMING

TECHNICAL NOTE NO. 12

March 1993

Nazir Ahmad Malik and Gary G. Naughton [1]

Farmers in Pakistan have traditionally kept a few trees on their farms for local use as fuel, forage, and construction materials. Their opportunity to grow trees, of course, varies from farm to farm and region to region according to the limitations of soil, climate, water availability, and farm size. There are also some distinct variations in farmers' willingness to grow trees which can be attributed to traditional, social, cultural, and behavioral factors.

In spite of all these variations and limitations, the interest of farmers is quickly roused when they anticipate the chance to increase farm income by growing trees as a cash crop. Unfortunately, a lot of farmers take the gamble of growing tree crops without clear understanding of the market place, the cost of time deferment on their investment, or the necessary skills for managing, harvesting and marketing. The fact that farmers are willing to take these risks can be viewed, on the one hand, as a kind of desperation to find new ways to assure their livelihood. It can also be argued, on the other hand, that farmers have good market instincts about the profitability of growing crops (wood in this case) which are in short supply.

Foresters need to have access to good information about the economic opportunities (and pitfalls) of tree farming so that they can better advise and counsel farmers who look to them for technical support. This paper presents some brief case studies of costs and returns from some tree farm investments taken by Pakistani farmers since the mid-1980s. Most of these examples come from farmers who have planted and sold trees under the general guidance of social forestry personnel of the Forestry Planning and Development Project.

In a few cases the farmers planted trees independent from the project, but later got technical advice and assistance from the FPDP in marketing their trees.

The field data for this report are based upon personal knowledge of the tree farming operations described, coupled with personal interviews with the farmers. In most cases the trees were evaluated as a standing crop before harvest, and the harvesting and marketing operations were personally monitored to assure the accuracy of estimates and to minimize the assumptions.

[1] The authors are, respectively: DFO, Barani II Integrated Rural Development project; and Field Demonstration Forester, Winrock International (Technical Assistance Team), Forestry Planning and Development Project, Islamabad.

Basic Assumptions and Standards

Land Cost: the farmers in this survey were owners of the land either singly or with other family members. In the cases analyzed all of the land costs on a particular tract were the same whether trees were grown or some other crop was grown. Taken as a constant, there was no advantage to showing a separate calculation for land costs.

Opportunity Cost: the choice to grow trees instead of some other crop denies the use of the land (or a part of it) for that other crop. Where the farmer gives up a production alternative -- a wheat crop, sugarcane crop, etc. -- we have shown the average net return from that crop alternative as a cost of growing trees. This means that the tree farming cases shown in this document will produce at least as much income as the alternative crop. Where the calculated annual income exceeds **one rupee**, it is in addition to the amount that could have been earned from the other crop(s). In cases where the trees are in linear plantation or intermingled with other crops, only the portion of the crop loss attributable to the space taken up by the trees is considered as an opportunity cost.

Subsidy: the effects of subsidy, mostly in the form of free tree seedlings, have been taken out of the calculations by making the assumption that all the farmers paid the full market price for their seedlings and all other inputs. This means that in the case of free seedlings, the net income from any particular case would be greater than the amount shown in the calculations

Full Year: time comparisons between cases have been regularized by assuming that all cost and return inputs run from the first of a full year. Thus, the number of periods in the calculations are = **years - 1**. In actual practice some farmers harvested their trees several months before the end of the final year in the cycle. Shortening the time span between investment cost and harvest will increase the real net income.

Stumpage: all harvest values (incomes) have been standardized to reflect stumpage value (value of the standing crop) at harvest time, even though in some cases the farmers harvested and transported the trees themselves. This avoids the complications of accounting for additional variables of labor and transport costs, and is standard forestry practice for comparison across cases.

Interest on Money: all of the cases analyzed have accounted for the cost of borrowing money. Even if a farmer has all of his own funds, the decision to use the money on one investment instead of another makes that money unavailable until a harvest income is taken and is considered as a cost of doing business.

