FIELDPRINT CALCULATOR: A SUSTAINABILITY ANALYSIS IN THE TEXAS HIGH PLAINS

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Abstract

The Fieldprint Calculator was developed by Field to Market: The Alliance for Sustainable Agriculture to assist producers in evaluating their sustainability. Producers can use this tool to compare their operations to county, state, and national averages. The objective of this study was to revisit previous analysis on the relationship between sustainability and profitability and to determine the impact of various irrigation systems and tillage practices on Fieldprint metrics. The data for this project came from irrigated cotton production demonstrations sites associated with the Texas Alliance for Water Conservation located in nine counties across the Southern High Plains. Results show a positive relationship between sustainability and profitability; however, results analyzing the impact of irrigation and tillage on Fieldprint metrics are less clear.

Introduction

The Texas Alliance for Water Conservation (TAWC) is an ongoing demonstration project that began in 2005. The TAWC works with over 20 producers covering over 6,000 acres in nine counties across the Southern High Plains of Texas. Producers involved in the project represent a variety of agricultural production systems including cotton monoculture systems to fully integrated livestock systems, crop rotations, and tillage practices. Producers use furrow irrigation, LEPA, LESA, and MESA center pivot irrigation systems, as well as sub-surface drip (SDI) irrigation systems. TAWC activities are monitored for soil moisture depletion, crop productivity and economic returns. The TAWC has a cotton pilot with the National Cotton Council. Data for the Fieldprint Calculator includes crop production years from 2007-2015, which represents 26 producers, 34 sites, and 193 observations. Field sizes range from 13 acres to 400 acres. Tillage practices include no-till, strip till (minimum till) and conventional tillage.

Field to Market evaluates sustainability based on seven metrics: land use (ac/lb lint), irrigation water use (in/lb lint), energy use (gal diesel/lb lint), greenhouse gas emissions (lbs CO_2/lb lint), soil conservation (tons of soil loss/ac/yr), a soil carbon index, and a water quality index. This study concentrates on the first five sustainability metrics. The soil carbon and water quality indices were excluded from this analysis. The sustainability metrics were converted to indices based on the mean value across all 193 observations. The conversion of the metrics to an index value standardized the units for each metric, allowing for direct comparisons. Figure 1 represents the sustainability indices for the land use, irrigation, energy, greenhouse gas emission, and soil conservation metrics averaged across all sites from 2007 to 2015. These results indicate a relatively flat trend across time, with a slight increase in index values in more recent years. This suggests that TAWC producers are becoming slightly more unsustainable over time. The effects of the 2011 drought are reflected in higher index values, with irrigation use at over 200 index points. The results for 2015 indicate that on average, TAWC producers performed poorly when it came to soil conservation (soil erosion) and very well with regard to irrigation water use.

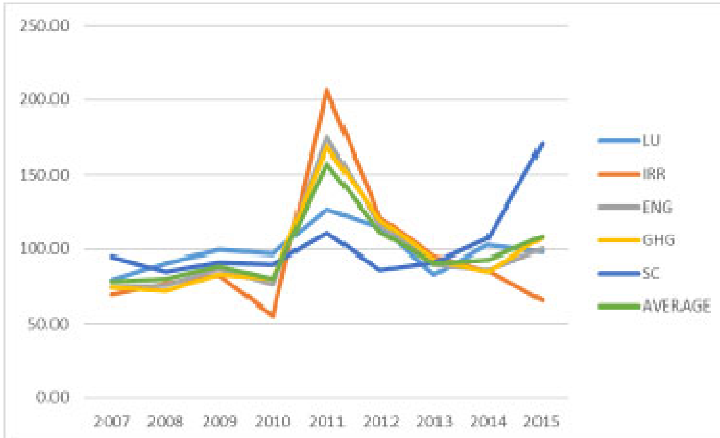

Figure 1. Values of Sustainability Indices for Each Metric from 2007 to 2015.

The objective of this study was to build on the analysis of Stokes et al. (2014) and Gillum and Johnson (2015) by evaluating the relationship between sustainability and profitability using the most recent TAWC data and to determine the impact of irrigation systems and tillage practices on the calculation of the metrics estimated by the Fieldprint Calculator.

