ESTIMATING YIELDS FOR A COST-BENEFIT ANALYSIS OF SUBSURFACE DRAINAGE IN SOUTHERN ONTARIO

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This study outlines a method used to estimate potential increases in grain corn yield resulting from subsurface drainage. Experimental data over a 10-year period were used. Yield differences between drained and undrained land were regressed against precipitation amounts in crucial periods of the planting and growing season. The resulting regression coefficients were employed to estimate yield differences over a 79-yr time period, using precipitation amounts recorded during this period. The resulting annual yield differences were found to be normally distributed and the expected value of this yield distribution was considered to be the true estimate of the annual addition to grain corn yield resulting from subsurface drainage. The actual yield difference to be obtained in the future may differ from this estimate. The range in which the true yield differences may vary was established. A cost-benefit analysis was performed at two different price levels for corn and fertilizer, illustrating that evaluation of economic viability of the system is highly dependent on the yield estimate used and on relative prices. The higher the price of corn relative to investment and recurrent annual costs, the lower the required yield increase making the system economically viable needs to be.

INTRODUCTION

It is estimated that 60-70 million dollars are invested annually in plastic pipe and tile drainage in Ontario. While it is generally accepted that this investment in subsurface drainage boosts net farm income, few economic calculations have been carried out to confirm this supposition. Even these limited studies (Brooks 1971; Found et al. 1976) are based on unrepresentative yield data, because of a paucity of data necessary to construct a good estimate of the additional yield resulting from subsurface drainage. An important data set needed to perform a cost-benefit analysis of subsurface drainage is an appropriate long-term record of crop yields on both drained and undrained fields. These records are not available.

Annual differences in crop yields between drained and undrained land depend largely on precipitation received during planting time and crucial periods of the growing season. Since both amount and distribution of precipitation vary greatly over the lifetime of a drainage system, short-term yield differences in a particular year or an average over a few successive years, as commonly used (Brooks 1971; Found et al. 1976; Galloway and Johnston 1982; Leitch and Kerestes 1981; Trafford 1970), can give misleading results if used in a cost-benefit analysis.

Profitability of subsurface drainage is highly affected by (1) the possibility of changing from low to high value crops, and (2) the degree by which crop yields increase. This study addresses only grain corn yield increases due to the installation of subsurface drainage, since corn is one of the most important crops in Southern Ontario benefiting from such drainage.

The study outlines a method used to obtain the statistically expected potential increase in annual grain corn yield resulting from subsurface drainage over the lifetime of the system. It will show that the result of a cost-benefit analysis can differ greatly according to which yield estimate is used. The major emphasis is on estimating long-term yield increases; the cost-benefit analysis is subsidiary. The latter analysis is performed under two different price assumptions for corn and fertilizer. The cost-benefit analysis is mainly used to illustrate that the yield estimate affects the expected economic viability of the system. Using the wrong yield estimate could result in installing a system which, according to the appropriate estimate, may not be viable. Likewise, deciding not to install the system on the basis of an erroneous estimate, is wrong, if it turns out that the system would have been viable if the correct yield estimate had been used. It is therefore essential that any cost-benefit analysis be based on the increase in yield statistically expected to occur over the lifetime of the system.

DATA AND METHODS

One of the few data sources available was a 10-yr corn yield series from drained plots, with a 9.1-m space between the drain laterals, and undrained plots, each pair on two separate soils; one a poorly drained soil (Colwood silt loam) and the other an imperfectly drained soil (Conestoga silt loam) at the Elora research station of the University of Guelph.

Poorly and imperfectly drained soils are defined on the basis of field moisture capacity and extent of the period during which excess moisture is present in the soil. Moisture in excess of the field capacity remains in subsurface horizons for moderately long periods during the year in imperfectly drained soils, and for large parts of the year in poorly drained soils (Canada Soil Survey Committee 1974). The water table of an imperfectly drained soil is more frequently lower than that of a poorly drained soil (MacIntosh and Van Der Hulst 1978).

