Farm Level Economics and Capital Costs Analysis of Three Wetland-Reservoir Subirrigation System Sites in Northwestern Ohio[1]

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Abstract

Three Wetland-Reservoir-Subirrigation Systems (WRSIS) have been designed and constructed in Northwestern Ohio. These systems have the potential to improve downstream water quality by reducing discharge to streams, to provide wildlife habitat, to increase wetland acres and vegetation, and to provide a reliable supply of subirrigation water for sustained crop production. In a WRSIS, a wetland is constructed to receive subsurface drainage and runoff from adjacent cropland. The cropland is subirrigated by a water supply reservoir that is also linked to the constructed wetland. The wetland, reservoir and subirrigated cropland are integrated to recycle runoff and drainage waters. The construction of all three sites was completed in 1996 and 1997. Construction and all other capital costs were documented and analyzed. A survey of drainage and land improvement contractors has been implemented to ascertain local construction cost information (average costs and ranges) for different system components (design, site preparation, wetland, reservoir, subirrigation, pumping plant, drainage, waterways, etc.) to compare to the costs data for these three systems. Yield data from the first two years of this project and from subirrigation research plots from other locations in Ohio, are being used to analyze the benefits of these systems for improved and sustained crop production. Analysis of these costs will be used to provide to farmers with information for use in evaluating their application of the technology.

Introduction

Farmers are continually searching for new ways to increase farm outputs or reduce average production costs, and thereby increase profits. Concomitantly, society is seeking ways to diminish the adverse effects of agricultural production on the environment. Both

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of these goals may be addressed with an emerging technology -- the combined wetland-reservoir-subirrigation system (WRSIS). This innovative, ecologically sound crop production system will recycle runoff and drainage waters, reduce runoff, sediment, and agricultural chemical discharges to streams, increase wildlife habitat, increase wetland acres, and has the potential to improve surface water quality and enhance farm profitability.

In 1994, a five-year demonstration and research project began in Northwest Ohio. These demonstration sites link subirrigation systems with water supply reservoirs and constructed wetlands. At these sites, WRSIS will be examined for its ability to recycle runoff and drainage waters, reduce sediment and agricultural chemical flow to watersheds, improve water quality, increase wildlife habitat, increase wetland acres, and improve crop yields (Brown et al., 1997). One objective of this study is to determine whether the WRSIS system is an economically sound capital investment for farmers. This paper will address the latter issue. Estimates will be made of private farm level economic impacts for the adoption of WRSIS technology.

Literature Review

In 1972, subirrigation was touted as a new farming practice that could result in advantages such as greater savings of water, eliminating runoff, and increasing the yield of crops (Popkin, 1971). Since that time, data concerning yield improvements, comparisons with conventional irrigation technology, and the economic feasibility of subirrigation systems have been examined. Also included in this literature review will be a discussion of the economic value that is created by wetlands and watershed management.

Yield improvements with subirrigation have been shown to be positive by previous studies. Doss and Pearson (1972) in their study concerning soybean growth in Alabama, concluded that soybean height and yield were improved through subirrigation, but that the increased yields were not significantly higher than conventionally irrigated soybeans. Doss and Pearson submitted that the lower horizons of soil on the test site were too permeable for the practical use of subirrigation. In 1988, Melvin et al. (1990) evaluated a dual subirrigation/drainage management system and its effects on corn crops in Iowa. Melvin determined that this system was best suited to flat, poorly drained land. The results of this study concluded subirrigation was most effective in humid climates where annual excess precipitation slightly exceeds annual irrigation requirements. Melvin suggested that subirrigation technology had good potential where higher value crops can justify the high investment costs. Cooper, Fausey, and Streeter (1992) found that soybean yields averaged 43% higher when grown under a subirrigation/drainage system in Wooster, Ohio. Also during the six years of research in Wooster, Ohio, corn averaged a 30% higher yield under subirrigation/drainage systems (Zucker and Brown, 1998).

Comparison studies with conventional irrigation techniques and subsurface drainage have also been conducted. Shirmohammadi et al. (1985) determined that a properly designed subirrigation/drainage system could save up to $144/ha/year over center pivot and traveling gun irrigation/drainage systems. Massey et al. (1983) concluded that a subirrigation system used less energy than sprinkler irrigation systems, but required more water. Smith et al (1985) determined that the water requirement for subirrigation could be reduced by 6.7% through using a float switch triggered control mechanism to aid system management.