One-Acre Standard: all case data have been calculated on a per acre basis for ease of comparison. In the actual cases studied, the size of the operations varied from slightly less than one acre to more than 15 acres. While the scale of the operation is of

major importance to the farmer's decisions regarding cropping systems, we don't have enough data from large operations to state with certainty how the scale of the investment would change the outcome in a particular case. But, in advising an individual farmer, the forester needs to be aware of the effects of large versus small scale in terms of changes in opportunity costs and the variations in the efficiency of labor and capital. For example, protection costs are much less per acre as size increases.

Calculation Procedures

Discounted cash flow analysis was done on each case to determine: Net Present Value (NPV) and Equivalent Annual Income (EAI).

Net Present Value is defined as the sum of all future returns minus the sum of all future costs, discounted to the present time. **Equivalent Annual Income** is explained in detail in Appendix A.

Calculations were facilitated by the use of CASH (version 3.5), a general cash flow microcomputer program for conducting investment analysis (Blinn and Rose, 1987). This menu driven program is 'user friendly' and operates on any IBM compatible personal computer with at least 256K RAM.

All cases presented here use the same values for discounting; 15% nominal discount rate and 12% inflation rate. This gives an **analysis interest rate** of 2.679%, using the formula:

$$\textbf{Analysis Rate} = \left[\frac{(1+\text{Nominal Rate})}{(1+\text{Inflation Rate})}\right] - 1;$$

$$\textbf{thus,} = \frac{1.15}{1.12} - 1 = (1.026786) - 1 = \mathbf{.02679}$$

These rates may or may not reflect the conditions in effect at any given place and time, but were selected as being reasonably close to the 1993 conditions in Pakistan. By keeping all cases on the same basic assumptions, we can at least make valid comparisons of relative values.

The example in **Figure 1**, below, shows one future return (8,000 rupees) at the start of 5th year and a series of annual costs. Costs in Year #1 include tree planting and an annual charge of Rs. 100. The later years have only the annual charge of Rs. 100.

The value of each cost event is compounded forward to the end of the rotation using the analysis rate (**2.679%**), and these costs are summed to get Total Future Cost (Rs.**1,882**). This is then subtracted from the Total Future Return to give Rs. **6,118** Net Future Return. Additional costs and returns could be incurred at other points on the time line, and would still be handled in the same way by the calculation technique in the computer's program.

FIGURE 1: SIMPLIFIED PERIODIC CASH FLOW (EXAMPLE)

