This paper represents an attempt at evaluating some soil amendment practices by using both the experimental and farm level primary data. Experimental data generated over the period 1980-81 to 1984-85 in farmer's fields by the University of Agriculture, Faisalabad and primary data for the year 1990-91 from 100 farm respondents from Sheikhupura district, were analyzed using the partial budgeting technique. The results of the study with respect to controlled experiments showed that gypsum + subsoiling was the best practice for Gandhra soil series and gypsum alone for the Khurrianwala series. However, analysis of farm level data revealed that gypsum + subsoiling + green manuring was the best alternative in terms of field benefits.

Key words: agriculture, economics, reclamation, salt-affected soils, stressed lands

INTRODUCTION
Land and water are the basic resources of agriculture. In Pakistan, the limits to the expansion of the cultivated area are rapidly approaching a point of saturation, particularly of the more productive lands. There is, in fact, an increasing loss of productive agricultural land to non-agricultural uses such as urbanization, industrialization and highway construction. It follows that the future increases in agricultural production must come from increased land productivity (GOP. 1988). A closer examination of the farming conditions in the agriculture sector in Pakistan reveals that low crop productivity is attributable mainly to soil deterioration from the menace of salinity and waterlogging, lack of water supply, natural calamities, pests and plant diseases, inferior quality of seed, small and scattered holdings, etc.

One major cause responsible for low crop yields in Pakistan is unquestionably the problem of salinity. At present about 41% of the salt-affected soils are saline in nature and 51% are saline-sodic. Use efficiency of fertilizers and other inputs is very low on the salt-affected soils. The problem of soil salinity is becoming still worse, especially due to continuous and unchecked use of brackish tubewell water. At present about one-third of the total farm-gate water availability is coming from tubewells. About 80% of the tubewells are pumping water which is not suitable for irrigation. Thus, in future, the agriculture sector will likely face a serious threat from the salinity problem.

Sufficient experimental work has been done on the salt-affected soils by the soil scientists but without the active involvement of agricultural economists (Haider and Ali, 1972; Chaudhry, 1982; Chaudhry and Abaidullah, 1985 and DLR, 1985). Various amendments like gypsum, sulphur, farm yard manure, press mud, hydrochloric acid, calcium chloride, sulphuric acid, etc. have been tried over the years. Effect of simple leaching, deep tillage, subsoiling and green manuring with Diplachne fusca (Leptochloa fusca) was also studied. Similarly, various levels of leaching and amendments and combinations thereof were tried on saline-sodic soils and their effects were noted on various crops in terms of infiltration rate, electrical conductivity, sodium adsorption ratio (SAR) at different soil depths, pH of soil, ESP and yield of crops. However, the data generated through these experiments were not subjected to economic analysis, nor any recommendations extended to the farmers. Thus at present no worthwhile information is available about (a) the various reclamation practices that should be adopted to build up and maintain soil productivity for efficient and abundant production on a sustained basis, and (b) the effect of the reclamation measures on farmers cost and income.

The general objective of this paper is to present the economics of the use of various soil amendments based on experimental as well as on farm level primary data.

METHODOLOGY
In order to arrive at the real economics of the use of various soil amendments, experimental data generated
by the Department of Soil Science, University of Agriculture, Faisalabad during the period 1980-81 to 1984-85, were subjected to rigorous analysis. These experiments were conducted at the farmer's fields for two soil series i.e. Khurrianwala, district Faisalabad and Gandhra in Shahkot area of district Sheikhupura.

There were four treatments i.e.
1. T1 Control (leaching with saline-sodic ground water)
2. T2 Subsoiling (SS) (50 cm deep, 150 cm apart crosswise furrows)
3. T3 Gypsum (GYP) (@100 % GRofindividual plot)
4. T4 Subsoiling plus gypsum (SS + GYP)

There were nine replications making a total of 36 plots each for Khurrianwala and Gandhra series. Rice-wheat rotation was practised during the period of experiment. The farm level effects of various soil amendments, have been ascertained through primary data collected from 100 farm respondents of Sheikhupura district reporting more than 15 % of their farm area as salt-affected. The data pertained to the year 1990-91. The following farm level practices were reported by farms on their salt-affected soil:
1. Without reclamation (farm fields on which no soil reclamation practices are followed by the farmers)
2. Subsoiling + green manuring
3. Gypsum
4. Gypsum + subsoiling + green manuring

The experimental data and the farm level primary data thus generated were subjected to economic analysis by using the partial budgeting technique as prescribed by CIMMYT (1988).

