ECONOMIC OPTIONS FOR AGRICULTURAL PRODUCTION IN SALINE AREAS OF PAKISTAN

SHAUKAT ALI SHAHID, HAFEEZ UR REHMAN
and MUHAMMAD AFZAL*

Abstract. Various studies have shown that farmers optimize their benefits from a given set of resources and constraints. However the economics of tree and forage/shrub production as compared with the traditional crops have not been analyzed so far. The major objective of this paper is to examine the financial/economic viability of forest trees, grasses/shrubs and traditional crops in salt-affected and good agricultural lands.

The results have been derived using 'with' (saline area) and without (non-saline area) project comparison approach. The study area represents the conditions of saline area and the control area represents the good agricultural lands, i.e. six villages from salt affected lands (Joint Satiana Pilot Project) and two villages with no or minimum acreage of salt affected area (adjoining to the project area).

The comparison of economic rents (net return) of traditional crops, tree crops and grasses/shrubs etc. with various categories of soils provides guidelines that tree crops can be planted on marginal lands. Experimentation on social benefits and costs of Eucalyptus also provides support to the hypothesis that tree crops grown for wood should be restricted to marginal lands. Good agricultural lands, slightly saline and moderately saline lands should be reserved for traditional crops or salt tolerant varieties of these crops. This objective can be achieved through instrument such as pricing of water. Farmers on marginal lands should be exempted from water charges for tree crops (may be related with the depth of water table). Farmers planting trees on good agricultural lands should be charged water rates equivalent to opportunity cost of water.

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I. INTRODUCTION

Agriculture is the key sector in the economy of Pakistan as it employs about 48.8% of the labour force (Government of Pakistan, 2002). The share of agriculture in the GDP at a constant factor cost has slowly decreased from 38.9% during 1969-70 to 23.9% during 2001-02. The share of industry in GDP has slowly increased under structural adjustment programmes introduced in successive Five Year Plan. Crops are the most important agricultural sub-sector. Major crops constitute 40% of agricultural GDP, whereas the share of minor crops, livestock, fisheries and forestry in agricultural GDP is 16.5%, 39.3%, 3.1% and 1.1% respectively.

Irrigated land contributes substantially in agriculture in Pakistan. The canal irrigation has been a key cause of the problem known as secondary salinity, mainly through seepage from the canal system and subsequent evaporation, rising water tables (which draw up saline groundwater), inadequate water to meet the leaching requirements of soils, insufficient attention to drainage around saline soils, and tubewells (which draw on salty water). Salinity is more extensive in arid parts of Pakistan. Secondary salinity can be reversed with rehabilitation and reclamation measures. Application of gypsum to the soils, additional water for leaching, and drainage under the Salinity Control and Reclamation Projects (SCARPs) have been effective in reducing salinity.

The cost of salinity in terms of lost yields is hard to evaluate (Faruqee, 1995). It is estimated that yields are reduced by about one third for crops grown on slightly saline areas, while crop yields on moderately saline areas are about two-thirds lower than what would be expected on normal land. Crop production of any kind is difficult on highly saline soils.

<table>
<thead>
<tr>
<th>Province</th>
<th>Saline</th>
<th>Sodic</th>
<th>Saline Sodic Non Gyp</th>
<th>Saline Sodic Gyp</th>
</tr>
</thead>
<tbody>
<tr>
<td>NWFP</td>
<td>480</td>
<td>-</td>
<td>240</td>
<td>720</td>
</tr>
<tr>
<td>Punjab</td>
<td>55330</td>
<td>69160</td>
<td>96820</td>
<td>82990</td>
</tr>
<tr>
<td>Sindh/Balochistan</td>
<td>21070</td>
<td>26260</td>
<td>78780</td>
<td>577690</td>
</tr>
<tr>
<td>Total</td>
<td>265880</td>
<td>95420</td>
<td>175840</td>
<td>661400</td>
</tr>
</tbody>
</table>

Revised action plan studies show that the extent of saline lands is decreasing due to sub-soil drainage and enhanced water supplies for leaching. The area affected by sodic conditions may, in fact, be increasing in Sindh Province. The study conducted by IIMI has also indicated that sodic soils are on rise in Rechna Doab (Rehman, 1997). There is substantial practical experience in Pakistan which demonstrates conclusively that most salt affected soils can be reclaimed by leaching (given good drainage) and the water requirements for desalinization. The data regarding land area according to soil chemistry is presented in Table 1.

The world’s largest canal network established in the country to supply irrigation water without appropriate drainage system was resulting in waterlogging. The data regarding waterlogging are shown in Table 2. The area having 5 feet depth in June 1995 was 2059 (000 ha), which have decreased to 544 (000 ha) during June 2000. The area with 5 feet depth during October 1995 was 4972 (000 ha), which decreased to 3140 (000 ha)

<table>
<thead>
<tr>
<th>Province</th>
<th>1995</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>June</td>
<td>October</td>
</tr>
<tr>
<td>Punjab</td>
<td>475</td>
<td>889</td>
</tr>
<tr>
<td>Sindh</td>
<td>1456</td>
<td>3883</td>
</tr>
<tr>
<td>NWFP</td>
<td>37</td>
<td>63</td>
</tr>
<tr>
<td>Balochistan</td>
<td>86</td>
<td>137</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>2059</strong></td>
<td><strong>4972</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Province</th>
<th>1995</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>June</td>
<td>October</td>
</tr>
<tr>
<td>Punjab</td>
<td>2821</td>
<td>3566</td>
</tr>
<tr>
<td>Sindh</td>
<td>4981</td>
<td>5202</td>
</tr>
<tr>
<td>NWFP</td>
<td>200</td>
<td>215</td>
</tr>
<tr>
<td>Balochistan</td>
<td>210</td>
<td>261</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>8212</strong></td>
<td><strong>9244</strong></td>
</tr>
</tbody>
</table>

during October 2000. Out of a total area (with 5 feet water depth) about 73.8% was noted is Sindh during October 1995. In Punjab, the area reported under waterlogging with 5 feet depth was 22.7% of the total waterlogged area. Such area in NWFP and Balochistan was about 3.5% of total waterlogged area during October 2000.

**Effects of Soil Salinity on Crop Yields**

The relationship of soil salinity and crop yields have been monitored in Revised Action Plan studies and Left Bank Outfall Stage-I Project Preparation Report. The results conclude that the soil salinity causes depressing effects on crop yields and overall productivity of agriculture. According to Table 3 sugarcane was the most effective crop, which could be grown only on non-saline or slightly saline area. The average yield of slightly saline area was 47.2% less than non-saline area. Imported varieties of wheat as well as rice were also yielding less return than traditional varieties on slightly saline, moderately saline and much strongly saline area.