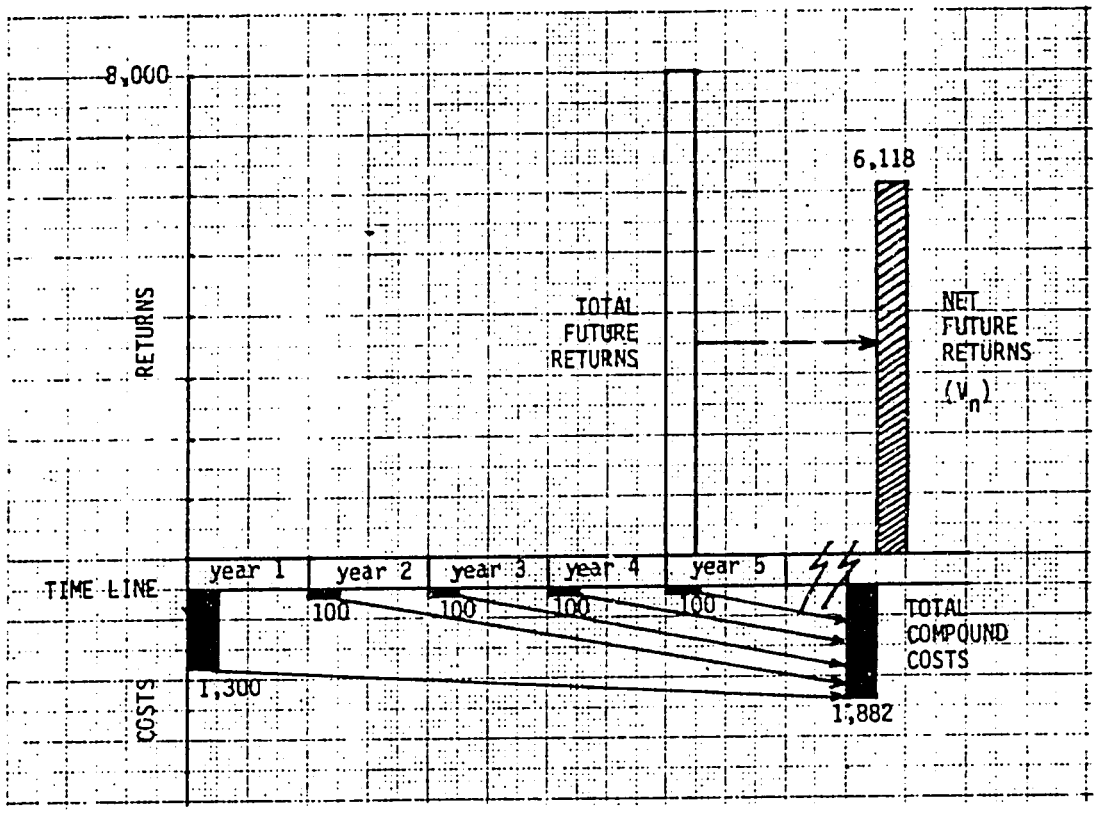


FIGURE 2: NET ANNUALIZED RETURN (or EAI)

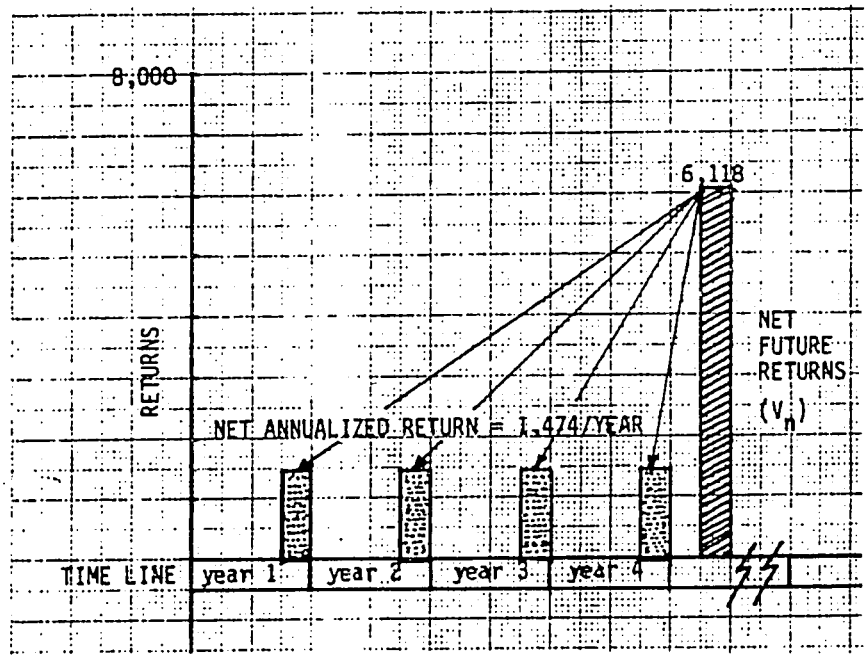


Figure 2 shows that, after obtaining the Net Future Returns, this value is then discounted (at the **analysis rate**), using the

complex formula for equal annual series (see APPENDIX A). This calculated **Equivalent Annual Income** is shown to illustrate how the net future return may be spread out equally over all of the earning periods of the rotation as a comparison to earnings from annual crops.

The Case Studies

Thousands of farmers have recently taken up tree farming in one or more of its various forms. In selecting the following cases for analysis, we have consciously limited our choices to those in which actual sales have been made and in which good records are available. It will also be noticed that all of these cases show a positive increase in cash income from the tree farming activity. We have, in fact, not come across any failures at the time of this analysis, although some probably exist.

