

# This document is discoverable and free to researchers across the globe due to the work of AgEcon Search. 

## Help ensure our sustainability. Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

Papers downloaded from AgEcon Search may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.

# IMPACT OF YIELDS AND TAXES <br> ON PROFITABILITY OF SUBSURFACE DRAINAGE INVESTMENT IN SOUTHERN ONTARIO 

by W. van Vuuren and H. Jorjani


GIANNINT by bation or
AGRICULTURAMgONOMICS
AGRICULTURAEAGEO
LIBRAR

Department of Agricultural Economics and Business Ontario Agricultural College University of Guelphr

## IMPACT OF YIELDS AND TAXES

## ON PROFITABILITY OF SUBSURFACE DRAINAGE INVESTMENT

IN SOUTHERN ONTARIO
by

## W. van Vuuren and <br> H. Jorjani

## Department of Agricultural Economics and Business University of Guelph

PREFACE

The purpose of this paper is twofold. It develops a method to estimate the average annual additional yield from investing in subsurface drainage. Moreover, the effect of taxation on income derived from drainage is examined. There is a large discrepancy in after-tax income derived from drainage investment among the various income brackets of cash crop farmers and between cash crop and livestock farmers.

The study was part of the continuing research program in Agricultural Land Use supported by the Ontario Ministry of Agriculture and Food. In addition, the study was supported by a research grant from the Regional Development Branch, Agriculture Canada.

Special thanks are due to Dr. R.W. Sheard of the Land Resource Science Department, University of Guelph, for providing the corn yield data. The authors wish to express their special gratitude to P.A. Kahn and L. Spitzig who spent numerous hours in assisting with the development of the computer programs. As well, professors W.M. Braithwaite and J.H. Clark reviewed the manuscript and provided helpful comments and suggestions prior to its publication. Any errors of fact or interpretation are, of course, solely the responsibility of the authors.

TABLE OF CONTENTS
Page
CHAPTER 1 INTRODUCTION ..... 1
CHAPTER 2 PHYSICAL YIELDS EMANATING FROM SUBSURFACE DRAINAGE ..... 5
2.1 Methodology ..... 5
2.1.1 Estimating Production Functions ..... 6
2.1.2 Estimating Which Precipitation Periods Affect Yield ..... 7
2.1.3 Estimating Statistically Expected Yield Additions ..... 8
2.1.4 Price Assumptions ..... 9
2.2 Statistical Results ..... 10
2.2.1 Estimating Production Functions ..... 10
2.2.2 Estimating Which Precipitation Periods Affect Yield ..... 13
2.2.3 Estimating Statistically Expected Yield Additions ..... 16
CHAPTER 3 INVESTMENT ANALYSIS OF SUBSUURFACE DRAINAGE ..... 18
3.1 Assumptions ..... 18
3.2 Effect of Taxation on Profitability of Drainage Investment for Cash Crop Farmers ..... 24
3.3 Effect of Taxation on Profitability of Drainage Investment for Livestock Farmers ..... 29
3.4 After-Tax Return on Subsurface Drainage Invest- ment from Lower Yields ..... 33
CHAPTER 4 EFFECT OF DIFFERENT VARIABLES ON THE PROFITABILITY OF SUBSURFACE DRAINAGE INVESTMENT ..... 40
4.1 Introduction ..... 40
4.2 The Effect of Inflation ..... 40
4.3 The Effect of Borrowing ..... 44
4.4 The Effect of Subsidies ..... 46
4.5 The Effect of Partial-Indexing ..... 51
4.6 The Effect of Changing Income Levels Over Time ..... 57
CHAPTER 5 TAXES FROM THE NATIONAL VIEWPOINT ..... 59
5.1 Introduction ..... 60
5.2 Effect of Taxes on the Treasuries ..... 60
5.3 Effect of Interest Deductions and Subsidies on the reasuries ..... 62
5.4 Allocation Distortions Resulting from Taxes ..... 63
Page
CHAPTER 6 SUMMARY AND CONCLUSIONS ..... 66
6.1 Summary ..... 66
6.2 Conclusions ..... 67
6.2.1 Estimating Physical Yields Emanating from Subsurface Drainage ..... 67
6.2.2 Basic Investment Analysis ..... 67
6.2.3 Effect of Different Variables on the Profitability of Drainage Investment ..... 68
6.2.4 Tax Benefits for the Government and Investment Allocation Distortions ..... 69
REFERENCES ..... 71
APPENDICES ..... 74
Table Page
2.1 Estimated Regression Coefficients of Production Functions ..... 11
2.2 Planting Times and Corn Yields Derived from Optimum Fertilizer Use from Drained and Undrained Plots on Poorly Drained and Imperfectly Drained Soils ..... 12
2.3 Estimated Regression Coefficients for Yield Differences Resulting from Subsurface Drainage with Respect to Precipitation Levels ..... 14
3.1 Net Present Values (NPV) at 4\% and Internal Rates of Return (IRR) of After-tax Income over 50 Years from a $\$ 12,000$ Investment in Subsurface Drainage for Cash Crop and Livestock Farmers ..... 26
3.2 Net Present Values (NPV) at $4 \%$ and Internal Rates of Return (IRR) of After-tax Income over 50 Years from a $\$ 12,000$ Investment in Subsurface Drainage for Live stock Farmers with Different Livestock Inventory Ceilings ..... 32
3.3 Net Present Values (NPV) at 4\% and Internal Rates of Return (IRR) of After-tax Income from a \$12,000 Invest- ment in Subsurface Drainage Yielding a Before-tax Annual Income Stream of $\$ 558.89$ over 50 Years ..... 34
3.4 Net Present Values (NPV) at $4 \%$ and Internal Rates of Return (IRR) of After-tax Income from a $\$ 12,000$ Invest- ment in Subsurface Drainage Yielding a Before-tax Annual Stream of $\$ 558.89$ over 50 Years for Livestock Farmers with Different Livestock Inventory Ceilings ..... 35
3.5 Net Present Values (NPV) at $4 \%$ and Internal Rates of Return (IRR) of After-tax Income from a \$12,000 Invest- ment in Subsurface Drainage Yielding a Before-tax Annual Income Stream of $\$ 590$ over 50 Years ..... 37
3.6 Net Present Values (NPV) at $4 \%$ and Internal Rates of Return (IRR) of After-tax Income from a \$12,000 Invest- ment in Subsurface Drainage Yielding a Before-tax Annual Income Stream of $\$ 590$ over 50 Years for Livestock Farmers with Different Livestock Inventory Ceilings ..... 38
4.1 Net Present Values (NPV) and Internal Rates of Return (IRR) of After-tax Income over 50 Years from a $\$ 12,000$ Investment in Subsurface Drainage, Assuming Various Inflation and Discount Rates ..... 42
Table Page
4.2 Net Present Values (NPV) and Internal Rates of Return (IRR) of After-tax Income over 50 Years from a \$12,000 Investment in Subsurface Drainage Financed by Equity and by a Loan During a Period of Inflation of $8 \%$ Annually ..... 45
4.3 Net Present Values (NPV) at $12.32 \%$ and Internal Rates of Return (IRR) of After-tax Income over 50 Years from a $\$ 12,000$ Investment in Subsurface Drainage Financed by a Loan and by Subsidies During a Period of Inflation of 8\% Annually ..... 48
4.4 Net Present Values (NPV) at $12.32 \%$ and Internal Rates of Return (IRR) of After-tax Income over 50 Years from a $\$ 12,000$ Investment in Subsurface Drainage Financed by a Subsidized Loan of $\$ 8400$ at $8 \%$ During a Period of Inflation of $8 \%$ Annually ..... 50
4.5 Net Present Values (NPV) at $12.32 \%$ and Internal Rates of Return (IRR) of After-tax Income from a $\$ 12,000$ Investment in Subsurface Drainage During a Period of Inflation of $8 \%$ Annually, Assuming Full and Partial Indexing of Taxes ..... 52
4.6 Net Present Values (NPV) at $12.32 \%$ and Internal Rates of Return (IRR) of After-tax Income from a $\$ 12,000$ Investment in Subsurface Drainage During a Period of Inflation of $8 \%$ Annually for Livestock Farmers with Different Livestock Inventory Ceilings, Assuming Full and Partial Indexing of Taxes ..... 55
4.7 Net Present Values (NPV) and Internal Rates of Return (IRR) of After-tax Income from a $\$ 12,000$ Investment in Subsurface Drainage Financed by a Subsidized Loan of $\$ 8400$ (Interest Subsidy 65\%) During a Period of Infla- tion, Assuming Full and Partial Indexing of Taxes . . . . 56
5.1 Net Present Values (NPV) at $12.32 \%$ and Internal Rates of Return (IRR) of After-tax Income over 50 Years from a $\$ 12,000$ Investment in Subsurface Drainage Financed by a Loan of $\$ 12,000$ at $12.32 \%$ During a Period of Inflation of $4.5 \%$ Annually ..... 65

It is estimated that $\$ 60-70$ million are invested annually in plastic pipe and tile drainage in Ontario. While it is generally accepted that investment in subsurface drainage increases net farm income, few economic calculations have been carried out to confirm this supposition. The paucity of economic calculations stems largely from a lack of reliable data on physical yield emanating from drainage. The few studies that have been carried out in Ontario (Brooks, 1971; Found, Hills and Spencer, 1976; Galloway and Johnston, 1982) are based on unrepresentative yield data. An important data set needed to perform cost-benefit analysis for 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 the drainage system, short-term yield differences in a particular year or an average over a few successive years, as commonly used (Brooks, 1971; Found, Hills and Spencer, 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 deals exclusively with yield increases from grain corn resulting from the installation of subsurface
drainage. Corn is one of the most important crops in Southern Ontario benefiting from such drainage.

Economic feasibility studies for subsurface drainage can be carried out at two different levels. The feasibility of the investment can be examined from the public or national point of view. In that case, income taxes are irrelevant for this kind of study, at least if one assumes that these taxes are neutral with respect to the level of investment. It is generally believed that taxes do not increase or decrease national income, but merely redistribute income among members of society. This is not necessarily so as will be shown in chapter 5 . From the farmer's point of view, however, taxes are highly relevant. The farmer is interested in after-tax profitability of the investment. Economic feasibility studies of drainage have all been of the former kind. The authors have not encountered investment analyses of subsurface drainage in the literature where taxes were included.

The impact of taxation is twofold. Subsurface drainage is an operating expense for tax purposes. As a consequence, taxable income in the year of installation will be lower than if drainage had not been installed. If net income becomes negative through the expense deduction, the "negative portion" can be written off against net income in the three previous years and in the ten subsequent years. These expense deductions result in tax savings. On the other hand, additional income from the investment will be taxed over the entire lifetime of the drain. The tax savings are derived in the beginning of the economic life of the drain, while the tax payments are spread over the entire period. The magnitude of these tax payments and tax savings are dependent on the marginal tax rate.

Although all farmers are subject to the same tax provisions regarding the expense deduction for subsurface drainage, low-income livestock farmers can use another provision, the livestock inventory provision, to better their situation. The report will therefore distinguish between cash crop and livestóck farmers.

In investment analysis at the business level, one must consider the long-term effects of taxes in order to achieve the objective of maximizing long-run after-tax net income (Hill, 1981; Williams, 1981). Maximizing current after-tax net income may not be consistent with maximizing after-tax income for the period over which the investment lasts.

Three major objectives are pursued in this report. Firstly, a method is developed to obtain the statistically expected potential increase in annual grain corn yield resulting from subsurface drainage over the lifetime of the system. These yield data are crucial for performing cost-benefit or investment analyses.

Secondly, the effect of taxation on after-tax profitability of subsurface drainage will be examined for farmers in various income brackets. Farmers in the various tax brackets are differently affected by taxation. Moreover, the effect of taxation on after-tax profitability of the investment depends on the rate of inflation, on how the tax tables are corrected for inflation, and on how the investment is financed. The effect of inflation, of partial indexing of inflation in correcting the tax tables, and of borrowing and subsidies will be examined.

Thirdly, the effect of taxation on the level of subsurface drainage investment will be examined. Certain tax provisions may result in under-investment of drainage from the nation's point of view. Likewise,
there are conditions under which taxes may encourage investments which are not economically feasible from the nation's point of view. Thus, taxation can result in too much or too little subsurface drainage investment. If all income from a particular expenditure is not derived in the year in which the expenditure is made, the tax system can cause distortions in efficient investment allocations.

## PHYSICAL YIELDS EMANATING FROM SUBSURFACE DRAINAGE

### 2.1 Methodology

One of the few data sources available for estimating reliable yields resulting from investment in subsurface drainage was a 10-year corn yield series from drained, with a 9.1 meter 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 $180 \mathrm{~kg} / \mathrm{ha}$ 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 $\mathrm{kg} / \mathrm{ha}$ respectively. All treatment effects influencing yields, other than fertilizer usage, were identical on each set of drained and undrain-
ed 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, optimal nitrogen use and corresponding corn yield at each plot was 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.

### 2.1.1 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 yields, since this gave the best fit (Jorjani, 1982). This function can be written as:

$$
\begin{aligned}
& Y=b_{o}+b_{1} N-b_{2} N^{2}+\sum b_{i+2} D_{i+2} \\
& Y=\text { corn yield in } k g / h a \\
& N=\text { nitrogen use in } k g / h a \\
& D_{i+2}=\begin{array}{l}
\text { dummy variable } \\
\text { data, }
\end{array} \\
&\text { o otherwise })
\end{aligned}
$$

A statistical test (F-test) was used to determine whether or not a statistically non-significant dummy variable could be eliminated from the equation.

The second step in determining fertilizer use was to relate that use to the prices of corn and fertilizer. Economic optimizing requires that the price ratio of nitrogen to corn equals the marginal product of corn with respect to nitrogen. The marginal product can be obtained from equation (1) and equated to the price ratio. This gave the following equation:

$$
\begin{equation*}
b_{1}-2 b_{2} N=\frac{P_{n}}{P_{y}} \tag{2}
\end{equation*}
$$

From equation (2), $N$, the optimal level of nitrogen use, was computed for the drained and undrained plots on the poorly drained and on the imperfectly drained soils. These four $N$-levels, thus derived, were substituted in equation (1) for each of the plots to obtain annual yields on each plot.

### 2.1.2 Estimating Which Precipitation Periods Affect Yield

Annual yield differences between drained and undrained land were expected to differ because of varying amounts of precipitation. This should be reflected in the regression coefficients of the dummy variables which were statistically different from zero. Reduction of excess moisture is particularly important at certain stages of the growing cycle (Lembke, Drablos, Arnold and Scarborough, 1982). 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,

Hunter and McLaughlin, 1981; Stevenson, Hunter, Dynard and Jones, 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-year 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:
$\Delta Y=b_{o}+\sum b_{i} X_{i}$
$\Delta Y=: ~ y i e l d ~ d i f f e r e n c e ~ i n ~ k g / h a ~ b e t w e e n ~ d r a i n e d ~ a n d ~ u n d r a i n e d ~ l a n d ~$
$X_{i}=$ precipitation in millimeters in period "i".

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 equation (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 percent level or less.

### 2.1.3 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 ín 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 years (Enṿironment Canada, various issues).

