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PROFITABILITY OF SUBSURFACE DRAINAGE ON  
OPERATOR OWNED AND ON RENTED LAND

by

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DEPARTMENT OF AGRICULTURAL ECONOMICS AND BUSINESS

# PROFITABILITY OF SUBSURFACE DRAINAGE ON OPERATOR OWNED AND ON RENTED LAND

## ABSTRACT

The profitability of subsurface drainage on imperfectly as well as on poorly drained operator owned and rented land in southwestern Ontario was investigated. The return on drainage investment was more than twice as high for owner operators as for owner non-operators. The return on drainage investment for owners letting their land was relatively low, thus providing little or no incentive to drain. Tenants are also disinclined to drain because of great insecurity of tenure. Under reasonable price scenarios the return for owner operators is sufficient to induce them to invest in drainage. The different incentive structures lead to great differences in land improvement between operator owned and rented land. The drainage condition on operator owned land is considerably better than that on rented land.

## INTRODUCTION

Excess water in fields results in a negative effect on soil productivity and is thus expected to exert a negative impact on land values. Installing subsurface drainage will improve the drainage condition of soils where surplus water is extant, provided that outlets exist for the disposal of surplus water. The benefits from subsurface drainage are manifold, such as enabling increased aeration of the soil, higher soil temperature, better soil structure, and earlier planting date. These benefits influence productivity either as higher yields of crops grown on land prior to installing subsurface drainage, or by enabling cultivation of high value crops which could not have been profitably grown on land containing surplus water.

The removal of excess water is not exclusively an agronomic and engineering problem, but also has economic ramifications. Investment in water removal pays if its internal rate of return (IRR) over the lifetime of the drain exceeds the borrowing rate or the relevant opportunity rate of return. The IRR is defined as that discount rate that makes the present value of the incremental net benefit stream equal to the investment cost. It can be visualized as the maximum interest rate that a drainage project can pay for the resources used if the project is to recover its investment and operating expenses and still just breaks even (Gittinger, 1982). In cases where the planning horizon is shorter than the lifetime of the drain, the expected increase in land value between drained and undrained land at the end of the planning period will be entered in the calculation.

If the planning horizon for owner operators is shorter than the lifetime of the drain, the effect of the productivity increase on land values becomes important in deciding whether or not to install subsurface drainage. Whether or not land values are affected by subsurface drainage is a matter for empirical investigation, usually done by means of hedonic regression analysis. A hedonic regression relates the price of a differentiated product, in this case land, to the various characteristics it contains, such as the physical features of the soil. Palmquist and Danielson (1989) performed a hedonic regression of land values on estimated soil loss from erosion and on degree of soil wetness, using data from North Carolina. They found a statistically significant relationship between the price of land and the drainage condition of the soil. If investment costs are recouped within owner operators' planning periods, on the other hand, the effect of drainage investment on land values will have little relevance for their investment decisions.

The situation is markedly different for owners leasing land to tenants. Their investment decisions are entirely based on the extent of rent increase because of drainage. Here it becomes crucial to know whether rents are affected and to what extent. It is highly unlikely that subsurface drainage will be installed on rented land by tenants. Because of insecurity of tenure they are disinclined to invest in subsurface drainage. Most tenancies in North America are short-term, in any case shorter than the time over which the investment can be recouped. Thus tenants would not gain from such investment, unless the contract contains compensation clauses for land improvements incurred by them. Such compensation clauses are rare in North American tenancy contracts (Ketchabaw and van Vuuren, 1991).

Whether productivity increases brought about by subsurface drainage are reflected in increased rents and to what extent is a matter for empirical investigation. This paper will address these issues. The major emphasis is on three closely related topics. One, the question studied will be whether an increase in agricultural land rent obtainable from upgrading the land is sufficient inducement for investment in subsurface drainage for owners letting land. Second, incentives for investment in subsurface drainage will be contrasted between owner operators and owner non-operators. Third, the resulting drainage condition on owner operated as opposed to rented land will be examined for similarities or differences.