**TABLE 3**

Effects of Soil Salinity on Crop Yield

(Yield/Acre)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Traditional Varieties</th>
<th>Imported Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non Saline</td>
<td>Slightly Saline</td>
</tr>
<tr>
<td>Wheat</td>
<td>17.5 (100.0)</td>
<td>15.8 (90.3)</td>
</tr>
<tr>
<td>Rice</td>
<td>23.0 (100.0)</td>
<td>22.5 (97.8)</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>662.0 (100.0)</td>
<td>318.0 (52.8)</td>
</tr>
</tbody>
</table>

Note: Figures in parentheses indicate the average yield proportion of respective saline land to yield attained at good farm land.

The extent of saline areas in Pakistan is large. The Salinity Control and Reclamation Projects are capital intensive and require a long time to implement. To arrest decreasing agricultural productivity through cultivation of salt tolerant crop varieties and trees are a short-term measure. Since the comparative economics of various crops and tree species in salt affected area is not known with any certainty, the present study has been undertaken to determine economic options for growing crops and trees in saline areas.
OBJECTIVES OF THE STUDY
The principal objectives focused in the study are as under:

1. To undertake an economic analysis of growing traditional crops in both non-salt affected and salt-affected irrigation areas in the Punjab in order to obtain a general understanding of farm viability in these areas.
2. To undertake a comparative economic analysis for substituting the latest salt tolerant crops in saline areas.
3. To conduct an economic analysis of tree growing in saline areas and potential cost benefit ratios of growing trees under saline and salt-free farm environments.

II. DATA SOURCES AND METHODOLOGY

DATA SOURCES
To assess economic options of agricultural production in saline area project comparison approach was applied.

The paper has been derived from a study titled “Economic Options of Agricultural production in Saline Areas of Pakistan” conducted by the International Waterlogging and Research Institute (1998) jointly sponsored by UNDP and Australian Agency for International Development (AusAID). The results have been derived using ‘with’ (saline area) and without (non-saline area) project comparison approach. The study area represents the conditions of saline area and the control area represents the good agricultural lands, so six villages from salt affected lands (Joint Satiana Pilot Project) and two villages with no or minimum acreage of salt affected area (adjoining to the project area) were considered for study. The data collection technique followed the Rapid Appraisal Method/PRA tools covering a group of 10 farmers/key informants from each village with a total of 80 farmers/key informants. The secondary data compilation were mainly from several institutions and research organizations including IWASRI, IIMI, PARC, Agricultural Prices Commission, Peshawar Forest Research Institute and University of Agriculture, Faisalabad, and Pakistan Forest Research Institute, Peshawar.

METHODOLOGY
Various economic terms relating to financial and economic analysis are used for decision making in farm business. In this section the relevant terms have been elaborated with considered criteria.
Economic Rent of Various Quality Saline Land

\[ Y_w = f(L, K, Q) \]

Where

- \( Y_w \) = Production of wheat
- \( L \) = Labour used in wheat production process
- \( K \) = Capital used in wheat production
- \( Q \) = Farm land
- \( i \) = \( a \) to \( e \) (quality of land on salinity basis in descending order such as \( a \) = good farm land, \( b \) = slightly saline, \ldots and so on.

\[ \frac{\partial Y_w}{\partial Q_a} = MP \text{ of wheat crop on good quality land.} \]

\[ \frac{\partial Y_w}{\partial Q_b} = MP \text{ of wheat on 'b' level (slightly) saline land.} \]

\[ \frac{\partial Y_w}{\partial Q_c} = MP \text{ of wheat on 'c' level saline land.} \]

\[ \frac{\partial Y_w}{\partial Q_d} = MP \text{ of wheat on 'd' level saline land.} \]

\[ \frac{\partial Y_w}{\partial Q_e} = MP \text{ of wheat on 'e' level saline land.} \]

On the basis of this

\[ ME = \frac{\partial Y_w}{\partial Q_a} - \frac{\partial Y_w}{\partial Q_d} \]

Where

- \( ME \) = Extensive margin between \( MP \) of land \( a \) and land \( d \).

Max \( Y_w = \frac{\partial Y_w}{\partial Q_a} = \frac{\partial Y_w}{\partial Q_b} = \frac{\partial Y_w}{\partial Q_c} = \frac{\partial Y_w}{\partial Q_d} = \frac{\partial Y_w}{\partial Q_e} \)

Where

- Max = Maximum
So intensive margin \( IM = \frac{\partial Y_w}{\partial Q_c} - \frac{\partial Y_w}{\partial Q_d} \) at maximum production point.

Now

\[ C_i = L_i + K_i. \]

Where

\( C_i \) = Cost of producing wheat at \( i \) level quality land
\( L_i \) = Labour employed on \( i \)th type of land for production of wheat
\( K_i \) = Capital used on \( i \)th type of land to produce wheat

\[ ER_i = Y_w \cdot P_w - C_i \]

Where

\( ER_i \) = Economic rent of \( i \)th quality of land

\[ ER_n = \frac{\partial Y_w}{\partial Q_n} - \frac{\partial Y_w}{\partial Q_d} \]

at maximum production point.

Where \( ER_n \) = Economic rent of ‘\( n \)’ or good quality farm land. The elaboration is given in Appendix II.

Net Present Value

\[ NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1 + i)^t} \]

Where

\( NPV \) = Net present value
\( B_t \) = Benefits received by the respondent farmers in year \( t \).
\( C_t \) = Cost incurred in year \( t \) to receive benefits in that year.
\( i \) = Interest rate.
\( t \) = Life of the activity introduced to add in income by utilizing the farm land.

Internal Rate of Return (IRR)

\( IRR = \) the discount rate ‘\( i \)’ for which \( NPV = 0 \).
There is no specific formula for calculating the IRR and it has to be found by trial and error. If a particular discount rate gives a positive present value then a higher discount rate is tried. If the present value is then negative, the discount rate is reduced. This procedure is continued until a rate is found, which gives a net present value of approximately zero. Consequently the actual IRR then is estimated by using the following formula:

\[
    IRR = LDR + DDR \times \left( \frac{NPV_L}{SNPV} \right)
\]

Where

- **IRR** = Internal rate of return
- **LDR** = Lower discount rate
- **DDR** = Difference between both the discount rates
- **NPV_L** = Net present value at lower discount rate
- **SNPV** = Summation of Net Present Value at both the discount rates ignoring the sign, i.e. positive or negative.

**Benefit Cost Ratio**

\[
    \text{Benefit/Cost Ratio or B/C Ratio} = \frac{\sum_{t=1}^{n} B_t}{\sum_{t=1}^{n} (1+i)^t}
\]

Where

- **B_t** = Benefits realized in period t
- **C_t** = Cost incurred in year t to gain benefits in that year
- **i** = Discount rate
- **n** = Length of life of the activity concerned.