The plots at the research station were used to measure fertilizer response. The experiments started in 1972. For the period 1972-1977, four different levels of nitrogen fertilizer were applied; 0, 60, 120 and 180 kg/ha, respectively. The experiments were discontinued in 1978 and started again in 1979. For the period 1979-1982, eight different levels of nitrogen were applied; 0, 30, 60, 90, 120, 150, 180 and 210 kg/ha, respectively. All treatment effects influencing yields, other than fertilizer usage, were identical on each set of drained and undrained plots. The effect of fertilizer can be statistically removed. The remaining difference in yield between the drained and undrained plots is then due to subsurface drainage effects plus error.

In order to obtain the potential addition in yield due to subsurface drainage, opti-
nal nitrogen use and corresponding corn yield at each plot were first established by means of estimating production functions from the experimental plot data. Because of annual variability in weather conditions, a particular level of fertilizer use did not give identical yields from year to year. Therefore, the next step was to relate annual yields to the amount of precipitation during planting time and crucial periods of the growing season.

**Estimating Production Functions**

Optimum fertilizer use and corresponding yields were established in two steps. First by obtaining a "best-fit" production function, relating nitrogen to yield, by means of a regression analysis for each of the four sets of plots. For each year a dummy variable was added to capture the annual effect of weather conditions on yield.

The production function used had a quadratic form with decreasing marginal yield.

\[ \frac{\text{annual yield}}{\text{annual corn yield} + \text{nitrogen use}} \]

It is well known that critical stages in corn growing are the time of planting, seedling emergence and leaf initiation and tasselling and silk emergence (Morris et al. 1981; Stevenson et al. 1970).

In order to determine the time periods in which a reduction in excess moisture due to subsurface drainage is crucial for corn yield, a stepwise linear regression analysis was performed, regressing the 10-yr annual corn yield differences between drained and undrained land, as obtained from the previous analysis, on annual precipitation amounts recorded at the research station in 13 different periods within a year. The regression equation tested was:

\[ \Delta Y = b_0 + \sum b_i X_i \]

where \( \Delta Y \) = yield difference between drained and undrained land (kg/ha); and \( X_i \) = precipitation in period \( i \) (mm).

Two regression equations were obtained, one for the poorly drained and the other for the imperfectly drained soil. The ultimate choice of the periods \( i \) in regression Eq. 3 was based on eliminating those periods which did not statistically reduce the error sum of squares. Periods included in the equation gave regression coefficients which were statistically different from zero at the 20% level or less.

**Estimating Statistically Expected Yield Additions**

The aim was to estimate the average annual corn yield increase caused by subsurface drainage. This average should be representative of all possible additions in yield that can be expected under prevailing precipitation conditions occurring in the area. Prevailing weather data must be available over a long time period in order to be assured of a representative sample of possible frequencies of occurrence and their distribution in time. Precipitation data for the area were available for 79 yr (Environment Canada, various issues).

One would expect that precipitation in each period \( i \), used in regression Eq. 3, is normally distributed over the 79 yr, and that this probability distribution is expected to prevail over the long term. Short-term precipitation data over a 10-yr period, on the other hand, are not considered to be representative of all probable outcomes. This is why the average annual yield difference over the 10-yr period would give an unrepresentative picture of the yield effects over the lifetime of the drain.

In order to get a representative estimate of the yield difference between drained and undrained land, Eq. 3 was used. Annual yield differences were computed by substituting the precipitation amounts recorded in each of the 79 yr in Eq. 3. The 79 yield differences between drained and undrained land thus computed were expected to be normally distributed. The expected value of this distribution was considered to be a representative estimate of the annual addition in yield caused by subsurface drainage over the lifetime of the system.

**Economic Analysis**

A cost-benefit analysis was performed in order to show that a statistically sound estimate of the yield increase caused by subsurface drainage, is indispensable for drawing conclusions about the economic viability of the system. A cost-benefit analysis can be used for evaluating investments made in the past, the benefits of which have been fully recovered. In that case, all parameters for such analysis are known. Its major use, however, is as a decision-making tool in deciding whether or not an investment should be made currently. Such analysis must incorporate future prices and quantities, which are highly uncertain. It is therefore based on many assumptions. In this study, the cost-benefit analysis was used in this latter fashion.