One would expect that precipitation in each period "i", used in regression equation (3), is normally distributed over the 79 years, and that this probability distribution is expected to prevail over the long term. Short-term precipitation data over a 10-year 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 -year 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, equation (3) was used. Annual yield differences were computed by substituting the precipitation amounts recorded in each of the 79 years in equation (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.

### 2.1.4 Price Assumptions

In order to determine optimal fertilizer use, prices of corn and fertilizer must be ascertained. It was assumed that the investment took place in 1983. For corn, the average $1973-1982$ price was used, amounting to $\$ 110$ per tonne. The 1982 price for nitrogen fertilizer was used at $\$ .443$ per kg (actual N ). Nitrogen was applied in the form of anhy-
drous ammonia $(82 \% N)$ and urea (46\% N) in a ratio of 11.5 to 1.

### 2.2. Statistical Results

### 2.2.1 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 2.1. Dummy variables which were statistically non-significant 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 equation (2). The average 1973-1982 price of corn was $\$ .0915$ per kg (net of drying and trucking) and for nitrogen (actual N ) $\$ .443 \mathrm{per} \mathrm{kg}$. The ratio of the price of nitrogen to the price of corn was 4.815 . Using this ratio and the coefficients of equation (1), the optimal nitrogen use on the poorly drained soil, as computed according to equation (2), was $133 \mathrm{~kg} / \mathrm{ha}$ on drained land and $142 \mathrm{~kg} / \mathrm{ha}$ on undrained land; on the imperfectly drained soil it was $132 \mathrm{~kg} / \mathrm{ha}$ and $136 \mathrm{~kg} / \mathrm{ha}$, respectively. Note that on both soii types optimum fertilizer use on the undrained plots exceeded that on the drained plots slightly.

Substituting these optimal fertilizer levels in equation (1) gave annual yield levels. These are recorded in Table 2.2. In addition, the table provides the annual yield differences between drained and undrained land on both soil types.

TABLE 2.1
ESTIMATED REGRESSION COEFFICIENTS OF PRODUCTION FUNCTIONS

| ```Explanatory variables and statistics``` | ```Regression coefficient in equation(1)``` | Poorly drained soil |  | Imperfectly drained soil |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Drained plot | Undrained plot | Drained plot | Undrained plot |
| Constant | $\mathrm{b}_{0}$ | 3,110.91 | 2,836.17 | 3,259.16 | 3,437.24 |
| Nitrogen, N | $\mathrm{b}_{1}$ | 25.95** | 27.46** | 31.09** | 26.45** |
| Nitrogen, $\mathrm{N}^{2}$ | $\mathrm{b}_{2}$ | -0.08** | -0.08** | -0.10** | -0.08** |
| Dummy 1973 | $\mathrm{b}_{4}$ | 2,098.24** | 1,338.02** | 2,012.77** | 984.52** |
| Dummy 1974 | $\mathrm{b}_{5}$ | 1,006.56** | - | 600.0* | - |
| Dummy 1975 | $\mathrm{b}_{6}$ | 524.91* | - | - | - |
| Dummy 1976 | $\mathrm{b}_{7}$ | 648.24** | - | - | - |
| Dummy 1977 | $\mathrm{b}_{8}$ | 2,253.12** | 2,139.80** | 1,757.46** | 1,844.85** |
| Dummy 1979 | $\mathrm{b}_{10}$ | 2,003.88** | 517.32* | 1,485.30** | 1,295.56** |
| Dummy 1980 | $\mathrm{b}_{11}$ | 1,317.48** | - | 1,222.92** | 807.13** |
| Dummy 1981 | $\mathrm{b}_{12}$ | 1,176.51** | 463.60* | 1,003.25** | 498.40* |
| Dummy 1982 | $\mathrm{b}_{13}$ | - | - | - | - |
| $\mathrm{R}^{2}$ |  | . 84 | . 72 | . 80 | . 74 |
| Number of observations |  | 56 | 56 | 56 | 56 |

[^0]TABLE 2.2

| Year | PLANTING TIMES AND CORN YIELDS DERIVED FROM OPTIMUM FERTILIZER USE <br> FROM DRAINED AND UNDRAINED PLOTS ON POORLY DRAINED AND IMPERFECTLY DRAINED SOILS// |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Poorly drained soil |  |  |  |  | Imperfectly drained soil |  |  |  |  |
|  | Yield on drained plot $\mathrm{kg} / \mathrm{ha}$ | Planting time | Yield on undrained plot $\mathrm{kg} / \mathrm{ha}$ | Planting time | Yield difference kg/ha | Yield on drained plot kg/ha | Planting time | Yield on undrained plot $\mathrm{kg} / \mathrm{ha}$ | Planting time | Yield difference kg/ha |
| 1982 | 5,147 | May 13 | 5,124 | May 13 | 23 | 5,621 | May 13 | 5,555 | May 13 | 66 |
| 1981 | 6,323 | May 14 | 5,588 | June 2 | 735 | 6,624 | May 14 | 6,053 | June 2 | 571 |
| 1980 | 6,464 | May 20 | 5,124 | June 10 | 1,340 | 6,844 | May 20 | -6,362 | June 10 | 482 |
| 1979 | 7,151 | May 18 | 5,641 | June 4 | 1,510 | 7,106 | May 18 | 6,851 | June 4 | 255 |
| 1977 | 7,400 | May 10 | 7,264 | May 12 | 136 | 7,378 | May 10 | 7,400 | May 12 | -22 |
| 1976 | 5,795 | May 13 | 5,124 | May 13 | 671 | 5,621 | May 13 | 5,555 | May 13 | 66 |
| 1975 | 5,672 | May 9 | 5,124 | May 20 | 548 | 5,621 | May 9 | 5,555 | May 20 | 66 |
| 1974 | 6,153 | May 8 | 5,124 | May 28 | 1,029 | 6,221 | May 8 | 5,555 | May 28 | 666 |
| 1973 | 7,245 | May 8 | 6,462 | May 19 | 783 | 7,634 | May 8 | 5,555 | May 19 | 2,079 |
| 1972 | 5,147 | June 14 | 5,124 | June 14 | 23 | 5,621 | June 14 | 5,555 | June 14 | 66 |

1/Optimum use is based on 1982 prices

### 2.2.2 Estimating Which Precipitation Periods Affect Yield

The annual yield differences between drained and undrained land, as recorded in Table 2.2, 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 percent level) reduction in the error sum of squares were those from May 11 to May 21, May 22 to May 31, and July 25 to August 3. The corresponding regression equation was:
$\Delta Y=b_{0}+b_{1} X_{1}+b_{2} X_{2}+b_{3} X_{3}$
$\Delta Y=$ yield difference in $\mathrm{kg} / \mathrm{ha}$ between drained and undrained land
$X_{1}=$ precipitation in millimeters from May 11 to May 21
$X_{2}=$ precipitation in millimeters from May 22 to May 31
$X_{3}=$ precipitation in millimeters from July 25 to August 3.

The annual precipitation during each of these three periods over the 10 years of data explains 78 percent of the annual yield difference on the poorly drained soils as indicated in Table 2.3. The May 11 to May 21 period 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, May 22 to May 31 , 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.

TABLE 2.3
ESTIMATED REGRESSION COEFFICIENTS FOR YIELD DIFFERENCES RESULTING FROM SUBSURFACE DRAINAGE WITH RESPECT TO PRECIPITATION LEVELS

| Explanatory variables and statistics | ```Regression coefficient in equation (3)``` | Poorly drained soil | Imperfectly drained soil |
| :---: | :---: | :---: | :---: |
| Constant | $\mathrm{b}_{0}$ | 608.78 | -374.18 |
| Precipitation May 11-21 ( $\mathrm{X}_{1}$ ) | $\mathrm{b}_{1}$ | 13.65* | - |
| Precipitation May 22-31 ( $\mathrm{X}_{2}$ ) | $\mathrm{b}_{2}$ | -13.18** | - |
| Precipitation July 25-Aug. 3 $\left(X_{3}\right)$ | $b_{3}$ | 8.94* | 20.42** |
| $\mathrm{R}^{2}$ |  | . 78 | . 47 |
| Number of Observations |  | 10 | 10 |

[^1]Yield differences between drained and undrained land could be affected differently by excess moisture in the May 22 to May 31 period.

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 May 22 were about the same in 3 out of 10 years.

The second possibility was that corn on undrained land was planted prior to May 22 , 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 :sced on drained land. This would make the yield difference smaller. This situation occurred twice during the 10 years. The planting dates on the undrained plots were May 19 and 20.

The third possibility was that corn on undrained land was not planted prior to the May 22 to May 31 period, but was planted on the drained land. This situation occurred 4 times out of the 10 years with 17 to 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 "Personal Communication").

Considering the above three alternatives, one would expect a positive sign associated with the level of precipitation during the May 22-31
period 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 July 25-August 3 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 2.3, on the imperfectly drained soil, precipitation during the July 25 -August 3 period was the only variable reducing the error sum of squares in a stepwise regression analysis. Only 47 percent of the variation in yield difference between drained and undrained land could be explained by the precipitation amounts during this period over 10 years. The poor results from equation (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 reliable investment analysis of subsurface drainage on imperfectly drained soils. Proceeding with the analysis on the basis of this 10 -year average may give misleading results. The remainder of the analysis concentrates on corn yield differences on poorly drained land.

### 2.2.3 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 years for which precipitation data were available. These 79 additions in yield were normally distributed. (The Kolmogorov-Smirnov-statistic was . 08 which, at the 95 percent probability level, was smaller than the table-
value . 15 of a two-sided test. Hence, the null-hypothesis that the distribution is normal was accepted.) The expected value of this distribution was $770 \mathrm{~kg} / \mathrm{ha}$. This statistically expected value differs from the average 10-year yield increase, which was $680 \mathrm{~kg} / \mathrm{ha}$.

It was assumed that this normal distribution gave a good representative picture of the distribution of yield differences under all possible precipitation levels that reasonably can be expected. The mean of this normal distribution provided an estimate for the average annual yield increase caused by subsurface drainage. This increase of $770 \mathrm{~kg} / \mathrm{ha}$ was used in the investment analysis. This does not imply that with hindsight one could not get a different average over the 50 -year period that the investment is expected to last. The expected value of the yield increase of a sample of 50 years is itself a random variable. The actual realized annual yield average over a 50-year investment period will fall within a certain range. This interval can be calculated by means of the following formula:
$\mu-\mathrm{t} \quad .025 \frac{\sigma}{\sqrt{\mathrm{n}}}<\overline{\mathrm{Y}}<\mu+\mathrm{t} .025 \frac{\sigma}{\sqrt{\bar{n}}}$
$\mu=$ population mean, $770 \mathrm{~kg} / \mathrm{ha}$
$\sigma=$ standard deviation, 506.27
$\mathrm{n} \quad=$ number of years in investment period
$\bar{Y} \quad=$ sample mean
$\mathrm{t} .025=\mathrm{t}$ distribution table-value indicating the probability that the mean of a sample of size $n$ lies within the above limits with 95 percent confidence.

Using this formula we conclude that there is a 95 percent chance that the average annual yield over a 50-year investment period will lie between 626 and $884 \mathrm{~kg} / \mathrm{ha}$, although the most probable value is 770 $\mathrm{kg} / \mathrm{ha}$.

## INVESTMENT ANALYSIS OF SUBSURFACE DRAINAGE

### 3.1 Assumptions

An investment analysis is used mainly as a decision-making tool, thus as an aid in deciding whether or not an investment should be undertaken. Such analysis must incorporate future prices and quantities, which are highly uncertain. It is therefore based on many assumptions. How a figure was derived for future physical yield emanating from the drainage investment was discussed in the previous chapter.

It was assumed that the investment occurred on 10 hectares in 1983 at a total cost of $\$ 12,000$, based on 9 metres spacing between the lateral drains. The lifetime of the system was assumed to be 50 years.

The average corn price over the period 1973 to 1982 was assumed to be the relevant price for the next 50 years. Net of trucking and drying, this price became $9.15 \mathrm{k} / \mathrm{kg}$. At an average annual yield increase of $770 \mathrm{~kg} / \mathrm{ha}$, the average annual gross return from drainage was \$70.46/ha. Optimal fertilizer use on drained land was 9 kilograms per hectare lower than on undrained land. This became an additional benefit attributable to drainage, amounting to \$3.99/ha. Annual maintenance cost of the drain was $\$ 5.38 / \mathrm{ha}$. The annual recurrent benefits from drainage were thus $\$ 69.07 /$ ha. This benefit figure was used as a base value in the analysis.

It should be stressed that the benefit of the investment in this study refers to the increase in corn yield from what that yield was on undrained land. It 'does not refer to the benefit realized from a change in cropping pattern made possible by the investment, although the
pay-off of drainage is usually higher from a change in cropping patterns from low-value to high-value crops than for an increase in existing crop yields. This report deals exclusively with the increase in grain corn yield, as derived in Chapter 2. It is important to interpret the results within this framework.

The tax analysis was performed for a time span of 51 years, 1984 being the first year in which drainage benefits were realized and in which the investment cost could be written off against 1983 total net income. From year 51 onwards, the drainage benefits will be exhausted, but taxes will be paid in year 51 (year 2034) on the additional income derived in year 2033. The 1983 tax table was used as a basis.

The relevant taxes are federal and provincial Ontario income taxes. The combined federal-provincial 1983 tax table can be found in Appendix 1. The Ontario property tax-, sales tax , and home heating-credits were ignored in this analysis. It was assumed that the 1983 tax table will remain unchanged for the next 51 years, unless corrected for inflation as discussed in the next chapter.

The federal government allowed in 1983 a $\$ 200$ tax reduction on the basic federal tax calculated from the table if it is greater than $\$ 200$, and equal to the calculated federal tax if it is smaller than $\$ 200$. The Ontario government does not tax individuals with taxable incomes smaller than $\$ 1986$. It is assumed that this $\$ 200$ provision prevails over time but is not subject to inflation adjustments. Taxable incomes below $\$ 1986$ are therefore exempt from both federal and provincial taxation.

It was assumed that personal tax exemptions amounted to $\$ 7070$, it. being the basic personal exemption and the married exemption in 1983. Taxable income is thus the difference between net income and
these exemptions.
Various levels of pre-drainage total net income were assumed. The analysis was done in marginal terms, the marginal investment unit being $\$ 12,000$. The marginal benefits were the after tax net increases in farm incomes resulting from this investment. The additional income derived from the investment unit is taxed at different rates corresponding to the various tax brackets. Moreover, tax savings resulting from the expense deduction of the investment differ among the various income tax brackets. As indicated, tax regulations require that the cost of subsurface drainage be written off in the year in which it is installed.

In case the investment cost is not fully deducted in the year of installation, because the investment cost exceeds net income in that year, the investor can refile his income taxes for the three years prior to investment. The farmer will not reduce his taxable income in those years beyond $\$ 1,986$ since this amount is tax-free. It was assumed that if the investment cost exceeds pre-drainage net income in the year of installation, 1983, this excess was first deducted from net income in 1980. If the excess prevailed, the remaining excess was forwarded to 1981 and any excess in that year was forwarded to 1982. If the excess still prevailed, this process was repeated up to 10 years subsequent to drainage installment for as long as the full investment cost had not been exhausted. Again, for those 10 years it was assumed that the farmer would not reduce his taxable income beyond $\$ 1,986$ from the expense deduction.