The eight cases which follow represent a wide range of tree farming activities over diverse geographic and climatic regimes, and can be taken only as examples and not as averages for broad generalization.

TABLE 1: COMPARISON OF TREE FARMING CASES

CASE NO.	TYPE	LOCATION	ROTATION (YEARS)	EAI (RUPEES)
1	Poplar	Daska	4	5,355
2	Eucalyptus	Hazro	6	5,257
3	Kiker	Hyderabad	7	4,964
4	Poplar	Gujrat	4	4,262
5	Eucalyptus	Kalar Kahar	5	3,942
6	Eucalyptus	Tarbela	7	1,672
7	Eucalyptus	Pindi Gheb	15	1,045
8	Eucalyptus	Kalar Kahar	5	701

Details of the inputs and outputs of each case are given in APPENDIX B. An environmental profile of each production area is given in APPENDIX C, and examples of some alternative crop production costs and returns are given in APPENDIX D.

General Conclusions

The cases presented here suggest that tree farming has good potential for increasing farmers' income, and support the farmers' decisions to raise trees. They also show that farmers can absorb substantial reductions in the yield from annual crops and still realize high over-all gains by using agro-forestry combinations.

Foresters are cautioned to avoid using the simple arithmetic of dividing the total net income by the number of years to derive "net income per year" because the effect of tying up money for a period of years requires complex discounting of cost and harvest values. The CASH program is designed to handle these complex formulas accurately and efficiently.

In working with farmers, the most important value derived from all these data and calculations is the one for **EAI** (equivalent annual income). The **EAI** gives the calculated net income per acre per year even though there may be only periodic harvests after a number of years. This is the common denominator for comparing the value of alternatives, and the one that will interest farmers.

Literature Cited

Blinn, Charles R. and Dietmar W. Rose, 1987. "CASH: User's Manual", Staff Paper Series No. 54, Department of Forest Resources, University of Minnesota, St. Paul, Dec. 1987.

Davis, Lawrence S. and K. Norman Johnson, 1987. "Forest Management", third Edition, McGraw-Hill, New York, Chapter 7.

* * *

APPENDIX A - CALCULATION OF 'EQUIVALENT ANNUAL INCOME'

The comparison of tree-farming and agro-forestry production systems to traditional agricultural grain crops requires that all of the net product from a unit (acre) of land be put into directly comparable terms. Dealing with tree crops which may need a period of years to pass between cost or income 'events' requires that all of the cost and return inputs throughout the crop rotation be discounted to put them into annualized amounts for comparison purposes.

Where two or more cropping systems are being compared for the purpose of deciding which one to implement, the systems have to be comparable. When dealing with systems which include varying mixtures of periodic (tree) crops with annual (grain) crops, the variability is infinite. As the length of time from planting to harvest increases, the effects of time-risk and compounding of investment costs increase rapidly. So, the analysis of an annual crop such as wheat or cotton is much simpler than is the analysis of long-term tree crops.

To compensate for this time effect on the investment and to give a workable common denominator for comparison purposes, we have used the CASH program to put all of the production systems on a time scale comparison, then discount all of the costs and returns to derive a value which represents the <u>net annual income</u> from the system (called **EAI** or Equivalent Annual Income in the tabled reports).

To do this, some important assumptions were made:

1. that the entire calculation would be governed by the rotation age of the longest production cycle (trees);
2. that the annual grain or vegetable crops would continue each year at the same level of output for the entire rotation;
3. that the nominal discount rates and inflation rates at the start of the rotation would stay at the same levels throughout;
4. that the farm operator would be able to wait the required time to harvest the tree crops in the system.

Calculation of this annualized income is done using the following formula:

$$EAI = V_n \left[\frac{i}{(1+i)^n - 1}\right]$$

where EAI = Equivalent Annual Income,
V_n = future value (return - costs) in <u>n</u> periods,
n = number of periods (years minus one)
i = the analysis rate as a decimal.