Materials and Methods

A multiple regression analysis was performed to determine the relationship between sustainability and profitability. Profitability was measured by gross margin (total revenue minus variable cost) and the land use, irrigation, and energy metrics were included as independent variables. The square of energy use was also included. Dummy variables were used to represent each crop production year from 2008-2015, with 2007 being the base production year. Greenhouse gas emissions were removed from the model due to high correlation with the energy use metric. The soil conservation index was not significant, and was therefore excluded from the model. The multiple regression model is specified as:

$$GM = \beta_0 + \beta_1 * LU + \beta_2 * IRR + \beta_3 * EG + \beta_4 * EG2 + \beta_5 * D8 + \beta_6 * D9 + \beta_7 * D10 + \beta_8 * D11 + \beta_9 * D12 + \beta_{10} * D13 + \beta_{11} * D14 + \beta_{12} * D15$$

where: *GM* is gross margin, *LU* is the land use index, *IRR* is the irrigation index, *EG* is the energy use index, and *EG2* is the square of the energy index. The D8-D15 variables represent dummy variables for each of the 2008-2015 crop production years.

The following regression was used to determine the impact of the irrigation technologies and tillage practices on each of the metrics:

$$Index = \beta_0 + \beta_1 * FUR + \beta_2 * LEPA + \beta_3 * MESA + \beta_4 * SDI + \beta_5 * MinT + \beta_6 * NT$$

where: *Index* is a representative for each of the metrics: land use, irrigation, energy, greenhouse gas emissions, and soil conservation, *FUR*, *LEPA*, *MESA*, and *SDI* are dummy variables to represent each of the irrigations systems, *MintT* is a dummy variable for minimum tillage and *NT* is a dummy variable for no till. Two-tailed t-tests were performed at the 90% significance level to determine if there were any statistical differences in the means between all independent variables.

Results and Discussion

The results of the multiple regression analysis using gross margin is presented in Table 1. The results indicate that all of the variables with the exception of the 2009, 2014 and 2015 crop years were statistically significant. The land use, irrigation, and energy metrics have the appropriate signs suggesting a positive relationship between sustainability and profitability.

Table 1. Multiple Regression Results.

Variable	Coefficients	Standard Error	T-value	Pr> |t|
Intercept	999.20	55.63	17.96	0.000
Land Use	-3.98	0.40	-10.05	0.000
Irrigation	-1.43	0.45	-3.14	.002
EG	-2.95	0.82	-3.60	0.000
EG2	0.01	.002	4.66	0.000
2008	-102.75	50.47	-2.04	0.043
2009	-69.80	47.72	-1.46	0.145
2010	169.17	47.12	3.59	0.000
2011	506.74	57.65	8.80	0.000
2012	495.49	47.08	10.53	0.000
2013	280.85	46.38	6.10	0.000
2014	-36.89	45.75	-0.81	0.421
2015	-52.07	56.99	-0.91	0.362

To assess the impact of each irrigation system and tillage practice had on each of the metrics, a regression analysis using the metrics as dependent variables and dummy variables for furrow, LEPA, MESA, SDI irrigation systems, using LESA as a base irrigation system. Also included in the analysis were dummy variables for strip till (minimum tillage) and no-till with conventional tillage as the base. Tables 2, 4, 6, 8, and 10 in the Appendix represent the regression results for land use, irrigation, energy, greenhouse gas emissions, and soil conservation indices. Tables 3, 5, 7, 9, and 11 in the Appendix represent the significant t-test results. In Table 2, results for land use indicate furrow and mesa are statistically significant, however, these results are to be interpreted with caution as the explanatory power of these models are about 10%. LEPA, SDI, and minimum tillage have negative coefficients, suggesting they are more sustainable systems when it comes to land use. Furrow and MESA have large positive coefficients, suggesting they are the least sustainable. Minimum tillage outperforms conventional and no till. The significant t-tests for land use show LEPA, LESA, and SDI are significantly different on average than compared to furrow. Furrow has higher means than compared to the other systems, suggesting it is a less sustainable system. LEPA, LESA, and SDI are also significantly different than MESA at the mean. Tables 4 and 5 represent the multiple regression analysis and t-tests for irrigation use. LEPA and SDI have negative coefficients, suggesting they are the most sustainable irrigation systems. Minimum till and no till have positive coefficients, suggesting that conventional tillage is the most sustainable for irrigation use. The only significant t-test was between furrow and SDI under conventional tillage. With regard to energy use in Tables 6 and 7, SDI had the only negative coefficient. Again, minimum and no till had positive coefficients, suggesting conventional tillage is more sustainable. Tables 8 and 9 represent results for greenhouse gas emissions. The MESA irrigation system and minimum tillage had negative coefficients. The significant t-test is Table 9 was between LEPA and SDI. Results for soil conservation are presented in Tables 10 and 11. All irrigation systems with the exception of MESA had negative coefficients, with furrow being the most negative. This was the only situation where no-till outperformed the other tillage practices. Results for t-tests show a significant difference at the mean between furrow and LESA, furrow and MESA, LEPA and MESA and MESA and SDI.