**III. RESULTS AND DISCUSSION**

Economic options for agricultural production in saline area have been assessed on the basis of the financial and economic viability of forest trees and traditional crops. Moreover, different models have been developed under certain assumptions to analyse alternative options.
FINANCIAL VIABILITY OF FOREST TREES

Based on farm budget data for various tree species, the Financial Rates of Return, Benefit Cost Ratios and NPVs at 16% discount rate have been computed. The results of the analysis are shown in Table 4. The results of financial analysis given in the table lead to the conclusion that Eucalyptus and Acacia rank No. 1 and 2 respectively from the point of view of financial profitability to the farmers. The financial rate of return for Eucalyptus and Acacia is 30.9% and 27.5% respectively. The rate of return is greater than the financial rate of interest (16 %). Albizia spp. when analyzed using Rs. 37 as the price for 40 kg fresh wood (equivalent to Acacia) is also financially viable and the rate of return is 26.4%. However, wood merchants have revealed that the wood of Albizia spp. is not popular with the customers, neither as timber nor as fuel wood.

TABLE 4

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Price 40 kg</th>
<th>Labour man Day per Acre</th>
<th>Benefit Cost Ratio @16%</th>
<th>Net Present Value (NPV) @16%</th>
<th>Financial Rate of Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eucalyptus</td>
<td>40</td>
<td>309</td>
<td>1.59 : 1</td>
<td>16450</td>
<td>30.9%</td>
</tr>
<tr>
<td>Acacia nilotica</td>
<td>37</td>
<td>302</td>
<td>1.42 : 1</td>
<td>6084</td>
<td>27.5%</td>
</tr>
<tr>
<td>Albizia spp.</td>
<td>37</td>
<td>275</td>
<td>1.32 : 1</td>
<td>4467</td>
<td>26.4%</td>
</tr>
<tr>
<td>Pongamia pinataia</td>
<td>20</td>
<td>224</td>
<td>0.53 : 1</td>
<td>5792</td>
<td>–1.5%</td>
</tr>
<tr>
<td>Lucaena spp.</td>
<td>20</td>
<td>235</td>
<td>0.58 : 1</td>
<td>5338</td>
<td>–0.7%</td>
</tr>
<tr>
<td>Terminalia arjuna</td>
<td>20</td>
<td>227</td>
<td>0.54 : 1</td>
<td>5940</td>
<td>–2.1%</td>
</tr>
<tr>
<td>Prosopis cineraria</td>
<td>37</td>
<td>198</td>
<td>0.76 : 1</td>
<td>2738</td>
<td>8.8%</td>
</tr>
<tr>
<td>Tamarix aphylla</td>
<td>20</td>
<td>185</td>
<td>0.35 : 1</td>
<td>7412</td>
<td>–12.2%</td>
</tr>
</tbody>
</table>

SENSITIVITY ANALYSIS

As discussed above, Albizia spp. as a fuel wood does not fetch a market price equivalent to Acacia. To look into the effect of a low retail price on the economics of Albizia, a sensitivity analysis has been made. Similarly the prices of Acacia nilotica have been reduced in the sensitivity analysis. Low prices of Eucalyptus have also been used, assuming that wood is consumed in the fuel market. The prices of other species have been raised to Rs. 37 per 40 kg of fresh wood, assuming that the wood from these species are used as low quality timber or prices of these species as fuel wood are high in remote or highly waterlogged areas where source of fuel wood from agricultural crops diminishes due to waterlogging conditions. The results of the analysis
show that Eucalyptus and Acacia are financially viable, though cultivation of Acacia becomes more attractive compared to Eucalyptus (when Eucalyptus is used as fuel wood). Returns from Albizia spp. become negative at low prices. Lucaea spp. and Terminalia arjuna also became financially viable at higher prices (Table 5).

**TABLE 5**  
Sensitivity Test of Financial Analysis

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Price 40 kg</th>
<th>Labour man Day per Acre</th>
<th>Benefit Cost Ratio @ 16%</th>
<th>Net Present Value (NPV) @ 18%</th>
<th>Financial Rate of Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eucalyptus</td>
<td>27</td>
<td>309</td>
<td>1.02 : 1</td>
<td>354</td>
<td>6.7%</td>
</tr>
<tr>
<td><em>Acacia nilotica</em></td>
<td>30</td>
<td>302</td>
<td>1.15 : 1</td>
<td>2199</td>
<td>20.6%</td>
</tr>
<tr>
<td>Albizia spp.</td>
<td>30</td>
<td>275</td>
<td>1.06 : 1</td>
<td>5338</td>
<td>-1.2%</td>
</tr>
<tr>
<td><em>Pongamia pinnata</em></td>
<td>37</td>
<td>224</td>
<td>0.98 : 1</td>
<td>225</td>
<td>15.4%</td>
</tr>
<tr>
<td>Lucaea spp.</td>
<td>37</td>
<td>235</td>
<td>1.08 : 1</td>
<td>814</td>
<td>17.8%</td>
</tr>
<tr>
<td><em>Terminalia arjuna</em></td>
<td>37</td>
<td>227</td>
<td>1.00 : 1</td>
<td>115</td>
<td>16.2%</td>
</tr>
<tr>
<td><em>Prosopis cineraria</em></td>
<td>30</td>
<td>198</td>
<td>0.62 : 1</td>
<td>4427</td>
<td>3.2%</td>
</tr>
<tr>
<td><em>Tamarix aphylla</em></td>
<td>37</td>
<td>85</td>
<td>0.64 : 1</td>
<td>4077</td>
<td>4.4%</td>
</tr>
</tbody>
</table>

The results of this analysis show that production of tree crop is very sensitive to prices of wood. Production of Eucalyptus, *Acacia nilotica* is financially viable at low prices. These tree species can be grown in diversified agro economic conditions and the wood of these species has also multiple usages. Major emphasis should be laid on production of these two species. Plantation of these trees in different areas should be specialized on the basis of market demand and possible prices in that area. For example, for Eucalyptus areas away from pulp factories would fetch low prices (as a fuel wood). In such area plantation of *Acacia nilotica* should be encouraged.

**ECONOMIC VIABILITY OF FOREST TREES**

Financial analysis has revealed that Eucalyptus and Acacia are financially attractive to the farmers. As discussed earlier the financial prices of agricultural commodities and inputs are distorted as a result of government interventions. Present water rates also do not represent the market clearing prices or the opportunity cost of water. Prices play an important role in determining the profitability and resources allocation. The combination of crops that farmers will grow where water is a free commodity will be different compared to a scenario where the opportunity cost of water is
charged to the farmers. To guide the policy decisions on resource allocation to Eucalyptus production, four models of production have been adopted for the Economic Analysis.

**Model I**
- Represents 90% maturity and 10% mortality.
- Good farm land.
- Farmers irrigate the trees up to the fourth year of crop cycle.

**Model II**
- Represents 70% maturity and 30% mortality.
- Saline farm land with good management.
- Irrigation is provided to the trees during the first two years of crop cycle and during the remaining years the trees exist on ground water.

**Model III**
- Represents 50% mortality and 50% maturity.
- Saline farm land with good management.
- Irrigation is provided to the trees during the first two years of crop cycle and during the remaining period, considered for maturity, the trees will depend upon ground water.

**Model IV**
- Represents 30% maturity and 70% mortality.
- Wet saline land with poor management.
- Irrigation is provided in the first year and for the remaining six years trees draw water from ground.