This formula has the same mathematical effect as compounding all of the costs and all of the returns forward to the end of the rotation, then subtracting the compounded costs from the compounded revenues to determine the net return at the end of the rotation, then multiplying that net return by the discounted time fraction.

Thus, **EAI** (Equivalent Annual Income) is defined as: **the net future value converted to an annual value paid at the end of each full period for the life of the investment, with interest at the selected analysis rate.**

* * *

APPENDIX B: CASES

CASE # 1: Hybrid poplar block plantation near Daska, Sialkot, on good cropland. Plantation is 8.5' X 8.5' (600 per acre). The high opportunity cost of this land (Rs 6,000 per acre per year) is based upon the farmer's own experience over many years with standard crops of wheat, maize and sugarcane.

At the time of planting in 1989 the intent was to grow the trees on a 5 year rotation for match stock. Heavy rains during Monsoon 1992, followed by unusually high winds, caused a large number of the trees to go down. The farmer elected to cut the entire crop and start over because of the danger of insect attack on the weakened trees. The trees were sold standing ("stumpage" sale) for lump-sum price of Rs. 51,000 per acre.

COST ITEM	PERIOD(S)	CURRENT PRICE
Site Preparation	1	Rs. 800
Seedlings	1	1,200
Planting	1	1,200
Pruning	1 & 3	600*
Irrigation	1 & 2	1,000*
Protection	1 & 2	500*
Cultivation	1 - 3	500*
Opportunity	1 - 4	6,000*

(Note: * indicates **recurring** cost in the periods shown)

RETURN ITEM	PERIOD(S)	CURRENT PRICE
Stumpage	4	51,000

INVESTMENT PERFORMANCE ANALYSIS:
(All values in today's rupees per acre)

NET PRESENT VALUE (NPV)	=	15,243
EQUIVALENT ANNUAL INCOME (EAI)	=	5,355

CASE # 2: Eucalyptus high density block plantation on a waterlogged site near Hazro, Attock. There are 2 blocks totalling a little more than one acre, with an alley about 3/4ths acre in size between the blocks. The alley has been successfully cropped with wheat and maize since one year after the trees were planted. Crop production from this alley is not included in this analysis. Trees were planted on a spacing of 3' X 3' (4,800 per acre). The plantation was thinned 3 times (3rd, 4th, and 5th years). The opportunity cost of this land is 'zero' because it was too badly waterlogged for crop production. The value of the final sale (Rs. 25,000 per acre) is estimated.

COST ITEM	**PERIOD(S)**	**CURRENT PRICE**
Site Preparation	1	Rs. 500
Seedlings	1	4,800
Planting	1	4,800
Thinning	3	500
Protection	1 - 6	500*
Opportunity cost	1 - 6	0

(Note: * indicates **recurring** costs in the periods shown)

RETURN ITEM	**PERIOD(S)**	**CURRENT PRICE**
Firewood	3	9,000
Pulp/poles	4	2,000
Pulp/poles	5	6,000
Stumpage	6	25,000

INVESTMENT PERFORMANCE ANALYSIS
(All values in today's rupees per acre)

NET PRESENT VALUE (NPV)	=	24,302
EQUIVALENT ANNUAL INCOME (EAI)	=	5,257

CASE # 3: This is a composite case representing the standard model 'hurrie' of direct seeded kiker on worn out cropland in the Hyderabad area. It applies best to old cotton fields which have become too salty to farm as a result of years of heavy irrigation. After one 7-year rotation of kiker, the land is again returned to cotton or sugarcane and is well rejuvenated. The hurrie system also has the advantage of requiring very little irrigation, allowing the farmer to divert water to other fields. The opportunity cost on this land is 'zero' because it has become sub-marginal for standard crops. The returns listed for pasture and stumpage are local per acre averages.