Summary

A multiple regression analysis used data from the TAWC in the Texas Southern High Plains to assess the relationship between profitability and sustainability suggests there is a positive relationship between gross margin and sustainability. If a producer was to become more sustainable, they may become more profitable. However, results analyzing the relationship between irrigation systems and tillage practices and the metrics are unclear. TAWC producers have demonstrated LEPA irrigation systems can be just as effective as SDI if managed correctly. We would have expected to see no-till practices as the most sustainable tillage practice but, it was only evident in the soil conservation metric.

Acknowledgements

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References

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Appendix

Table 2. Land Use Index

Variable	Coefficients	Standard Error	T-value	Pr>|t|
Intercept	95.43	6.65	14.36	0.000
FUR	27.93	11.05	2.53	0.012
LEPA	-6.81	9.07	-0.75	0.453
MESA	21.21	9.20	2.31	0.022
SDI	-5.06	8.44	-0.60	0.550
Min Till	-0.91	7.20	-0.13	0.899
No Till	3.92	10.12	0.40	0.699

Table 3. Significant T-tests for Land Use

Variables	Mean	Variance	N	df	T-test
FUR	123.36	2143.43	22	26	3.32
LEPA	88.62	428.00	36		
FUR	123.36	2143.43	22	33	2.48
LESA	95.74	1338.61	51		
FUR	123.36	2143.43	22	34	2.95
SDI	90.33	1389.86	49		
LEPA	88.62	428.00	36	40	-2.59
MESA	117.27	3763.56	34		
LESA	95.74	1338.61	51	49	-1.84
MESA	117.27	3763.56	34		
SDI	90.33	1389.86	49	50	2.28
MESA	117.27	3763.56	34		

Table 4. Irrigation Use Index

Variable	Coefficients	Standard Error	T-value	Pr>|t|
Intercept	98.05	10.59	9.26	0.000
FUR	33.98	17.61	1.93	0.055
LEPA	-5.20	14.45	-0.36	0.720
MESA	-4.91	14.66	-0.34	0.738
SDI	-12.83	13.44	-0.95	0.341
Min Till	8.98	11.45	0.78	0.434
No Till	4.81	16.13	0.30	0.766

Table 5. Significant T-tests for Irrigation Use

Variables	Mean	Variance	N	df	T-test
C FUR	132.03	13686.24	22	23	2.10
C SDI	78.58	835.43	36		

Table 6. Energy Index

Variable	Coefficients	Standard Error	T-value	Pr>|t|
Intercept	97.13	9.97	10.82	0.000
FUR	26.88	14.92	1.80	0.073
LEPA	1.22	12.25	0.10	0.920
MESA	6.50	12.43	0.52	0.602
SDI	-11.19	11.39	-0.98	0.327
Min Till	1.64	9.71	0.17	0.866
No Till	6.87	13.67	0.50	0.616

Table 7. Significant T-tests for Energy

Variables	Mean	Variance	N	df	T-test
FUR	124.01	6912.52	22	26	3.32
SDI	86.59	866.66	49		
LEPA	99.89	1073.60	36	71	1.93
SDI	86.59	866.66	49		

Table 8. Greenhouse Gas Emissions Index

Variable	Coefficients	Standard Error	T-value	Pr>|t|
Intercept	97.72	9.83	10.04	0.000
FUR	6.98	16.35	0.43	0.670
LEPA	10.14	13.41	0.76	0.451
MESA	-7.73	13.61	-0.57	0.571
SDI	0.91	12.48	0.07	0.942
Min Till	-4.63	10.64	-0.44	0.664
No Till	9.34	14.97	0.63	0.534

Table 9. Significant T-tests for Greenhouse Gas Emissions

Variables	Mean	Variance	N	df	T-test
C FUR	99.01	1049.93	36	69	1.75
C SDI	87.20	799.86	49		

Table 10. Soil Conservation Index

Variable	Coefficients	Standard Error	T-value	Pr>|t|
Intercept	109.12	10.50	10.39	0.000
FUR	-26.10	17.46	-1.50	0.137
LEPA	-22.59	14.33	-1.57	0.117
MESA	24.93	14.54	1.71	0.088
SDI	-22.25	13.32	-1.67	0.097
Min Till	0.92	11.37	0.08	0.936
No Till	-7.79	15.99	-0.49	0.627

Table 11. Significant T-tests for Soil Conservation

Variables	Mean	Variance	N	df	T-test
FUR	83.01	533.25	22	63	-1.87
LESA	108.20	8008.47	51		
FUR	83.01	533.25	22	39	-3.06
MESA	132.51	8057.93	34		
LEPA	86.09	795.10	36	39	-2.88
MESA	132.51	8057.93	34		
MESA	132.51	8057.93	34	44	2.76
SDI	86.75	1841.87	49		