## MATERIALS AND METHODS

### Study area

To evaluate the extent rents are affected by soil wetness, a hedonic regression analysis was performed on data from southwestern Ontario. Data for this study were gathered from a mailed questionnaire sent by the author in 1989 to farmers in southwestern Ontario who rented



land in census year 1986. The response rate was 21%. Addresses were randomly selected and provided by Statistics Canada. The data referred to cropping year 1988. The study area consists of the 12 adjoining most southwesterly counties of the Province. This area contains cash crop, dairy, mixed, and specialty farms. Only fixed cash rent contracts were investigated. Seventy-two percent of the contracts in the area are fixed cash leases.

### **Model parameters**

Agricultural land rent is affected by economic, physical, locational, and institutional factors. Since the data are a cross-section from the same year, it is assumed that farmers faced similar output and input prices as well as interest rates.

Given the macroeconomic climate, agricultural land rent is hypothesized to be a function of five groups of characteristics: 1) the physical properties of the land itself and climatic conditions; 2) the utilization of the site; 3) the location of the parcel relative to urban centres; 4) the content of the contract; and 5) the participants in the market.

For this study's purpose only the physical drainage features will be discussed. Land varies in physical features. Soil texture, drainage, topography, erosion damage (loss of soil by water and wind), level of stoniness, damage due to periodic flooding, and depth to bedrock vary among parcels. Quality differences of these features are expressed in encumbrance points (Noble, 1977). This point system was developed in the Department of Land Resource Science at the University of Guelph. The number of encumbrance points assigned to each feature of a particular parcel measures the degree of limitation of that feature for agricultural productivity. The minimum number of encumbrance points is zero, indicating no physical limitation, while the maximum value varies with the importance of the maximum limitation of

that particular feature for agricultural use. Weighted average encumbrance points are calculated for each soil characteristic, the weight being the percentage of land in the contract having a particular limitation of that soil characteristic.

Drainage is divided into five classes. Naturally well-drained land scoring zero encumbrance points poses no hazards to soil productivity. These soils are either naturally well drained or sufficiently tiled. The next category, imperfectly drained land scoring 10 encumbrance points, contains land where water in excess of field capacity leaves the soil slowly in relation to supply of water so that the soil remains wet for a medium length of time, around 7 to 8 months annually. Land is poorly drained if water in excess of field capacity leaves the soil so slowly in relation to the supply of water that the soil remains wet for a comparatively large part of the year, around 10 to 11 months. This category scores 25 points. Dryness prevails where drainage is so rapid that hardly any moisture is contained. Such land scores 30 points. The maximum number of encumbrance points is 40, corresponding to very poor drainage (usually swamps or bogs). A negative relationship is expected between rent and encumbrance points, because the higher the encumbrance points the greater the hazards to agricultural production.

Since the paper concentrates on the effect of the drainage condition on land rent, details of the other independent variables and impact expectations are not relevant for the topics under consideration. They are therefore not discussed here. For details of the model, see van Vuuren and Ketchabaw (1994). Although not discussed, they must be included in the regression analysis. Otherwise the model is inadequately specified and the regression coefficients become biased.



### Model specification

The following functional relationship was used:

$$Y_i = \alpha_0 X_{i1}^{\alpha_1} X_{i2}^{\alpha_2} X_{i3}^{\alpha_3} \exp \left( \sum_{j=4}^n \alpha_j X_{ij} \right) \quad (1)$$

where  $Y_i$  is the rent per hectare of contract  $i$ ,  $X_{i1}$  is the length of occupancy on the same parcel of a tenant with contract  $i$ ,  $X_{i2}$  is the stipulated period of time over which user rights are surrendered in contract  $i$ ,  $X_{i3}$  is the distance from the centre of the township in which the property with contract  $i$  is located to the nearest population centre of over 20,000 inhabitants,  $X_{i4}$  is the drainage encumbrance points, and the other  $X_{ij}$  are the remaining measures of soil, climate, land utilization, contract and market participant characteristics describing contract  $i$ . The model was estimated by taking the natural logarithm of both sides of Equation (1) and utilizing ordinary least squares.

