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ECONOMIC OPTIONS FOR AGRICULTURAL PRODUCTION IN SALINE AREAS OF PAKISTAN

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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 1

Land Areas According to Soil Chemistry (ha)

Province	Saline	Sodic	Saline Sodic	
			Non Gyp	Gyp
NWFP	480	–	240	720
Punjab	55330	69160	96820	82990
Sindh/Balochistan	210070	26260	78780	577690
Total	265880	95420	175840	661400

Source: WAPDA (1990), Water Sector Investment Planning Study, Volume I, Main Report, Federal Planning Cell, Lahore.

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 effected 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 2

Extent of Waterlogging in Pakistan

('000' hectares)

Province	1995		2000	
	June	October	June	October
'0' to '5' feet or 152 cm water table depth				
Punjab	475	889	227	280
Sindh	1456	3883	285	2789
NWFP	37	63	32	51
Balochistan	86	137	–	20
Total:	2059	4972	544	3140
'0' to '10' feet or 305 cm water table depth				
Punjab	2821	3566	1721	1500
Sindh	4981	5202	454	4624
NWFP	200	215	183	203
Balochistan	210	261	20	–
Total:	8212	9244	2378	6327

Source: Government of Pakistan (2002), *Agricultural Statistics of Pakistan 2001-02*. Ministry of Food, Agriculture and Livestock (Economic Wing), Islamabad.

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)

Crop	Traditional Varieties				Imported Varieties			
	Non Saline	Slightly Saline	Moderately Saline	Strongly Saline	Non Saline	Slightly Saline	Moderately Saline	Strongly Saline
Wheat	17.5 (100.0)	15.8 (90.3)	9.5 (54.3)	6.0 (34.3)	23.6 (100.0)	20.2 (85.6)	13.4 (56.8)	4.2 (17.8)
Rice	23.0 (100.0)	22.5 (97.8)	17.5 (76.1)	–	32.3 (100.0)	28.7 (88.9)	24.4 (75.5)	12.4 (38.4)
Sugarcane	602.0 (100.0)	318.0 (52.8)	–	–	534.0 (100.0)	349.0 (65.4)	–	–

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

$$Y_w = f(L, K, Q_i)$$

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, … and so on.

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

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

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

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

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

On the basis of this

$$ME = \frac{\partial Y_w}{\partial Q_e} - \frac{\partial Y_w}{\partial Q_d}$$

Where

ME = Extensive margin between MP of land e and land d.

$$\text{Max } Y_w = \frac{\partial Y_w}{\partial Q_a} = \frac{\partial Y_w}{\partial Q_b} = \frac{\partial Y_w}{\partial Q_c} = \frac{\partial Y_w}{\partial Q_d} = \frac{\partial Y_w}{\partial Q_e}$$

Where

Max = Maximum

So intensive margin = $IM = \frac{\partial Y_w}{\partial Q_c} - \frac{\partial Y_w}{\partial Q_c}$ 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 ith type of land for production of wheat

K_i = Capital used on ith type of land to produce wheat

$$ER_i = Y_w \cdot P_w - C_i$$

Where

ER_i = Economic rent of ith quality of land

$$ER_a = \frac{\partial Yw_a}{\partial Q_a} - \frac{\partial Yw}{\partial Q_d} \text{ at maximum production point.}$$

Where ER_a = Economic rent of 'a' 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

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

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 %). Albizzia 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 Albizzia spp. is not popular with the customers, neither as timber nor as fuel wood.

TABLE 4

Financial Analysis of Forest Trees

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

SENSITIVITY ANALYSIS

As discussed above, Albizzia 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 Albizzia, 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 Albizzia spp. become negative at low prices. Lucaena spp. and *Terminalia arjuna* also became financially viable at higher prices (Table 5).

