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The Economic Feasibility of Variable Rate Irrigation Technology for Wetland Restoration

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The purpose of this NebGuide is to evaluate the economic feasibility of installing variable rate irrigation with a cost-share program when restoring wetlands on previously cropped land.

Wetland Habitat and Policy in the Rainwater Basin

Restoring wetland habitat provides ecosystem services such as habitat for migratory waterfowl, reductions in soil erosion, reduced flood frequency, aquifer recharge, and enhanced water filtration. However, wetland restoration can be costly for landowners. Programs like the Divots in the Pivots Regional Conservation Partnership Program (RCPP), administered through USDA-Natural Resources Conservation Service (NRCS), provide financial and technical assistance to producers to restore wetland habitat on previously cropped land. Images such as *Figure 1* are common across the Rainwater Basin portion of Nebraska.

Figure 1. Spring flooding in a portion of a crop field

Need for Variable Rate Irrigation Technology when Restoring Wetlands on Cropped Fields

Wetland restoration requires restoring the hydrology of the flood-prone cropland. To maximize irrigation efficiency within fields that contain the restored wetland requires an upgrade from standard center pivot technology to Variable Rate Irrigation (VRI), along with prescription mapping. VRI allows individual control of each sprinkler in the irrigation system, which provides precision in meeting crop-water needs. This technology also allows producers to eliminate irrigation inputs over the restored wetland acres and to vary application amounts on the rest of the field, applying more or less irrigation water in sections of the field that require differential inputs.

In addition to applying water more precisely, VRI can also be used for precise pesticide and fertilizer application. This allows producers to potentially save on non-water input costs. *Figures 2a* and *2b* illustrate the yield map for a single field before and after VRI was installed. *Figure 2a* has large areas of low yield (white sections), while *Figure 2b* has a more uniform yield map. This difference is due to the VRI system, which adjusts applied inputs across the field to meet crop needs based on varying soil conditions. The technology can be costly (the total cost was about $92,000 and $80,000 for the two operations included in the study),

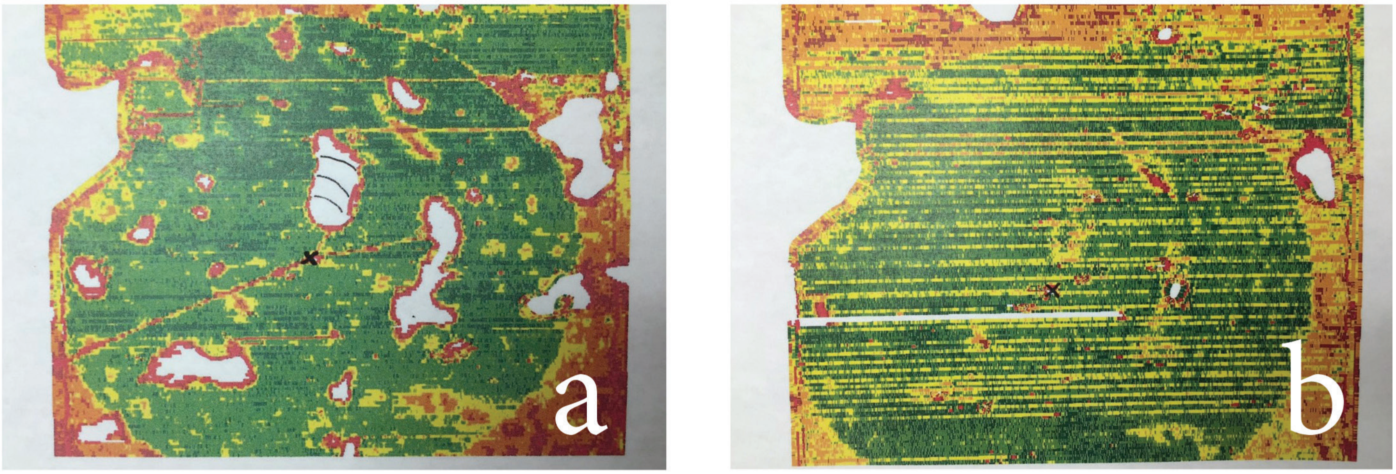

Figure 2a and 2b. Crop yield before (a) and after VRI technology (b). Figure a (left) has large areas of low yield represented by the white areas while Figure b has a more uniform yield map.

but programs are available to help with the investment costs. Evaluation of the economic impact of participating in those programs is discussed this publication.

The RCPP provides easement compensation for the restored wetland acres and 85% of the cost of VRI technology upgrades, along with technical assistance, for a producer who enrolls in the program. The program also provides 85% cost-share for the development of grazing infrastructure so the restored wetlands can be maintained as working lands through grazing or haying. The producer pays for the other 15% of the cost of VRI upgrades and construction of grazing infrastructure (perimeter fence, cross fence, livestock water, pivot bridges, etc.).

