

Economics of Irrigating Field Crops

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Introduction

There are a number of issues affecting the profitability and financial feasibility of installing irrigation for field crops. The per-acre investment is large. The yearly cost of applying water and increased crop production expenses must be covered. There is large variation in the year-to-year the amount of natural rainfall, which estimating the yield response to irrigation difficult. Profitability depends on the effects of irrigation over the lifetime of the equipment. Profitability is also affected by the choice of crop(s) to be irrigated, the crop rotation and any other changes in the farming operation that result from installing irrigation. Cash flow should be considered if the new investment is debt financed, because the financial benefits attributable to irrigation vary from year-to-year. Irrigation is likely to reduce the year-to-year variation in yields but adding to a farms debt load may increase financial risk.

Financial, Yield and Revenue Data

There is little actual farm financial data comparing irrigated to non-irrigated crops. Some universities have developed enterprise budgets for irrigated and non-irrigated crops. Recent corn budgets from Alabama, South Carolina and Georgia are summarized in Table 1.

Table 1. Corn Enterprise Budgets, Selected States, cost per acre and per bushel, \$

Item	Alabama Dry land 2007	Alabama Irrigated 2007	S. Car. Dry land 2006/7	S. Car. Irrigated 2006/7	Georgia Dry land 2007	Georgia Irrigated 2007
Yield, bu.	--	--	100	160	85	185
Variable cost per acre	\$300	\$416	\$284	\$427	\$198	\$440
Fixed cost/ac	\$65	\$175	\$40	\$139	\$41	\$132
Total/acre	\$365	\$591	\$324	\$566	\$239	\$572
Total cost per bushel	--	--	\$3.24	\$3.54	\$2.81	\$3.09

Although the assumptions about costs and yields vary among these budgets, in each case the cost of production per acre is significantly higher for irrigated corn and the cost per bushel is somewhat higher. The fixed costs per acre are much larger for irrigated corn and variable costs increase as well. However, because of yield differences,

profitability per acre also depends on the price of corn. For the South Carolina budgets, net income per acre is similar for both production methods at \$4.00 per bushel. In the Georgia case, this same price generates an advantage of \$67 per acre to irrigation.

Because of variation among farms, we cannot take these estimates as being the whole story on cost or profitability of irrigation but they do provide a guide to the likely magnitudes of the costs involved.

A key question is whether the expected increase in yield and revenue will more than offset these higher costs of production. Tables 2 and 3 show some research results for corn in two North Carolina locations. The average increase in the Piedmont was 39 bushels per acre but there was a range from a low of a six-bushel increase one year to a high of 71 bushels, Table 2. The average increase in yield was higher in the Wilson County trials, at 91 bushels, Table 3. The smallest increase was 23 bushels and the highest was 237 in a year when the dry land corn crop failed.

Table 2. Corn Yield Increases, Piedmont, NC, 2002-05, bushels per acre

Year	Dry Land	Irrigated	Difference
2002	74	145	71
2003	179	208	29
2004	152	198	46
2005	202	208	6
Average	151	190	39

Source: Garry Grabow, Dept. of Biological and Agricultural Engineering, NCSU

Table 3. Corn Yield Increases, Wilson, NC, 1980-86, bushels per acre

Year	Dry Land	Irrigated	Difference
1980	88	166	78
1981	90	194	104
1982	196	219	23
1983	188	237	49
1984	204	262	58
1985	13	250	237
1986	137	222	85
Average	131	221	91

Source: John R. Anderson, Dept. of Crop Science, NCSU

Table 4 summarizes some research results for soybeans. Average response to irrigations was about 7 bushels. On average, there was an increase in yield of one bushel for each time irrigation was applied.

Table 4. Soybean Yield Increases, Wilson Co., bushels per acre

Years	1980-83	1980-86
Number of trials	38	50
Non-irrigated yield	47.3	47.5
Irrigation response	7.7	6.7
Maximum irrigation response	11.1	15.7

Source: Jim Dunphy, Dept. of Crop Science, NCSU

These research results have several implications. Corn responds more to irrigation than soybeans. The corn response was greater in Wilson County than in the Piedmont. Yield responses varied significantly from year-to-year. One would expect yield responses to be farm and field specific because of variation among soil types, local rainfall patterns, fertility, etc. Given the large differences in soil and climate resources among farms, any producers considering irrigation should check their yield records and search for any research data or local experience that might be applicable for their locations. This approach will provide the best estimates of expected yield responses.