The literature shows that yield improvements under subirrigation are generally positive given the right climate, soil, crop mix, and management. How economically feasible is a subirrigation/drainage system? Previous authors in the literature have researched this question. Harrison et al. (1985) determined break even values for different types of irrigation technology. The break even calculations were based on investment costs, operating costs, and yield benefits. Using 20 year depreciation, 10% interest, and 6 inches of water application a year, the break even points of center pivot and travelling gun systems were determined. The yield increases necessary to break even were also calculated. However, this study did not analyze a subirrigation investment and noted that additional production costs may need to be calculated to account for higher yields. Belcher (1992), determined an acceptable positive return on subirrigation improvements. He estimated that the cost of subirrigation improvements should not exceed $480/ac for corn and $660/ac for soybeans (1992 dollars). However, variables such as future costs of production, market value, inflation, tax benefits (costs), and value of land were not included in this economic study. Evans et al. (1996) performed an extensive analysis on the capital costs involved in a subirrigation/drainage investment. Evans amortized the cost (based on an interest rate and estimated life of the asset) of the subirrigation improvement to find a yearly total cost per acre. Annual total cost for a sample subirrigation site was estimated to be $116.47 per acre. The yearly income of the farm (increased by yield benefits) was then compared to the amortized annual cost per acre to find a break even point for the investment.

Previous research has not appraised the societal value of a subirrigation project. However, research does exist concerning the economic externalities generated by wetlands and watershed management. Marra and Zering (1996) give a good introduction to this subject. The economic activity of farming creates external costs of pollution due to degradation of water quality. Because this cost is not visible to farmers (hence external to their operations), profit-maximizing behavior will produce more pollution than is socially optimal. The intervention needed, according to Marra and Zering, is watershed management. To encourage effective watershed management, either taxation or a cost-sharing approach may be used. Policy makers may wish to charge farmers for an estimated share of the water pollution, or pay farmers to reduce their agricultural runoff. Knapp et al. (1990) discussed policies on charging farmers for their agricultural drainage in order to maximize economic efficiency. It could be argued that these policies are efficient because the farmer, facing fines, would minimize the amount of effluent produced by his or her farm. Thibodeau (1981) used economic analyses to determine compensation for owners of wetland acreage. First, Thibodeau attempted to place an economic value on wetland acreage. The economic value of wetlands was derived using factors such as water supply value, flood prevention, increased privacy from neighbors, pollution-reduction potential, recreation and esthetics, scientific interest, and undiscovered benefits. This value turned out to be estimated in a range of $153,535 to $190,009 per acre (1981 dollars). Market value of the wetlands, at that time, was $1,000/ac. Compensation, he argued should take into account the additional economic value created by the wetland. Regardless of what policy is adopted, farmers and society will benefit through better management of agricultural effluent. The WRSIS project is expected to improve watershed management at the farm level.

The previous analyses of subirrigation systems have provided good estimates of the fixed costs involved in constructing such a project. Break even analyses and per acre investment cost/income comparisons have included sources of variable costs. One study used present value calculations to reflect the interest and depreciation of a subirrigation investment. Although thorough, we believe that these studies did not provide a complete analysis of all the variables affecting a project similar to a WRSIS investment. The model created for this paper reflects the complex variables of financing terms, opportunity cost of capital, inflation, marginal improvements in yields (and corresponding marginal increases in input costs), changes in acreage under production, changes in land value, and federal and state income tax benefits (costs). The investment will be studied in net present value terms—what the investment would be worth in today's dollars, given all the costs, variables, and benefits. Because the parameters in the model may change from site to site, sensitivity analyses have also been performed. Finally, a discussion of positive and negative influencing factors will preclude the paper summary.

Data and Methods

The data for this study were collected from three demonstration sites in Northwest Ohio. The test sites were chosen for this research by considering factors such as soil physical properties, land conformation, and water table depth. The sites chosen were in the Ohio Counties of Defiance, Van Wert, and Fulton (hereafter each site will be referred to by the county name). Specific measures of unit size, subirrigation design and soil composition for each site are:

<u>Defiance County Site</u>: contains 7.0 acres of subirrigated cropland, a 0.25 acre wetland, a 0.5 acre reservoir, and a 27 acre watershed. Subirrigation pipes are placed 8 and 16 feet apart. The soil composition is clay.

<u>Van Wert County Site</u>: contains 30 acres of subirrigated cropland, a 3.0 acre wetland, a 3.1 acre reservoir, and a 50 acre watershed. Subirrigation pipes are placed 16 feet apart. The soil is of silty-clay composition.

<u>Fulton County Site</u>: contains 20 acres of subirrigated cropland, a 1.5 acre wetland, a 2.0 acre reservoir, and a 25 acre watershed. Subirrigation pipes are 16 feet apart. The soil is silty-clay similar to that of the Van Wert County site.

The data collected from each site include capital costs, variable input costs, management costs, maintenance costs, yield benefits, and land allocation. Investment data are summarized in Table 1.

Table 1: Description of the Three Test sites.