These write-off provisions can result in a loss of personal exemptions and other legitimate deductions from net income. Although the write off provisions regarding subsurface drainage are the same for all
farmers, livestock farmers are able to prevent the loss of legitimate deductions from net income. A livestock farmer may add the value of livestock inventory to cash income in a given tax year. The following year the same value of jivestock must be "bought back" and will be recorded as an expense for tax purposes. The personal exemptions, medical expenses, charitable donations, and possible farm losses due to the full write-off of the investment, can be converted into livestock inventory, so that these "exemptions" will not be lost in the year the investment is undertaken. In future years, when the investment yields taxable income, the "buying back" provision lowers net income and therefore reduces taxes.

The basic investment analysis will be performed for both cash crop and livestock farmers. For livestock farmers it was assumed that the write-off in the year of installation would not exceed the difference between net income in that year and personal exemptions plus \$1986 tax-free income. If there is any excess, this will be transformed into a livestock "sale". In that case the full investment cost will be deducted in the year of installation, so that there is no excess to carry back. Livestock "sales" in one year must be "bought back" in the following year. If taxable income through this transaction becomes again smaller than the $\$ 1986$ tax-free income, then livestock will be "sold" again. This process is repeated over time until taxable income becomes greater than $\$ 1986$ after the "purchase" of livestock has been accounted for. Note that in this case, the excess can be forwarded beyond 10 years after installation of the drain, which was applicable for cash crop farmers.

A numerical example will clarify this issue. Assume a livestock
farmer has a net income of $\$ 11,000$ before a $\$ 12,000$ drainage investment is made. For tax purposes the farmer must deduct the investment cost from net income in the year of installation, resulting in a negative net income of $\$ 1,000$. In that case, the farmer would "lose" his personal exemptions of $\$ 7,070$ and his tax-free income of $\$ 1,986$. By "selling" livestock inventory he can avoid these "losses". He will "sell" $\$ 10,056$ so that his net income becomes $\$ 1,986$ which is tax-free. Assume that the investment yields $\$ 690$ annually and that non-drainage income remains at $\$ 11,000$ annually. One year after installation he must "buy back" this inventory from the government. His taxable income becomes negative again $(11,000+690-7,070-10,056)$. In order to reach the $\$ 1,986$ taxable income bracket, he will "sell" again livestock inventory worth $\$ 7,422(11,000+690-10,056-7.070-1,986)$. Two years after instal-lation he must "purchase" inventory valued at $\$ 7,422$. His taxable income then becomes $11,000+690-7,070-7,422=-\$ 2,802$. He will again."sell" inventory at a value of $\$ 4,788$ in order to obtain the tax free income of $\$ 1,986$. This process continues till taxable income becomes larger than $\$ 1,986$.

In the above example, livestock "sales" decline over time. However, if annual net incomes are smaller than $\$ 9,056$ ( $\$ 7,070$ personal tax exemptions plus $\$ 1,986$ tax-free income), livestock "sales" must increase annually in order to reach the $\$ 1,986$ tax-free income bracket. However, the farmer can never "sell" more than the value of his total livestock inventory. It is necessary therefore to put a ceiling on the amount the farmer can "sell". Even if livestock "sales" are not exploding over time, it may be neceśsary to constrain the value that the farmer can "sell". If annual net income is equal to $\$ 9,056$ and remains so over
time, then the amount of livestock "bought" and "sold" each year will be identical indefinitely into the future. For annual net incomes over time in excess of $\$ 9,056$, the amount of livestock "sold" each year will decline till taxable income becomes greater than $\$ 1,986$.

We have assumed two ceilings on livestock inventory: one of $\$ 12,000$ and the other of $\$ 9,000$. Although the drainage investment on ten hectares does not necessarily imply that the farm is only ten hectares in size, it is reasonable to assume that low-income farmers have small holdings. The ceiling of $\$ 9,000$ reflects an average of livestock inventory values on ten hectares on OFMAP farms in 1983 and 1984 (dairy $\$ 950 /$ ha; beef $\$ 790 /$ ha; swine $\$ 975 / \mathrm{ha}$ ). The ceiling of $\$ 12,000$ is used as the basic model. Unless the $\$ 9,000$ ceiling is explicitly indicated in the tables, a $\$ 12,000$ ceiling is assumed.

It was assumed that pre-drainage income as well as the additional net income derived from drainage remains the same for the next 50 years, unless it is affected by inflation. The investment occurred in 1983 and the first additional income realized from the investment is in 1984 (year 1 of the analysis). Taxes on this additional income are paid with a 1-year timelag in 1985.

Net present values (NPV) and internal rates of return (IRR) will be calculated. One of the most important variables needed in the computation of an NPV is a discount rate. This rate should reflect the aftertax cost of capital for the farmer. It is unlikely that all farmers face the same before-tax cost of capital. The cost of capital for low-income farmers is usually higher than that for high-income farmers. Even if the before-tax cost of capital were identical for all farmers, the after-tax cost differs because farmers in the various income tax brackets have
different marginal tax rates. As a consequence, the appropriate discount rate for low-income farmers is higher than that for high-income farmers. The calculation of NPVs in this report ignores the differential rates among farmers and uses a uniform real discount rate of 4 percent. Since deflated incomes are assumed over time, these must be discounted by the real interest rate rather than by a nominal interest rate. It was assumed that the real interest rate is 4 percent.

The NPV at the same discount rate for farmers in the various tax brackets is a good indication of how much the federal and provincial treasuries gain from drainage investment. The relevant rate for the government is the before-tax rate, ignoring risk. It is important to realize that the government uses the same discount rate, regardless from whom the taxes are received. This aspect is further discussed in Chapter 5. However, the use of a uniform discount rate to calculate the profitability of the investment for farmers in the various tax brackets, is not entirely correct. Although both NPVs and IRRs are presented, this note of caution is important in interpreting private profitability of the investment. The IRR avoids this problem as no discount rate is pre-assigned. The emphasis in the report is therefore on the IRR if the investments are considered from the farmer's point of view.

### 3.2 Effect of Taxation on Profitability of Drainage Investment for Cash Crop Farmers

The first analysis involves the computation of the IRR and NPV of the investment project. It was assumed that farmers finance subsurface drainage from equity and that thus no interest payment deductions for tax purposes can be claimed. The investment cost is $\$ 12,000$ for $10^{\circ}$
hectares, the annual net before-tax increments in benefits from drainage are $\$ 690.70$ for 10 hectares and no inflation occurs during the lifetime of the drain. Sixteen different pre-drainage net income levels will be considered. The question to be addressed is how, under these conditions, the tax system affects the IRR and NPV of the subsurface drainage investment in the various income brackets.

The IRR of the $\$ 12,000$ investment varies between 3.65 percent and 5.32 percent, as can be seen in column 3 of Table 3.1. The highest rates of return are obtained for farmers in the $\$ 4,000$ and $\$ 8,000$ net income brackets who do not pay any taxes during the entire lifetime of the drain. The lowest rate is obtained by farmers in the $\$ 9,150$ income bracket. These farmers are eligible for the Ontario Tax Reduction Program under pre-drainage conditions. Taxable incomes up to $\$ 2,178$ are eligible for that program, which results in a rebate in provincial taxes. A taxable income of $\$ 2,178$ translates into a net income of $\$ 9,248$ under our assumptions. Farmers with a net income of $\$ 9,150$ get a rebate on their provincial taxes of $\$ 49$. Drainage investment will increase farm incomes annually beyond the level eligible for the above program. These farmers therefore would lose these tax rebates for the entire period over which the drain lasts compared to a non-drainage investment situation. This kind of program acts as a deterrent for drainage investment.

Apart from the two lowest income levels, which do not pay any taxes, the IRR of the investment is lower for low-income than for high-income farmers. This results from the tax provisions which stipulate that the investment cost be treated as an operational expense which must be deducted from income in the year of insca_ation. This in turn results

TABLE 3.1

NET PRESENT VALUES (NPV) AT 4\% AND INTERNAL RATES OF RETURN (IRR)
OF AFTER-TAX INCOME OVER 50 YEARS FROM A $\$ 12,000$ INVESTMENT IN SUBSURFACE DRAINAGE FOR CASH CROP AND LIVESTOCK FARMERS

| Pre-drainage net income | Cash crop farmers |  | Livestock farmers |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NPV | IRR | NPV. | IRR |
| \$ | \$ | \% | \$ | \% |
| 4,000 | 2838 | 5.32 | 2838 | 5.32 |
| 8,000 | 2838 | 5.32 | 2838 | 5.32 |
| 9,150 | -648 | 3.65 | 1456 | 4.82 |
| 10,000 | 201 | 4.11 | 2319 | 5.36 |
| 10,500 | 113 | 4.06 | 2300 | 5.37 |
| 11,000 | 25 | 4.01 | 2257 | 5.35 |
| 11,500 | -121 | 3.93 | 2175 | 5.32 |
| 12,000 | -185 | 3.90 | 2079 | 5.27 |
| 14,000 | 151 | 4.08 | 1953 | 5.22 |
| 15,000 | 391 | 4.22 | 1887 | 5.18 |
| 19,000 | 1270 | 4.78 | 1820 | 5.17 |
| 23,000 | 1756 | 5.13 | 1756 | 5.13 |
| 27,000 | 1476 | 4.99 | 1476 | 4.99 |
| 33,000 | 1499 | 5.06 | 1499 | 5.06 |
| 50,000 | 1466 | 5.18 | 1466 | 5.18 |
| 70,000 | 1130 | 4.99 | 1130 | 4.99 |

in a "loss" of personal exemptions and of the $\$ 1,986$ tax-free income threshold, and of other legitimate deductions which were not considered in this analysis. For example, a farmer with a pre-drainage net income of $\$ 12,000$ making a drainage investment of $\$ 12,000$ ends up with zero net income in the year of installation. His pre-drainage taxable income was $\$ 4,930$ and becomes negative after drainage installment. Since no tax rebates are given on negative incomes, the farmer would only save taxes on these $\$ 4,930$ if he installed drainage. Due to the above tax provisions, he cannot take advantage of his personal exemptions and the tax free income threshold. A farmer with a net pre-drainage income of, for example, $\$ 25,000$, on the other hand, paid taxes on $\$ 17,930$ under predrainage conditions. In the year of installation his taxable income drops to $\$ 5,930$, resulting in a considerable tax saving. The $\$ 12,000-$ income farmer saved taxes on $\$ 4,930$ due to drainage installment, while the $\$ 25,000$-income farmer saved taxes on $\$ 12,000(\$ 17,930$ minus $\$ 5,930)$. The IRR drops if net incomes increase up to a level of $\$ 12,000$. Farmers earning less than $\$ 12,000$ can deduct that part of the operating expense exceeding pre-drainage net income, from income earned in the three years prior to drainage installment or in the next 10 years subsequent to the investment. In that case, the amount to be deducted is not prescribed. Therefore farmers will deduct only so much in those years that their net income becomes $\$ 9,056$, which is tax-free. The lower the pre-drainage income level, the more of the operating expense can be switched to those years which results in a slight increase in the IRR. More details on why these IRRs and NPVs differ among income brackets can be found in Appendix 2.

Farmers with net pre-drainage incomes between $\$ 12,000$ and $\$ 19,070$
would not "lose" their entire personal exemptions in the year of installation. The higher their income, the lower this "loss", reflected in an increase in IRRs if pre-drainage incomes increase from $\$ 12,000$ to \$19,000.

The NPVs show a similar pattern to the IRRs. The tax savings on expense deductions and tax payments on additional income derived from drainage over the entire lifetime of the drain results in large differences in NPVs among the various tax brackets. From the farmer's point of view, these differences are even more pronounced since low-income farmers are faced with higher discount rates than high-income farmers.

The IRRs must be compared with the after--tax cost of capital for the farmers. If the IRR exceeds this cost, the project is profitable. Since low-income farmers are faced with a higher after tax cost of capital than high-income farmers, and the IRR of the drainage investment for the former income brackets is lower than that for high-income farmers, low-income cash crop farmers are more likely to have an IRR on drainage investment lower than the cost of capital. In that case the project would result in a loss. Prevailing tax provisions are heavily stacked against low-income cash crop farmers.

The IRR.is quite sensitive to the time phasing of costs and benefits. The higher the marginal tax rate, the higher the benefits in the early part of the economic life of the investment, the period over which the investment cost is deducted from net income for tax purposes, and the lower the benefits in the remainder of the economic life of the investment. The earlier the benefits accrue to the investment, the higher the IRR, ceteris paribus. The IRR is a growth rate on capital till it matures. At the end of each year part of the capital matures. High
benefits in the beginning of the economic life results in high growth rates for that portion of the capital which matures early, while low benefits in the remainder of the economic life result in lower growth rates for capital which matures in this later period. If the overall IRR increases by moving to a higher income bracket, then the average increase in growth rates for that portion of the capital which matures early when the investment cost has been fully deducted is greater than the average decrease in growth rates caused by the increase in taxes for that portion of the capital which matures in the remainder of the economic life. For example, the $\operatorname{IRR}$ of the investment for an income level of $\$ 33,000$ is 5.06 percent, and for a $\$ 50,000$ income level is 5.18 percent. According to Appendix 3 , the increase in benefits from a $\$ 33,000$ to a $\$ 50,000$ income bracket is $\$ 1,072.70$ in the first year, while for the remainder of the economic life of the drain the decrease in benefits is $\$ 51.60$. Apparently the increase in the growth rate for the capital which matures the first year exceeds the average decrease in the growth rates for the capital which matures from year 2 to year 50 .

### 3.3 Effect of Taxation on Profitability' of Drainage Investment for Livestock Farmers

Since livestock farmers may add the value of livestock inventory to cash income in a given year, they are able to prevent the loss of legitimate deductions from net income for tax purposes in the year when drainage is installed. The possibility of being able to carry forward these "exemptions" can result in considerable tax savings for low-income farmers. Since the tax provisions require that drainage investment be deducted in the year in which it is installed, many low-income farmers could end up with negative taxable income, thereby losing their legiti-
mate deductions and the $\$ 1986$ tax-free income threshold. Through the paper transaction of "selling" livestock up to a value of $\$ 1986$ minus what taxable income would have been without this transaction, the loss of legitimate deductions and the first $\$ 1986$ tax-free income can be avoided.

The following year the livestock must be "bought back", but if through this transaction taxable income is again lower than \$1986, the farmer can engage himself in another transaction of "selling" livestock. This procedure will continue annually until taxable income becomes greater than $\$ 1986$ through the "buying back" provision. This procedure is identical to an annual write-off of drainage investment of taxable income without the write-off minus $\$ 1986$, provided that taxable income exceeds $\$ 1986$, till the full investment cost has been written off. The maximum livestock inventory was set at $\$ 12,000$.