TABLE 5

Sensitivity Test of Financial Analysis

Commodities	Price 40 kg	Labour man Day per Acre	Benefit Cost ratio @ 16%	Net Present Value (NPV) @ 16%	Financial Rate of Return
Eucalyptus	27	309	1.02 : 1	354	6.7%
Acacia nilotica	30	302	1.15 : 1	2199	20.6%
Albizzia spp.	30	275	1.06 : 1	5338	−1.2%
Pongamia pinnata	37	224	0.98 : 1	225	15.4%
Lucaena spp.	37	235	1.08 : 1	814	17.8 %
Terminalia arjuna	37	227	1.00 : 1	115	16.2%
Prosopis cineraria	30	198	0.62 : 1	4427	3.2%
Tamarix aphyla	37	85	0.64 : 1	4077	4.4%

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 upto 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

Net Financial and Economic Return on Farms in the Salt Affected and Good Agricultural Land Areas (1997-98)

(Rupees)

Area	Net Financial Return	Net Economic Return
Salt Affected Area		
– Per Farm	20679	21996
– Per Acre	3780	4150
Good Agricultural Land		
– Per Farm	31049	34711
– Per Acre	5676	6549
Difference (%)	50.2	57.8

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

Net Financial and Economic Return for Different Crops of Farms in the Salt affected Areas (1997-98)

(Rs./Acre)

Crops	Salt Affected		Good Agri. Land	
	Financial	Economic	Financial	Economic
Wheat	3650	6192	5322	8692
Basmati Rice	2625	1685	3439	2525
Cotton	5090	4516	7408	6776
Sugarcane	11654	4772	18057	11629
Kharif Fodder	1494	954	1784	1219
Rabi Fodder	4446	2429	6331	4773

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 I, 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 benefits could be achieved under the situations of Models 1 and 2 (Table 8).

TABLE 8

Different Models of Financial Analysis for Crops Cultivation

(Rupees)

Decision Criteria	Model 1	Model 2	Model 3	Model 4
Benefit Cost Ratio (BCR) (@ 16%)	2.41 : 1	2.23: 1	2.15: 1	1.07 : 1
Net Present Value (NPV) (@ 16%)				
– Per Farm	110443	104124	89886	5818
– Per Acre	20191	19035	16433	1064

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)

Decision Criteria	Model 1	Model 2	Model 3	Model 4
Benefit Cost Ratio (BCR) (@ 15%)	2.02 : 1	1.87 : 1	1.83 : 1	0.91 : 1
Net Present Value (NPV) (@ 15%)				
– Per Farm	103241	95120	84305	–8698
– Per Acre	18874	17389	15412	–1590

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)

Crops	Benefit Cost Ratio (@ 15%)	Net Present Value (@ 15%)
Wheat	2.76 : 1	28117
Basmati Rice	1.24 : 1	6516
Cotton	2.04 : 1	21572
Sugarcane	1. 80 : 1	27553
Kharif Fodder	1.49 : 1	4574
Rabi Fodder	1.65 : 1	14167

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 11

Net Returns from Grasses/Shrubs

(Rs./Acre)

Grasses/Shrubs	Net Financial Return	Net Economic Return
Kallar Grass	–140	–2981
Elephant Grass	833	–2251
Napier Grass	–171	–3249
Jantar	2892	615
Atriplex	411	–727

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)

Model	Crops	Eucalyptus	
		Without Social Costs and Benefits	With Social Costs and Benefits
Model I	18874	12354	7772
Model II	17389	4783	11571
Model III	15412	3873	8717
Model IV	–1590	1347	2463

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)

Income of Category	Years of Development							NPV @ 15%	B/C Ratio	EIRR
	1st	2nd	3rd	4th	5th	6th	7^{th}			
Model I										
GVP	–	–	17100.0	–	–	–	57000	32672		
Farm Costs	10261	6330	8287.00	4255	210	189	11340	24690		
NVP (yield 3 mds.)	(10261)	(6330)	8813.00	(4255)	(210)	(189)	45660	6632	1.25:1	24.9%
NVP (yield 4 mds.)	(10261)	(6330)	8813.00	(4255)	(210)	(189)	60880	12354	1.45:1	31.1%
Model II										
GVP	–	–	9889.00	–	–	–	47500	24367	1.24:1	
Farm Costs	10261	6330	2991.00	394	210	189	9450	19584		
NVP	(10261)	(6330)	6898.00	(394)	(210)	(189)	38050	473		23.0%
Model III										
GVP	–	–	2850.00	–	–	–	57000	23307	1.20:1	
Farm Costs	10261	6330	1591.00	394	210	189	11340	19434		
NVP	(10261)	(6330)	1259.00	(394)	(210)	(189)	45660	3873		20.0%
Model IV										
GVP	–	–	2850.00	–	–	–	29982	13148	0.91:1	
Farm Costs	10261	2469	1591.00	394	210	189	5965	14495		
NVP*	(10261)	(2469)	1259.00	(394)	(210)	(189)	24017	1347		12.0%