Labour is one of the major factors of production in a tree enterprise and its estimation can influence the rate of return. Hence labour requirements of tree enterprises (particularly at harvest time) have been concisely adjusted in relation to yields, based on labour requirements data used in the financial analysis (model with 50% maturity).

The cost of irrigation water has been calculated based on opportunity cost of water in all four models. The economic price of
wood and labour has been used in this analysis. The analysis also includes the cost of extension support services etc. (termed as public/government costs).

The opportunity cost of capital has been assumed 15% for this analysis.

The results of analysis reveal that production of Eucalyptus under Models I, II and III is economically viable. However, the production of Eucalyptus on wetland with poor management is not economically feasible. NPV is an indicator, which provides guidelines for resource allocation among mutually exclusive tree enterprises. The results of analysis in this section suggest that the resources for Eucalyptus production should be allocated to good lands as compared to saline lands. However, these are preliminary results, which need further examination. Management of Eucalyptus should be improved on wet-saline lands to obtain the potential returns. Production of Eucalyptus with poor management on wetlands is not economically viable and shall lead to a wastage of resources.

Three models for Acacia nilotica at 10% mortality, 50% mortality and 70% mortality have been assumed. Yields of wood have also been taken from the financial farm budgets already discussed. An economic analysis of these three situations have been made. In the base case (without social benefits and costs) production of Acacia is economically feasible on good agricultural land as well as on saline lands. However production on saline lands with poor management is not economically viable. Net Value of Production (NVP) of economic rent on good agricultural land is greater when compared to saline land. However, when the social benefits and costs (opportunity cost of water) are included, production of Acacia on saline land has a comparative advantage (Appendix I, Tables A, B and C).

SOCIAL BENEFITS/COSTS
One of the social benefits will be transpiring/pumping of brackish groundwater by trees. To capture this benefit, it was assumed that during the initial year the sapling will require irrigation, but during the remaining years (depends on assumption of Models) plants will pump groundwater and save the cost incurred by public tubewells to lower the groundwater. The pumping of groundwater by trees has been accounted for as the opportunity cost of pumping tubewell water and assumed as a social benefit. For Model I, where the groundwater is sweet, the pumping by the tree is depleting the sweet water aquifer. The depletion of sweet water aquifer is a social cost for the purpose of this analysis. In Model I the plant consumes water from the
aquifer during the last three years of its production cycle. In this model, pumping by the tree has been taken as a social cost instead of a benefit.

The results of the analysis show that production of Eucalyptus on good agricultural lands is economically feasible. However economic internal rate of Return falls as compared to situation where social costs and benefits have not been accounted in the analysis. Net value of production in Models II and III is greater as compared to Model I. Hence good agricultural lands do not rank high when social benefits and costs are accounted in the analysis. The production in Model IV even with poor management becomes economically viable. Model II and Model III are economically feasible. The economic Internal Rate of Return and net value of production is the highest in Model II. Hence, Model II should be recommended for resource allocations, even on marginal lands (Appendix I, Table B).

There are competing demands for water between trees and agricultural crops. In saline areas farmers mostly receive irrigation water from canals only. In such areas, lands are abundant compared to the quantity of water. In these areas farmers spread water extensively, not intensively. As a result there are water shortages. In the saline areas, irrigation supplies from canal alone cover 57% of total water requirements to crops (WAPDA, 1983). This results in water stress on crops and a consequent decrease in crop yields. Ahmad (1992) has estimated losses of crop output to Rs. 4.279 billion during 1990 in the Indus Basin due to water stress on crops. As a result of scarcity of water the economic marginal value of water in saline zones has been reported to be as high as Rs. 4,800 per acre feet of water.

Based on the cost of Chotiari Reservoir (sunk cost not included) the economic price per acre foot of water has been estimated to be Rs. 1,600. If the sunk costs are included the economic price of an acre foot would be Rs. 2,000 (WAPDA, 1996). To meet the shortage of water, besides other measures, water saving through canal lining has also been adopted in water scarce areas. The economic cost of saving water through canal lining has been calculated at approximately Rs.3,800 per acre foot (Abid Bodla et al., 1997).

Canal lining is also a measure of arresting waterlogging where both the cost of irrigation and public benefits are accounted at Rs. 3,800 per acre foot, the cultivation of both Eucalyptus and Acacia on good agricultural land is not economically feasible. However under this scenario the rate of return for Eucalyptus improves for Models II, III and IV. For Acacia in Models II and III, the Rate of Return goes up, making the tree production under these scenarios very attractive.
In case of cost of irrigation water is taken as Rs. 3,800 per acre foot and the cost of public benefit as Rs. 585 per acre foot (cost of drainage by public tubewells) cultivation of both Eucalyptus and Acacia on good agricultural lands becomes uneconomic.

When the value of water is taken as Rs. 1,600 per acre foot and cost of drainage as Rs. 585 per acre foot, the production of Acacia and Eucalyptus becomes economic for the Model showing 70% mortality. The rate of return in Model II (30% mortality) has been calculated to be 16% and in case of 50% mortality the rate of return drops to 13% for Eucalyptus plantations. Thus when the value of water is high and public benefits are low Model II (30% mortality) remains economically viable. Similarly the rate of return in Acacia for Model II (50% mortality) is 15.2% and in case of Model III (70% mortality), the rate of return drops to 10.97%. When the value of water is high and public benefits are low production of Acacia (Model II) is marginally economical. Model II at 50% mortality of Acacia is economically feasible because acacia needs less water compared to Eucalyptus.

As the surface water is very scarce in saline areas the tree crops should be planted and grown under intensive management. Drainage effluent where feasible should be used for tree plantations to maintain a low economic cost. Eucalyptus plantations, as given in Models III and II showing high mortality rates, 70% and 50% respectively are not acceptable for cultivation in areas where the value of water is very high.

In case of salt affected areas, drainage relief may be provided with surface drainage and public tubewells and additional water to tree plantation particularly during Rabi could be made available from storage. In view of high value of water, plantations of Eucalyptus should be intensively managed to optimize the benefits of scarce water.

FINANCIAL AND ECONOMIC VIABILITY OF TRADITIONAL CROPS

As discussed earlier, there is a peculiar difference in benefits attained from crops and forest-trees. For crops, income and expenditure is realized during the same year/season whereas for forest-trees, generally, there is gap of years for maturity between the expenditures and income. Thus, to study the worth of growing crops in the same period of 7 years (the life of forest trees) as of tree-crops is essential to see the relative significance/comparative advantage of crops versus forest-trees. Financial and economic analysis of crops to cater for a period of seven years has also been estimated.
The findings presented in Table 6 reveal that, on the whole, the average net return per acre in financial and economic terms was Rs. 3,780 and Rs. 4,150 respectively in the salt affected area, whereas in the good agricultural land, the corresponding figures were Rs. 5,858 and Rs. 6,549 per acre respectively. This indicates that growing traditional crops had a significant greater return per acre both in financial and economic terms in the good agricultural land relative to that of the saline land. Thus, it can be concluded that the incidence of salinity and waterlogging had a significant adverse effect on crop production and ultimately on net return in the salt affected areas. On an overall basis, in the salt affected areas, the average net financial and economic return per farm was Rs. 20,679 and Rs. 21,996 respectively, while the corresponding figures were Rs. 31,049 and Rs. 34,711 respectively in the good agricultural lands.