As can be seen from Table 3.1 low-income livestock farmers gain considerably from this livestock inventory provision as compared to cash crop farmers. Under this provision, taxation from drainage income is progressive, while for cash crop farmers it is regressive. Since during the entire lifetime of the drain no taxes are paid on income from drainage and on non-drainage income in the $\$ 4000$ and $\$ 8000$ pre-drainage income brackets, the NPVs and IRRs of the investment for livestock and cash crop farmers in these income brackets are identical. Livestock farmers with pre-drainage incomes from $\$ 9,150$ to $\$ 19,000$ make large gains from the inventory provision, although the gain diminishes if incomes increase, since cash crop farmers would lose lower amounts of legitimate deductions if incomes rise. Compared with cash crop farmers, no gains are obtained for livestock farmers with net pre-drainage incomes in excess of $\$ 21,056$. In this case, the write-off of the
investment in the year of installation results in a net income in excess of the tax-free income of $\$ 1986$. No paper transactions are therefore required.

As indicated, taxation on income from subsurface drainage for livestock farmers using the inventory provision, is progressive. There is a tendency for the IRR, although fluctuating, to decrease somewhat, except for a farmer in the $\$ 9150$ pre-drainage income bracket. Without drainage, this farmer is eligible for the Ontario Tax Reduction program. He would lose this subsidy over the entire lifetime of the drain if he drained his land, resulting in a smaller increase in the IRR and NPV of the investment.

It is interesting to note that the IRR of the investment for livestock farmers in the pre-drainage income brackets between $\$ 10,000$ and $\$ 11,000$ is higher than those for farmers who do not pay any taxes. This is due to the time-phasing of the benefits. Farmers in the $\$ 10,000$ to 11,000 income brackets make relatively large after-tax net incomes in the early years of the investment period compared with farmers who do not pay any taxes, exerting upward pressure on the IRR.

If a livestock inventory ceiling of $\$ 9,000$ is used, the IRRs of low-income livestock farmers decline compared with a $\$ 12,000$ ceiling, except for income levels of $\$ 4,000$ and $\$ 8,000$, as indicated in Table 3.2 These latter two income levels are not liable for taxation for the entire economic life of the drain, thus they are not affected by the livestock inventory provision. From income levels of $\$ 9,150$ to $\$ 12,000$, the effect of the lower ceiling on the IRRs diminishes. Beyond an income level of $\$ 12,056$, there is no effect since these farmers would "sell" a lower inventory than $\$ 9,000$. These lower ceilings introduce

TABLE 3.2

NET PRESENT VALUES (NPV) AT 4\% AND INTERNAL RATES OF RETURN (IRR)
OF AFTER-TAX INCOME OVER 50 YEARS FROM A $\$ 12,000$ INVESTMENT IN SUBSURFACE DRAINAGE FOR LIVESTOCK FARMERS WITH DIFFERENT LIVESTOCK INVENTORY CEILINGS

| Pre-drainage <br> net income | Inventory ceiling <br> $\$ 12,000$ |  | NPV | Inventory ceiling <br> $\$ 9,000$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\$$ | $\%$ | IRR | NPV |  |
| 4,000 | 2838 | 5.32 | 2838 | $\%$ |  |
| 8,000 | 2838 | 5.32 | 2838 | 5.32 |  |
| 9,150 | 1456 | 4.82 | 836 | 5.32 |  |
| 10,000 | 2319 | 5.36 | 1863 | 4.47 |  |
| 10,500 | 2300 | 5.37 | 1967 | 5.08 |  |
| 11,000 | 2257 | 5.35 | 2037 | 5.15 |  |
| 11,500 | 2175 | 5.32 | 1976 | 5.21 |  |
| 12,000 | 2079 | 5.27 | 2067 | 5.19 |  |

some regressiveness in taxation for livestock farmers.

### 3.4 After-Tax Return on Subsurface Drainage Investment from Lower Yields

Thus far we have assumed that the expected average annual yield increase of $770 \mathrm{~kg} / \mathrm{ha}$ will be realized. As indicated in the previous chapter, this expected value is itself a random variable which can vary between 626 and $884 \mathrm{~kg} / \mathrm{ha}$ with a 95 percent probability.

In this section the after-tax IRR of the investment will be examined if the average annual corn yield increase is equal to the lower bound of the interval, $626 \mathrm{~kg} / \mathrm{ha}$. This results in an increase in annual net income of $\$ 558.89$. Table 3.3 gives the results for both cash crop and livestock farmers.

As can be seen from the table, this yield increase is about the before-tax break-even yield increase, where neither a gain nor a loss is made on the investment, assuming that the relevant cost of capital is 4 percent. Note that farmers in income brackets of $\$ 4000$ and $\$ 8000$ do not pay any taxes over the entire lifetime of the drain. The IRR of the investment for them is therefore equal to the before-tax IRR. The IRRs for all income brackets are quite low and are likely not sufficient to cover the cost of capital, particularly not for low-income cash crop farmers since they lose their personal exemptions and tax-free income in the year of installation. Again, livestock farmers in low income brackets are considerably better off than cash crop farmers in these brackets. Livestock farmers in four low income brackets gain more than the actual before-tax return. For them, the gain from tax savings through the inventory provision exceeds the sacrifice in the tax payments on the additional income made from drainage. Table 3.4 gives the

TABLE 3.3

NET PRESENT VALUES (NPV) AT 4\% AND INTERNAL RATES OF RETURN (IRR) OF AFTER-TAX INCOME FROM A $\$ 12,000$ INVESTMENT IN SUBSURFACE DRAINAGE YIELDING A BEFORE-TAX ANNUAL INCOME STREAM OF $\$ 558.89$ OVER 50 YEARS

| Pre-drainage net income | Cash crop farmers |  | Livestock farmers |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NPV | IRR | NPV | IRR |
| \$ | \$ | \% | \$ | \% |
| 4,000 | 6 | 4.003 | 6 | 4.003 |
| 8,000 | 6 | 4.003 | 6 | 4.003 |
| 9,150 | -2738 | 2.424 | -662 | 3.616 |
| 10,000 | -1940 | 2.918 | 219 | 4.134 |
| 10,500 | -2028 | 2.875 | 188 | 4.117 |
| 11,000 | -2116 | 2.833 | 184 | 4.115 |
| 11,500 | -2221 | 2.772 | 65 | 4.041 |
| 12,000 | -2285 | 2.733 | -30 | 3.981 |
| 14,000 | -1909 | 2.899 | -112 | 3.927 |
| 15,000 | -1669 | 3.018 | -176 | 3.885 |
| 19,000 | -749 | 3.519 | -200 | 3.866 |
| 23,000 | -163 | 3.890 | -163 | 3.890 |
| 27,000 | -421 | 3.706 | -421 | 3.706 |
| 33,000 | -317 | 3.767 | -317 | 3.767 |
| 50,000 | -147 | 3.877 | -147 | 3.877 |
| 70,000 | -321 | 3.706 | -321 | 3.706 |

TABLE 3.4

NET PRESENT VALUES (NPV) AT 4\% AND INTERNAL RATES OF RETURN (IRR) OF AFTER-TAX INCOME FROM A $\$ 12,000$ INVESTMENT IN SUBSURFACE DRAINAGE YIELDING A BEFORE-TAX ANNUAL INCOME STREAM OF \$558.89 OVER 50 YEARS FOR LIVESTOCK FARMERS WITH DIFFERENT LIVESTOCK INVENTORY CEILINGS

| Pre-drainage <br> net income | Inventory ceiling <br> $\$ 12,000$ |  | IRR | Inventory ceiling <br> $\$ 9,000$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | NPV | $\$$ | $\%$ | NPV |  |

investment results for livestock farmers with a $\$ 9,000$ livestock inventory ceiling under this yield scenario.

No taxes would be paid if no profits were made in a particular year from non-investment income. For a project which yields income over more than one year and which just breaks even, the situation is different. For example, a cash crop farmer in the $\$ 12,000$ income bracket pays annually $\$ 150.12$ in taxes on $\$ 558.89$ additional annual net income, at a marginal tax rate of 26.86 percent. This results for the government in a total NPV of $\$ 3,101$ at 4 percent. The tax savings from the $\$ 12,000$ investment expense deduction amount to $\$ 842$. In this case the government receives net $\$ 2,259$ in taxes from this investment income, while in actuality no net income is derived from the investment. The after-tax cost of capital for this farmer is 2.93 percent [4-(1-.2686)], while his IRR is 2.73 percent.

Even at yields greater than the break-even yield from drainage, the IRRs of the investment are low for low-income cash crop farmers. At a yield of $660 \mathrm{~kg} / \mathrm{ha}$, the annual net income from draining 10 hectares is $\$ 590$. At these values the before-tax IRR of the drainage investment is 4.33 percent. Table 3.5 shows the after-tax NPVs and IRRs under these conditions for cash crop and livestock farmers. At this yield, drainage investment for low-income cash crop farmers would hardly pay if the before-tax cost of capital is 4 percent. Table 3.6 gives the investment results for livestock farmers with a $\$ 9,000$ livestock inventory ceiling.

Although the yield range from 526 to $824 \mathrm{~kg} / \mathrm{ha}$ appears to result in profitable investments at a real capital cost of 4 percent, the after-tax profitability of subsurface drainage investment for yields in the lower portion of the yield interval is negative, particularly for low-income

TABLE 3.5

NET PRESENT VALUES (NPV) AT 4\% AND INTERNAL RATES OF RETURN (IRR) OF AFTER-TAX INCOME FROM A $\$ 12,000$ INVESTMENT IN SUBSURFACE DRAINAGE YIELDING A BEFORE-TAX ANNUAL INCOME STREAM OF $\$ 590$ OVER 50 YEARS

| Pre-drainage net income | Cash crop farmers |  | Livestock farmers |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NPV | IRR | NPV | IRR |
| \$ | \$ | \% | \$ | \% |
| 4,000 | 674 | 4.33 | 674 | 4.33 |
| 8,000 | 674 | 4.33 | 674 | 4.33 |
| 9,150 | -2280 | 2.71 | -171 | 3.90 |
| 10,000 | -1435 | 3.21 | 731 | 4.44 |
| 10,500 | -1522 | 3.17 | 698 | 4.43 |
| 11,000 | -1610 | 3.12 | 659 | 4.41 |
| 11,500 | -1725 | 3.06 | 564 | 4.35 |
| 12,000 | -1789 | 3.02 | 468 | 4.30 |
| 14,000 | -1423 | 3.19 | 376 | 4.24 |
| 15,000 | -1183 | 3.31 | 311 | 4.20 |
| 19,000 | -272 | 3.83 | 277 | 4.18 |
| 23,000 | 307 | 4.20 | 307 | 4.20 |
| 33,000 | 112 | 4.08 | 112 | 4.08 |
| 50,000 | 234 | 4.20 | 234 | 4.20 |
| 70,000 | 21 | 4.02 | 21 | 4.02 |

TABLE 3.6

NET PRESENT VALUES (NPV) AT 4\% AND INTERNAL RATES OF RETURN (IRR) OF AFTER-TAX INCOME FROM A \$12,000 INVESTMENT IN SUBSURFACE DRAINAGE YIELDING A BEFORE-TAX ANNUAL INCOME STREAM OF \$590.00 OVER 50 YEARS FOR LIVESTOCK FARMERS WITH DIFFERENT LIVESTOCK INVENTORY CEILINGS

| $\begin{array}{c}\text { Pre-drainage } \\ \text { net income }\end{array}$ | $\begin{array}{c}\text { Inventory ceiling } \\ \$ 12,000\end{array}$ |  | $\begin{array}{c}\text { Inventory ceiling } \\ \$ 9,000\end{array}$ |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NPV | $\$$ | $\%$ | IRR |$]$| $\%$ |
| :---: |
| 4,000 |

cash crop farmers. This indicates that taxes can cause distortions in optimal investment allocation. This will further be examined in Chapter 5.

## CHAPTER 4

EFFECT OF DIFFERENT VARIABLES ON THE PROFITABILITY
OF SUBSURFACE DRAINAGE INVESTMENT

### 4.1 Introduction

The profitability of an investment depends not only on prevailing prices and annual input and output quantities related to the investment, but also on such factors as the rate of inflation and how inflation is corrected in the tax tables, and investment subsidies.

This chapter will examine the effect of the following factors on the profitability of the investment: the rate of inflation, partial-indexing of the tax tables as a method of inflation correction, borrowing, subsidies, and changing non-drainage income levels during the lifetime of the drain. Since the direction of the effects of these factors on the profitability of drainage investment is the same for cash crop and livestock farmers, the examples used will be for cash crop farmers. However, partial-indexing and interest subsidies will be considered for both cash crop and livestock farmers.

The calculations in this chapter are all based on the expected average annual yield increase of $770 \mathrm{~kg} / \mathrm{ha}$. Otherwise, the same assumptions regarding prices and input quantities hold, as outlined in the previous chapter.

### 4.2 The Effect of Inflation

The effect of inflation is usually deleted from an investment analysis. This is permissible, provided that future net revenues are deflated and discounted at the real intercst rate. The outcome of an
investment analysis excluding taxation is identical whether inflated future net revenues are discounted at the nominal interest rate or deflated future net revenues are discounted at the real interest rate. However, if after-tax incomes are considered in the analysis, the effect of inflation can no longer be ignored (Hill, 1981; Williams, 1981).

Taxes are paid on nominal incomes with a timelag of one year. Therefore one expects the NPV's at the same real discount rate and the IRRs of the investment to be higher the higher the rate of inflation, since taxes on additional income derived from the investment are worth less by the rate of inflation in the year they are paid. On the other hand, tax savings derived from expense deductions are also received with a time lag of one year and are therefore worth less by the rate of inflation in the year in which they are received, exerting a negative influence on the NPV and IRR of the investment.

In Table 4.1, three different rates of inflation are assumed: zero, 4 and 8 percent. The corresponding nominal interest rates are 4 , 8.16 , and 12.32 percent, respectively. The real interest rate is the same in all three cases, namely 4 percent. It is assumed that pre-drainage income and income derived from drainage rise annually by the rate of inflation. The tax bracket, the personal exemptions, and the basic tax on the lower end in each bracket also increase by the rate of inflation. One would expect, therefore, that over time, taxes would increase at the same rate as the rate of inflation. However, due to the universal \$200 federal tax reduction, which is not subject to an inflation correction, taxes will increase slightly more than the rate of inflation. This force would have a decreasing effect on the NPV and IRR of the investment as the rate of inflation increases.
Table 4.1

| NET PRESENT VALUES (NPV) AND INTERNAL RATES OF RETURM (IRR) OF AFTER-TAX INCOME OVER 50 YEARS FROH A $\$ 12,000$ INVESTMENT IN SIIBSURFACE DRAINAGE, ASSUMING VARIOUS INFLATION AND DISCOUNT RATES |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Pre-drainage | fll/ $=0$; | $i i^{2 /}=.04$ | $\underline{1 /}=.04 ;$ | $\mathrm{ii}^{2 /}=.0816$ | f ]/ $=.08$; | $i i^{2} /=.1232$ |
| net income | NPV | IRR | NPV | IRR | NPV. | IRR |
| \$ | \$ | \% | \$ | \% | \$ | \% |
| 4,000 | 2838 | 05.32 | 2838 | 09.54 | 2838 | 13.75 |
| 8,000 | 2838 | 05.32 | 2125 | 09.24 | 1868 | 13.31 |
| 9,150 | -643 | 03.65 | -531 | 07.83 | -562 | 12.00 |
| 10,000 | 201 | 04.11 | 252 | 08.30 | 306 | 12.49 |
| 10,500 | 113 | 04.06 | 188 | 08.26 | 262 | 12.46 |
| 11,000 | 25 | 04.01 | 134 | 08.23 | 234 | 12.45 |
| 11,500 | -121 | 03.93 | -7 | 08.15 | 99 | 12.37 |
| 12,000 | -185 | 03.90 | -68 | 08.12 | 39 | 12.34 |
| 14,000 | 151 | 04.08 | 254 | 08.30 | 350 | 12.52 |
| 15,000 | 391 | 04.22 | 485 | 08.44 | 572 | 12.66 |
| 19,000 | 1270 | 04.78 | 1331 | 09.00 | 1386 | 13.22 |
| 23,000 | 1756 | 05.13 | 1798 | 09.35 | 1836 | 13.56 |
| 27,000 | 1476 | 04.99 | 1529 | 09.21 | 1577 | 13.42 |
| 33,000 | 1499 | 05.06 | 1551 | 09.27 | 1598 | 13.49 |
| 50,000 | 1466 | 05.18 | 1519 | 09.40 | 1568 | 13.61 |
| 70,000 | 1130 | 04.99 | 1195 | 09.21 | 1256 | 13.44 |

[^2]There are, therefore, opposing forces at work in a period of inflation. The universal $\$ 200$ federal tax reduction for each income bracket decreases the NPV and IRR slightly. The depreciation of tax savings also decreases the NPV and IRR of the investment. On the other hand, the depreciation of tax payments tends to increase the NPV and IRR of the investment.