RESULTS
Experimental Data: The results obtained by analyzing the experimental data are presented in Tables 1 and 2. A cursory look at the results would show that economically the most feasible soil amendment for farmer's practice is gypsum (GYP) for Khurrianwala soil series and subsoiling + gypsum (SS+GYP) for Gandhra soil series. It is therefore concluded that subsoiling and gypsum were the most feasible amendments for the reclamation of salt-affected soil especially gypsum for the coarse (i.e. Khurrianwala) soils and subsoiling + gypsum for fine loamy (i.e. Gandhra) soils.

Farm Level Primary Data: On the basis of analysis of farm level data, it can safely be concluded that a combination of practices i.e. application of gypsum + subsoiling + green manuring represented the best option for the reclamation of salt-affected soils in the rice-wheat cropping system. However, the analysis of experimental data generated over time without the inclusion of green manuring showed that subsoiling + gypsum was the best soil amendment for Gandhra soil series and Gypsum alone for Khurrianwala soil series. Thus the package of amendments that proved the most economical varied with the nature of soil.

It should also be noted that the net field benefits attributed to a given package of soil amendments in this study reflect only those benefits which were obtained during the period of experiment at the farmer's fields. Similarly, in the case of farm level data, the benefits of following a given soil management practice, as reported by the farmer respondents, represented only those benefits which accrued to them during the specific crop rotation period. The long term positive effects of the above soil amendment, practices on crop yields and farm incomes in both the cases are hopefully substantially higher than the benefits identified in this study.

Policy Suggestions
1. Since Pakistan is located mostly in arid and semi-arid region of the world, salinity and sodicity shall remain the major threat to agriculture in the country. Moreover, the reclamation of saline and saline-sodic soils is a difficult, time consuming and an expensive process. It is therefore very important, that the farming community is made fully aware of the possible amendments/practices that can be profitably used to overcome this menace. For this purpose, the mass media can play an important role in educating the farmers.
2. Although, the Government of Pakistan has been subsidizing the use of an important amendment i.e. gypsum, but unfortunately, the major bottleneck in the use of this important amendment has been its non-availability to the common farmers. Immediate steps need to be taken to ensure its availability on regular basis. In this connection the existing crushing capacity of gypsum stone should be substantially enhanced.
3. As the results of the study have clearly shown that green manuring combined with subsoiling and gypsum is the best alternative for adoption at the farm level, it is high time that these practices are popularized among the farmers through the provincial extension services in the country.
4. The available empirical evidence shows that a significant proportion of irrigation water supplies comes from tube wells, which mostly pump out hazardous water, adding both to salinity and sodicity. It eventually
### Economics of stressed lands agriculture