Project Variables:	**Fulton**	**Defiance**	**Van Wert**
Total Site Acreage	23.5	7.75	36.1
Wetland acreage	1.5	0.25	3.0
Reservoir acreage	2.0	0.5	3.1
Reservoir existing prior to project?	Yes	No	Yes
Subirrigated acreage	20	7	30
Was the subirrigation a retrofit of drainage tile?	Yes	No	Yes
Project Costs:			
-Subirrigation Construction	$28,161	$6,405	$46,373
-Wetlands Construction	$11,158	$13,430	$19,567
-Reservoir Construction	$3,158	$9,630	$6,583
-Pumping Facility Construction	$17,254	$15,201	$13,803
- WRSIS construction (*Total Capital Costs*)	$60,091	$44,666	$86,325
Project Costs *Per Acre*	$3,005	$6,381	$2,878

The Fulton County site will be used as the basis for the profitability analyses reported in this paper. This site is privately owned and is managed by the owner with the intention to maximize net returns. Total WRSIS investment costs for this site was $60,091 or $3,005 per acre. Nearly half of this expenditure ($28,161) was incurred retrofitting the existing tile drainage for subirrigation. New tile lines were installed to accomplish a 16 foot subirrigation spacing from the original 32 foot subsurface drainage spacing. Infrastructure for pumping and water control represented the next largest investment at $17,254. The remainder of the capital investment ($14,315) was the artificial wetland construction and existing reservoir modification. Because the 2.0 acre reservoir existed prior to the project, the total investment for this site is understated to the extent of reservoir construction cost. The resulting 20 acres of subirrigated cropland was broken into three subirrigation zones due to the uneven topography of the Fulton County test site. Costs generated from the construction of this site were a mix of in-kind contributions and actual contractor billings.

The Defiance site differed in investment costs from the Fulton County and Van Wert sites for various reasons. Defiance was the only site at which all the features of the WRSIS system were installed new. Because Defiance was designed as a demonstration site for a land contractors' field day, the total acreage was held to a minimum. Also, WRSIS construction costs for this site were estimated from land contractor in-kind contributions (labor and machinery) at the field day event. These factors combined to make this a high per acre investment site.

Van Wert is the largest of the three Northwest Ohio demonstration sites. The retrofitted subirrigated acreage is 30 acres compared to 20 acres at Fulton and 7 acres at Defiance. The wetland at the Van Wert site is also larger -- designed to accommodate the water generated from an additional 20 acres of subsurface drainage. The 3.1 acre reservoir was also existing prior to the subirrigation project, so the actual costs are understated. The impact of economies of scale are beginning to be seen at the Van Wert site, as the per acre costs are over $100 lower than those incurred at the Fulton County site. Unfortunately, complete yield and operating cost data currently are unavailable for this site. Costs generated from construction of this site were generated from actual land contractor work.

Net Present Value (NPV) Analysis:

The WRSIS investment is characterized by a sizable initial investment followed by a lengthy stream of annual returns over the life of the investment. When analyzing investments with substantial time duration and significant differences in the timing of expenditures and receipts over time, net present value analysis (NPV) is recommended. NPV analysis employs discounting techniques to explicitly recognize the opportunity cost associated with the timing of a receipt or expenditure flow. Analysis techniques that do not account for the differences in the timing of cash flows do not completely account for differences in profitability.

The present value (PV) of a dollar received (or expended) one year from today is not one dollar, but rather is:

$$PV = \$1 \times \frac{1}{1 + k}$$

where k is the discount interest rate (cost of capital).

A dollar to be received one year from today, assuming a 10 percent opportunity cost of capital, has a present value of only \$0.9091. This suggests that the individual would be <u>indifferent</u> between having \$0.91 today, or owning a pledge to receive \$1.00 in one year.

The discounting equation reflects the lost use (earnings potential or borrowing cost) of the dollar for a year. Receipt (or expenditure) of a dollar **n** years hence is worth still less due to the incidence of n years opportunity cost:

$$PV = \$1 \times \frac{1}{(1+k)^n}$$

The objective of NPV analysis is to measure the profitability of the assets committed to an investment project. The net present value method uses the discounting formulas for a series of payments to value the projected net cash flows for each investment alternative in today's dollars. In this fashion, the net present value criterion directly accounts for the time-value opportunity cost of the cash flows.

$$NPV = \sum_{t=0}^{T} \frac{NCF_t}{(1+k)^t}$$

Where
NCF_t = net cash flow (receipts less expenditures) at the end of year t
k = discount rate
T = the project's duration in years

The NPV is a single-valued number which represents the value of the multi-period investment in today's dollars. The sign and size of the project's NPV determines its ranking and acceptability. If NPV is positive, the investment project is profitable. If several investment alternatives are to be considered, and assuming the absence of capital rationing, the one with the largest positive NPV is most profitable.