COST ITEM	PERIOD(S)	CURRENT PRICE
Site Preparation	1	Rs. 800
Seeding	1	500
Protection	1	1,000
Irrigation	1 - 3	200*
Thinning	3	500
Pruning	4	500
Opportunity Cost	1 - 7	0

(Note: * indicates **recurring** costs in the periods shown)

RETURN ITEM	PERIOD(S)	CURRENT PRICE
Forage/pasture	3 - 7	1,200*
Stumpage	7	30,000

INVESTMENT PERFORMANCE ANALYSIS:
(All values in today's rupees per acre)

NET PRESENT VALUE (NPV)	=	27,181
EQUIVALENT ANNUAL INCOME (EAI)	=	4,964

CASE # 4: This is a typical poplar field border plantation around croplands near the city of Gujrat. The trees are on a 4 year rotation, spaced 8 feet apart (100 trees per cropland acre). The adjacent fields produce birseem, wheat and maize in rotation.

This is the simplest model of agro-forestry, and one of the most advantageous in Pakistan. The farmer planted the trees on the water ditch around the farm, pruned them a couple of times, and sold them for cash (stumpage) after just 4 years.

Even though the farmer insisted that the trees had not cost him any crop production during the 4 years, we have assigned a 5% net crop loss (annually) for the final 3 years as an opportunity cost.

COST ITEM	**PERIOD(S)**	**CURRENT PRICE**
Seedlings	1	Rs. 250
Planting	1	200
Pruning	2 - 4	200*
Opportunity Cost (5%)	2 - 4	150*

(Note: * indicates **recurring** costs in the periods shown)

RETURN ITEM	**PERIOD(S)**	**CURRENT PRICE**
Stumpage	4	14,700

INVESTMENT PERFORMANCE ANALYSIS:
(All values in today's rupees per acre)

NET PRESENT VALUE (NPV)	=	12,133
EQUIVALENT ANNUAL INCOME (EAI)	=	4,262

CASE # 5: This is a low-density eucalyptus block planting in the Kalar Kahar area of Chakwal. Because of low rainfall barani conditions and poor stony soils, the trees were planted on 6' X 10' spacing (726 per acre) for a 5 year rotation of firewood. Soil conditions and lack of water prevent the production of an auxiliary crop between the trees. The trees were sold as a lump-sum stumpage sale.

The land was previously open grassland of poor quality and the owner's share of the grass was worth about Rs 100 per year prior to tree planting. This is the opportunity cost.

COST ITEM	**PERIOD(S)**	**CURRENT PRICE**
Site Preparation	1	Rs. 400
Seedlings	1	725
Planting	1	725
Opportunity cost	1 - 5	100*

(Note: * indicates **recurring** costs in the periods shown)

RETURN ITEM	**PERIOD(S)**	**CURRENT PRICE**
Stumpage	5	19,000

INVESTMENT PERFORMANCE ANALYSIS:
(All values in today's rupees per acre)

NET PRESENT VALUE (NPV)	=	14,769
EQUIVALENT ANNUAL INCOME (EAI)	=	3,942

CASE # 6: This is the standard field border planting model so popular as an agroforestry system in Pakistan, using double rows of eucalyptus, spaced 5 feet apart, around the border of a barani wheat field. This configuration gives a net of 160 trees per perimeter acre.

Because of drouthy conditions the rotation age is 7 years even though some cutting commenced in the 5th year. The soil is coarse and sandy and the yield of wheat is reduced by competition from the trees (for moisture), beginning in the third year. An opportunity cost of 10% net loss of wheat income is assessed from the 3rd year onward.

COST ITEM	PERIOD(S)	CURRENT PRICE
Seedlings	1	Rs. 180
Planting	1	200
Protection	1	200
Opportunity Cost @ 10%	3 - 7	150*

(Note: * indicates **recurring** costs in the periods shown)

RETURN ITEM	PERIOD(S)	CURRENT PRICE
Stumpage # 1	5	1,100
Stumpage # 2	6	5,400
Stumpage # 3 (est.)	7	5,500

INVESTMENT PERFORMANCE ANALYSIS:
(All values in today's rupees per acre)

NET PRESENT VALUE (NPV)	=	9,159
EQUIVALENT ANNUAL INCOME (EAI)	=	1,672

CASE # 7: This is a eucalyptus windbreak planting between a crop field and a river bank on sandy outwash land near Pindi Gheb, Attock. The trees are in a 50' wide belt planted on 10' X 10' spacing for a 15 year rotation and coppice regeneration.