#### Table 1. Partial budget for the project period (1980-81 to 1984-85) Khurrianwala soil series

<table>
<thead>
<tr>
<th>Items</th>
<th>Control</th>
<th>SS</th>
<th>GYP</th>
<th>SS+GYP</th>
</tr>
</thead>
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<tr>
<td>I. Gross Field Benefits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Wheat grain</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) Gross output (kg/ha)</td>
<td>7146</td>
<td>10349</td>
<td>14112</td>
<td>12579</td>
</tr>
<tr>
<td>ii) Adjusted output (kg/ha)</td>
<td>6074</td>
<td>8796</td>
<td>11995</td>
<td>10692</td>
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<tr>
<td>iii) Gross field benefits @ Rs. 84 per 40 kg (Rs./ha)</td>
<td>12755</td>
<td>18471</td>
<td>25189</td>
<td>22455</td>
</tr>
<tr>
<td>b) Wheat bhusa (Straw)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) Gross output (kg/ha)</td>
<td>20443</td>
<td>29099</td>
<td>34295</td>
<td>33291</td>
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<tr>
<td>ii) Adjusted output (kg/ha)</td>
<td>17377</td>
<td>24734</td>
<td>29151</td>
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<tr>
<td>iii) Gross field benefits @Rs. 12 per 40 kg (Rs./ha)</td>
<td>5213</td>
<td>7240</td>
<td>8745</td>
<td>8489</td>
</tr>
<tr>
<td>c) Rice grain</td>
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<td></td>
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<tr>
<td>i) Gross output (kg/ha)</td>
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<td>iii) Gross field benefits @Rs.124 per 40 kg (Rs./ha)</td>
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<td>20792</td>
<td>19400</td>
<td>16201</td>
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<tr>
<td>d) Rice bhusa (Straw)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>i) Gross output (kg/ha)</td>
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<td>30029</td>
<td>23123</td>
<td>24482</td>
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<tr>
<td>ii) Adjusted output (kg/ha)</td>
<td>18271</td>
<td>25525</td>
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<td>iii) Gross field benefits @Rs.4 per 40 kg (Rs./ha)</td>
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<td>2081</td>
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<td>i) Gypsum @ 188 bags per ha in treatment GYP @ Rs. 29 per bag (Rs./ha)</td>
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<tr>
<td>ii) Gypsum @ 138 bags per ha in treatment GYP @ Rs. 29 per bag (Rs./ha)</td>
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<td>iii) Subsoiling once (Rs. per ha)</td>
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<td>741</td>
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<tr>
<td>iv) Labour cost for gypsum application (10 days @ Rs. 35 per man day in treatment GYP)</td>
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<td>v) Labour cost for gypsum application (7 man days @ Rs.35 per man day in treatment SS + GYP)</td>
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<td>III. Net Field Benefits (Rs./ha)</td>
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<td>49498</td>
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<tr>
<td>IV. Average Annual Benefits (Rs./ha)</td>
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<td>12375</td>
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<td>GYP</td>
<td>SS+GYP</td>
</tr>
<tr>
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<tr>
<td>I. Gross Field Benefits</td>
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<td></td>
<td></td>
<td></td>
</tr>
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<td>a) Wheat grain</td>
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<td>i) Gross output (kg/ha)</td>
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<td>8543</td>
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<td>2890</td>
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<td>iii) Gross field benefits @ Rs. 84 per 40 kg (Rs./ha)</td>
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<td>6069</td>
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<td>15204</td>
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<td>b) Wheat husa (Straw)</td>
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<td>i) Gross output (kg/ha)</td>
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<td>6790</td>
<td>15918</td>
<td>18319</td>
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<td>iii) Gross field benefits @ Rs. 12 per 40 kg (Rs./ha)</td>
<td>1949</td>
<td>2037</td>
<td>4775</td>
<td>5496</td>
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<td>c) Rice grain</td>
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<td>i) Gross output (kg/ha)</td>
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<td>5966</td>
<td>10434</td>
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<td>ii) Adjusted output (kg/ha)</td>
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<td>5072</td>
<td>8869</td>
<td>9920</td>
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<td>iii) Gross field benefits @ Rs. 124 per 40 kg (Rs./ha)</td>
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<td>15720</td>
<td>27494</td>
<td>30752</td>
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<td>d) Rice husa (Straw)</td>
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<tr>
<td>i) Gross output (kg/ha)</td>
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<td>15977</td>
<td>24377</td>
<td>31478</td>
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<tr>
<td>ii) Adjusted output (kg/ha)</td>
<td>13325</td>
<td>13580</td>
<td>20720</td>
<td>26756</td>
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<tr>
<td>iii) Gross field benefits @ Rs. 4 per 40 kg (Rs./ha)</td>
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<td>1358</td>
<td>2072</td>
<td>2676</td>
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<td>Total gross field benefits (Rs./ha)</td>
<td>23633</td>
<td>25184</td>
<td>49591</td>
<td>54128</td>
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<td>II. Total Costs That Vary</td>
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<tr>
<td>i) Gypsum @ 376 and 455 bags</td>
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<td></td>
<td>10904</td>
<td>13195</td>
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<td>for treatment GYP and SS + GYP @ Rs. 29 per bag (Rs./ha)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii) Subsoiling once (Rs. per ha)</td>
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<td></td>
<td>741</td>
<td>741</td>
</tr>
<tr>
<td>iii) Labour cost for GYP application</td>
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<tr>
<td>19 man days in treatment GYP and SS + GYP @ Rs. 35/man day (Rs./ha)</td>
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<td></td>
<td>665</td>
<td>805</td>
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<td>Total Costs That Vary (Rs./ha)</td>
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<td>11569</td>
<td>14741</td>
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<tr>
<td>III. Net Field Benefits (Rs./ha)</td>
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<td>24443</td>
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<td>IV. Average Annual Benefits (Rs./ha)</td>
<td>5908</td>
<td>6111</td>
<td>9506</td>
<td>9847</td>
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Table 3. Partial budget of wheat based on farm level primary data