The annual net revenue stream derived from the investment during its lifetime was assumed to remain constant. In actuality this assumption is not correct since prices are expected to rise due to inflation. A cost-benefit analysis should be performed in dollars with constant purchasing power. This is done either by discounting the expected nominal net revenue stream using the prevailing interest rate which includes the expected rate of inflation, or by discounting the expected net revenue stream at constant dollars (1982 dollars in this case) using the real interest rate. The latter method was followed in this analysis. The rate of return which savers require to postpone consumption with constant prices is referred to in this study as the time preference rate or the real interest rate. This rate is approximately equal to the difference between the prevailing market rate and the expected rate of inflation. It was assumed that the real interest rate is four %.

Not only may the general price level increase, but the price of corn and fertilizer may change relative to other prices. Two analyses were performed. The first used a 1982 corn price of $110/tonne. The av-
The effect of taxation on the economic viability of the system for the farmer was excluded from the analysis. This effect varies greatly among farmers, depending on their marginal tax rates. This aspect warrants a separate study which goes far beyond the scope of this paper. Moreover, taxes are irrelevant if economic viability is judged from an overall provincial viewpoint.

Economic viability of the investment will depend on the lifetime of the system. Two different periods were considered, 25 and 40 yr.

RESULTS AND DISCUSSION

Estimating Production Functions

The results of the estimation procedure to obtain “best-fit” production functions for the four sets of plots are recorded in Table 1. Dummy variables which were statistically nonsignificant were eliminated from the equation on the basis of a statistical F-test. These variables failed to contribute statistically to the explanation of output levels. Blanks in the table refer to these deleted dummy variables.

Optimum fertilizer use on each of the plots was computed, using Eq. 2. The 1982 prices for corn were $0.0915/kg (net of drying and trucking) and for nitrogen (actual N) $0.443/kg. The ratio of the price of nitrogen to the price of corn was 4.815. A 20% increase in both prices, used as one of the options in the cost-benefit analysis, gives the same ratio. Using this ratio and the coefficients of Eq. 1, the optimal nitrogen use on the poorly drained soil, as computed according to Eq. 2, was 133 kg/ha on drained land and 142 kg/ha on undrained land; on the imperfectly drained soil it was 132 kg and 136 kg/ha, respectively. Note that on both soil types optimum fertilizer use on the undrained plots slightly exceeded that on the drained plots.

Substituting these optimal fertilizer levels in Eq. 1 gave annual yield levels. These are recorded in Table II. In addition, the table provides the annual yield differences between drained and undrained land on both soil types.

Precipitation Analysis

The annual yield differences between drained and undrained land, as recorded in Table II, were regressed against precipitation levels in 13 different periods within the planting and growing season in a stepwise regression analysis.

For the poorly drained soil, the periods in which the amount of precipitation which produced a statistically significant (20% level) reduction in the error sum of squares were those from 11 May to 21 May, 22 May to 31 May, and 25 July to 3 Aug. The corresponding regression equation was:

\[
\Delta Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3
\]  

(3)

TABLE II. PLANTING TIMES AND CORN YIELDS DERIVED FROM OPTIMUM FERTILIZER USE FROM DRAINED AND UNDRAINED PLOTS ON POORLY DRAINED AND IMPERFECTLY DRAINED SOILS†