**TABLE 6**


(Rupees)

<table>
<thead>
<tr>
<th>Area</th>
<th>Net Financial Return</th>
<th>Net Economic Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt Affected Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Per Farm</td>
<td>20679</td>
<td>21996</td>
</tr>
<tr>
<td>- Per Acre</td>
<td>3780</td>
<td>4150</td>
</tr>
<tr>
<td>Good Agricultural Land</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Per Farm</td>
<td>31049</td>
<td>34711</td>
</tr>
<tr>
<td>- Per Acre</td>
<td>5676</td>
<td>6549</td>
</tr>
<tr>
<td>Difference (%)</td>
<td>50.2</td>
<td>57.8</td>
</tr>
</tbody>
</table>

The average net financial return per acre for wheat, rice, cotton and sugarcane was Rs. 3,650, Rs. 5,090, Rs. 2,625 and Rs. 11,654 respectively in the salt affected area while in the good agricultural land area the corresponding figures were Rs. 5,322, Rs. 3,439, Rs. 7,408 and Rs. 18,057 respectively during the crop year 1997-98 (Table 7).

The average economic return per acre was Rs. 6,192, Rs. 1,685, Rs. 4,516 and Rs. 4,772 for wheat, basmati rice, cotton and sugarcane respectively in the project area. In the control area, such returns per acre were Rs. 8,692 for wheat, Rs. 2,525 for basmati rice, Rs. 6,776 for cotton and Rs. 11,629 in case of sugarcane.
TABLE 7

<table>
<thead>
<tr>
<th>Crops</th>
<th>Salt Affected</th>
<th>Good Agri. Land</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Financial</td>
<td>Economic</td>
</tr>
<tr>
<td>Wheat</td>
<td>3650</td>
<td>6192</td>
</tr>
<tr>
<td>Basmati Rice</td>
<td>2625</td>
<td>1685</td>
</tr>
<tr>
<td>Cotton</td>
<td>5099</td>
<td>4516</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>11654</td>
<td>4772</td>
</tr>
<tr>
<td>Kharif Fodder</td>
<td>1494</td>
<td>954</td>
</tr>
<tr>
<td>Rabi Fodder</td>
<td>4446</td>
<td>2429</td>
</tr>
</tbody>
</table>

(Rs./Acre)

Thus, it can be concluded from the study that the net financial and economic returns per acre for main crops were significantly greater on the good farm lands compared with those in the salt affected area.

FINANCIAL AND ECONOMIC ANALYSIS MODELS FOR CROPS

Basic Approach and Assumptions

In the financial and economic analysis, the following four different types of models were established:

Model 1: Yields of different crops will be increased in the salt affected area equivalent to the yields of the non-saline area as a result of adoption of biological drainage measures (plantation of Eucalyptus etc.) and engineering interventions to control the salinity and waterlogging in the area.

Model 2: In the salt affected area, the yields could be increased by using additional dose/quantity of selected inputs, i.e. deep tillage, farm yard manure, gypsum and irrigations. This model is applicable to moderately and slightly saline areas.

Model 3: The yields of various crops will remain at the present level as a result of delays in the implementation of drainage biological/engineering projects.

Model 4: The incidence of salinity will be increased overtime. As a result, the yields for different crops will decrease (equivalent to the lowest yields of salt affected/saline areas).
Thus, on the basis of assumptions given in these models, the estimation of financial and economic analysis was undertaken.

**Model Basis Financial Analysis for Crops**

Under Model 1, traditional crops cultivation was highly profitable in the salt affected area where, the Net Present Value (NPV) per farm and per acre was Rs. 110,443 and Rs. 20,191 respectively. For Model 2, the net present value per farm was Rs. 10,4124 whereas on a per acre basis, the magnitude was Rs. 19,035. For Model 3, the Net Present Value per farm and per acre was Rs. 89,886 and Rs. 16,433 respectively. In Model 4, the Net Present Value was Rs. 5,818 per farm and Rs. 1,064 per acre and the magnitude of benefit cost ratio was close to the unity.

Thus, by using the decision criteria of net present value (NPV) per acre it is concluded that the cultivation of traditional crops in the salt affected area was financially feasible under the circumstances of all the Models except Model 4, where the net present value was marginally feasible for crop cultivation. Moreover, it can also be concluded that the highest financial benefit could be achieved under the situations of Models 1 and 2 (Table 8).

**TABLE 8**

Different Models of Financial Analysis for Crops Cultivation (Rupees)

<table>
<thead>
<tr>
<th>Decision Criteria</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefit Cost Ratio (BCR) (@ 16%)</td>
<td>2.41 : 1</td>
<td>2.23 : 1</td>
<td>2.15 : 1</td>
<td>1.07 : 1</td>
</tr>
<tr>
<td>Net Present Value (NPV) (@ 16%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Per Farm</td>
<td>110443</td>
<td>104124</td>
<td>89886</td>
<td>5818</td>
</tr>
<tr>
<td>- Per Acre</td>
<td>20191</td>
<td>19035</td>
<td>16433</td>
<td>1064</td>
</tr>
</tbody>
</table>

**ECONOMIC ANALYSIS FOR CROPS BASED ON MODELS**

The Net Present Value (NPV) in Models 1, 2 and 3 show that the cultivation of traditional crops in the salt affected area was economically viable. For Model 4, the Net Present Value for growing crops was not profitable. Furthermore it can also be observed from data given in Table 9 that the highest profit from growing crops in the salt affected area could be attained under the conditions defined for the first two Models.
TABLE 9
Economic Analysis for Crops Cultivation

(Rupees)

<table>
<thead>
<tr>
<th>Decision Criteria</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefit Cost Ratio (BCR) (@ 15%)</td>
<td>2.02 : 1</td>
<td>1.87 : 1</td>
<td>1.83 : 1</td>
<td>0.91 : 1</td>
</tr>
<tr>
<td>Net Present Value (NPV) (@ 15%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Per Farm</td>
<td>103241</td>
<td>95120</td>
<td>84305</td>
<td>-8698</td>
</tr>
<tr>
<td>- Per Acre</td>
<td>18874</td>
<td>17389</td>
<td>15412</td>
<td>-1590</td>
</tr>
</tbody>
</table>

Crop-wise comparison of Net Present Value (NPV) per acre is presented in Table 10.