NPV Analysis of a WRSIS Investment:

The net present value of the WRSIS investment will recognize all sources of private costs and benefits to the farmer. These costs and benefits will vary with the following variables:

- Size of the required capital investment
- Opportunity cost of capital
- Terms of financing
- Marginal improvement in commodity yields
- Change in acreage under production due to wetlands and reservoir construction
- Marginal change in production input costs
- Additional WRSIS management and maintenance costs
- Change in the market value of the land asset resulting from the WRSIS improvement.
- Change in federal and state income tax liabilities resulting from additional commodity sales and changes in tax deductible expenses.

The after-tax net present value of the WRSIS investment is:

$$\mathrm{NPV} = -\mathrm{I}_0 + \sum_{t=1}^{T} \left\{ \frac{(\Delta \mathrm{R}_t - \Delta \mathrm{EC}_t) - [(\Delta \mathrm{R}_t - \Delta \mathrm{CC}_t - \Delta \mathrm{D}_t) \times \mathrm{MTR}] + \mathrm{S}_t + \mathrm{ESV}_t}{(1+\mathrm{k})^t} \right\} + \frac{\Delta \mathrm{LV} \times (1 - \mathrm{CGR})}{(1+\mathrm{k})^T}$$

Where,

I_0 = The amount of investment ($) required to construct the WRSIS.

ΔR = Change in revenue resulting from the WRSIS investment. This is the change in crop yield X change in cropped acreage X market price for the commodity.

ΔEC = Change in the economic costs of production resulting from the WRSIS investment. Economic costs include all cash and noncash (e.g., unpaid family labor and management) costs of production excluding financing costs and depreciation.

ΔCC = Change in cash costs of production resulting from the WRSIS investment. These costs are included in the calculation of federal and state tax liabilities.

ΔD = Change in depreciation expenses resulting from the WRSIS investment. Depreciation is calculated using the provisions of current (1997) federal income tax codes.

MTR = The individual's marginal tax rate (combined federal and state rate).
ΔLV = Difference in terminal value of land (at the end of the planning horizon) with and without the WRSIS investment.
CGR = The individual's capital gains tax rate.
k = The after-tax opportunity cost of capital.
S = Subsidy (positive) or Tax (negative) amount due to government or third party payments
ESV = Economic Social Value. Environmental benefits such as: improving downstream water quality, reducing agricultural runoff, providing wildlife habitat, and increasing wetland acreage.

The value for ΔR varies positively with the yield improvements from subirrigation and negatively with the diversion of cropped land to wetlands and reservoir uses. Brown (1993) has explored the impact of subirrigation on corn and soybean yields in Ohio. Long term average yield increases for corn and soybeans have averaged 30% and 43%, respectively. These average yield increases are assumed for the base model. Sensitivity analyses are performed on this assumption. It is also assumed that all land required for wetland and reservoir was previously in crop production. Hence, land in production is reduced with the addition of the WRSIS project. Construction guidelines typically suggest that the wetland and reservoir are sized at 3% and 7% of the total WRSIS acreage, respectively. The wetlands and existing reservoir at Fulton County site are sized at 6.4 and 8.5 percent of the total WRSIS acreage, respectively.

The change in production costs with and without the WRSIS investment, ΔEC, is influence by several factors as well. The number of acres under production decreases with WRSIS, thereby decreasing the acres treated with inputs. Fertility costs were modeled based on the cost of replacing nutrients removed by the crop. The higher yields resulting from subirrigation will remove more fertilizer nutrients, thereby increasing fertility costs. Also associated with the higher yields are higher fuel and labor requirements. Utility costs associated with the pumping plant and other direct costs of operating the WRSIS system were included. Costs of seed, tillage, pest control, and other variable inputs were thought to be invariant with subirrigation and were held constant for the with and without WRSIS scenarios.

The NPV analysis is conducted on an after-tax basis. The numerator terms enclosed in square brackets estimates the net addition of federal and state income taxes. If this term is positive, it decreases NPV. However, if this term is negative (that is, the value of tax deductions exceed the tax value of additional income), then the tax provisions serve to increase project NPV. Note that this last statement can only hold true if the individual has other taxable income against which these excess deductions can be applied. We have made such an assumption in our analyses and believe it to be reasonable where the size of the WRSIS project is small relative to the farming business.

The value of tax off-sets will be influenced by a number of factors. Clearly, the individual's marginal tax rate is of paramount importance. Also, because only debt capital costs are deductible, the proportion of the investment that is financed with debt is important. For the base model, a 34% marginal tax rate (combined state and federal) is used as is a 25% down payment. Depreciation provisions of current tax law are used to calculate tax liabilities. All WRSIS assets are assumed depreciable over a period of 20 years. Current capital gains tax provisions also were modeled. An important assumption in these analyses is that the farmer has sufficient tax liabilities to be able to fully utilize depreciation and interest deductions of the WRSIS investment.