### RESULTS

The regression estimates are reported in Table 1. Five of the seven soil characteristic variables are negatively signed as expected. The soil drainage condition is statistically significant at the .001 level. An increase in 1 drainage encumbrance point changes land rent by a factor  $e^{-.02707} = .973$ .

Upgrading poorly drained to well-drained land will decrease the encumbrance points from 25 to 0. The effect of such improvement on rent can be calculated from Table 1. On average, everything else being equal, rent on well-drained land is 97% higher than on poorly drained land ( $e^{(-.02707) (-25)} = 1.97$ ).

**Table 1: Estimates of the impact of selected characteristics on per-hectare agricultural land rent**

Characteristic	Parameter estimate (t-values)	Standard. paramet. estimate	Characteristic	Parameter estimate (t-values)	Standard. paramet. estimate
<b>Soil and climate characteristics:</b>			<b>Location:</b>		
Soil texture	.00021 (.017)	.001	Distance to urban centres of 20,000 and over	-.14308 (-2.072)	-.157
			<b>Contract terms:</b>		
Drainage condition	-.02707 (-5.253)	-.390	Lease type (1 verbal, 0 written)	-.21324 (-2.094)	-.148
Stoniness	.02229 (2.188)	.189	Lease duration	.00927 (.139)	.010
Topography	-.02756 (-1.771)	-.159	Restrictive covenants (1, 0 otherwise)	.02616 (.254)	.018
Erosion damage	-.00089 (-.052)	-.005	Compensation clauses (1, 0 otherwise)	-.20651 (-.452)	-.035
Flood damage	-.00231 (-.234)	-.018	<b>Market participant characteristics:</b>		
Depth to bedrock	-.00349 (-.867)	-.063	Residence of landlord (1 local, 0 absentee)	.30367 (2.382)	.172
Corn heat units	.00099 (4.250)	.347	Kinship (1 related, 0 non-related)	.10936 (.448)	.034
<b>Land utilization characteristics:</b>			Length of tenant occupancy	-.15943 (2.740)	-.194
Fruit & vegetable farms (1 if 51% or more of the land is occupied by fruits and vegetables, 0 otherwise)	.72769 (3.987)	.329	Constant	4.17024 (2.385)	
High gross margin crops (1 if 51% or more of the land is occupied by high gross margin crops, 0 otherwise)	.30047 (2.382)	.200	R-Square	.4834	
			Adjusted R-Square	.4059	
			F-Value	6.2370	
			N	139	

Improving imperfectly to well drained land will lead to a decrease of 10 encumbrance points. On average, everything else being equal, rent on well drained land is 31% higher than on imperfectly drained land ( $e^{(-0.02707) \cdot (-10)} = 1.31$ ). Since the paper limits itself to the effect of drainage on land rent, the remainder of Table 1 will not be discussed.

## DISCUSSION

The discussion will concentrate on the four objectives noted in the introduction. The results section shows that rents are affected by soil wetness. Absolute change in rent depends on absolute change in encumbrance points (extent of improvement) and on the rent level of unimproved land.

### Upgrading imperfectly drained land

If land is imperfectly drained, installing subsurface drainage will usually not result in a shift from low- to high value crops, but instead, in higher yields of crops grown prior to drainage. For this discussion, only corn land will be considered. Corn is one of the most important crops in southern Ontario which benefits from subsurface drainage. To upgrade imperfectly drained into well drained corn land requires around 550 meters of tiles per hectare. Installing subsurface drainage costs about \$1.50/m (OMAF, 1993). The investment cost therefore is \$ 825/ha.