Table 10
Crop-wise Benefit Cost Analysis in Economic Terms

(Rs./Acre)

<table>
<thead>
<tr>
<th>Crops</th>
<th>Benefit Cost Ratio (@ 15%)</th>
<th>Net Present Value (@ 15%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>2.76 : 1</td>
<td>28117</td>
</tr>
<tr>
<td>Basmati Rice</td>
<td>1.24 : 1</td>
<td>6516</td>
</tr>
<tr>
<td>Cotton</td>
<td>2.04 : 1</td>
<td>21572</td>
</tr>
<tr>
<td>Sugarcane</td>
<td>1.80 : 1</td>
<td>27553</td>
</tr>
<tr>
<td>Kharif Fodder</td>
<td>1.49 : 1</td>
<td>4574</td>
</tr>
<tr>
<td>Rabi Fodder</td>
<td>1.65 : 1</td>
<td>14167</td>
</tr>
</tbody>
</table>

FINANCIAL AND ECONOMIC VIABILITY OF GRASSES/SHRUBS
To determine the financial and economic viability of grasses/shrubs, the benefit cost analysis was undertaken. Keeping in view the ranking criteria of net present value per acre, the different types of grasses/shrubs have been prioritized/ranked.

Net return is the gross value of production of grasses/shrubs, minus the value of the various inputs utilized. The opportunity cost of canal water has
been used in estimating the net economic returns. The data regarding net return in financial and economic terms is summarized in Table 11 which reveals that the average net financial return per acre was Rs. 833 for Elephant Grass, Rs. 2,892 for Jantar and Rs. 411 for Atriplex. For Kallar and Napier Grass, the net financial returns were Rs. (−)140 and Rs. (−)171 per acre. In economic terms, net return per acre was positive, i.e. Rs. 615 only in case of Jantar, while for all other grasses/shrubs, net returns were negative ranging from Rs. 727 to Rs. 3,249 per acre.

<table>
<thead>
<tr>
<th>Grasses/Shrubs</th>
<th>Net Financial Return</th>
<th>Net Economic Return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kallar Grass</td>
<td>−140</td>
<td>−2981</td>
</tr>
<tr>
<td>Elephant Grass</td>
<td>833</td>
<td>−2251</td>
</tr>
<tr>
<td>Napier Grass</td>
<td>−171</td>
<td>−3249</td>
</tr>
<tr>
<td>Jantar</td>
<td>2892</td>
<td>615</td>
</tr>
<tr>
<td>Atriplex</td>
<td>411</td>
<td>−727</td>
</tr>
</tbody>
</table>

Thus, it can be concluded that amongst the all grasses/shrubs/plants, only the cultivation of Jantar was financially and economically profitable.

**COMPARATIVE ADVANTAGES OF FOREST-TREES VERSUS AGRICULTURAL CROPS**

Waterlogging, salinity and water shortage are some of the major constraints on irrigated agriculture of Pakistan. In waterlogged area saline water produces negative returns from crops. However, certain tree crops like Eucalyptus can survive on waterlogged and saline lands. As the opportunity cost of groundwater in saline/waterlogged land is zero or negligible the cost of production of such tree crop is less in the saline areas as compared to good land where economic cost of water is high. The consumption of water by agricultural crop is less as compared to tree crop like Eucalyptus. The economic benefits of growing tree crops like Eucalyptus further increase on waterlogged soils where social benefits of pumping ground water by trees are accounted.

To compare the economics of trees and crop economic rent in term of Net Value of Production have been calculated for tree and agricultural crops purely using partial equilibrium approach.
The amount of agricultural crops that must be scarified to obtain additional units of tree is referred as opportunity cost of tree production. To justify production of trees in place of crops, economic rent from trees should be greater than alternative crops (Table 12).

### TABLE 12
Economic Rent in Terms of NVP Per Acre
(Rs./acre)

<table>
<thead>
<tr>
<th>Model</th>
<th>Crops</th>
<th>Eucalyptus</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Without Social Costs and Benefits</td>
<td>With Social Costs and Benefits</td>
<td></td>
</tr>
<tr>
<td>Model I</td>
<td>18874</td>
<td>12354</td>
<td></td>
<td>7772</td>
</tr>
<tr>
<td>Model II</td>
<td>17389</td>
<td>4783</td>
<td></td>
<td>11571</td>
</tr>
<tr>
<td>Model III</td>
<td>15412</td>
<td>3873</td>
<td></td>
<td>8717</td>
</tr>
<tr>
<td>Model IV</td>
<td>-1590</td>
<td>1347</td>
<td></td>
<td>2463</td>
</tr>
</tbody>
</table>

The economic rent for crops and trees have been computed using average attainable yields. Potentials yields of agricultural crops on good agricultural lands are in the range of two to three times of average yields used.

Table 12 reveals very interesting results. Economic rent (NVP) for the first three models of crop is greater than any of three models of Eucalyptus (with as well as without social benefits and costs). This analysis reveals that opportunity cost in terms of economic rent foregone in terms of crop production is greater as compared to economic rent received from the production of tree in first three models. Only in case of Model IV where returns are negative for crops, per acre return of Eucalyptus are greater than crops. The Model IV symbolizes Marginal Lands. On these lands there is no opportunity cost in terms of reduction of crop production for raising Eucalyptus. In view of opportunity cost analysis it is economically feasible to produce Eucalyptus on marginal lands.

**IV. CONCLUSION AND RECOMMENDATIONS**

In view of large food imports in Pakistan and results of comparative advantage, good agricultural lands should be reserved for food production. The yields of agricultural crops on moderately and slightly saline lands
should be increased by improving cultural practices, management, amendments and using salinity resistant varieties.

The comparison of Economic rents (net return) of traditional crops, tree crops and grasses/shrubs etc. with various categories of soils provide a guideline that tree crops should be planted on marginal lands. Experimentation on social benefits and costs of Eucalyptus also provides support to the hypothesis that tree crops grown for wood should be restricted to marginal lands. Good agricultural lands, slightly saline and moderately saline lands should be reserved for traditional crops. This objective can be achieved through instrument such as pricing of water. Farmers on marginal lands should be exempted from water charges for tree crops (may be related with the depth of water table). Farmers planting trees on good agricultural lands should be charged water rates equivalent to opportunity cost of water. Further recommendations to promote tree cultivation in wet/saline lands are as below:

- Easy access to institutional loans should be provided to the farmers.
- Extension services to the farmers for intensive management of tree plantations need to be made effective. Provision of tree seedlings to the farmers at nominal rates should be continued. Adaptive research by IWASRI to evolve a package for intensive management of plantations under wet/saline conditions should be accelerated. Dissemination of such a package should be given high priority.
- Pumping equipment to pump drainage effluent, marginally fit for irrigation, should be provided at subsidized rates to farmers. Similarly the farmers owning marginal lands be given priority for a subsidy grant for installation of tubewells.
- Extensions workers should guide the farmers how to use drainage water in combination with canal water, or using an amendment. This step is imperative to keep the cost of irrigation of forest trees low.
- Industries should be encouraged to make contracts with the farmers/ farmer’s associations for the cultivation of trees in wet saline lands. In such situations the industries may provide seedling, advice and credit to the farmers.
- The information regarding research on traditional crops in saline areas is scattered. The research results regarding management of saline land, and poor quality water, agronomic practices, use of fertilizers, chemicals etc. should be compiled in the shape of a
manual for the extension workers and farmers. The economic impact of various recommendations should be worked out and shown in the manual, as the farmers will have to make decisions on the basis of economics of technological packages.