The LV term in the NPV model reflects the change in land values attributable to the addition of the WRSIS. A land-bid model written by Lee (1976) was used to evaluate the differences in LV generated by a WRSIS investment. This model recognizes differences in land productivity with and without the WRSIS investment. A economically rational maximum bid price is established for both the WRSIS and non WRSIS land. The value of land, net of capital gains tax obligations, is included as a single value at the end of the analysis period.

The Subsidy (S) and ESV terms are put into the model to reflect the external value this technology may have to society, and the amount of subsidy the government may provide for wetland creation. The external value of this technology will not be recognized by the profit maximizing producer because individuals outside the business determine the social value. For this reason, the value of reduced surface water contamination or off-site soil sedimentation are not recognized in the above model. However, if policymakers were to impose taxes or other mechanisms to charge (internalize) these costs to farmers, such taxes would become a private cost and would be included in the above model. The actual values for these terms will be developed later in the WRSIS research. This will require estimates of the changed soil particulate, nutrient, and chemical loadings of water discharged from the system and estimates of the economic impact of each of these on off-farm populations.

Base-Case Model:

In the results section that follows, results will be presented for a *base-case* model. Sensitivity analyses will be conducted to explore the impact of changing individual assumptions of the base case with all other assumptions unchanged. Table 2 lists the assumptions of the base-case model, many of which are directly observed from the Fulton County site.

Table 2. Variables and assumptions of the base-case model.

Capital Investment costs	$60,091
Planning horizon (loan term)	30 Years
WRSIS acreage	Total acreage 23.5 acres. 20 acres are subirrigated.
Crop Mix	50% each of corn and soybeans.
Commodity prices	Corn: $2.50/bu. Soybeans: $6.00/bu
Marginal tax rate	34% (federal + state combined)
Down payment percent	25%
Financing interest rate	8% (after tax rate is 5.28%)
Opportunity Cost of Capital	12% (after tax rate is 7.92%)

Base Crop Yield (control)	150 bu/ac corn, 47 bu/ac soybeans
Subirrigation Yield Improvements	30% for corn, 43% for soybeans
Long term yield growth/yr	1% for both subirrigated and non-subirrigated crops
Inflation rate	3%
Farm land value inflation	4%
Dredging Interval and Cost	Dredging every 15 years at a cost of $5000
Net Income/acre	$141/ac non-subirrigated and $178 subirrigated
Capital Gains Tax Rate	20%
Price of recent land sales per acre	$2000/ac
Subsidy/Third Party Payments (S)	$0
Economic Social Value (ESV)	$0

Results

The results for this study will be based on the Fulton County (base-model) results. This site was chosen for a number of reasons: better cost accounting for capital costs, more data concerning operational costs, and more yield data. Table 3 summarizes the results of the NPV model.

Table 3: Net Present Value Analysis of the Fulton County Demonstration Site under the Base-Case Scenario.

Source of Cost or Return	Discounted Value
Investment	$ (60,091)
Value of Yield Improvements	35598
Additional variable inputs	-8031
Additional labor inputs (system management)	-342
Utilities and other operating costs for the SI/Wet system	-342
Periodic dredging of wetlands and upland reservoirs	-2487
Changed federal and state income tax liabilities	20340
Value of land sales after 30 years	4114
Total Net Present Value	**-11241**

The results show that, under the assumptions of the base-case model, the net present value of the Fulton County site is negative (-$11,241). The combined effect (discounted value over 30 years) of subirrigation-increased yields (but diminished cropped acreage) was $35,598. Additional production inputs associated with these higher yields were valued at ($8,031). The discounted value of periodic dredging of the wetlands and reservoir was ($2,487).

The importance of federal and state income tax provisions are very evident in these results. The changed income tax liabilities of the farm resulting from the addition of the WRSIS are $20,340. The positive sign indicates that tax provisions add to profitability. This result occurs because the value of tax offsets (deductions for depreciation and debt finance charges) exceed the tax liabilities created by the additional value of yield improvements. Again, we must underscore that this result can occur only if the farmer has sufficient other farm income against which these tax deductions can be applied.

Finally, the addition of the WRSIS investment also is expected to increase the market value of the land. Because yields are increased, the rational farmer-investor will be willing to pay more for the WRSIS land. The increased land value, net of capital gains tax liabilities, were recognized at the end of the 30 year investment horizon and totaled $4,114 in present value terms.