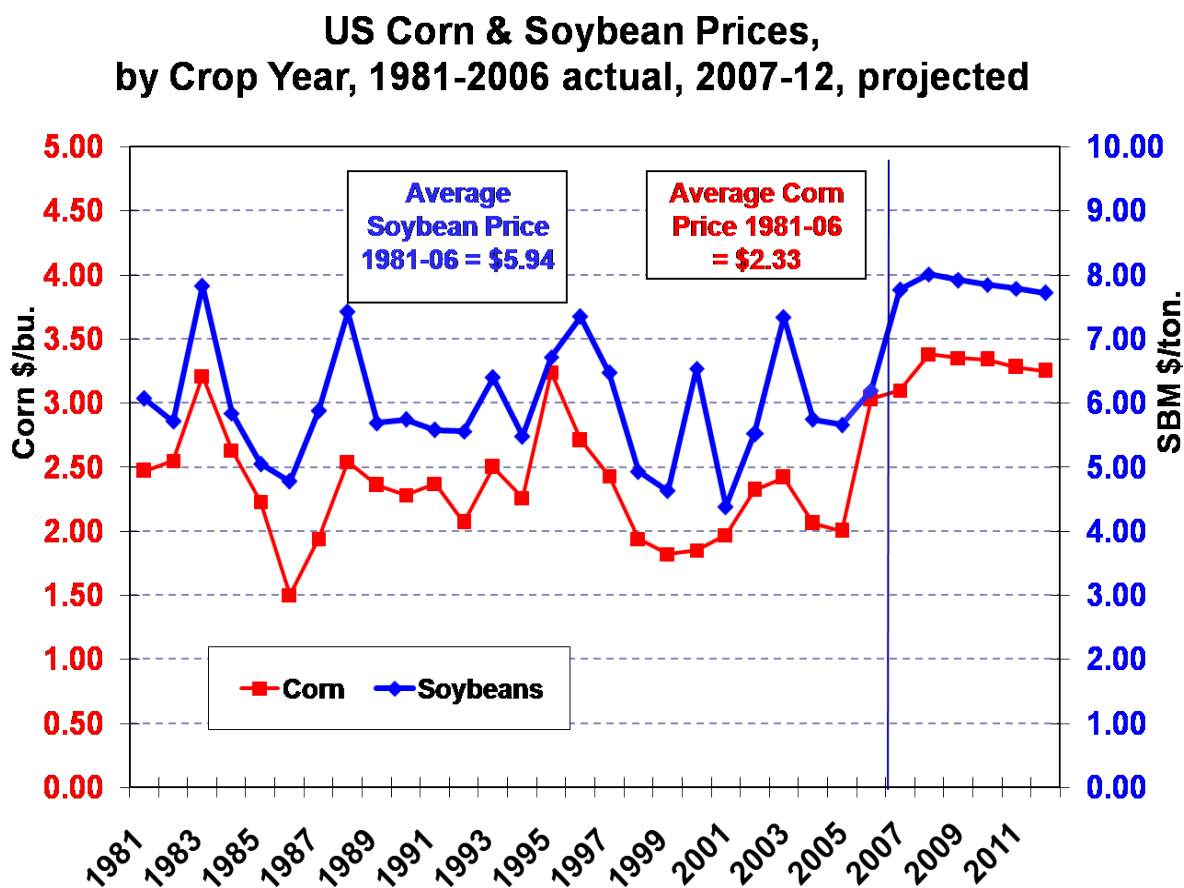
Table 5 shows revenue increases based on the research results from Wilson County and the annual average corn prices reported for North Carolina by the US department of Agriculture. In this example the increase in yield was worth \$271 per year, on average.

Table 5. Estimated Corn Revenue Increases with Irrigation, based on the Wilson, NC research results.

Year	Yield Difference	NC Average Price	Revenue Increase
	Bu./acre	\$/bu.	\$/acre
1980	78	3.38	264
1981	104	2.68	279
1982	23	2.45	56
1983	49	3.80	186
1984	58	2.80	162
1985	237	2.98	706
1986	85	2.78	236
Average	91	2.98	271

Using the soybean research response from the 1980-86 trials of 7 bushels per acre and the average NC soybean price for 1980-86 of \$6.18/bu. places an average value on the yield increase of \$43/acre.

Profit projections depend on expectations of future crop prices. The graph shows the history of US corn and soybean prices for the 1981-2006 crop years. The price projections for 2007-12 were made by the Food and Agricultural Policy Institute, which is well respected for its price forecasting and policy analysis work. This suggests price trends will continue at levels similar to the present. Weather will continue to cause price volatility, however.