For a pre-drainage income of $\$ 4000$, no taxes will be paid over the entire lifetime of the drain nor will any tax savings be realized from expense deductions, regardless of the rate of inflation, at least up to 8 percent. The NPV and the real IRR of the investment is therefore the same for all three levels of inflation considered.

For a pre-drainage income level of $\$ 8000$, no tax savings are realized from expense deductions for the rates of inflation considered. Neither are taxes paid on income derived from drainage at a zero inflation rate. However, due to the $\$ 200$ federal tax reduction, which is not subject to an inflation correction, there comes a point in time when taxes will be paid on the additional income if inflation prevails. This is in year 33 if inflation is 4 percent annually, and in year 17 if the annual rate of inflation is 8 percent. These taxes, therefore, reduce after-tax income, and the NPV and real IRR of the investment decrease if the rate of inflation increases for this pre-drainage income level.

For all other pre-drainage income levels the NPV at the real discount rate of 4 percent and the real $I R R$ of subsurface drainage investment grows as inflation increases. The depreciation of tax payments has apparently a greater effect than the depreciation in tax savings and the $\$ 200$ federal tax reduction.

The difference in NPVs and real IRRs of the investment between a
period with no inflation and one in which the rate of inflation is 8 percent, can be substantial. The largest difference is obtained for pre-drainage income levels between $\$ 10,500$ and $\$ 14,000$.

### 4.3 The Effect of Borrowing

Farm profits can be affected by the manner in which drainage investment is financed. The investment could be financed by equity or by a loan. The annual interest payments on the loan can be claimed as an annual expenditure for tax purposes.

It is assumed that the prevailing nominal interest rate is 12.32 percent and the rate of inflation is 8 percent. The real interest rate is thus 4 percent. Assume that 70 percent of the investment is financed by a loan, amounting to $\$ 8400$ at an interest rate of 12.32 percent to be repaid in 10 years in 10 equal annual installments. The remaining 30 acent of the investment is financed by equity.

Table 4.2 compares the outcomes between the two forms of financing. As can be seen from the table, the interest payment deductions from the loan result in considerable tax savings, thus increasing the NPV and IRR of the investment. This assumes that all tax benefits are attributed to the investment. The last column of the table indicates by how much the IRR of the investment increases if it is financed for 70 percent by a loan compared with full equity financing. No gains are made by farmers with low pre-drainage incomes. Their incomes are too low to be liable for taxation for the next 10 years and therefore the interest payment deductions do not affect them. Where the form of financing makes a difference to farm profits, the higher the pre--drainage income the more profitable loan financing becomes. This is due to the increase in

## TABLE 4.2

NET PRESENT VALUES (NPV) AND INTERNAL RATES OF RETURN (IRR) OF AFTER-TAX INCOME OVER 50 YEARS FROM A $\$ 12,000$ INVESTMENT IN SUBSURFACE DRAINAGE FINANCED BY EQUITY AND BY A LOAN DURING A PERIOD OF INFLATION OF 8\% ANNUALLY

| Pre-drainage net income | 100\% equity |  | $30 \%$ equity; <br> $70 \%$ loan at 12.32\% |  | Differences in IRRs |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  | NPV | IRR | NPV | IRR |  |
| \$ | \$ | \% | \$ | \% | \% point |
| 4,000 | 2838 | 13.75 | 2838 | 13.75 | 0 |
| 8,000 | 1868 | 13.31 | 1868 | 13.31 | 0 |
| 10,000 | 306 | 12.49 | 1255 | 13.07 | . 58 |
| 10,500 | 262 | 12.46 | 1211 | 13.04 | . 58 |
| 11,000 | 234 | 12.45 | 1183 | 13.02 | . 57 |
| 11,500 | 99 | 12.37 | 1089 | 12.97 | . 60 |
| 12,000 | 39 | 12.34 | 1045 | 12.94 | . 60 |
| 14,000 | 350 | 12.52 | 1401 | 13.19 | . 67 |
| 15,000 | 572 | 12.66 | 1633 | 13.36 | . 70 |
| 19,000 | 1386 | 13.22 | 2502 | 14.05 | . 83 |
| 23,000 | 1836 | 13.56 | . 2987 | 14.49 | . 93 |
| 27,000 | 1577 | 13.42 | 2862 | 14.49 | 1.07 |
| 33,000 | 1598 | 13.49 | 2994 | 14.72 | 1.23 |
| 50,000 | 1568 | 13.61 | 3243. | 15.33 | 1.72 |
| 70,000 | 1256 | 13.44 | 3155 | 15.55 | 2.11 |

marginal tax rates. The interest payment deductions are therefore highly regressive, resulting in higher net incomes for high- than for lowincome farmers.

The above does not imply that farmers are necessarily better of $f$ if they finance their investment with a loan rather than by equity capital. This depends on the opportunity rate of return on equity capital relative to the borrowing rate. If the after-tax cost of debt capital is lower than the after tax cost of equity capital, then it is to the farmer's advantage to borrow.

### 4.4 The Effect of Subsidies

Governments may want to stimulate investment in subsurface drainage by means of subsidies. If run-off on undrained land leads to external costs such as water pollution, then the public benefits from land improvement exceed the private benefits. The private net benefits may be too low to justify drainage investments. In this case subsidies can provide incentives to undertake land improvement investments, while such improvements may not occur without the subsidy.

Subsidies can be provided in several forms. One is an investment grant which lowers the investment cost by the amount of the grant. The Quebec government provides such subsidies for subsurface drainage. Another form is interest subsidies on loans. The Ontario government provides loans at subsidized interest rates for subsurface drainage under the Ontario Tile Drainage Act. These loans are administered by the township council. The loans cannot exceed 75 percent of the total cost of the drainage system and must be repaid over a 10 -year period.

Since taxation affects the ultimate outcome of a subsidy for the
farmer, both systems will be compared. It is assumed that 70 percent of the drainage cost is financed by a loan at a subsidized interest rate of 8 percent, while the prevailing interest rate is 12.32 percent and the rate of inflation is 8 percent. The loan will be repaid in 10 years in 10 equal installments. The subsidy amounts to 4.32 percentage points annually. These annual interest payment subsidies can be converted into a NPV of $\$ 1419$ discounted as the before-tax cost of capital. If a $\$ 4,000$-income farmer was charged the full interest rate of 12.32 percent, the NPV of the additional payments would have been $\$ 1419$. This interest subsidy of $\$ 1419$ will be compared with an investment grant of $\$ 1419$ to be received in the year the investment is made.

Table 4.3 compares the outcomes between the two forms of subsidies and between a subsidized and a non-subsidized loan for cash crop farmers. For farmers who are not subject to taxation, the kind of subsidy does not affect the NPV. However, the IRR is higher under an investment subsidy. This is because the cost of capital is irrelevant for calculating the IRR. Whether the investment is financed by equity or a subsidized loan, the IRR is the same for farmers who are not subject to taxation while the loan is paid off (compare columns 7 of Table 4.1 and 3 of Table 4.3). However, the investment subsidy reduces the investment cost by the amount of the subsidy and increases the IRR. For farmers who are subject to taxation, the investment subsidy provides a higher NPV and IRR than the interest subsidy. The investment subsidy reduces the investment cost. Moreover, it lowers the investment expense deduction in the year of installation, resulting in lower tax savings in that year. On the other hand, the higher interest on the loan compared with a subsidized loan increases the interest expense deductions for the
TABLE 4.3
NET PRESENT VALUES (NPV) AT 12.32\% AND INTERNAL RATES OF RETURN (IRR) OF AFTER-TAX INCOME OVER 50 YEARS

| Predrainage net income | Subsidized loan of $\$ 8400$ at $8 \%$ |  | Loan of $\$ 3400$ at $12.32 \%$; investment subsidy of \$1419 |  | $\begin{gathered} \begin{array}{c} \text { Difference } \\ \text { in subsidies } \end{array} \\ \text { IRR } \end{gathered}$ | $\begin{gathered} \text { Loan of } \$ 8400 \\ \text { at } 12.32 \% \\ \hline \end{gathered}$ |  | Difference in subsid.and non-subsid.loan |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | NPV | IRR | NPV | IRR |  | NPV | IRR | NPV | IRR |
| \$ | \$ | \% | \$ | \% | \% | \$ | \% | \$ | \% |
| 4,000 | 4257 | 13.75 | 4257 | 14.70 | . 95 | 2838 | 13.75 | 1419 | 0 |
| 8,000 | 3287 | 13.31 | 3287 | 14.26 | . 195 | 1868 | 13.31 | 1419 | 0 |
| 10,000 | 2318 | 12.84 | 2279 | 13.80 | . 96 | 1255 | 13.07 | 1063 | -. 23 |
| 10,500 | $2 ¢ 73$ | 12.81 | 2281 | 13.80 | . 99 | 1211 | 13.04 | 1062 | -. 23 |
| 11,000 | 2245 | 12.80 | 2376 | 13.87 | 1.07 | 1183 | 13.02 | 1062 | -. 22 |
| 11,500 | 2143 | 12.74 | 2395 | 13.91 | 1.17 | 1089 | 12.97 | 1054 | -. 23 |
| 12,000 | 2086 | 12.71 | 2464 | 13.97 | 1.26 | 1045 | 12.94 | 1041 | -. 23 |
| 14,000 | 2431 | 12.93 | 2820 | 14.30 | 1.37 | 1401 | 13.19 | 1030 | -. 26 |
| 15,000 | 2653 | 13.08 | 3052 | 14.51 | 1.43 | 1633 | 13.36 | 1020 | -. 28 |
| 19,000 | 3503 | 13.72 | 3921 | 15.44 | 1.7.2 | 2502 | 14.05 | 1001 | -. 33 |
| 23,000 | 3985 | 14.14 | 4076 | 15.64 | 1.50 | 2987 | 14.49 | 998 | -. 35 |
| 27,000 | 3798 | 14.07 | 3922 | 15.66 | 1.59 | 2862 | 14.49 | 936 | -. 42 |
| 33,000 | 3889 | 14.24 | 4036 | 15.97 | 1.73 | 2994 | 14.72 | 895 | -. 48 |
| 50,000 | 4033 | 14.64 | 4191 | 16.73 | 2.09 | 3243 | 15.33 | 790 | -. 69 |
| 70,000 | 3861 | 14.69 | 4008 | 16.96 | 2.27 | 3155 | 15.55 | 706 | -. 86 |

next 10 years. The tax savings from the expense deduction under the interest subsidy exceed those under an investment subsidy, but the tax savings from the interest payment deductions under the interest subsidy are smaller than those under an investment subsidy. Apparently the tax savings from the interest payment deductions are the stronger force, providing a higher NPV and IRR under an investment subsidy than under an interest subsidy.

The last two columns of Table 4.3 give the differences in NPVs and IRRs between drainage investment financed by a subsidized and a nonsubsidized loan. The NPVs at 12.32 percent of drainage financed by subsidized loans are greater than those financed by nonsubsidized loans, while the IRRs are smaller. The cost of the loan is irrelevant in computing the IRR while the tax savings on the interest payment deductions are greater from the nonsubsidized loan. The higher IRR does not mean that the profitability of the investment financed by a nonsubsidized loan is greater than that from a nonsubsidized loan. The IRR must be compared with the cost of capital and this is lower in the case of a subsidized loan.

Taxation on investment income for livestock farmers is progressive if the investment is financed by equity. Debt capital financing may change this. The interest payment deductions from net income favour high-income farmers more than low-income farmers. Table 4.4 indicates that this introduces a slight regressiveness in net taxes for livestock farmers under the stated conditions, since the IRRs tend to increase if incomes rise.

TABLE 4.4

NET PRESENT VALUES (NPV) AT 12.32\% AND INTERNAL RATES OF RETURN (IRR) OF AFTER-TAX INCOME OVER 50 YEARS FROM A $\$ 12,000$ INVESTMENT IN SUBSURFACE DRAINAGE FINANCED BY A SUBSIDIZED LOAN OF \$8400 AT 8\% DURING A PERIOD OF INFLATION OF 8\% ANNUALLY

| Pre-drainage net income | Cash crop farmers |  | Livestock farmers |  |
| :---: | :---: | :---: | :---: | :---: |
|  | NPV | IRR | NPV | IRR |
| \$ | \$ | \% | \$ | \% |
| 4,000 | 4257 | 13.75 | 4257 | 13.75 |
| 8,000 | 3287 | 13.31 | 4524 | 13.85 |
| 10,000 | 2318 | 12.84 | 3983 | 13.93 |
| 10,500 | 2273 | 12.81 | 4012 | 13.97 |
| 11,000 | 2245 | 12.80 | 4006 | 13.98 |
| 11,500 | 2143 | 12.74 | 4013 | 14.02 |
| 12,000 | 2086 | 12.71 | 3941 | 13.98 |
| 14,000 | 2431 | 12.93 | 3952 | 14.03 |
| 15,000 | 2653 | 13.08 | 3926 | 14.02 |
| 19,000 | 3503 | 13.72 | 3967 | 14.10 |
| 23,000 | 3985 | 14.14 | 3985 | 14.14 |
| 27,000 | 3798 | 14.07 | 3798 | 14.07 |
| 33,000 | 3889 | 14.24 | 3889 | 14.24 |
| 50,000 | 4033 | 14.64 | 4033 | 14.65 |
| 70,000 | 3861 | 14.69 | 3861 | 14.69 |

### 4.5 The Effect of Partial-indexing

Until 1985, income taxes were fully indexed. Full-indexing implies that the tax brackets, personal exemptions, and the basic tax on the lower end in each bracket, increase annually by the rate of inflation, while the tax rate on the remaining dollars in the bracket remains constant over time. Commencing in 1986, the annual indexation of income taxes reflects only those increases in the consumer price index in excess of 3 percent. This implies that personal exemptions, the tax brackets, and the basic tax on the lower end in each bracket will increase by the rate of inflation minus 3 percentage points.