Sensitivity Analyses

A number of the parameters included in the NPV model can be expected to vary among farmers or with the size of the WRSIS unit. In the following sections, sensitivity analyses will be conducted for several of these variables. The parameters that will be varied in the sensitivity analysis are the capital costs, the marginal tax rate, down payment percentage, financing terms, yield improvements, and crop mix. All sensitivity analyses are conducted with the data obtained from the Fulton County site. All parameters that are not subject to the sensitivity analysis are held constant at their base-case levels.

<u>Capital Investment:</u>

The initial capital investment assumed in the base-case model was $60,091. Table 4 summarizes the changes that would result if initial investment were smaller or larger. If one feels that a smaller construction bid could be negotiated, the effect on NPV can be examined.

Table 4: 30 Year NPV for 20 Acre Subirrigated Plot with Varying Levels of Initial Investment

Initial Capital Investment	NPV
$20,000.00	$20,458
$30,000.00	$12,551
$40,000.00	$4,644
$50,000.00	($3,262)
$60,000.00	($11,169)
$70,000.00	($19,076)
$80,000.00	($26,983)

Clearly, the higher the initial capital investment, the lower the net present value of the investment. Notice, however, that a reduction in initial investment of $10,000 (say, a reduction from $50,000 to $40,000 in the above table) does <u>not</u> increase NPV by $10,000. This result occurs because income tax liabilities are a function of depreciation and finance charges, both of which are diminished with the reduction of the WRSIS investment. The breakeven level of investment is $49,781. This translates into a per acre WRSIS investment of nearly $2500/acre for a site similar to that of Fulton County.

Marginal Tax Rate and Down Payment Percentage:

The magnitude of federal and state income tax liabilities is determined predominantly by the individual's marginal tax rate and the proportion of the investment that is debt financed. Federal and Ohio marginal tax rates for alternative levels of adjusted gross income are reported in Table 5. In this model, the NPV is calculated for the WRSIS investment using these combined marginal tax rates.

Table 5. Federal and Ohio Marginal Tax Rates.

	Marginal TR (%)		
Adjusted Gross Income	Federal	Ohio	Combined
< $41,200	15.00%	6.00%	21.00%
$41,200 - 99,600	28.00%	6.00%	34.00%
$99,600 - 151,750	31.00%	6.00%	37.00%
$151,750 - 271,050	36.00%	6.62%	42.62%
> $271,050	39.60%	7.20%	46.80%

Table 6 presents net present values for the WRSIS investment for alternative levels marginal tax rate and percent of debt employed.

Table 6. Combined effect of down payment percentage and MTR on WRSIS NPV

	% Down Payment (Equity Financed)			
Combined MTR	25%	50%	75%	100%
21.00%	($21,668)	($29,157)	($34,892)	($39,342)
34.00%	($11,241)	($22,036)	($29,985)	($35,971)
37.00%	($8,653)	($20,322)	($28,824)	($35,176)
42.62%	($3,767)	($17,096)	($26,651)	($33,687)
46.80%	**$24.56**	($14,687)	($25,037)	($32,579)

From this table, we learn that as the marginal tax rate rises, the net present value becomes greater. At first, this seems contradictory. However, an assumption of this model was that the individual undertaking the WRSIS project would be able to take advantage of all the tax benefits arising from both interest and depreciation deductions. The size of these deductions is positively related to the marginal tax rate. In the same manner, as the amount of non-equity financing rises, the net present value also increases. This is due to the larger amounts of deductible interest expense arising from greater reliance on debt financing.

Financing Terms:

Similar to the results of MTR and percent down payment, the term of the loan also has an effect on the net present value of the WRSIS system. Table 7 shows how the NPV varies as the length of the loan increases.

Table 7. Effect of Loan Term on WRSIS NPV

Term of Loan	NPV
5Years	($20,516.00)
10 Years	($18,083.00)
15 Years	($15,949.00)
20 Years	($14,108.00)
25 Years	($12,546.00)
30 Years	($11,241.27)

As the term of the loan increases, the net present value increases. This is explained by the increased amount of interest that accompanies a longer-term loan. As the interest payments rise, so do the tax deductions for the interest payments.

Yield Improvement:

Presented in table 8 are sensitivity analyses for subirrigation-induced yield improvements. Yield increase scenarios range from 110% of base to 170% of base yields. The base bushels used for the Fulton County site were 150bu/ac for corn and 47bu/ac for soybeans. By raising the bu/ac in 10% increments, we can see the break-even yield increases for a corn-bean rotation. As expected, as yield increases, the NPV of the WRSIS project increases.

Table 8: WRSIS Break Even Analysis with Corn and Soybean Yields Variable.