- Most of the marginal lands in Pakistan fall in the category of saline and saline sodic. Intensive cultivation on such soils without using gypsum has made them compact, hindering the penetration of roots to deeper layers. The physio-chemical conditions of such soils can be improved through better soil management practices. Use of gypsum, being a cash input, needs to be encouraged through advancing credit to the farmers and ensure its timely supply at convenient farm locations, at subsidized rates. Studies to increase the market supplies of gypsum at low prices with the participation of the private sector should be undertaken.
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APPENDIX I

TABLE A
Four Models of Eucalyptus – Results of Economic Analysis
(Value in Rupees)

<table>
<thead>
<tr>
<th>Income of Category</th>
<th>Years of Development</th>
<th>NPV @ 15%</th>
<th>B/C Ratio</th>
<th>EIRR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
<td>3rd</td>
<td>4th</td>
</tr>
<tr>
<td>Model I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GVP</td>
<td>–</td>
<td>–</td>
<td>17100.0</td>
<td>–</td>
</tr>
<tr>
<td>Farm Costs</td>
<td>10261</td>
<td>6330</td>
<td>8287.00</td>
<td>4255</td>
</tr>
<tr>
<td>NVP (yield 3 mds.)</td>
<td>(10261)</td>
<td>(6330)</td>
<td>8813.00</td>
<td>(4255)</td>
</tr>
<tr>
<td>NVP (yield 4 mds.)</td>
<td>(10261)</td>
<td>(6330)</td>
<td>8813.00</td>
<td>(4255)</td>
</tr>
<tr>
<td>Model II</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GVP</td>
<td>–</td>
<td>–</td>
<td>9889.00</td>
<td>–</td>
</tr>
<tr>
<td>Farm Costs</td>
<td>10261</td>
<td>6330</td>
<td>3991.00</td>
<td>394</td>
</tr>
<tr>
<td>NVP</td>
<td>(10261)</td>
<td>(6330)</td>
<td>6898.00</td>
<td>(394)</td>
</tr>
<tr>
<td>Model III</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GVP</td>
<td>–</td>
<td>–</td>
<td>2850.00</td>
<td>–</td>
</tr>
<tr>
<td>Farm Costs</td>
<td>10261</td>
<td>6330</td>
<td>1591.00</td>
<td>394</td>
</tr>
<tr>
<td>NVP</td>
<td>(10261)</td>
<td>(6330)</td>
<td>1259.00</td>
<td>(394)</td>
</tr>
<tr>
<td>Model IV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GVP</td>
<td>–</td>
<td>–</td>
<td>2850.00</td>
<td>–</td>
</tr>
<tr>
<td>Farm Costs</td>
<td>10261</td>
<td>2469</td>
<td>1591.00</td>
<td>394</td>
</tr>
<tr>
<td>NVP</td>
<td>(10261)</td>
<td>(2469)</td>
<td>1259.00</td>
<td>(394)</td>
</tr>
</tbody>
</table>

*NVP is abbreviation for Net Value of Production or Net Return.
TABLE B
Four Models of Eucalyptus Including Social Cost and Benefits Economic Analysis
(Value in Rupees)

<table>
<thead>
<tr>
<th>Income of Category</th>
<th>Year of Development</th>
<th>NPV @ 15%</th>
<th>B/C Ratio</th>
<th>EIRR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st  2nd  3rd  4th  5th  6th  7th</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GVP</td>
<td>–      –      17100</td>
<td>–        –       –       57000</td>
<td>32672</td>
<td></td>
</tr>
<tr>
<td>Social Benefits (costs)</td>
<td>–       –       –       –       –       2510</td>
<td>3510</td>
<td>3510</td>
<td>4580</td>
</tr>
<tr>
<td>Farm Costs</td>
<td>10261  6330  8287  4255  210  189  7749</td>
<td>24699</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NVP (yield 3 mds)</td>
<td>10261  6330  8812  4255  3720  3699  57370</td>
<td>2050</td>
<td>1.07:1</td>
<td>18.3%</td>
</tr>
<tr>
<td>Model II</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GVP</td>
<td>–      –      9889</td>
<td>–        –       –       47500</td>
<td>24367</td>
<td></td>
</tr>
<tr>
<td>Social Benefits</td>
<td>–      –      2703  2703  2703  2703  2703</td>
<td>6852</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farm Costs</td>
<td>10261  6330  2991  394  210  189  9450</td>
<td>19644</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NVP</td>
<td>10261  6330  9601  2309  2493  2514  40753</td>
<td>11571</td>
<td>1.60:1</td>
<td>33.0%</td>
</tr>
<tr>
<td>Model III</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GVP</td>
<td>–      –      2850</td>
<td>–        –       –       57000</td>
<td>23307</td>
<td></td>
</tr>
<tr>
<td>Social Benefits</td>
<td>–      –      1915  1915  1915  1915  1915</td>
<td>4854</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farm Costs</td>
<td>10261  6330  1591  394  210  189  11340</td>
<td>19433</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NVP</td>
<td>10261  6330  3174  1521  1705  1726  47575</td>
<td>8718</td>
<td>1.45:1</td>
<td>27.0%</td>
</tr>
<tr>
<td>Model IV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GVP</td>
<td>–      –      2850</td>
<td>–        –       –       29982</td>
<td>13148</td>
<td></td>
</tr>
<tr>
<td>Social Benefits</td>
<td>–      –      1158  1158  1158  1158  1158</td>
<td>3819</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farm Costs</td>
<td>10261  2469  1591  394  210  189  5965</td>
<td>14495</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NVP</td>
<td>10261  2469  2417  764  948  969  25175</td>
<td>2463</td>
<td>1.17:1</td>
<td>20.0%</td>
</tr>
</tbody>
</table>
**TABLE C**

Three Models of *Acacia nilotica*, Economic Analysis Base Case and Sensitivity Analysis (Including Social Benefits and Costs)

(Value in Rupees)