The effect of partial-indexing on the profitability of subsurface drainage investment is shown in Table 4.5. It was assumed that the investment is $\$ 12,000$, the discount rate 12.32 percent, and the rate of inflation 8 percent.

Over time, partial-indexing will increase taxes compared with full-indexing because taxable income increases at a faster rate than net income due to a diverging rate of increase between net income and personal exemptions. Moreover, there will be a shift to tax brackets with a higher marginal tax rate because of a diverging rate of increase between taxable income and tax brackets. This is particularly important for investments which are evaluated on a marginal basis. As a result, taxes from income derived from drainage will rise over time and net after-tax income will decrease over time, resulting in a reduction in the NPV and in the IRR of the investment. It does not mean that marginal taxes resulting from an increase in income from drainage investment will rise every year. Although marginal taxable income from drainage investment rises faster than the tax brackets, in many years this marginal
TABLE 4.5

| Pre-drainage net income | Full-indexing |  |  |  | Partial-indexing (5\%) |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Cash crop farmers |  | Livestock farmers |  | Cash | farmers | Lives | farmers |
|  | NPV | IRR | NPV | IRR | NPV | IRR | NPV | IRR |
| \$ | \$ | \% | \$ | \% | \$ | \% | \$ | \% |
| 4,000 | 2838 | 13.75 | 2838 | 13.75 | 1705 | 13.27 | 2706 | 13.72 |
| 8,000 | 1868 | 13.31 | 3105 | 13.85 | 118 | 12.39 | 1251 | 13.07 |
| 10,000 | 306 | 12.49 | 2022 | 13.57 | -183 | 12.21 | 1414 | 13.24 |
| 10,500 | 262 | 12.46 | 2070 | 13.61 | -276 | 12.15 | 1380 | 13.23 |
| 11,000 | 234 | 12.45 | 2070 | 13.62 | -399 | 12.08 | 1325 | 13.20 |
| 11,500 | 99 | 12.37 | 1928 | 13.54 | -505 | 12.02 | 1349 | 13.23 |
| 12,000 | 39 | 12.34 | 1952 | 13.57 | -556 | 11.99 | 1363 | 13.25 |
| 14,000 | 350 | 12.52 | 1901 | 13.56 | -296 | 12.13 | 1260 | 13.20 |
| 15,000 | 572 | 12.66 | 1860 | 13.54 | -143 | 12.23 | 1155 | 13.13 |
| 19,000 | 1386 | 13.22 | 1859 | 13.57 | 428 | 12.62 | 907 | 12.99 |
| 23,000 | 1836 | 13.56 | 1836 | 13.57 | 552 | 12.73 | 552 | 12.73 |
| 33,000 | 1598 | 13.49 | 1598 | 13.50 | 602 | 12.80 | 602 | 12.80 |
| 50,000 | 1568 | 13.62 | 1568 | 13.62 | 1026 | 13.21 | 1026 | 13.21 |
| 70,000 | 1256 | 13.44 | 1256 | 13.44 | 1256 | 13.44 | 1256 | 13.44 |

income could still remain within the bracket with the same marginal tax rate. However, due to the compounded effect, the difference between the marginal increase in income and the increase in the tax brackets increases over time, shifting marginal taxable income to higher tax brackets.

As can be seen from Table 4.5 , the $N P V$ and the IRR of the investment under partial-indexing will decrease compared with full-indexing, except for a pre-drainage income level of $\$ 70,000$. This latter level is in the highest tax bracket. There is no possibility that taxable income can shift to a higher income tax bracket. The additional income derived from drainage will all be taxed at 50.73 percent regardless of the extent of de-indexing. For all other pre-drainage income levels, the return on the investment will decline under partial-indexing.

Farmers earning a net pre-drainage income of $\$ 4000$ are exempt from taxation under full-indexing for the entire period over which the investment lasts. However, under partial-indexing they start paying taxes in year 29. In that year cash crop farmers are no longer able to deduct the investment cost from net income. On the other hand, livestock farmers can still deduct the paper "purchase" of livestock, assuming that they had used this provision to deduct the investment cost in the year of installation. Note also that a livestock farmer in the $\$ 8000$ income bracket realizes a larger after-tax than before-tax gain from the investment under full-indexing. Without the investment, farmers in this income bracket would start paying taxes from year 21 on. The livestock farmer is able to postpone taxation indefinitely, at least till the end of the investment period, through the livestock inventory provision, thereby saving the taxes he otherwise would have paid.

The decline of the $I R R$ through partial-indexing is relatively small. The after-tax cost of capital will also decrease through partial-indexing. Although the after-tax return on the investment goes down through partial-indexing, the amount invested may not be affected.

Table 4.6 shows the investment results for livestock farmers under a $\$ 12,000$ and under a $\$ 9,000$ livestock inventory ceiling. As can be seen, the lower ceiling has a decreasing effect on the ultimate return, except for the $\$ 4,000$-income farmer under full-indexing who is not liable for taxation during the entire economic lifetime of the drain. The decline in returns peters out if income levels of $\$ 12,000$ are approached.
, Table 4.7 summarizes the profitability of drainage investment under full- and partial-indexing, assuming the investment is financed by a loan of $\$ 8400$ at a subsidized interest rate. The rate of inflation is 8 percent, the discount rate 12.32 percent and the interest rate on the loan 8 percent. The only difference between the entries in Tables 4.5 and 4.7 is the manner in which the investment is financed. The IRR increases due to the subsidized loan. The interest subsidy by itself does not affect the $I R R$. The effect comes from the expense deduction of the interest payments. For the two income levels of $\$ 4,000$ and $\$ 8,000$ where no interest expense deductions are made in the first 10 years during which the loan is paid off, the IRRs are similar whether the investment is financed by equity or by a subsidized loan. However, for higher income levels the interest payment deductions increase the IRR.

The last two columns in Table 4.7 refer to partial-indexing, where the inflation rate is 5 percent, the interest rate on the loan 6 percent, and the discount rate' 9.2 percent, giving the same real discount rate of 4 percent as in previous cases. The real IRRs of the investment have
TABLE 4.6

| Pre-drainage net income | Full-Indexing |  |  |  | Partial-indexing (5\%) |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Inventory ceiling \$12,000 |  |  | $\begin{gathered} \hline \text { Inventory ceiling } \\ \$ 9,000 \end{gathered}$ | $\begin{gathered} \text { Inventory ceiling } \\ \$ 12,000 \end{gathered}$ |  | $\begin{gathered} \text { Inventory ceiling } \\ \$ 9,000 \end{gathered}$ |  |
|  | NPV | IRR | NPV | IRR | NPV | IRR | NPV | IRR |
| \$ | \$ | \% | \$ | \% | \$ | \% | \$ | \% |
| 4,000 | 2838 | 13.75 | 2838 | 13.75 | 2706 | 13.72 | 1995 | 13.42 |
| 8,000 | 3105 | 13.85 | 3105 | 13:85 | 1251 | 13.07 | 785 | 12.79 |
| 10,000 | 2022 | 13.57 | 1658 | 13.33 | 1414 | 13.24 | 1036 | 12.98 |
| 10,500 | 2070 | 13.61 | 1742 | 13.39 | 1380 | 13.23 | 1057 | 13.00 |
| 11,000 | 2070 | 13.62 | 1811 | 13.44 | 1325 | 13.20 | 1156 | 13.08 |
| 11,500 | 1928 | 13.54 | 1840 | 13.48 | 1349 | 13.23 | 1256 | 13.16 |
| 12,000 | 1952 | 13.57 | 1942 | 13.56 | 1363 | 13.25 | 1333 | 13.23 |

Table 4.7
NET PRESENT VALUES (NPV) AND INTERNAL RATES OF RETURN (IRR) OF AFTER-TAX INCOME

| Pre-drainage net income | Full indexing$\mathrm{f}^{\mathrm{I} /}=.08 ; \mathrm{i} \mathrm{i}^{2 /}=.1232 ; \mathrm{s} \underline{3} /=.08$ |  | $\begin{aligned} & \text { Partial indexing } \\ & \mathrm{f} \underline{l} /=.08 ; \mathrm{i} \mathrm{I}^{2} /=.1232 ; \mathrm{s}-\frac{3}{}=.08 \end{aligned}$ |  | Partial indexing$\mathrm{f} \underline{1 /}=.05 ; \mathrm{ij} \frac{2 /}{}=.092 ; \mathrm{s} \underline{3}=.06$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | NPV | IRR | NPV | IRR | NPV | IRR |
| \$ | \$ | \% | \$ | \% | \$ | \% |
| 4,000 | 4256 | 13.75 | 3124 | 13.27 | 2832 | 10.12 |
| 8,000 | 3287 | 13.31 | 1932 | 12.62 | 1605 | 9.47 |
| 10,000 | 2318 | 12.84 | 1842 | 12.58 | 1388 | 9.35 |
| 10,500 | 2273 | 12.81 | 1759 | 12.53 | 1301 | 9.30 |
| 11,000 | 2245 | 12.80 | 1647 | 12.46 | 1169 | 9.22 |
| 11,500 | 2143 | 12.74 | 1549 | 12.40 | 1044 | 9.14 |
| 12,000 | 2086 | 12.71 | 1502 | 12.37 | 996 | 9.11 |
| 14,000 | 2431 | 12.93 | 1786 | 12.56 | 1283 | 9.29 |
| 15,000 | 2653 | 13.08 | 1943 | 12.67 | 1439 | 9.40 |
| 19,000 | 3503 | 13.72 | 2558 | 13.16 | 2065 | 9.87 |
| 23,000 | 3985 | 14.14 | 2782 | 13.39 | 2282 | 10.08 |
| 27,000 | 3798 | 14.07 | 2790 | 13.43 | 2287 | 10.11 |
| 33,000 | 3889 | 14.24 | 2915 | 13.58 | 2420 | 10.26 |
| 50,000 | 4033 | 14.64 | 3497 | 14.25 | 2991 | 10.89 |
| 70,000 | 3861 | 14.70 | 3861. | 14.70 | 3343 | 11.30 |

[^3]reduced compared with a situation where the rate of inflation and the interest rate on the loan are higher. The reduction is caused by two factors. Firstly, the loan. rate is lower which results in lower interest payment deductions and therefore in lower tax savings. Secondly, the higher the rate of inflation, the higher the profitability of the investment, as explored previously.

### 4.6 The Effect of Changing_Income Levels Over Time

In the previous analyses it was assumed that income from sources other than drainage remains unchanged over the entire lifetime of the drain. This is a restrictive assumption which can be relaxed. If in addition to income resulting from drainage investment, income from other sources increases also over time, future income derived from drainage will be taxed at a higher marginal tax rate, while the tax savings derived from the expense allowance of the investment cost is calculated at the lower tax rate corresponding with pre-drainage income at the time of investment. This will result in a lower profitability of the investment.

Two examples will show the effect. Assume an investment of $\$ 12,000$, a discount rate of 4 percent, no inflation, and the investment being financed by equity (columns 2 and 3 in Table 4.1). Assume further, that income from non-drainage sources is $\$ 10,000$ annually up to the end of year $5, \$ 12,000$ from year 6 to year $10, \$ 19,000$ from year 11 to year 15 , and $\$ 23,000$ from year 16 onward. The NPV of the investment in this case is .. $\$ 305$. Note that if income from other sources than drainage had remained at $\$ 10,000$ per year, the NPV would have been $\$ 201$.

Another example applies to a somewhat higher income-farmer. Suppose
that income from non-drainage sources is $\$ 14,000$ annually to the end of year 5, $\$ 19,000$ from year 6 to year $10, \$ 27,000$ from year 11 to year 15 , and $\$ 33,000$ from year 16 onward. The NPV of the investment under these circumstances is $-\$ 739$, while the $N P V$ would have been $\$ 151$ if income from non-drainage sources had remained. $\$ 14,000$ annually. The after-tax NPVs and IRRs will decrease if farmers' income from other sources than those derived from the investment, goes up over time.

TAXES FROM THE NATIONAL VIEWPOINT

### 5.1 Introduction

Income taxes are considered as an expense for the investor. In order to calculate the return on his investment, the investor is interested in after-tax profitability. From the national economy's point of view, tax payments do not necessarily represent real sacrifices in the sense that national income declines. In order to calculate the profitability of an investment for the nation, the before-tax NPV or IRR of the investment suffices. True, tax collection requires input use and has therefore some effect on national income, but this effect is not measured by the after-tax profitability of the investment. Lately, mention has been made in the public finance literature of distortions in the factor and product markets caused by taxation (Browning, 1976; Stewart, 1984). These distortions will not be subject of inquiry in this chapter.

The purpose of this chapter is more modest. It will be assumed that undertaking investments showing a positive before-tax payoff advances national income. From the nation's point of view, it is immaterial whether after-tax gains are smaller than before-tax gains. However, if taxation affects the level of investment, then national income can be negatively influenced by taxation. We will examine whether taxation on investment income can affect the level of drainage investment. Moreover, this chapter will examine what the treasuries gain from investment income realized over 50 years versus an equivalent income earned in one particular year.

### 5.2 Effect of Taxes on the Treasuries

In general, the federal and provincial treasuries gain from profitable investments by taking some of the gains away from investors. The gain to the treasuries is equal to the difference between before tax and after-tax profitability. For example, a drainage investment of $\$ 12,000$, yielding an annual net benefit of $\$ 690.70$ over 50 years, discounted at 4 percent, and assuming no inflation over the lifetime of the investment, has a before-tax NPV of $\$ 2838$, similar to the profitability of that for farmers with a pre-drainage income of $\$ 4000$ and $\$ 8000$ whose income is too low to be subject to taxation. This situation is recorded in the second column in Table 4.1. Almost half or more of the profits flow back to the treasuries from those farmers who pay income taxes. In times of inflation, the treasuries gain somewhat less, as can be seen from columns 4 and 6 in Table 4.1.

A good measure for finding out the return from taxes paid from drainage income that the government receives from farmers in the various income brackets is the NPV of those taxes. In this case the NPV calculated at the same discount rate for all income brackets does not suffer the limitations this measure has in comparing drainage profitability among farmers in various income brackets. The relevant discount rate is the one the government faces. This rate is fixed at any point in time and is not dependent on the after-tax cost of capital for the individual. The only factor which causes the differences among the NPVs of the different farmers is the amount of taxes paid. Therefore, these differences record the NPV of the taxes paid at the relevant discount rate.

Table 4.1 shows that the gain from profitable investments for the treasuries is considerable, assuming the relevant discount rates for the
government are the nominal interest rates used. It is interesting to note that the NPV of the gain for the treasuries from investment income accruing over 50 years is substantially larger than that obtained from income earned in one particular year. For example, the highest income farmer $(\$ 70,000)$ pays an extra $\$ 1,440$ in taxes on a marginal increase in income of $\$ 2,838$. However, on the extra annual income of $\$ 690.70$ over 50 years from investing $\$ 12,000$ in drainage, which amounts also to a NPV of $\$ 2,838$ at 4 percent, the NPV of the net tax payments is $\$ 1,708(\$ 2,838$ before-tax NPV minus $\$ 1,130$ after-tax NPV from Table 4.1). The NPV of the gain for the treasuries from lower income cash crop farmers is considerably larger. For a farmer with a net income of $\$ 15,000$, the marginal tax on an additional $\$ 2,838$ income in a particular year would be \$805, while the NPV of the extra taxes payable on the drainage investment income over 50 years and discounted at 4 percent is $\$ 2,447$.