<table>
<thead>
<tr>
<th>Year</th>
<th>Yield on drained plot (kg/ha)</th>
<th>Planting time</th>
<th>Yield on undrained plot (kg/ha)</th>
<th>Planting time</th>
<th>Yield difference (kg/ha)</th>
<th>Yield on drained plot (kg/ha)</th>
<th>Planting time</th>
<th>Yield on undrained plot (kg/ha)</th>
<th>Planting time</th>
<th>Yield difference (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>5147</td>
<td>13 May</td>
<td>5124</td>
<td>13 May</td>
<td>23</td>
<td>5621</td>
<td>13 May</td>
<td>5555</td>
<td>13 May</td>
<td>66</td>
</tr>
<tr>
<td>1981</td>
<td>6323</td>
<td>14 May</td>
<td>5588</td>
<td>2 June</td>
<td>735</td>
<td>6064</td>
<td>14 May</td>
<td>6053</td>
<td>2 June</td>
<td>71</td>
</tr>
<tr>
<td>1980</td>
<td>6464</td>
<td>20 May</td>
<td>5124</td>
<td>10 June</td>
<td>1340</td>
<td>5844</td>
<td>20 May</td>
<td>6362</td>
<td>10 June</td>
<td>482</td>
</tr>
<tr>
<td>1979</td>
<td>7151</td>
<td>18 May</td>
<td>5641</td>
<td>4 June</td>
<td>1510</td>
<td>7106</td>
<td>18 May</td>
<td>6851</td>
<td>4 June</td>
<td>255</td>
</tr>
<tr>
<td>1977</td>
<td>7400</td>
<td>10 May</td>
<td>7264</td>
<td>12 May</td>
<td>136</td>
<td>7378</td>
<td>12 May</td>
<td>7400</td>
<td>12 May</td>
<td>-22</td>
</tr>
<tr>
<td>1976</td>
<td>5795</td>
<td>13 May</td>
<td>5124</td>
<td>13 May</td>
<td>671</td>
<td>5621</td>
<td>13 May</td>
<td>5555</td>
<td>13 May</td>
<td>66</td>
</tr>
<tr>
<td>1975</td>
<td>5672</td>
<td>9 May</td>
<td>5124</td>
<td>20 May</td>
<td>548</td>
<td>5621</td>
<td>9 May</td>
<td>5555</td>
<td>20 May</td>
<td>66</td>
</tr>
<tr>
<td>1974</td>
<td>6153</td>
<td>8 May</td>
<td>5124</td>
<td>28 May</td>
<td>1029</td>
<td>6221</td>
<td>8 May</td>
<td>5555</td>
<td>28 May</td>
<td>666</td>
</tr>
<tr>
<td>1973</td>
<td>7245</td>
<td>8 May</td>
<td>6462</td>
<td>19 May</td>
<td>783</td>
<td>7634</td>
<td>8 May</td>
<td>5555</td>
<td>19 May</td>
<td>2079</td>
</tr>
<tr>
<td>1972</td>
<td>5147</td>
<td>14 June</td>
<td>5124</td>
<td>14 June</td>
<td>23</td>
<td>5621</td>
<td>14 June</td>
<td>5555</td>
<td>14 June</td>
<td>66</td>
</tr>
</tbody>
</table>

†Optimum use is based on 1982 prices.
where, \( \Delta Y \) = yield difference between drained and undrained land (kg/ha); \( X_1 \) = precipitation from 11 May to 21 May (mm); \( X_2 \) = precipitation from 22 May to 31 May (mm); and \( X_3 \) = precipitation from 25 July to 3 Aug. (mm).

The annual precipitation during each of these three periods over the 10 yr of data explains 78% of the annual yield difference on the poorly drained soils as indicated in Table III. The period 11 May to 21 May represents the normal time of planting at this location. An increase in precipitation would delay planting on undrained land more than on drained land, making the yield difference larger.

The negative regression coefficient for the second period, 22 May to 31 May, is more difficult to interpret. An increase in moisture, particularly when it is excessive, during this period would delay germination and root development of corn which is already planted, because of colder soil temperature, saturation and anaerobic conditions. Yield differences between drained and undrained land could be affected differently by excess moisture in the period 22 May to 31 May.

If corn on undrained land was planted about the same time as on drained land, prior to this period, one would expect the yield from undrained land to be more negatively affected than that from drained land due to excess moisture, making the yield difference larger. The dates of planting on both plots prior to 22 May were about the same in 3 out of 10 yr.

The second possibility was that corn on undrained land was planted prior to 22 May, but later than on the drained land. In that case the germination on undrained land had not advanced far enough to be greatly affected by moisture excess, while germination was affected on drained land. This would make the yield difference smaller. This situation occurred twice during the 10 yr. The planting dates on the undrained plots were 19 and 20 May.

The third possibility was that corn on undrained land was not planted prior to the period 22 May to 31 May, but was planted on the drained land. This situation occurred four times in the 10 yr with 17-21 days difference in planting time. In this case, excessive moisture would delay planting on undrained land. The yield difference would become smaller if a reduction in yield from drained plots caused by adverse germination and root development conditions exceeded a reduction in yield from undrained plots caused by a delay in planting time. While feasible, this effect has not been tested (Reddy and Vyn 1983 Pers. Commun.).