<table>
<thead>
<tr>
<th>Income Category</th>
<th>Years of Development</th>
<th>NVP (@15%)</th>
<th>Benefit Cost Ratio (BCR)</th>
<th>Economic Internal Rate of Return (EIRR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st</td>
<td>2nd</td>
<td>3rd</td>
<td>4th</td>
</tr>
<tr>
<td>Model I</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GVP</td>
<td>–</td>
<td>–</td>
<td>11484</td>
<td>–</td>
</tr>
<tr>
<td>Social Benefits/Costs</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Farm Costs</td>
<td>8330</td>
<td>4399</td>
<td>5600</td>
<td>2325</td>
</tr>
<tr>
<td>NVP Base Case</td>
<td>(8330)</td>
<td>(4339)</td>
<td>5884</td>
<td>(2325)</td>
</tr>
<tr>
<td>NVP with Social Benefits</td>
<td>(8330)</td>
<td>(4339)</td>
<td>5884</td>
<td>2325</td>
</tr>
<tr>
<td>Model II</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GVP</td>
<td>–</td>
<td>–</td>
<td>2376</td>
<td>–</td>
</tr>
<tr>
<td>Social Benefits/Costs</td>
<td>–</td>
<td>–</td>
<td>957</td>
<td>957</td>
</tr>
<tr>
<td>Farm Costs</td>
<td>8330</td>
<td>4399</td>
<td>1568</td>
<td>394</td>
</tr>
<tr>
<td>NVP Base Case</td>
<td>(8330)</td>
<td>(4339)</td>
<td>808</td>
<td>(394)</td>
</tr>
<tr>
<td>NVP with Social Benefits</td>
<td>(8330)</td>
<td>(4339)</td>
<td>1765</td>
<td>563</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2475</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>---</td>
<td>---</td>
<td>------</td>
<td>---</td>
</tr>
<tr>
<td><strong>Social Benefits/ Costs</strong></td>
<td></td>
<td></td>
<td>579</td>
<td>579</td>
</tr>
<tr>
<td><strong>Farm Costs</strong></td>
<td>8330</td>
<td>2469</td>
<td>1591</td>
<td>394</td>
</tr>
<tr>
<td><strong>NVP Base Case</strong></td>
<td>(8330)</td>
<td>(2469)</td>
<td>(394)</td>
<td>(210)</td>
</tr>
<tr>
<td><strong>NVP with Social Benefits</strong></td>
<td>(8330)</td>
<td>(1890)</td>
<td>884</td>
<td>185</td>
</tr>
</tbody>
</table>
ECONOMIC RENT

Ricardo defined rent as the compensation, which is paid to the owner of land for the original and indestructible powers of the soil (Rima, 1972). Stigler defines rent as "Any productive factor in inelastic supply receives a return that part takes in some measure of a rent" (Stigler, 1966). The genesis of rent may be explained, as when an area is just settled and there is rich and fertile land available in abundance relative to size of population to be supported, there will be no rent on any part of free land. Land is, in effect, a free good under such circumstances. It is not until the growth of population and the progress of society require land of second degree of fertility to be brought under cultivation that rent will emerge on land of first quality. The rent will depend on the difference in the productive powers of two pieces of land. The classical economists reached this result with the tabular representation as shown in Table D. The lumped doses of capital and labour are postulated against a schedule of diminishing marginal products of capital and labour on each quality of land in the table.

<table>
<thead>
<tr>
<th>Doses of Capital and Labour</th>
<th>Quality of Land (kgs. of wheat)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>1</td>
<td>140</td>
</tr>
<tr>
<td>2</td>
<td>150</td>
</tr>
<tr>
<td>3</td>
<td>160</td>
</tr>
<tr>
<td>4</td>
<td>150</td>
</tr>
<tr>
<td>5</td>
<td>140</td>
</tr>
<tr>
<td>6</td>
<td>125</td>
</tr>
<tr>
<td>7</td>
<td>110</td>
</tr>
<tr>
<td>8</td>
<td>110</td>
</tr>
<tr>
<td>9</td>
<td>95</td>
</tr>
</tbody>
</table>


The land of the lowest quality that will yield a product equal to the cost of a first dose of capital and labour is called the extensive margin. This will
be land ‘E’, if the cost of one dose of capital and labour is 100 kg of wheat. An example of this could be highly saline/sodic saline land. To extend the analysis further extensive land would be ‘D’ if the 2nd dose of capital and labour which cost 110 kg of wheat was applied. The last dose which is just remunerative on any type of land is called the intensive margin. At a cost of 100 kg on ‘C’ category of land this would be the sixth dose and on ‘A’ type of land would be eighth dose. Rent is thus the surplus over what the capital and labour costs are. With “competition” the variable input receives its marginal product. In the salt affected areas, there are many qualities of land and these could be put to diverse uses such as growing of trees (different species), traditional crops or salt resistant varieties. Each combination of land use will realize a rent. Planting of Eucalyptus for fuel will realize a different value of rent as compared to plantation for paper pulp. The value of rent from trees, crops can indicate the possible land uses in an area.

**ECONOMIC PRICE OF WATER**

To compute the economic price of water is a complex task especially when data is very limited. In such circumstances the best alternative is to use the secondary data. The economic price of tubewell water has been worked out as Rs. 585 per acre feet (Smedema, 1996) by a World Bank Consultant. We have used this cost as the opportunity cost of water for the economic analysis for base case. The economic cost of water saved by canal lining has been used for an alternative economic analysis (Shafique, 1993).

**MARGINAL SOCIAL COSTS AND SOCIAL BENEFITS**

The marginal private benefit of producing a product is, quite simply, the marginal revenue that the product yields to its producer. The marginal social benefit may be defined as the additional gain which its production confers on the community as a side effect but for which no payment can be exacted. Planting of Eucalyptus may have a side effect of transpiring groundwater and complementing the engineering intervention to lower the groundwater. Tree growers will not achieve any benefits in the short term as a result of a decrease in groundwater levels, but the farming community, as a whole, would benefit from this phenomenon in the long run. There may also be other social benefits such as improvement in the environment and health of the community. The marginal social cost of production is the incidental loss imposed on society which is not fully compensated by the prices the producer pay. For example, there could be an increase in population of birds near tree plantations. These birds may then damage the crops. Such social
costs may be difficult to estimate and similarly, the social benefits like improvement in the environment may be difficult to measure.

**PECULIARITY OF BENEFITS AND COSTS OF TREE CROPS**

The major benefits of a forestry are the production of wood of different categories and other by-products. The benefits from tree crops would be realized after a gestation period depending on the quality of wood to be produced. The costs will consist of farmer's cost and the expenditure being incurred by the supporting agencies/sponsoring agencies (Government costs). The government and farmer cost will be incurred from the planting stage to harvest time. Income to the farmers would be received, in most of cases, at the time of harvest. There will be a gap of many years between the expenditure and income. This is a peculiar situation when compared to agricultural crops, where income is realized during the same year when expenditure is made.

**FARM BUDGET FOR TREE CROPS**

Water rates for all seven years have been shown, since the irrigation authorities will charge the water rate on each standing crop. However, in wet saline land trees will require water from canals/tubewells during the first year only.

For estimating the farm budget of tree crops:

- Total number of trees grown
- Survival Rate = 50% for all types of trees
- Harvesting age of trees = 7 years
  \[ Y = WP_i \times P_i + B \]

Where

- \( WP_i \) = Wood production of crop tree \( i \)
- \( P_i \) = Prices of wood of \( i \) crop
- \( B \) = By product

**Tubewell Water Rate**

\[ \pi = Y - e \]

\[ e = \sum_{i=1}^{n} W_R + S + O \]
Where

\[ W_R = \text{Water rate} \]

\[ i...n = \text{Number of irrigation} \]

\[ S = \text{Cost of seedlings} \]

\[ O = \text{Other inputs required during planting to harvesting} \]

Economic price of tubewell water is Rs. 585 per acre foot (Semedema, 1996).

\[ BCR = NPV - NPC \]