Partial-indexing of taxes (above an inflation rate of 3 percent) provides considerable gains for the treasuries as Tables $4.5,4.6$ and 4.7 show. For example, under full-indexing the government gains nothing from a farmer with a pre-drainage income of $\$ 4000$ who invests in subsurface drainage if the inflation rate is 8 percent and the loss of capital is 12.32 percent. However, under partial-indexing, where the tax table is corrected by 5 percent rather than 8 percent annually, the treasuries gain $\$ 1133$ from the cash-crop farmer and $\$ 132$ from the livestock farmer. Note that from many low- income cash crop farmers the NPV of tax payments to the government, under partial-indexing, exceed $\$ 2,838$ over the economic lifetime of the drain. This is the maximum before-tax NPV at 12.32 percent and an annual inflation rate of 8 percent.

### 5.3 Effect of Interest Deductions and Subsidies on the Treasuries

If the investment is financed by a loan, the interest payment on the loan can be claimed as an expenditure. This has the effect of increasing the after-tax profitability of the investment for the farmer and lowering the amount flowing back to the treasury. If the interest on the loan is subsidized by the government, there are two opposite streams, one in the form of taxes flowing into the treasury and one in the form of subsidies flowing out of the treasury. On the basis of the assumptions underlying Table 4.3, the interest subsidy amounts to \$1419. The NPV of the investment, including the interest subsidy, is for many income brackets larger than $\$ 2838$ (before-tax profitability without the subsidy) as shown in the second column of Table 4.3. In these cases there is a net outflow from the provincial treasury, since the subsidy is entirely provided by that government.

What the treasuries gain or sacrifice can best be shown by two examples from Table 4.3. A farmer with a pre-drainage income of $\$ 12,000$ has a NPV of $\$ 2838-(\$ 2086-\$ 1419)=\$ 2171$ for taxes from income derived from subsurface drainage. The $\$ 2838$ refers to the NPV of the before-tax increase in net income, the $\$ 2086$ to the NPV of the after-tax net income from the investment under a subsidized loan, and the $\$ 1419$ to the NPV of the subsidy on interest payments. The Ontario tax in 1983 was 49.2 percent of the federal tax including the Ontario Social Services Maintenance Tax. Thus $\$ 1455$ goes to the federal and $\$ 716$ to the provincial treasuries. On the other hand, the provincial treasury pays a subsidy of \$1419, making a net loss for the provincial treasury of \$703. This provincial treasury loss is substantially larger for the higher income brackets. For example, the treasuries receive a NPV of $\$ 224$ at 12.32
percent in taxes on additional income derived from drainage from a farmer with a pre-drainage income of $\$ 50,000$ if the annual inflation rate is 8 . percent; $\$ 150$ for the federal and $\$ 74$ for the provincial treasuries. In this case the loss to the provincial treasury is $\$ 1419$ $\$ 74=\$ 1345$.

### 5.4 Allocation Distortions Resulting_from Taxes

Taxes not only redistribute income, but can also affect the level of investment. Let's go back to Table 3.5. Assume that the before-cost of capital for all farmers is 4.25 percent. Under the assumptions underlining Table 3.5, the before-tax IRR of the investment is 4.33 percent. Without tax payments and tax savings, the investment would yield a positive return to the nation and investment would be equally profitable for all farmers. Let's look now at how a cash crop farmer with a pre-drainage income of $\$ 12,000$ is affected by taxation. His marginal tax rate is 26.86 percent. His after-tax cost of capital is therefore $4.25(1-.2686)=3.11$ percent. The after-tax IRR of drainage investment for that farmer is 3.02 percent. Since the IRR is smaller than his cost of capital, the farmer would not undertake the investment, while from a national point of view the investment is worthwhile. These distortions caused by the tax system can result in serious under-investment in land improvements.

One of the major reasons why low-income cash crop farmers are slow in adopting subsurface drainage is that they are not able to take full advantage of the investment expense deduction. Moreover, if farmers expect lower yields than the mathematical expected average annual yield, profitable before tax investments may yield after-tax losses. Investment
in subsurface drainage appears to be a necessary condition for making investments in outlet drainage profitable. Governments subsidize these outlet drainage programs. The subsidy may be wasted if subsequent investment in subsurface drainage does not occur to a sufficient degree (Van Vuuren and McCaw, 1984).

In some cases, tax provisions encourage adoption of investments, which are not profitable without taxation. An example is provided in Table 5.1. Assume a drainage investment of $\$ 12,000$ yielding $\$ 721.78$ in the first year increasing at the rate of inflation of $41 / 2$ percent over 50 years, is financed by a loan of $\$ 12,000$ at 12.32 percent. Without any tax savings and tax payments, the investment yields 10.07 percent under these assumptions. At the before-tax cost of capital of 12.32 percent, this investment would decrease national income, if undertaken. Due to the interest payment deductions, the IRR of the investment increases the higher pre-drainage income becomes. Take a farmer with a pre-drainage income of $\$ 27,000$. His marginal tax rate is 34.32 percent and his after-tax capital cost $12.32(1-.3432)=8.09$ percent. The IRR for this farmer is 11.56 percent. Thus the investment is highly profitable for him. The farmer would gain from the investment but the nation would lose.

The above examples show how the tax system can distort investment funds. Either under-investment or over-investment can occur. If income is not received in the same year as the expenditure is made from which the income is derived, distortions can easily emerge through the tax system.

Table 5.1

NET PRESENT VALUES (NPV) AT 12.32\% AND INTERNAL RATES OF RETURN (IRR) OF AFTER-TAX INCOME OVER 50 YEARS FROM A $\$ 12,000$ INVESTMENT IN SUBSURFACE DRAINAGE FINANCED BY A LOAN OF \$12,000 at 12.32\% DURING A PERIOD OF INFLATION OF 4.5\% ANNUALLY

| Pre-drainage <br> net income | NPV | IRR |
| :---: | :---: | :---: |
| $\$$ | $\$$ | $\%$ |
| 4,000 | -3020 | 10.07 |
| 8,000 | -3326 | 9.74 |
| 10,000 | -2841 | 9.78 |
| 10,500 | -2896 | 9.74 |
| 11,000 | -2946 | 9.71 |
| 11,500 | -2987 | 9.66 |
| 12,000 | -2993 | 9.64 |
| 14,000 | -2557 | 9.93 |
| 15,000 | -2292 | 10.13 |
| 19,000 | -1337 | 10.92 |
| 23,000 | -804 | 11.43 |
| 27,000 | -656 | 11.56 |
| 33,000 | -320 | 11.93 |
| 50,000 | 433 | 12.95 |
| 70,000 | 756 | 13.53 |

### 6.1 Summary

The major occupation of this report was an after-tax investment analysis of subsurface drainage. In particular, three objectives were pursued. Firstly, a method was developed to obtain the statisticallyexpected potential increase in annual grain corn yield resulting from subsurface drainage over the economic life of the drainage system. This yield figure is of crucial importance for an investment analysis.

Secondly, the effect of taxation on after-tax profitability from drainage investment was examined for farmers in various income brackets. We saw that low-income cash crop farmers are adversely affected by the tax provision which stipulates that subsurface drainage is an operating expense which must be deducted from income in the year in which it occurs. Low-income livestock farmers can avoid this adverse effect through the livestock inventory provision, provided that the value of the inventory is sufficiently large to reach the tax free income of \$1,986 after all deductions have been made. Cash crop farmers are discriminated against as they are not able to "sell" their crop inventory to the government. Moreover, the effect of inflation, borrowing, subsidies, and partial indexing on the profitability of the investment were considered.

The third objective of the report was to investigate whether or not taxes affect the amount of investment undertaken by farmers. The report showed that from a natiónal point of view, taxes can result in a misallocation of investment funds. From the national point of view, taxes
can cause over-investment in certain cases and under investment in others. Moreover, the report examined the distribution of tax receipts between the provincial and federal treasuries and compared taxes received from investment and non-investment income.

### 6.2 Conclusions

This section lists the major conclusions from the report.

### 6.2.1 Estimating_Physical Yields Emanating from Subsurface Drainage

1. For investment analysis it is important to obtain the proper yield increase from drainage. This is the expected mathematical average yield increase over the entire lifetime of the drain and not an average obtained over a limited number of years.
2. The expected mathematical average yield increase is itself a random variable, varying within certain boundaries. It is important to know whether the investment yields a positive return at a physical yield near the lower boundary.

### 6.2.2 Basic Investment Analysis

1. After-tax income derived from drainage investment, which yields the same before-tax net income' for all farmers regardless of their income bracket, is highly unequally distributed among farmers in the various income brackets. For cash crop farmers, income taxes on drainage investment are regressive. The after-tax gain from drainage investment for low-income farmers is considerably smaller than that for high income farmers. This is caused by tax regulations requiring deduction of the investment costs from net income in the year of installation, leading to a loss of personal exemptions and other legitimate deductions and
non-taxable income for low income cash crop farmers in that year.
Livestock farmers, on the other hand, are able to avoid these "losses" through the livestock inventory provision. provided that the value of their livestock inventory is high enough to reach the $\$ 1,986$ tax-free income. After-tax income from the investment for these farmers decreases if incomes go up. Taxation on income from drainage for livestock farmers is progressive.
2. At yields near the lower boundary of the yield interval, the before-tax gain of the investment is positive, while the after-tax gain is negative for many low-income cash crop farmers. For these farmers the $I R R$ is lower than their after-tax cost of capital.
3. The Ontario Tax Rebate Program acts as a deterrent for land improvement investments. Due to additional income from the investment, the farmer eligible for this program under pre-investment conditions, would lose the rebate for the entire length over which the income stream from the investments lasts, if he decided to invest.

### 6.2.3 Effect of Different Variables on the Profitability of Drainage Investment

1. Inflation has two opposing effects on after-tax net income derived from investment. Both tax payments and tax savings have a lower real value in the year in which they are paid and received, because these payments and savings occur with a timelag of one year. Real lower payments increase the $N P V$ and IRR of the investment, while real lower tax savings decrease the NPV and IRR compared with a situation without inflation. The overall effect on the NPV and IRR of the investment depends on the magnitude of either force.
2. Subsidies for drainage investment by means of investment grants and subsidized interest rates on loans, improve the NPV and IRR of the investment. The IRR of the investment supported by an investment subsidy exceeds that rate of the investment supported by interest subsidies.
3. Partial-indexing of taxes has a depressing effect on NPVs and IRRs of an investment. Partial-indexing would also decrease the after-tax cost of capital. A decrease in the IRR and in the cost of capital may not affect the amount of investment undertaken. However, partial indexing will decrease the return on the investment. The longer the period lasts over which an investment yields net income, the more severe the effect of partial-indexing on returns becomes.
4. Increasing incomes over time from other sources than from drainage investments lead to a decrease in NPV and IRR of drainage investment. Resulting higher marginal tax rates lead to greater tax payments over time on income from investments, while tax savings from expense deductions are calculated under lower marginal tax rates in the beginning of the period. This has a negative effect on the NPV and IRR of after-tax net income from these investments.
5. The federal and provincial treasuries make considerable gains from profitable investments in subsurface drainage. It appears that the treasuries gain more from investment income derived over 50 years than from an equivalent income derived in one particular year.
6. Since net taxes on income from drainage investment are regressive for cash crop farmers, the treasuries gain more from these low- than from these high-income farmers.
7. Partial-indexing of income taxes results in large gains from investment income for the treasuries.
8. In many instances, the provincial treasury appears to lose money by providing subsidies on drainage investments. This is so when the subsidies exceed provincial tax receipts. If there is a loss, the government loses more on investment grants for high-income than for low-income cash crop farmers, while the reverse holds for livestock farmers.
9. Taxation can result in too much and too little drainage invest-ments. If all income from a particular expenditure is not derived in the year in which the expenditure is made, the tax system can cause distortions in efficient investment allocations. From the nation's point of view, tax regulations may prevent profitable investments from being adopted and may encourage unprofitable investments to be adopted. Particularly low-income cash crop farmers may make fewer investments in land improvements than are justified from the nation's point of view.

## REFERENCES

1. Brooks, S.E., 1971. A Study of the Agricultural Drainage Outlet . Assistance Program in Eastern Ontario. ARDA Branch, Ontario Department of Agriculture and Food: 38-44.
2. Browning, E., 1976. "The Marginal Cost of Public Funds". J. of Pol. Ec. 84:283-298.
3. Canada Soil Survey Committee, 1974. The System of Soil Classification for Canada. Canada Department of Agriculture Publication 1455. Ottawa, Ontario: 220-221.
4. Environment Canada, Monthly Record, Meteorological Observations in Eastern Canada. Ottawa, Ontario, various issues.
5. Found, W.D., A.R. Hills and E.S. Spencer, 1976. "Economic and Environmental Impacts of Agricultural Land Drainage in Ontario". J. Soil Water Conser. 31: 20-24.
6. Galloway, J. and J.R. Johnston, 1982. Drainage Benefits for Field Crops. American Society of Agricultural Engineering. No. 82-2545, St. Joseph, Michigan.
7. Hill, G.P., 1981. The Feasibility of Financing Investments Using Borrowed Money During'a Period of Inflation and High Interest Rates. F.B.U. Occasional Paper No.6, School of Rural Economics, Wye College, England.
8. Jorjani, H., 1982. A Multidisciplinary Approach to Economic Feasibility of Tile Drainage in Southern Ontario. Unpublished M.Sc. Thesis, University of Guelph, Guelph, Ontario: 68-78.
9. Leitch, J.A. and D. Kerestes, 1981. Agricultural Land Drainage: Costs and Returns in Minnesota. Staff Paper P81-15. Dept. of Agric. and Applied Econ., University of Minnesota, St. Paul, Minn.
10. Lembke, W.D., C.J.W. Drablos, J.G. Arnold and J.N. Scarborough, 1982. "A Model for Drainage Benefits". Transactions of the A.S.A.E., 25:1329-1332.
11. Mackintosh, E.E. and J. Vanderhulst, 1978. "Soil Drainage Classes and Soil Water Table Relations in Medium and Coarse Textured Soils in Southern Ontario." Can. J. Soil Sci. 58:287-301.
12. Morris. D.T., R.B. Hunter and R.J. McLaughlin, 1981. Corn Production. Ontario Ministry of Agric. and Food Publ. 13. Toronto, Ontario.
13. Ontario Ministry of Agriculture and Food,
a) Agricultural Statistics for Ontario, Publ. 20. Toronto, Ontario, various issues.
b) 1982. Fertilizer Prices, Agdex 547. Toronto, Ontario.
14. Stevenson, K.R., R.B. Hunter, T.B. Dynard and G.E. Jones, 1970. Corn Production. Ontario Ministry of Agriculture and Food Publ. 13. Toronto, Ontario:4-5, 22-23.
15. Stuart, C., 1984. "Welfare Costs per Dollar of Additional Tax Revenue in the United States." Am. Econ. Rev. 74:352-362.
16. Trafford; B.D., 1970. "Field Drainage." J. of the R.A.S.E. 131:129-152.
17. Van Vuuren, W. and G.W. McCaw, 1984. Economics of Drains in Eastern Ontario. American Society of Agricultural Engineering. No. 84-2569. St. Joseph, Michigan.
18. Williams, N.T., 1981. Appraising the Profitability and Feasibility

$$
\begin{aligned}
& \text { of an Agricultural Investment Under Inflation. F.B.U. Occa- } \\
& \text { sional Paper No. 5, School of Rural Economics, Wye College, } \\
& \text { England. }
\end{aligned}
$$