The trees have been used to help reclaim the field which was developing into a sand dune. Without the trees, the cropland was useless, so no opportunity cost is assessed.

In the "returns" portion of the tabled data, the 'erosion' entry represents money saved by not having to remove blow sand from the field; the 'flood' entry is the value of the crop saved from floods due to the trees.

COST ITEM	**PERIOD(S)**	**CURRENT PRICE**
Seedlings	1	Rs. 400
Planting	1	350
Watering	1 - 3	600*
Maintenance	1 - 15	200*
Opportunity cost	1 - 15	0

(Note: * indicates **recurring** costs in the periods shown)

RETURN ITEM	**PERIOD(S)**	**CURRENT PRICE**
Erosion	3 - 15	500*
Flood	3 - 15	200*
Home fuel (in kind)	9 - 15	600*
Stumpage # 1	9	3,900
Stumpage # 2	15	4,900

(Note: * indicates **recurring** returns in the periods shown)

INVESTMENT PERFORMANCE ANALYSIS:
(All values in today's rupees per acre)

PRESENT NET VALUE (NPV)	=	12,074
EQUIVALENT ANNUAL INCOME (EAI)	=	1,045

CASE # 8: This is a eucalyptus block plantation at Kalar Kahar on a dry barani site planted at 15' X 15' spacing (194 trees per acre) in 1987 and harvested in 1991 (4 years).

It is a stony and drouthy site with low potential. The trees were harvested 2 or 3 years prematurely because of clearing for a new road.

The opportunity cost of Rs 700 per year is the value of net production of wheat from this field in the farmer's own experience. It is fully Rs. 1,028 less than the average reported in Appendix D. However, the averages are not used in cases where we have actual crop production data. In this case, with wide spacing of trees, the farmer might have grown wheat between trees and increased his total income.

COST ITEM	PERIOD(S)	CURRENT PRICE
Site Preparation	1	Rs. 250
Seedlings	1	195
Planting	1	200
Protection	1 - 4	250*
Opportunity Cost	1 - 4	700*

(Note: * indicates **recurring** costs in the periods shown)

RETURN ITEM	PERIOD(S)	CURRENT PRICE
Fuelwood (in kind)	2 - 4	200*
Stumpage	4	6,880

(Note: * indicates **recurring** returns in the periods shown)

INVESTMENT PERFORMANCE ANALYSIS:
(All values in today's rupees per acre)

NET PRESENT VALUE (NPV)	=	2,625
EQUIVALENT ANNUAL INCOME (EAI)	=	701

APPENDIX C: ENVIRONMENTAL PROFILES

The 8 example cases used in this note come from 7 different farming zones (two cases are from Kalar Kahar). Each of these 7 zones represents limitations and opportunities for farming which are different from the others. This allows for contrasting of the production data from one zone to another, and the drawing of some conclusions about the potential for tree farming as compared to the potential for traditional crop production <u>within a zone</u>.

CASE # 1, Daska. Located on the Sialkot floodplain of Rachna Doab, Sialkot District. Rainfall is 25" to 30" per year, 75% coming during the summer monsoon. Soils are mostly very fine sandy loam, silt loam, silt, and very fine loamy sand; brown to light brown in color. Fertility is rated as high. Sandy surface materials are common on the well-drained soils. In the chhambs the soils are poorly drained and surface water stands year-round in some depressions. The water table is normally 10' to 15' below the surface and wells are commonly used for supplemental irrigation. The Sialkot plain is intensively cropped and almost all fields in the Daska area are supplied by well irrigation. Most common crops are sugarcane, cotton, vegetables, and wheat.