Table III, Estimated Regression Coefficients for Yield Differences Resulting from Subsurface Drainage with Respect to Precipitation Levels

<table>
<thead>
<tr>
<th>Explanatory variables and statistics</th>
<th>Regression coefficients ( \text{Eq 3} )</th>
<th>Poorly drained soil</th>
<th>Imperfectly drained soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant ( b_0 )</td>
<td>608.78</td>
<td>-374.18</td>
<td></td>
</tr>
<tr>
<td>Precipitation, 11-21 May ( X_1 )</td>
<td>( b_1 )</td>
<td>13.65*</td>
<td></td>
</tr>
<tr>
<td>Precipitation, 22-31 May ( X_2 )</td>
<td>( b_2 )</td>
<td>-18.18**</td>
<td></td>
</tr>
<tr>
<td>Precipitation, 25 July–3 Aug. ( X_3 )</td>
<td>( b_3 )</td>
<td>8.94*</td>
<td>20.42**</td>
</tr>
<tr>
<td>Number of observations</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

* ** Significant at the 0.20 and 0.05 probability levels, respectively, by two-tailed \( t \)-tests.

Considering the above three alternatives, one would expect a positive sign associated with the level of precipitation during the period 22-31 May if the first possibility prevailed and negative signs if the other two were prevalent. The first possibility occurred three times, while the second and third occurred six times. On balance, the negative regression coefficient for this period was to be expected.

The positive sign of the regression coefficient for the precipitation variable in the period 25 July–3 Aug. was as expected. An increase in precipitation had a greater positive or smaller negative effect on yield from drained land compared to that from undrained land.

As can be seen from Table III, on the imperfectly drained soil, precipitation during the period 25 July–3 Aug. was the only variable reducing the error sum of squares in a stepwise regression analysis. Only 47% of the variation in yield difference between drained and undrained land could be explained by the precipitation amounts during this period over 10 yr. The poor results from Eq. 3 for the imperfectly drained soil made it impossible to construct a good estimate of yield differences over the long term. For this reason we were not able to perform a cost-benefit analysis of subsurface drainage on imperfectly drained soils. Proceeding with the analysis on the basis of this 10-yr average may give misleading results. The remainder of the analysis concentrates on corn yield differences on poorly drained land.

### Estimating Statistically Expected Yield Additions

Equation 3 was used to estimate the yield differences between drained and undrained land on poorly drained soils over 79 yr for which precipitation data were available. These 79 additions in yield were normally distributed. (The Kolmogorov-Smirnov-statistic was 0.08 which, at the 95% probability level, was smaller than the table-value 0.15 of a two-sided test. Hence the null-hypothesis that the distribution is normal was accepted.) The expected value of this distribution was 770 kg/ha. This statistically expected value differs from the average 10-yr yield increase which was 680 kg/ha.

It was assumed that this normal distribution gave a good representative picture of the distribution of yield differences under all possible precipitation levels that can reasonably be expected. The mean of this normal distribution provided an estimate for the average annual yield increase caused by subsurface drainage. This increase of 770 kg/ha was used in the cost-benefit analysis. This does not imply that with hindsight one could not get a different average over a 25- or 40-yr period. The expected values of the yield increase of a sample of 25 and 40 yr are the same, but since the expected value is itself a random variable, its precision is greater for a 40-yr period than for a 25-yr period. The actual realized yield average over a 25-yr or a 40-yr investment period will fall within a certain range. This interval can be calculated by means of the following formula:

\[
\mu - t_{0.05}(a/\sqrt{n}) < \bar{Y} < \mu + t_{0.05}(a/\sqrt{n}) \tag{4}
\]

Where \( \mu \) = population mean (770 kg/ha); \( \sigma \) = standard deviation (506.27); \( n \) = number of years in investment period; \( \bar{Y} \) = sample mean; and \( t_{0.05} = t \) distribution table-value indicating the probability that the mean of a sample of size \( n \) lies within the above limits with 95% confidence.

Using this formula we conclude that there is a 95% chance that the average yield over a 25-yr investment period will lie between 561 and 979 kg/ha and for a 40-yr investment period between 608 and 932 kg/ha, although the most probable value is 770 kg/ha. The consequences of these intervals for the cost-benefit analysis will be discussed in the next section.