Irrigation Costs

Turning now to the costs to be considered, there is the initial investment. When evaluating the profitability of a new irrigation system we consider the total cost of the investment required to establish the system. For an existing system, the original investment is not relevant because it is not recoverable (a “sunk” cost in economic terminology). However, if existing equipment has a market value, we should consider

this value as the current investment – if we keep and use this equipment its value will decrease over time. When developing an annual enterprise budget, because irrigation equipment lasts for several years, we convert this investment cost into annual ownership costs. These fixed costs consist of an annual depreciation charge, interest on the investment, property taxes, and insurance. Then there are annual operating costs to consider, including the cost of running the irrigation equipment and additional crop production and harvesting costs. A final “cost” to consider is the opportunity cost of your time and money, which may form part of the initial investment, the annual fixed costs or the operating costs.

The initial investment depends on many factors, including:

- The water source -- surface water or well

- The power source for the pump – electricity or diesel

- The type of irrigation system

- The size of irrigation system and the area to be irrigated -- field shape and size

These will vary from farm-to-farm and affect the system design, the size of the initial investment, and operating costs.

Profitability

When evaluating profitability we spread the initial investment over the useful life of the project. This may be the physical life of equipment or the farmers planning horizon, if shorter. The annual depreciation cost or charge allocates a share of the initial investment to each year of the project. Depreciation charges are affected by intensity of use, age and obsolescence. If there is a salvage value at the end of an items useful life, this reduces the amount to be charged each year. A simplified average annual depreciation charge formula = $\frac{[\text{New Cost} - \text{Salvage Value}]}{\text{Years of life}}$

Years of life

This approach to economic depreciation differs from the procedures used to calculate IRS depreciation deductions when filing income taxes. It is appropriate for producers to use the tax rules to minimize their tax liability. The rules available to do this are the Section 179 expensing provisions and the choice of depreciation method. Most producers want to use these rules to generate depreciation allowances sooner rather than later, so a piece of equipment may be “depreciated out” for tax purposes but still be perfectly usable. This approach doesn’t make sense when we are trying to estimate profitability of a new investment over its useful life. In this case we want to use economic cost estimates and make an annual charge each year of the project.

A second cost associated with new investments is an interest charge on that investment. The value remaining in an investment decreases over time and this need to

be reflected in the way we figure the interest charge. A simplified average annual interest charge formula = $\frac{[\text{New Cost} + \text{Salvage Value}]}{2} \times \text{Interest rate}$

The appropriate interest rate to use depends on the source of the money. It will be the loan rate if a purchase is debt financed or the rate you would have earned on your own money if you draw on your savings to pay for a purchase (opportunity cost).

Operating or variable costs for irrigation include fuel or electricity, repairs and maintenance, and labor. There will be additional crop expenses as well. More fertilizer will be required to support the higher yields, particularly nitrogen. Higher yields mean additional harvesting costs, including combine use and grain transportation.

Table 6 provides a summary of some current estimates of the costs of Center Pivots of two different sizes and two types of power source.

Table 6. Cost Estimates, 2007*

Item	31 Acres Diesel	31 Acres Electric	81 Acres Diesel	81 Acres Electric
System	600 ft	600 ft	1000 ft	1000 ft
Investment	\$84,782	\$63,280	\$125,243	\$104,243
Fixed costs per year (DITI)	\$8,436	\$6,396	\$12,462	\$10,472
Operating costs per year*	\$4,434	\$570	\$7,976	\$1,407
Total cost per year	\$12,870	\$6,966	\$20,438	\$11,879
Cost per acre per year	\$410	\$221	\$252	\$147

* A total application of five acre-inches was used in these estimates

The system length refers to the boom and there is an end gun to provide additional coverage. It is assumed that a new well would be required to provide adequate water and this adds considerably to the total cost. A detailed cost budget for one of these systems is contained in the appendix. Excel spreadsheet versions are available at: http://www.ag-econ.ncsu.edu/extension/Ag_budgets.html

These estimates show significant cost differences based on the power source, with electrical power having a sizable advantage over diesel fuel at current prices. It also shows that size matters. The cost per acre is much lower for the larger system of each type. This is simple matter of geometry and economies of scale. A 600' system (radius) with end gun can cover 31.5 acres, the 1,000' system covers 81 acres, a 157%

increase. The investment cost for the larger system is 50% to 65% greater. The investment is significantly less if surface water is available instead of drilling a well.