In the year to which these data pertain, average rent for corn land in the most productive area of the study containing some imperfectly drained land was \$163/ha (Fisher, 1988). No rent figures are available for well drained or for imperfectly drained land. Since most land in the area is well drained, one may assume that rent on well drained land was

around \$170/ha. Rent on imperfectly drained corn land was then \$130/ha. Recall from the results section that rents on well drained land average 31% higher than on imperfectly drained land. Upgrading rented land would thus result in a \$40/ha increase in annual rent. The difference in rent between well and imperfectly drained land is what counts rather than absolute rent figures. A \$10 rent difference in imperfectly drained land results only in a \$3 change in rent differential between well and imperfectly drained land. Thus even if the assumed rent figures of the two drainage classes are not entirely accurate, the relevant rent differential is off only by a fraction of the inaccuracy.

Assuming a 40-year lifespan of the system, the IRR on drainage investment paid for by the owner leasing land to tenants is then 3.7%. This is an extremely low rate of return considering that high risk is involved over a 40-year period. Although the IRR is a real rate of return, 1988 real borrowing rates were substantially higher. Current (1994) real borrowing rates much lower than in 1988, still exceed 3.7%. This unprofitable IRR refers to the most productive area in the Province. The IRR is obviously lower in areas which are less productive. It appears therefore that the increase in rent resulting from installing subsurface drainage is not sufficient to induce owners letting out their land to undertake such investments.

The situation is different for owner operators. In the most productive areas of the Province corn yield increases by about 700 kg/ha by changing imperfectly drained land into well drained land (derived from van Vuuren and Jorjani, 1984). The 1986-1988 3-year average corn price was about \$111/tonne (OMAF, 1990). These figures result in an IRR of 9.1%, almost 2.5 times more than that of owner non-operators. At corn prices of \$98/tonne and \$118/tonne the resulting IRRs are 7.9% and 9.8% respectively. These figures show clearly that the incentives to invest in subsurface drainage for owner operators are considerably greater than for owners letting out their land.

### Upgrading poorly drained land

Subsurface drainage of poorly drained land usually results in changing cropping patterns from low- to high value crops. In most cases high value crops cannot be profitably grown on poorly drained land. Drainage of such land requires about 800 meters of tiles per hectare to upgrade into well drained corn land. The investment cost is therefore about \$1200/ha.

Poorly drained land is found primarily in the lesser productive areas of the study. In an area where corn yield averages about 6.28 tonnes/ha, average rent on such land was \$125/ha (Fisher, 1988). Assume that rent on well drained land was \$134/ha, then poorly drained land would fetch only \$68/ha, due to rent on well drained land being 97% higher than on poorly drained land, as can be noted in the results section. Conversion into well drained land would fetch an additional \$66/ha annually in rent. The resulting IRR of such conversion is 4.6% for owners letting their land to tenants. Again, this is a low rate of return providing little incentive for installing subsurface drainage.

For owner operators the incentives are different. Suppose drainage allows a shift from mixed grain to corn. As indicated, corn yields 6.28 tonnes/ha. The production cost of corn is approximately \$524/ha (OMAF, 1988). Production costs refer to all cost components incurred for the crop except overheads. Mixed grains yield about 2.6 tonnes/ha (OMAF, 1990) and cost approximately \$233/ha to grow (OMAF, 1988). Suppose corn and mixed grain prices are \$111/tonne and \$107/tonne respectively (average 1986-1988 prices from OMAF, 1990). Additional net returns from the change in cropping patterns made possible by subsurface drainage amounts to  $(111 \times 6.28 - 524) - (107 \times 2.6 - 233) = \$127.88/\text{ha}$  annually gross of drainage investment costs. Such annual net revenues over a 40 year time period yield a

10.5% IRR on subsurface drainage investment. This is 2.3 times as high as that obtainable for owners who lease out their land.