### Economic Analysis

Three criteria were used to evaluate whether investment in subsurface drainage in the area was economically viable or not. These investment criteria were the internal rate of return (IRR), the net present...
At 1982 prices, the value of the additional corn, net of trucking and drying, was $770 \times 0.9015 = \$70.46/(ha/yr)$. Optimal fertilizer use on drained land was 9 kg/ha lower than on undrained land, as explained earlier. This became an additional benefit attributed to drainage amounting to $9 \times 0.443 = \$3.99/(ha/yr)$. The net annual recurrent benefits were $70.46 + \$3.99 - \$5.38$ (annual maintenance cost) = $69.07/ha$

According to Table IV, IRRs exceeding 4% were positive NPVs, and B/C ratios exceeding 1 were evident for the 25-yr and 40-yr periods, indicating economic viability of the investment. However, over a 25-yr period, the investment was barely feasible.

The break-even annual net benefits were $68.80 for a 25-yr investment period and $54.30 for a 40-yr period, corresponding to 767 and 605 kg/ha, respectively. The probability that an average annual yield of 767 kg/ha or more will be obtained during a 25-yr lifetime of the system is 50.4% and that 605 kg or more will be obtained annually as average over the 40-yr period is 62.5%. Note that the 10-yr average of 680 kg/ha, using 1982 prices, would result in a loss in the case of subsurface drainage with a lifetime of 25 yr and a gain of $129 (NPV) over a lifetime of 40 yr.

Increasing the price of corn and fertilizer by 15% relative to other prices resulted in greater profitability of subsurface drainage, as indicated by Table V. The break-even yields for both periods were reduced, compared with using 1982 corn and fertilizer prices. These break-even yields were 643 and 508 kg/ha for a 25-yr and for a 40-yr investment period, respectively. There is a 59.9% chance that the break-even or a higher annual yield will be obtained as average over the 25-yr investment period, and a 69.5% chance that these annual yields will be obtained as average over the 40-yr period.

Both for a 25- and a 40-yr lifetime of the system, the investment was economically viable at 1982 prices on the basis of the most probable yield expected. However, this yield may not be realized. As indicated in the previous section, there is a 95% chance that the realized average annual yield for a 40-yr investment period will fall between 608 and 932 kg/ha. The break-even yield at 1982 prices was 605 kg. Thus, the most likely range within which the average will fall exceeds the break-even yield.

For a 25-yr investment period, on the other hand, there is a 95% chance that the realized average annual yield will fall between 561 and 979 kg/ha. The break-even yield was 767 kg/ha. Thus, there is a greater chance that the investment will not pay compared with a 40-yr lifespan of the system. The chance that the yield will lie between 567 and 767 kg is about 50%. If corn and fertilizer prices increased by 15% relative to other prices, the break-even yield for a 25-yr investment period was reduced to 643 kg/ha. The chance that the realized average yield will fall in the economically nonviable range is thus reduced.

Clearly, future yields to be obtained from subsurface drainage are not fully certain; neither are future prices. This uncertainty implies risk-taking on the part of the investor. Most farmers would take this into account by using an additional discount factor for risk or by using a lower yield than the most probable one in their calculation. Incorporating either risk allowance would result in a negative outcome at 1982 prices for the 25-yr investment period. In that case, the installation would not be undertaken if the lifespan of the system were only 25 yr.

**CONCLUSIONS**

The data base used to determine the addition in yield resulting from subsurface drainage, is crucial for a cost-benefit analysis. A long-term data base is essential, but is virtually nonexistent. This study outlines a method to estimate long-term yield additions from a short-term yield data base. However, the short-term yield series must be sufficiently long to establish a meaningful relationship with precipitation. For the imperfectly drained soil, the 10-yr series was apparently too short to establish such a relationship.

Using yield differences from a particular year or from two or three successive years can give misleading results. The break-even yield at 1982 prices was 605 kg/ha for a 40-yr investment period. According to Table II, there were many years in which this yield difference was not obtained. Using 2-yr or 3-yr averages can also be misleading. Several successive 2-yr or 3-yr averages provided lower yields than 605 kg/ha. More importantly, no meaningful probability distribution of annual yield differences between drained and undrained land can be established from such data. This would make it impossible to draw conclusions about the variability of outcome and hence about the yield risks involved.

In view of the huge annual investment outlays on drainage, including government subsidies, there is a great need for economic evaluations of these investments. Such evaluations can only be meaningfully performed if reliable yield estimates can be obtained.

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