APPENDIX I

COMBINED FEDERAL AND PROVINCIAL (ONTARIO) 1983 TAX TABLE
1983 Tax Table

| If Taxable Income Is | Then To | $\begin{gathered} \text { On First X Dollars } \\ X_{0} \end{gathered}$ | t | Ontario Tax Reduction Bo | On the Next |
| :---: | :---: | :---: | :---: | :---: | :---: |
| \$ | \$ | \$ | \% | \$ | \$ |
| 0-1179 | - | - | 6.00 | - | - |
| 1180-1986 | -71 | 1180 | 16.00 | - | 806 |
| 1987-2178 | 105 | 1180 | 23.68 | minus $\frac{2178-\text { tax. income }}{2}$ | 191 |
| 2179-23:5 | 106 | 1180 | 23.87 | - | 179 |
| 2359-4716 | 386 | 2359 | 25.36 | - | 2357 |
| 4717-7074 | 935 | 4717 | 26.86 | - | 2357 |
| 7075-11790 | 1619 | 7075 | - 28.35 | - | 4715 |
| 11791-16506 | 2956 | 11791 | 29.84 | - | 4715 |
| 16507-21222 | 4363 | 16507 | 34.32 | - | 4715 |
| 21223-33012 | 5981 | 21223 | 37.30 | - | 11789 |
| 33013-56592 | 10378 | 33013 | 44.76 | - | 23579 |
| > 56592 | 20933 | 56592 | 50.73 | - | remainder |

APPENDIX II

EFFECT OF TAXATION ON VARIOUS INCOME LEVELS FROM CASH CROP FARMERS UNDER EQUITY FINANCING, ASSUMING NO INFLATION

Taxation affects the various income levels quite differently. A detailed explanation follows.

## Effect on Tax Exempt Income Below \$9056

Farmers with net pre-drainage incomes of $\$ 4000$ and $\$ 8000$ do not pay any taxes during the entire lifetime of the drain. Additional annual income from the investment amounting to $\$ 690.70$ is not sufficient to put these farmers in the taxable income brackets. They neither gain from any tax write-offs nor pay any taxes on additional income derived from the investment. This situation is therefore identical to what the nation gains from the investment. To calculate the public benefit from subsurface drainage, taxation should be ignored, since it does not increase or decrease national income. Taxes are transfer items from a public point of view, but not from a private point of view.

## Effect on a $\$ 9150$ Income Level

The NPV of the investment decreases by $\$ 3474$ and the IRR by $1.67 \%$ as pre-drainage income goes up from $\$ 8000$ to $\$ 9150$. A farmer earning that income pays $\$ 69.12$ in taxes. Of the $\$ 12,000$ investment cost, he must write off $\$ 9150$ in the year of installation, thereby losing his personal tax exemptions of $\$ 7070$. The remainder of the investment expense can be carried back 3 years and forward 10 years. He will therefore refile for those previous years and write off $\$ 94$ annually (\$2080 taxable income minus $\$ 1986$ tax-free income) from his income in the 3 years prior to the year of investment. This makes his income tax free in those years. His
tax savings in 1984 are therefore all taxes paid in the 3 years prior to 1983 and the tax he would have paid in the year of installation, 1983. This amounts to $\$ 276.48$ ( 4 times $\$ 69.12$ ) Since the remainder of the investment expense which has not yet been written off can be carried forward, he will write off $\$ 784.70$ annually from 1985 onwards (\$2080 taxable pre-drainage income plus $\$ 690.70$ additional income from drainage minus $\$ 1986$ tax-free income) until he has exhausted his expense allowance. Because of these tax write-offs he will not pay any taxes in those years. If he had not made the investment, he would have paid $\$ 69.12$ in taxes annually. These then, are his annual tax savings for three years, namely for 1985 , 1986, and 1987. In 1988 he will write off the remaining $\$ 213.90$. His taxes for that year are $\$ 236.16$ on a taxable income of $\$ 2556.80$ (9150 pre-drainage income plus 690.70 additional income from drainage minus 7070 personal tax exemptions minus 213.90 remaining balance of investment cost). Without the investment he would have paid $\$ 69.12$ in taxes in 1988. The net tax increment in 1988 is thus $\$ 167.04$ (236.16 actual tax paid in 1988 minus 69.12 tax that would have been paid if the investment had not been made). This makes his additional net income from drainage for that year \$523.66 (690.70 before-tax net income from drainage minus 167.04 additional taxes paid compared with the taxes that would have been paid if the investment had not been made).

His nominal tax savings are relatively small, \$483.84, dispersed over 4 years. Since all investment costs have been written off in 1988, the annual income taxes from 1989 onwards payable on the additional $\$ 690.70$ income derived from subsurface drainage are $\$ 221.29$, leaving the net after-tax increase in income from drainage \$469.41. The
annual after-tax net benefits for the various income brackets are recorded in Appendix III. From 1989 onwards the annual after-tax increase in net income is 32 percent lower than the before-tax increase in net income derived from drainage. The NPV of this reduction exceeds by far the NPV of the tax savings derived from the investment expense deductions, making the NPV of the investment negative.

Compared with an $\$ 8000$-income farmer, the farmer in the $\$ 9150$ income bracket has a larger after-tax net income from drainage in the first year after installation of $\$ 276.48$, and for the following 3 years of $\$ 69.12$ annually due to tax savings on expense deductions. However, from year 6 to year 50 his annual after-tax income from the same investment is annually $\$ 221.29$ lower than that for the $\$ 8000$-income farmer. In NPV terms, this amounts to a difference of $\$ 3473.36$ for 10 hectares. The farmer in the $\$ 9150$-bracket did not have any income in 1983 to offset personal exemptions and non-taxable income in that year. Moreover, his tax rate was low for his pre-drainage income. His tax savings resulting from the expense allowance were therefore relatively small. On the other hand, the increase in income derived from drainage will result in a drastic increase in annual, taxes from year 6 onwards. The $\$ 8000$ income farmer, on the other hand, neither gained any tax savings nor paid any taxes on additional income derived from drainage.

The increase in taxes from year 6 on, when all investment expenses are deducted, is especially high for a farmer with a $\$ 9150$ pre-drainage income. Taxable incomes up to $\$ 2178$ are eligible for the Ontario Tax Reduction Program. This results in a $\$ 49$ decrease in taxes for a farmer with a net income of $\$ 9150$ (or taxable income of $\$ 2080$ ). Without the Ontario Tax Reduction Program, the farmer would have paid $\$ 49$ more on his
pre-drainage income and the additional taxes on the increase in income derived from drainage would have been \$172.29, instead of \$221.29. Therefore the annual net benefits from year 6 on would have been $\$ 518.49$ instead of $\$ 469.41$. The former figure compares more closely with the net increase in income of $\$ 515.54$ derived from drainage for a farmer earning a pre-drainage income of $\$ 10,000$, who was not eligible for the Ontario Tax Reduction Program. Without this program the NPV for a $\$ 9150$ incomefarmer would have been $\$ 748$ instead of $-\$ 648$. A farmer with this pre-drainage income would lose the Ontario tax rebate if he drained his land, for the entire 50 years that the drain lasts. This kind of program, therefore, may act as a deterrent for drainage or any other necessary land improvement investment.

## Effect on Income Levels Between $\$ 10,000$ and $\$ 12,000$

According to Table 3.1, the NPV and the IRR of the investment decrease as pre-drainage income increases in the range from $\$ 10,000$ to $\$ 12,000$. This is due to two factors. Firstly, although farmers earning between $\$ 10,000$ and $\$ 11,500$ pre-drainage income are in the same tax bracket prior to drainage, the effect of the expense deduction is different. Due to the Ontario Tax Reduction Program and the $\$ 200$ federal tax refund, no taxes are paid on taxable incomes less than $\$ 1986$. If the investment cost exceeds net income in the year of installation, the excess can be carried back 3 years and forward 10 years. However, in refiling income taxes from previous years, the farmer will not write off more than the difference between taxable income in that year and $\$ 1986$. Thus a farmer earning annually a pre-drainage income of $\$ 10,000$ and investing $\$ 12,000$ in drainage can carry back $\$ 2000$ to be deducted
from taxable income in the 3 years prior to drainage. He will write off $\$ 944$ in 2 of those years $(\$ 10,000$ minus $\$ 7070$ in tax exemptions minus $\$ 1986$ tax-free income). In doing so, his taxes become zero in those 2 years. There is still $\$ 112$ of investment cost to be written off against taxable income in 1982. Thus income taxes of $\$ 330.81$ annually paid in 2 of those years and the tax on $\$ 112$ in the third year amounting to $\$ 28.41$ will be refunded in 1984.

A farmer earning a pre-drainage income of $\$ 11,000$, on the other hand, can carry back only $\$ 1000$ as expense deduction. His pre-drainage taxable income was $\$ 3939$, therefore he will write off that full $\$ 1000$ in one year, thus saving $\$ 253.60$ in that year. The tax savings from the expense deduction in the year the investment is made are obviously larger for an $\$ 11,000$-income farmer than for a $\$ 10,000$-income farmer, namely $\$ 584.41$ against $\$ 330.81$. However, the $\$ 10,000$-income farmer is able to obtain a full refund of all taxes paid in 1980 and 1981 , because the expense deductions put him in the tax-exempt income bracket in those 2 years. The $\$ 11,000$-income farmer, on the other hand, is not able to reach the tax-exempt income bracket in 1980. Because the investment expense does not have to be fully deducted in those years, other than the year of installation, farmers who can carry back a relatively large proportion of their investment expenses have an advantage over farmers who are unable to do that.

The second reason why the $N P V$ and IRR decrease if pre-drainage incomes go up from $\$ 10,000$ to $\$ 12,000$ is that farmers earning a predrainage income above $\$ i j, 000$ move to the next higher tax bracket after the investment is undertaken and additional income from the investment is earned. Those farmers, therefore, pay higher taxes on income derived
from drainage for the entire period over which the drain lasts. This lowers after-tax net income for them and will decrease the NPV and IRR compared with farmers who stay in the same tax bracket after the investment is undertaken.

Subsurface drainage investment on a farm with a $\$ 12,000$ predrainage income level yields the lowest NPV and IRR of all pre-drainage income levels, except for the $\$ 9150$ income level which is subject to the Ontario Tax Reduction Program. The full investment cost must be deducted from income in the year of installation, making net income in that year zero. The full taxes at $\$ 842.21$, that would have been paid without the investment, are therefore saved. Note that the tax savings derived from the expense deduction of an income of $\$ 11,500$ are $\$ 838.01$, almost similar to that for farmers with a $\$ 12,000$ net income. However, the additional income derived from drainage, for the next 50 years for a farmer with a pre-drainage income of $\$ 11,500$, is partly taxed at a rate of 25.36 percent and partly at 26.86 percent, while for a pre-drainage income level of $\$ 12,000$ the entire additional income is taxed at 26.86 percent, making net after-tax income $\$ 3.29$ per year less than for the $\$ 11,500-$ income farmer. This then results in a lower NPV and IRR for a farmer with a pre-drainage income of $\$ 12,000$ compared with one earning $\$ 11,500$.

## Effect on Income Levels Above \$12,000

From columns 2 and 3 in Table 3.1 it can be seen that for predrainage incomes from $\$ 14,000$ to $\$ 23,000$ the NPV and IRR of drainage investment go up as pre-drainage income levels increase, the NPV being $\$ 151$ and the IRR $4.08 \%$ for the $\$ 14,000$-income farmer and $\$ 1,756$ and $5.13 \%$ respectively for the $\$ 23,000$-income farmer. These differences are mainly
the result of the tax write-offs in the first year. A farmer earning a pre-drainage income of $\$ 12,000$ loses all his personal exemptions in the year the investment is made; a farmer earning \$14,000 loses \$5070 in exemptions, while a farmer earning $\$ 19,000$ loses only $\$ 70$ in exemptions. Moreover, moving to a higher income bracket will increase the tax rate. Therefore the savings on the expense deductions will increase. On the other hand, taxes on additional income earned from the investment will also increase by moving to a higher tax bracket. The higher the predrainage income level between $\$ 14,000$ and $\$ 23,000$, the higher the NPV of tax savings in the first year, relative to the NPV of the tax increments of the following years, resulting in increasing NPVs of the investment for ascending pre-drainage income levels.

At incomes above $\$ 23,000$, on the other hand, an increase in predrainage income decreases the NPV of the investment on average. In this income range, the difference between the NPV from tax savings resulting from expense deductions in the first year and the NPV of the tax increments in the following years increases by moving to a higher income bracket, thus reducing the after-tax NPV of the investment. For example, the NPV of the tax saving for a pre-drainage income of $\$ 23,000$ is $\$ 585.76$ more than that for a $\$ 19,000$ income level, while the NPV of additional taxes in future years is only $\$ 99.97$ more on a $\$ 23,000$ - than on a $\$ 19,000$-income level. However, comparing a $\$ 50,000$ and a $\$ 70,000$ pre-drainage income, the NPV of the tax saving in the first year for a $\$ 70,000$ income is $\$ 514.88$ higher than that for a $\$ 50,000$ income, while the NPV of additional taxes in future years is $\$ 851.64$ more than for a $\$ 50,000$ pre-drainage income level, making the NPV of the investment for a $\$ 70,000$ pre-drainage income level $\$ 336.70$ less than for a $\$ 50,000$ pre-drainage income level.

ANNUAL AFTER-TAX INCREASES IN NET INCOME FOR CASH CROP FARMERS FOR 51 YEARS FROM A $\$ 12,000$ INVESTMENT IN SUBSURFACE DRAINAGE FOR VARIOUS PRE-DRAINAGE INCOME LEVELS, ASSUMING NO INFLATION]/

1/ If the annual after-tax increase in income for a particular income bracket appears twice at the same magnitude in two successive years, the additional annual incomes will be the same for the remaining years till year 50 , but are deleted from the table.
ANNUAL AFTER-TAX INCREASE IN NET INCOME FOR 51 YEARS



[^0]:    *Significant from zero at the . 10 probability level by a two-tailed t-test. ** Significant from zero at the .02 probability level by a two-tailed t-test.

[^1]:    *Significant at the .20 probability level by a two-tailed t-test.
    ** Significant at the . 05 probability level by a two-tailed t-test.

[^2]:    1/f $=$ annual inflation rate
    $\underline{2 / i i}=$ discount rate

[^3]:    1/f = annual inflation rate
    $\underline{2 /}_{i j}=$ discount rate
    $\underline{3}_{s}=$ subsidized interest rate on loan