Other issues affect profitability. The response to irrigation varies by crop type and a related issue is the crop rotation that will be followed on the irrigated area. If less responsive crops must be included in a rotation, for example for soil fertility, disease or pest control, the benefits from irrigation will be reduced. There may be portions of a field that cannot be irrigated and must be farmed differently. Many farms have irregularly shaped fields and, for example, a center pivot will only cover 78% of a perfectly square field. Installing irrigation on one field may cause changes in how other fields are used, for example, because of labor or equipment limitations. For these reasons, in many cases it is not possible to simply compare yields, revenues and costs for a single crop with or without irrigation. In these cases, it is important to consider the effect of installing irrigation on the whole farming operation.

The following approach is recommended in order to determine the effect irrigation is expected to have on total farm revenue, costs and profit over the planning horizon. First determine the crops to be grown, both on the irrigated area and on the rest of the farm. Second, develop individual crop budgets for each crop with and without irrigation. The farm history should be used as the basis for the “without irrigation” scenario. Finally combine these into whole farm budgets for both the irrigated and non-irrigated scenarios, taking account of any differences in the acreages of specific crops. This may seem like a lot of work but it will ensure that the full effect of irrigation on farm operations and profitability is considered. It would be prudent to discuss these projections with an accountant or qualified tax preparer to identify the relevant tax issues and to assess the after-tax impacts on farm earnings.

Decision tools

There are a number of decision tools that can be used to evaluate the profitability of a proposed investment. Net Present Value considers the new investment and the discounted stream of yearly income and expenses. Discounting recognizes the fact that a dollar received or spent sometime in the future is worth less than a dollar today. A NPV greater than zero indicates the investment is expected to be profitable, although the farmer may specify a desired net return that is significantly greater than zero. The formula is:

$$NPV = -C_{I_0} + \frac{NR_1}{(1+r)^1} \dots + \frac{NR_n}{(1+r)^n}$$

Internal Rate of Return is similar in concept but converts the income and expense stream to rate of return on the new investment, which can then be compared to the cost of capital.

A third method, which is not as accurate as the NPV approach but is easier for many farmers to understand and use, is to develop an annual budget of the projected farm revenue and cost under average or “typical ” expectations. In our example there would be two budgets, one with and one without irrigation. This approach is simpler to use and can give a reasonable estimate of the average difference in yearly profits. Any differences in profitability can be interpreted in a straightforward manner. This approach can also be used to estimate the effects of alternative plans or scenarios.

Cash Flow

If the investment will be large and the irrigation project will be debt financed then the effects of the loan repayments on farm cash flow should be considered because loans typically must be repaid over a shorter period than the useful life of the project. The terms of the loan, i.e., the interest rate and repayment period, affect the size of the annual payments. Some examples of annual payments of principal and interest on a loan of \$100,000 are:

5-year, 6% interest = \$23,740

5-year 10% interest = \$26,380

10-year 6% interest = \$13,587

10-year, 10% interest = \$16,275

Loan payments must be paid regardless of crop performance!

Risk

Risk is a final consideration. Irrigation reduces crop yield risk but increases financial risk because of the added investment, which creates added debt or reduces the financial reserves of the business. There are a number of simple tools to evaluate risk. A common one is to estimate the break-even yield increase and evaluate the likelihood of exceeding this. However, as discussed above, the effects of irrigation may well affect more than one crop and may extend beyond the actual area irrigated, making this approach unreliable. A second method is to estimate the number of years of increased profitability it will take to recover the initial investment. In this case, the shorter the time to breakeven the better. A third method is sensitivity analysis, where alternative (more conservative) assumptions are used for yields, crop prices and costs under both dry land production and irrigation in order to assess the robustness of the base projections. One final approach is contingency planning – what if? – and developing a coping strategy. There are other, more complex tools, but these likely require the assistance of a professional financial advisor.

Summary

From this discussion it is clear that there is no “one-size-fits-all” answer to the profitability and financial feasibility of installing irrigation. The farm situation and the

specific details of the plan drives the economics. Important factors affecting profitability include: water availability; field size, shape and topography; soil type and fertility; local weather patterns; crop selection and rotation under irrigation; past crop performance; historic cost of production and profitability; price projections, and the financial health of the farm business.

Producers should project yield responses for the individual crops under irrigation based on the best available local information. Because of the large investment, producers should “run the numbers”, that is, plan and cost out the irrigation system investment, estimate fixed and operating costs for each crop, and consider the whole farm effects on crop rotation and crop acreage, including areas not irrigated. The decision should be based on these estimates of profitability, cash flow considerations and an assessment of risk.