*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)

Income of Category	Year of Development							NPV @ 15%	*B/C* Ratio	EIRR
	1st	2nd	3rd	4th	5th	6th	7th			
Model I										
GVP	–	–	17100	–	–	–	57000	32672		
Social Benefits (costs)	–	–	–	–	3510	3510	3510	4580		
Farm Costs	10261	6330	8287	4255	210	189	7749	24699		
NVP (yield 3 mds)	10261	6330	8813	4255	3720	3699	42150	2050	1.07:1	18.3%
NVP (yield 4 mds)	10261	6330	8813	4255	3720	3699	57370	7772	1.24:1	25.8%
Model II										
GVP	–	–	9889	–	–	–	47500	24367		
Social Benefits	–	–	2703	2703	2703	2703	2703	6852		
Farm Costs	10261	6330	2991	394	210	189	9450	19644		
NVP	10261	6330	9601	2309	2493	2514	40753	11571	1.60:1	33.0%
Model III										
GVP	–	–	2850	–	–	–	57000	23307		
Social Benefits	–	–	1915	1915	1915	1915	1915	4854		
Farm Costs	10261	6330	1591	394	210	189	11340	19433		
NVP	10261	6330	3174	1521	1705	1726	47575	8718	1.45:1	27.0%
Model IV										
GVP	–	–	2850	–	–	–	29982	13148		
Social Benefits	–	1158	1158	1158	1158	1158	1158	3819		
Farm Costs	10261	2469	1591	394	210	189	5965	14495		
NVP	10261	2469	2417	764	948	969	25175	2463	1.17:1	20.0%

TABLE C

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

(Value in Rupees)

Income Category	Years of Development							NVP (@15%)	Benefit Cost Ratio (BCR)		Economic Internal Rate of Return (EIRR)	
	1st	2nd	3rd	4th	5th	6th	7th		Base Case	Sensitivity Analysis	Base Case	Sensitivity Analysis
Model I												
GVP	–	–	11484	–	–	–	47355	2531,1				
Social Benefits/ Costs	–	–	–	–	(1755)	(1755)	(1755)	2290				
Farm Costs	8330	4399	5600	2325	210	189	11025	19919				
NVP Base Case	(8330)	(4339)	5884	(2325)	(210)	(183)	36330	8440	1.30:1		27.0%	
NVP with Social Benefits	(8330)	(4339)	5884	2325	(1965)	(1944)	34573	3152		1.10:1		23.0%
Model II												
GVP	–	–	2376	–	–	–	47355	19368				
Social Benefits/ Costs	–	–	957	957	957	957	957	2427				
Farm Costs	8330	4399	1568	394	210	189	11025	16161				
NVP Base Case	(8330)	(4339)	808	(394)	(210)	(189)	36330	3208	1.20:1		21.0%	
NVP with Social Benefits	(8330)	(4339)	1765	563	747	768	37287	5634		IAn: I		25.0%

Model III												
GVP	–	–	2475	–	–		2.037	11419				
Social Benefits/ Costs		579	579	579	579	579	579	1905				
Farm Costs	8330	2469	1591	394	189	189	6174	12893				
NVP Base Case	(8330)	(2469)	2088	(394)	(210)	(189)	19863	(1473)	0.89:1		11.0%	
NVP with Social Benefits	(8330)	(1890)	884	185	390	390	20442	432		0.03:1		16.0%

APPENDIX II

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 D

Marginal Product from Various Agricultural Lands

Doses of Capital and Labour	Quality of Land (kgs. of wheat)					
	A	B	C	D	E	F
1	140	135	120	110	100	90
2	150	140	120	100	95	
3	160	135	115	90		
4	150	125	110			
5	140	110	105			
6	125	105	100			
7	110	100	95			
8	110	95				
9	95					

Source: Stigler, Geage J. (1966), *The Theory of Prices*, 3rd edition. The Macmillan Company, Collier-Macmillan Limited, London.

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 = Water rate

$i \ldots n$ = Number of irrigation

S = Cost of seedlings

O = Other inputs required during planting to harvesting

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

$$BCR = NPV - NPC$$