#### **Pay-back period for owner operators**

Profitability of drainage investment for owner operators has been calculated over the lifetime of the drain. Most farmers will quit or retire before the system ceases to perform adequately. Thus their planning periods are shorter than the lifetime of the drain. In that case farmers make decisions based on their own planning periods rather than on the lifetime of the drain. Then they will enter the difference in expected land values between drained and undrained land at the end of their planning period. In that case the effect of drainage on land value becomes important in deciding whether or not to drain. For this research, no information is available on the effect of drainage on land value. Most likely, a similar impact exists to that in the rental market, although the extent of land value change is not known. If land values do not fully reflect the increase in productivity, then incentives to drain could be affected. Nevertheless owner operators' incentives to drain are affected by the land market to a much lesser extent than owner non-operators' incentives by the rental market. As long as owner operators can recoup the investment cost within the time period during which they plan to farm, the possible incentives or disincentives provided by the land market become less relevant. The higher the IRR the sooner the investment costs are recouped. Suppose farmers require an 8% real rate of return on their investments to cover the cost of capital and risk. If drainage results in \$127.88 additional annual net revenues over the lifetime of the drain, then a \$1200 investment is recouped at 8% in 18 years, far shorter than the lifetime of the drain. As long as farmers intend to farm more than 18 years, they gain by installing drainage even if land

values are not affected at all. At lower discount rates the pay-back period shortens. At 6%, for example, the pay-back period is between 14 and 15 years.

#### **Drainage condition on operator owned and on rented land**

The above results clearly show that inducement to drain is much greater for owner operators than for owners leasing land to tenants. Tenants are disinclined to drain because of insecurity of tenure. The difference in investment incentives shows up in the drainage condition of the soil. A remarkable difference in soil drainage quality exists between operator owned and rented land. Van Vuuren and Ysselstein (1986) found a statistically significant difference in average drainage encumbrance points between owner operated and rented land in 10 adjoining counties in southern Ontario. Average drainage encumbrance points on rented land were 150% higher than those on owner operated land. Ketchabaw (1991) found a similar statistically significant pattern for all of southern Ontario, although the difference in drainage quality was not as large. He found the average drainage encumbrance points on rented land to be 39% higher than those on owner operated land. It appears then that owner operatorship is more efficient than tenancy under prevailing leasing arrangements. This shows up in higher productivity on operator owned than on rented land (van Vuuren and Ysselstein, 1986). Lower productivity on rented land is mainly the result of soil wetness and unprofitability of draining such land. Installing subsurface drainage on rented land is not unprofitable because the productivity increase of such investment is insufficient, but because the productivity increase is not sufficiently reflected in rents.



## SUMMARY AND CONCLUSIONS

Although agricultural land rents in southwestern Ontario are affected by soil wetness, upgrading the land through subsurface drainage has a relatively low payoff for owners letting land to tenants, thus providing little incentive to undertake such land improvement. The payoff of subsurface drainage investment for owner operators, on the other hand, is considerably higher. Obviously, the return on investment is dependent on output prices. However, at prevailing output prices between 1986 and 1988, the return on drainage investment for owner operators was almost 2.5 times as high as that for owner non-operators, thus providing much greater incentive to drain compared to that of owners letting land to tenants. Due to short contract terms and great uncertainty of tenure, tenants have little or no incentive to drain. The different incentive structures lead to different degrees of drainage investments on owned and rented land. Several studies have shown that the drainage condition on rented land in southern Ontario is considerably poorer than that on owner operated land.

The difference in rent between on the one hand well-drained and on the other imperfectly and poorly drained land would increase the higher output prices become, assuming that the difference measured in percentages remains the same. Thus, under output prices considerably higher than those now prevailing, owner non-operators may find it then profitable to invest in subsurface drainage. If food were to become scarce in the future and output prices would increase relative to input prices, land improvement on rented land may become profitable then and hence food production per hectare on those lands would increase.

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