Resources

NCSU Enterprise Budgets are available on-line at:

http://www.ag-econ.ncsu.edu/extension/Ag_budgets.html

4 irrigation cost spreadsheets

5 corn budgets (dry land)

6 budgets for soybeans and/or wheat

3 budgets for cotton, and more

National Ag Risk Library has an enterprise budget library at

<http://www.agrisk.umn.edu/>

Appendix

NC STATE UNIVERSITY						IRR-E81	Nov.07	
IRRIGATION COST SPREADSHEET								
ENTER YOUR DATA IN THE YELLOW HIGHLIGHTED CELLS								
TYPE: CENTER PIVOT, 1,000 FOOT SYSTEM, ELECTRICITY POWERED								
BRIEF DESCRIPTION:								
1000 ft sprinkler system plus end gun. Full circle covers 81 acres. Power source is commercially supplied electricity. Adequate water requires drilling a new well. Well capacity of 600 GPM is required. System operates 65.5 hours to apply 1 acre inch of water.								
ENTER EFFECTIVE ACREAGE COVERED ==> 81 ACRES								
ENTER HOURS REQUIRED TO APPLY 1 ACRE INCH ==> HOURS								
INVESTMENT COST								
ITEM	UNIT	QUANTITY	COST/UNIT	TOTAL	PER ACRE			
Power service		1	\$ 2,000.00	\$ 2,000	\$ 24.69			
8" PVC pipe and fittings	Feet	1,000	\$ 7.20	\$ 7,200	\$ 88.89			
Sprinkler System (5 towers)		1	\$ 52,543.00	\$ 52,543	\$ 648.68			
Pump motor, 40 HP		1	\$ 15,000.00	\$ 15,000	\$ 185.19			
Well		1	\$ 27,500.00	\$ 27,500	\$ 339.51			
TOTAL INVESTMENT COST:				\$104,243	\$1,286.95			
ANNUAL FIXED COSTS								
ITEM	INVESTMENT COST	SALVAGE VALUE	USEFUL LIFE YEARS	DEPRECIATION	INTEREST	TAX & INS	TOTAL DITI	TOTAL PER ACR
ENTER INTEREST AND PROPERTY TAX + INSURANCE RATE, AS A PERCENTAGE OF VALUE==>					8.50%	1.40%		
Power service	\$ 2,000	\$ 0.00	10	\$ 200.00	\$ 85.00	\$ 14.00	\$ 299	\$ 3.69
8" PVC pipe and fittings	\$ 7,200	\$ 0.00	20	\$ 360.00	\$ 306.00	\$ 50.40	\$ 716	\$ 8.84
Sprinkler System (5 towers)	\$ 52,543	\$ 0.00	20	\$ 2,627.15	\$ 2,233.08	\$ 367.80	\$ 5,228	\$ 64.54
Pump motor, 40 HP	\$ 15,000	\$ 0.00	20	\$ 750.00	\$ 637.50	\$ 105.00	\$ 1,493	\$ 18.43
Well	\$ 27,500	\$ 0.00	20	\$ 1,375.00	\$ 1,168.75	\$ 192.50	\$ 2,736	\$ 33.78
TOTAL FIXED COST	\$104,243			\$5,312.15	\$4,430.33	\$729.70	\$10,472	\$129.29
ANNUAL OPERATING COST								
ITEM	HOURS PER ACRE INCH	RATED HORSE POWER	FUEL USE KWH/HP/HR	FUEL COST \$/KWH	ACRE INCHES APPLIED	TOTAL	TOTAL PER ACRE	
Electricity	65.5	40	0.746	\$ 0.085	5.0	\$ 831	\$ 10.26	
REPAIRS AND MAINTENANCE								
Power service	\$ 2,000	0.00%				\$ 0	\$ 0.00	
8" PVC pipe and fittings	\$ 7,200	0.00%				\$ 0	\$ 0.00	
Sprinkler System (5 towers)	\$ 52,543	0.50%				\$ 263	\$ 3.24	
Pump motor, 40 HP	\$ 15,000	2.00%				\$ 300	\$ 3.70	
Well	\$ 27,500	0.00%				\$ 0	\$ 0.00	
LABOR								
Labor	1.5	\$ 9.03				\$ 14	\$ 0.17	
TOTAL OPERATING COST						\$1,407	\$17.37	
TOTAL ANNUAL COST						TOTAL	PER ACRE	
TOTAL FIXED AND OPERATING COST						\$11,879	\$146.66	
¹ Depreciation = (Initial cost - Salvage value) / years of life ² Based on the average investment = (Initial cost + Salvage value) / 2 multiplied by the indicated percentage rate ³ The number of irrigation events likely will vary from 3 to 9 per season. A total application of five acre inches is used in this budget.								
Costs estimates and the spreadsheet were developed by: Gary Bullen, Department of Agricultural and Resource Economics, NC State University Geoff Benson, Department of Agricultural and Resource Economics, NC State University								
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