Key Results of Study

- New grazing revenue from restored wetlands makes the RCPP with VRI profitable under most economic conditions.
- Incorporating crop insurance and a high probability of flooding on the wetland acres reduces the payback period to as little as two years.

Economic Impacts of Wetland Restoration with RCPP

An important factor in choosing to enroll in RCPP is the impact on farm profit (Jones, 2018). The current study used farm-level data for two producers over a four-year period (pre-and post-VRI installation) to evaluate the economic impact of enrolling land in the RCPP. *Table 1* provides a summary of the basic characteristics of the two operations and the cost of the system upgrade.

Payback period (definition): The number of years necessary to recover the investment cost, incorporating the change in the value of money over time

The analysis uses financial and production records for four years from the two operations. The information is used to calibrate a Crop Enterprise Budget model, which allocates the fixed and variable costs of an operation to different activities. The Crop Enterprise Budget model compares the return from a VRI field with a non-VRI field, which is referred to as the net return of VRI. The net return of VRI is the additional income that a producer gets from using VRI. The net return is used to calculate the payback period for the VRI technology (see box). The analysis uses corn production for the 2017 growing season for two agricultural operations in the Rainwater Basin portion of Nebraska. The analysis uses the actual corn prices received, which were \$2.99 and \$3.10 per bushel for Operations 1 and 2, respectively.

This study also uses the discounted payback method to determine the payback period for an investment. The method takes into account a discount rate, which measures how people value money today versus the future. For example, a discount rate of 5% means that someone is indifferent to receiving \$100 today or \$105 next year.

The payback period is calculated based on the difference between the per-acre profit under VRI irrigation and a standard center pivot system using the following equation.

$$Net\ Profit\ (per\ acre) = \frac{Total\ Profit\ (VRI) - Total\ Profit\ (No\ VRI)}{Cropped\ Acres\ (VRI)}$$

Table 1. Characteristics of Operations Evaluated

	Operation 1	Operation 2
Pivot Acres	243 (100 in VRI)	105 (all in VRI)
Proportion of Years with Flooding (2006–2017)	0.91	0.73
Cropping History	Corn	Corn, grassland, Pasture
Full Cost of VRI Upgrade and Support	$92,125	$80,229
Producer Cost for VRI (per VRI Acre)	$138	$115

Table 2. Per-acre net benefit and payback period under alternative scenarios

Scenario		Operation 1	Operation 2
2017 (actual)	Per-Acre Annual Net Profit ($)	$23.00	$58.81
	Payback Period (years)	7.3	2.1
Learning (20% less water applied than 2017)	Per-Acre Annual Net Profit ($)	$29.00	$68.81
	Payback Period (years)	5.6	1.8
VRI and non-VRI acres with same energy source*	Per-Acre Annual Net Profit ($)	$32.37	n/a
	Payback Period (years)	4.9	
Crop insurance and expected loss due to flooding included**	Per-Acre Annual Net Profit ($)	$71.7	$39.1
	Payback Period (years)	2.1	3.3

All results are based on a 5% discount rate and an 85% producer cost-share.

* Operation 1 results for 2017 are based on VRI acres in electricity and non-VRI acres in natural gas.

** Results are based on 75% coverage with indemnities earned 50% of the time.

For example, if the per-acre profit is $34 and $11 for the VRI and non-VRI fields, respectively, the $23 difference ($34–$11 = $23) is attributed to the VRI technology.

Results: *Table 2* provides a summary of the primary results of four scenarios within the study. The first scenario is the actual net profit of VRI in 2017. The estimated net profit VRI for Operation 1 was $23 per acre and $58.81 per acre for Operation 2. If the outcome in future years is the same as 2017, it would take 7.3 and 2.1 years, respectively, for Operations 1 and 2 to recover the 15% cost of the VRI technology not covered by the RCPP program and see an increase in net farm income. Operation 2 earns a higher return than Operation 1 with VRI technology because of higher yields in 2017 and lower VRI costs. These results reflect the 85% cost-share of the RCPP program. The full report (Jones, 2018) includes results at different cost-share levels.

Several factors are not reflected in the 2017 results. Three alternative scenarios are highlighted in *Table 2*. The second scenario in *Table 2* shows the expected profit of VRI technology when producers have time to learn more about using the irrigation prescription software. Since the technology was new to both producers, neither producer used the technology to reduce irrigation water use in the 2017 season. This may be due to high precipitation in 2017, which reduced the need for irrigation inputs. Water use in 2017 was 2.25 and 5 acre-inches per acre for Operations 1 and 2, respectively. Water use in an average year is 7.5 and 6.1 acre-inches per acre.