<table>
<thead>
<tr>
<th>Item</th>
<th>Without reclamation</th>
<th>Subsoiling + green manuring</th>
<th>Gypsum</th>
<th>Gypsum + subsoiling + green manuring</th>
</tr>
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<tbody>
<tr>
<td>I. Gross Field Benefits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Wheat grain</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average yield (kg/ha)</td>
<td>441.64</td>
<td>1218.20</td>
<td>1482.00</td>
<td>1712.2Cl</td>
</tr>
<tr>
<td>Field price (Rs./kg)</td>
<td>2.38</td>
<td>2.38</td>
<td>2.38</td>
<td>2.38</td>
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<tr>
<td>Gross field benefits (Rs.)</td>
<td>1051.08</td>
<td>1899.34</td>
<td>3527.16</td>
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<tr>
<td>b) Wheat straw</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average yield (kg/ha)</td>
<td>441.64</td>
<td>1218.20</td>
<td>1482.00</td>
<td>1712.2Cl</td>
</tr>
<tr>
<td>Field price (Rs./kg)</td>
<td>2.37</td>
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<td>0.37</td>
<td>2.37</td>
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<tr>
<td>Gross field benefits (Rs.)</td>
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<td>456.83</td>
<td>555.75</td>
<td>642.08</td>
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<tr>
<td>Total gross field benefits (Rs.)</td>
<td>1216.70</td>
<td>3356.16</td>
<td>4082.91</td>
<td>4717.13</td>
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<tr>
<td>11. Variable Costs (Rs./ha)</td>
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</tr>
<tr>
<td>Cultivation</td>
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<td>617.50</td>
<td>988.00</td>
<td>617.50</td>
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<tr>
<td>Fertilizer</td>
<td>504.97</td>
<td>504.97</td>
<td>504.97</td>
<td>504.97</td>
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<td>Plant protection</td>
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<td></td>
<td>113.62</td>
<td>165.49</td>
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<td>Farm yard manure</td>
<td>123.50</td>
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<td></td>
<td>247.00</td>
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<td>Harvesting</td>
<td>176.36</td>
<td>587.86</td>
<td>705.43</td>
<td>705.43</td>
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<tr>
<td>Threshing</td>
<td>105.10</td>
<td>289.93</td>
<td>352.72</td>
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<td>Gypsum</td>
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<td></td>
<td>1230.80</td>
<td>738.48</td>
</tr>
<tr>
<td>Subsoiling</td>
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<td>395.20</td>
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<td>Green manuring</td>
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<td>308.75</td>
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<td>Total variable cost</td>
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<td>Net field benefits (Rs./ha)</td>
<td>194.24</td>
<td>454.36</td>
<td>187.37</td>
<td>1329.38</td>
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</table>

results in hardening of soils. It is therefore very important to realize the long-term implications of the use of brackish water, especially from the point of view of sustainability of agriculture. Immediate steps should be taken to add to our canal water supplies by building additional capacity reservoirs at appropriate places. This would not, only greatly help in substituting the underground brackish water with good quality canal water but would also help improve the conjunctive use of canal and tubewell water.

REFERENCES
Table 4. Partial budget of rice based on farm level primary data

<table>
<thead>
<tr>
<th>Practices followed</th>
<th>Without reclamation</th>
<th>Subsoiling + green manuring</th>
<th>Gypsum</th>
<th>Gypsum + subsoiling + green manuring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td></td>
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</tr>
<tr>
<td>I. Gross Field Benefits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Rice paddy</td>
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<tr>
<td>Average yield (kg/ha)</td>
<td>448.55</td>
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<td>3.325</td>
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<td>4329.76</td>
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<td>b) Rice straw</td>
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<tr>
<td>Average yield (kg./ha)</td>
<td>897.10</td>
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<td>0.07</td>
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<tr>
<td>Gross field benefits (Rs.)</td>
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<td>182.31</td>
<td>213.04</td>
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<td>Total gross field benefits (Rs.)</td>
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<td>4512.07</td>
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<tr>
<td>II. Variable Costs (Rs./ha)</td>
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<td>Cultivation</td>
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<td>Fertilizer</td>
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<td>Harvesting/threshing</td>
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<td>Total variable cost</td>
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<td>3210.33</td>
<td>4374.69</td>
<td>4277.05</td>
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<td>Net field benefits (Rs./ha)</td>
<td>46.60</td>
<td>1301.74</td>
<td>897.40</td>
<td>1716.87</td>
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