	Bean Yield (Bu/Ac)						
Corn (Bu/Ac)	52	56	61	66	71	75	80
165	(39078)	(34254)	(29430)	(24605)	(19781)	(14957)	(10133)
180	(33119)	(28295)	(23471)	(18647)	(13823)	(8999)	(4175)
195	(27161)	(22337)	(17513)	(12689)	(7864)	(3040)	**1784**
210	(21203)	(16378)	(11554)	(6730)	(1906)	**2918**	**7742**
225	(15244)	(10420)	(5596)	(772)	**4053**	**8877**	**13701**
240	(9286)	(4462)	**363**	**5187**	**10011**	**14835**	**19659**
255	(3327)	**1497**	**6321**	**11145**	**15970**	**20794**	**25618**

Crop Mix:

Sensitivity analyses reported in table 9 gives some indication of how higher-valued crop mixes would affect the NPV for the WRSIS system.

Table 9. Crop Mix Variation (Corn Vs. Soybeans)

Crop Mix	NPV
100% Corn	($14129)
75% Corn, 25% Soybean	($12685)
50% Corn, 50% Soybean	($11241)
25% Corn, 75% Soybean	($9798)
100% Soybean	($8354)

Previous research in Ohio has suggested that soybeans enjoy a relatively larger increase in yield from subirrigation than does corn. As the percentage of soybeans in the crop mix is raised, the NPV also increases.

The Effects of Payments and Economic Value

There are many factors that interact to determine the value of a wetland. A wetland creates environmental value by increasing wildlife diversity and helping to filter soil sediments, nutrients, and agricultural chemicals from effluents (Sibbing, 1995). Wetlands also create amenity value to society. Both of these value sources are extramarket, making them difficult to quantify. Thibodeau (1981) argues that these values are substantial -- up to $200,000 per acre of wetland.

Although environmental and social values attributed to wetlands may be significant, only those values that can be internalized -- transferred back to the owner of the wetland -- will influence the market value of the wetland or serve as an incentive for an individual to create an artificial wetland. In this section, we will consider two methods by which some of the external benefits can be internalized: 1.) direct market payments for creation of a new wetland and 2.) annual subsidies paid to wetland investors.

Market Payments

Environmental policy can create a demand for artificial wetlands. Ohio mandates that before a wetland can be destroyed, a new wetland site must be created elsewhere (mitigation). Wetland market value is influenced by the number of parties on each side of the market, by the potential value created from developing the existing wetland, and by the costs and lost values associated with converting land into a new wetland. Costs of wetland creation and maintenance are estimated in prior sections of this article. To insure that the wetland is not converted to cropland at a later date, an easement is granted for the new wetland. This easement is expected to diminish the market value of the land: The discounted value of the market price reduction must be incorporated into the profitability calculation. Discussions with professionals at the Ohio Department of Natural Resources (Marshall, Evans, and Rennick) estimate the current market value for an acre of wetlands at $20,000. However, it must be noted that mitigation payments can only be made if the proposed wetland site meets certain environmental criteria.

In table 10 we summarize the impact of a mitigation payment on the net present value of the WRSIS project. We assume that our base case model qualifies for a wetland mitigation payment and that the current market price is $20,000 per acre of wetland can be negotiated. Because the wetland is 1.5 acres, our farmer receives a $30,000 market payment to construct the WRSIS system and place an easement on his land holdings. These payments are assumed to be available immediately, and thus are not discounted. Subtracting this payment from the total capital costs of the WRSIS project, the adjusted NPV is $1041.

In addition to the changes in the capital costs, state and federal tax liabilities also change. This is due to the wetland no longer being deductible as a conservation expense. Also, the percentage of equity financing is increased by the amount of the mitigation payment, thereby reducing tax deductible interest payments and altering the weighted cost of capital (discount rate). Note that our analyses do not include an estimate of decreased future land values resulting from the wetland easement (however, the land values have decreased in table 10 due to a higher equity proportion in the weighted cost of capital determination). Empirical data are not available to quantify the impact of this type of easement. Our judgement is that this omitted value is small and will not change the conclusion of the NPV analysis.

Table 10: Net Present Value Analysis of the Fulton County Demonstration Site under the Base-Case Scenario with Mitigation Payments.

Source of Cost or Return	**Discounted Value**
Investment (less mitigation payments)	$ (30,091)
Value of Yield Improvements	29138
Additional variable inputs	-6645
Additional labor inputs (system management)	-283
Utilities and other operating costs for the SI/Wet system	-283
Periodic dredging of wetlands and upland reservoirs	-1860
Changed federal and state income tax liabilities	8709
Value of land sales after 30 years	2356
Total Net Present Value	**1041**