The second scenario uses 2017 yield and revenue values, but reduces irrigation application by 20% relative to actual applied irrigation inputs. Experimental evidence from researchers suggests that this is a reasonable expectation for adoption of VRI technology when it is fully utilized. Incorporating this potential benefit of VRI reduces the payback period from 7.3 to 5.6 years for Operation 1 and from 2.1 to 1.8 years for Operation 2.

The third scenario in *Table 2* estimates the return and payback period if both the VRI and non-VRI fields are powered using natural gas. Since Operation 1's VRI field is powered with electricity, which is more expensive than natural gas, it reduces the estimated profit of VRI. Analyzing both fields with the same energy source shows that the per-acre profit of VRI increases from $23 to $32.4 per acre, and the payback period decreases from 7.3 to 4.9 years.

The fourth scenario includes the impact of crop insurance on the profit of VRI. Crop insurance is also an important factor in calculating the payback period. Scenarios 1 through 3 in *Table 2* assume that in the absence of the RCPP program, the return on the wetland area would be the same as the non-VRI field. However, those acres have ponding frequencies of 0.91 and 0.73 (i.e., the wetland has at least some flooded area in 91% and 73% of the years during the early spring). Interviews with the producers confirmed that the wetland acres were often the last acres harvested, and that sometimes harvesting those acres was not possible.

Due to the high probability of crop failure or prevented planting, crop insurance is a tool that can provide some revenue for the flooded acres. Thus, the final scenario in *Table 2* shows the payback period when crop insurance is incorporated. A 50% probability of crop loss and 75% crop insurance coverage (total revenue protection) was used on the wetland acres. This reduces the payback period for Operation 1 from 7.3 to 2.1 years. This occurs because with 2017 crop prices and yields, there is an expected loss when crop insurance only covers 75% of total revenue, and there is a high probability of crop failure or prevented planting.

In contrast, Operation 2 earns a positive expected profit on wetland acres, even with crop insurance coverage at 75%. Thus, the payback period for Operation 2 increases from 2.1 to 3.3 years. While this reduces the profit to Operation 2 relative to the no insurance case, a payback period of 3.3 years is still relatively short for typical capital investments.

Other factors that affect VRI payback period: Since the payback period depends on the difference between farm profitability under VRI and under a standard pivot system, many factors affect the payback period. The importance of grazing revenue has already been identified. Thus, the ratio of wetland acres (which can be grazed) to crop acres is a critical factor. A larger wetland area can earn more grazing revenue, which increases the value of the associated crop acres. Higher energy prices will increase the profit with reduced irrigation inputs under VRI, and higher output prices will increase the profit with yield increases.

Summary

Some of the critical parameters and values that affect the payback period for VRI technology are:

- Returns from grazing revenue relative to crop production: When commodity prices are low, the net return from grazing can be higher than from crop production. Incorporating this additional revenue after VRI technology is adopted and fencing is added increases net revenue for a producer.
- Ratio of wetland to cropland: In cases where per-acre grazing revenue is higher than crop revenue, having a larger part of the field restored increases the net revenue of VRI and wetland restoration.
- Frequency of crop loss on the wetland area: A higher frequency of crop loss and/or prevented planting due to flooding in the wetland area increases the net revenue of VRI and wetland restoration.

Differences in these values between locations will affect the economic viability of enrolling in the RCPP program and restoring wetland areas that were formerly in crop production.

Our results show that under a range of realistic parameter choices and scenario designs, it is economically feasible to invest in VRI technology with the RCPP program. The payback period ranges from 2.1 to 7.3 years for the scenarios included. Any payback period in this range is expected to be attractive for a business. However, these payback periods, and the results, are based on a cost-share of 85% for the producer/landowner. If the cost-share decreases significantly below that level, the investment is not likely to be attractive over the scenarios examined in the current study. Alternative scenarios, such as those with high rates for irrigation water, or greater efficiency gains from VRI, will increase the profit of VRI technology adoption at lower cost-share levels.

Future Research: The results presented in this work are based on two operations over a limited period, and thus do not fully represent the range of producers, operation management choices, and economic conditions that exist in Nebraska. It will be important to continue to collect economic data from RCPP participants to understand the full range of economic impacts.

Resources

Jones, Hannah (2018). "An Application of Economics & Environmental Planning: The Impacts of Variable Rate Irrigation Technology on Net Farm Income," Professional Project, Community and Regional Planning Department, University of Nebraska–Lincoln.

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