CASES # 2 & 6, Hazro/Tarbela. Located on the chhach plain of the Potwar upland, northeastern Attock District. Rainfall is about 20" per year with 70% coming during the summer monsoon. The landform is mostly flat with gently undulating parallel troughs. Soils are mostly fine and very fine sands, often stratified with coarser outwash material. The soils are generally fertile and respond well to constant crop rotation and multi-cropping. The water table is high, leading to pockets of water-logged soils in some areas. Well irrigation covers nearly 30% of the land area. Almost every acre in the chhach plain is under plough. Barani cropping of wheat and groundnut predominate on 55% of the area. Tobacco and vegetables are the major high-value crops on the better soils where additional water is available.

CASE # 3, Hyderabad. Located within the Rohri plains of central Sindh, Hyderabad District. Rainfall is only 5"-10" per year, mostly during monsoon. The area is characterized by a basin-like floodplain entirely surrounded by a more recent meandering floodplain. The soils are predominantly fine textured, fertile, and prone to salinization through intense irrigation. Waterlogging is common in areas below the primary canals. Summer crops under canal irrigation predominate and cotton is the most important crop. Nearer to the city of Hyderabad, millet is commonly grown due to high demand for food and fodder. Wheat is a common winter crop.

CASE # 4, Gujrat. Located on the Gujrat plain of the Himalayan piedmont. Rainfall averages 25" per year, 70% coming during the summer monsoon. The landform is flat to gently sloping. Most soils are thinly stratified with layers of coarse and moderately fine materials running to sand, fine sand, silt loam and very fine sandy loam; color is mostly light brown and light yellow-brown. Most of the fine textured soils are well-irrigated and produce mostly vegetables, sugarcane, and other high value crops. The coarser soils are generally not irrigated and are predominantly used for production of wheat and fodder crops.

CASES # 5 & 8, Kalar Kahar. Located in the Salt Range Mountains of Chakwal District, in the central part of the range on a broad plateau at 2,500 - 2,700 feet in elevation. Rainfall is 16" - 18" per year, 70% coming in summer monsoon. Soils are mostly of local origin, coarse to moderately coarse, thin and stony. The general fertility is low and the exposure of bedrock and red marl in fields is common. Barani crops of wheat, bojra, and sorghum are the most common and there is little irrigation.

CASE # 7, Pindi Gheb. Located in the Khaur Bedrock Plain of Attock District. Rainfall is about 20" and over 70% comes during the summer monsoon. This is a rolling upland area with broad sandstone ridge outcrops. Soils are commonly sand, fine sand, loamy sand and loamy fine sand of alluvial origin. Soil thickness is extremely variable from only a few inches to several feet. Farming is limited because soils are extremely drouthy; common winter crops are wheat and gram. Bajra is the main summer crop. Vegetables are grown anywhere that well water is available for irrigation.

* * *

APPENDIX D - ALTERNATIVE CROP PRODUCTION COSTS

The following data are provided by the Barani Research Institute, village Thoa, District Chakwal, from its studies of on-farm costs and returns from traditional crops, 1991-92. These data have been used to assist in the estimation of "opportunity costs" for cases # 5, 6, 7, and 8 (Kalar Kahar, Pindi Gheb, and Tarbela).

WHEAT

1. COSTS (per acre)

- plowing and tillage	Rs. 300
- fertilizer	457
- seed, seed treatment, and sowing	278
- harvesting & threshing @ 30 maunds/acre	840
- interest at 12.5% for 6 months	117
Total costs	1,992

2. RETURNS

- straw @ Rs. 12/maund	360
- grain @ Rs. 112/maund X 30	3,360
Total Returns	3,720

3. NET RETURN PER ACRE PER YEAR: Rs. 3,720 - 1,992 = Rs.1,728

* * * *

GROUNDNUT

1. COSTS

- plowing and tillage	200
- seed, seed treatment, sowing	917
- fertilizer/manure	263
- cultivation	160
- protection	740
- harvesting/threshing (@ 20 maunds/acre)	1,100
- interest charges for 6 months at 12.5%	210
Total costs	3,590

2. RETURNS

- groundnuts @ Rs. 400/ maund X 20	8,000

3. NET RETURN PER ACRE PER YEAR: Rs. 8,000 - 3,590 = Rs. 4,410