Annual Subsidies

Many of the annual benefits flowing from the wetland -- wildlife habitat, recreational opportunities, aesthetics -- are realized by individuals outside the farm firm without compensation to the wetlands owner. However, a portion of these benefits are realized by public organizations and take the form of reduced operating costs. Research performed in Ohio by Forster and Abrahim (1985), Forster et. al (1987), and Hitzhusen (1991) place values on water quality and sedimentation costs caused by agricultural production. Based on this Ohio research, summarized by Hitzhusen, some agricultural impacts can be illustrated. The costs summarized in table 11 assume a gross erosion of 15 tons/year/acre, sediment delivery ratio of 10%, and our base case model of a 20 acre farm in the Lake Erie watershed area of Ohio. Water treatment costs in the first column are only due to sedimentation. Estimates have been made on the effects that agricultural chemicals have on ground water quality. Neilsen and Lee (1982) estimated that Ohio groundwater contamination costs (due to agriculture) were $11.2 million. For a rough estimate, this dollar figure would be close to $18,000,000 in 1998 terms. Dividing this number by the amount of Ohio farmland (15,200,000 acres), we arrive at a rounded figure of $1.18/acre. This adds an additional $23.60 per year in external costs generated by our base case model.

The total environmental impact due to sedimentation and groundwater contamination is *roughly* $100 per year. Please note that there may be many more environmental factors and more comprehensive methods for determining this type of impact. We have made this analysis brief due to the fact the farmer will not realize these costs, and will therefore not be influenced to change his or her behavior.

Table 11: Environmental Impacts of Agricultural Production

Type of Receptor Affected	$/ton	Base Model Total/year*
Lake Erie Harbor Dredging	$2.90	$58.00
Drainage Ditch Dredging	$1.87	$11.22
Water Treatment Costs**	$0.32	$6.40
Subtotal	$5.09	$75.62
Groundwater Contamination Costs	---	$23.60
Total		**$99.22**

* = Total impact is tons of sediment x delivery ratio x cost per ton
**= Costs due to sediment contamination

Assuming that the WRSIS system can decrease sedimentation and improve water quality, economic benefits may be realized. These costs could be internalized by either taxing the farmer for not adopting a WRSIS technology or by paying the farmer to maintain a WRSIS (subsidy).

Assuming that the external economic costs of agricultural production are internalized into this model. For simplicity, let us have an annual transfer payment from society to the farmer in the amount of $100/year. The new NPV shown in table 12 is $1976, a $13,217 NPV improvement over the base case model (Table 3).

Table 12: Net Present Value Analysis of the Fulton County Demonstration Site under the Base-Case Scenario with Mitigation and Transfer Payments.

Source of Cost or Return	Discounted Value
Investment (less mitigation payments)	$ (30,091)
Value of Yield Improvements	29138
Additional variable inputs	-6645
Additional labor inputs (system management)	-283
Utilities and other operating costs for the SI/Wet system	-283
Periodic dredging of wetlands and upland reservoirs	-1860
Changed federal and state income tax liabilities	8228
Value of land sales after 30 years	2356
Value of Transfer Payments to the Farmer (inflation adjusted)	1416
Total Net Present Value	**1976**

Discussion

Preliminary results from the three test sites in Northwest Ohio contain both encouraging and discouraging dimensions. On the discouraging side, the negative NPV for the base model (and for many sensitivity analyses) suggest that many farmers will not rush to adoption unless a market payment is made. Furthermore, much of the positive value arising from the investment is tax related. This will have full value only if the farmer has other farm tax liabilities in excess of these deductions. Tax laws also are subject to change. This introduces an element of risk to the producer who may be counting on the continued deductibility of cash interest and depreciation as a source of benefit from this investment.

Capital costs for the project are by far the largest expense. Reducing the required investment greatly increases the likelihood that the WRSIS will be profitable. Previous studies have shown that subirrigation/subsurface drainage projects have been completed at a lower cost. In addition, researchers involved with this project believe that the system can be built with less outlay. The learning curve for this type of project has been navigated for at least five years. Now that three test sites have been built and tested, future sites may be created in a more cost efficient manner. It is encouraging to note that, given our base analysis, the breakeven level of WRSIS investment per acre is nearly $2,300 per acre. This is substantially higher than estimates given in previous studies, and is a level of investment that may be achievable in the future.

Additional inputs are necessary to grow and harvest a larger yield. Research is currently underway to study variable input usage under subirrigation. Preliminary results suggest that input utilization efficiency may increase with subirrigation technology. Also, land set aside for construction of reservoirs and wetlands lessens the impact of positive yield effects. If the WRSIS project were built on a larger scale, the proportion of land removed from production may be lessened. Furthermore, it is expected that the cost of creating larger reservoirs and wetlands is a nonlinear function of their capacity.

Evidence from the WRSIS demonstration sites suggest that the cost (time) required to manage the system is not trivial. System management costs may be reduced in the future through more automated procedures as well as cost reduction through learning. Perhaps a technology such as that described in the literature review by Smith et al. (1985) will prove beneficial to this project.

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