COST ANALYSIS OF MANURE SUBSURFACE DRIP SYSTEM ON CALIFORNIA DAIRIES

Prepared by Sustainable Conservation

Abstract

This report provides an assessment of the costs related to the installation, operation and maintenance costs of a manure subsurface drip irrigation system compared to flood or conventional drip irrigation systems. With cost-share support through the NRCS EQIP, the change in net income of switching from flood to manure SDI becomes positive, but remains negative for a switch from flood to conventional SDI. The analyses presented here should help a grower evaluating a switch from flood to manure SDI.

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Contents

1.0 Introduction

The study documented and analyzed the differences in capital costs (equipment and installation) of conventional sub-surface drip irrigation (conventional SDI) and manure sub-surface drip irrigation (manure SDI). For the operations and maintenance costs, the differences were calculated for switching from flood irrigation to manure SDI and from flood irrigation to conventional SDI. The final analysis of the overall change in net income focused on switching from flood (the most common irrigation type on California dairies) to conventional SDI or manure SDI.

The conventional SDI and manure SDI systems capital costs were based on quotes and the operations and maintenance costs were based on actual costs incurred. Most dairies using conventional SDI do not have automation. In contrast, the manure SDI manufacturer recommends automation for all manure SDI systems. In order to best inform real-world decision-making, a non-automated conventional SDI system was compared with an automated manure SDI system. While comparing a non-automated system to an automated system introduced differences in costs solely due to automation, that approach seemed to be the most informative for a dairy considering a switch from current standard practices to the manure SDI system.

The cost study is intended to provide cost information to support growers in conducting their own analysis of switching to manure SDI, taking into account their specific circumstances. The data was based on the costs associated with one dairy that utilizes flood irrigation, conventional SDI and manure SDI. Only direct, irrigation-related costs were considered. The boundary of the analysis includes equipment, materials, and labor needed for:

- Connecting the system to the source of fresh water and to pre-separated manure effluent (flood and manure SDI only).
- Pumping and filtering
- Delivering water and nutrients to the fields.

Costs related to land preparation and pre-system manure separation were excluded from the analysis but are important cost factors for producers to consider. The report excluded them from the analysis because the magnitude of those costs will vary greatly from dairy to dairy, based on their current equipment and practices and a range of options to choose from when switching systems.

Likewise, manure separation is an important factor because the performance of a manure SDI system will be strongly influenced by the efficiency of pre-separation, as noted in a separate technical report, "Nutrient and Salinity Management Guidance for Manure Subsurface Drip Irrigation Systems."

While the report does not include land preparation and manure separation costs due to the high variability, they are important costs to consider. Dairy producers are encouraged to do their own calculations based on their situation and include these costs in their analyses.

2.0 Capital Cost Analysis

2.1 Scope of Analysis

The capital cost analysis compares the purchase and installation of a manure SDI system with automated controls to a conventional SDI system without automated controls. The study does not include capital costs for installing a flood irrigation system because it is assumed that dairies already have a flood irrigation system, so the decision would be whether to switch from flood to conventional SDI or to manure SDI. Therefore, the capital cost analysis focuses on the relative costs of purchasing and installing conventional SDI and manure SDI systems.

2.2 Methodology

2.2.1 Sources of Cost Information

Cost information for the capital cost analysis was sourced from a 2019 quote for an automated conventional SDI system, including installation labor, at current market value and a second 2019 quote for an automated manure SDI system, including installation labor, at current market value.[1] Both quotes were provided by the same irrigation dealer serving California's San Joaquin Valley farmers and were for the same 144 acre field. An alternative option was to use the actual costs of a conventional SDI system installed in 2016, but as prices have changed since then, the quotes at current market costs were chosen.

The capital cost analysis utilized the costs from the quotes, because they represented current market value for both equipment and labor, rather than a historical price or a grant-subsidized cost.

2.2.2 Removing Automation Costs

Most dairies using conventional SDI do not have automation, as demonstrated by the conventional SDI system studied for the project. Given that, the analyses needed to remove the automation capital costs from the quote for an automated conventional SDI system in order to provide an accurate comparison to current standard practice.

The automation features included in the quote for the automated conventional SDI system were identified and removed. The variable frequency drive (VFD) costs were replaced with a regular pump, based on estimates provided by the

[1] The quotes for the automated conventional SDI and automated manure SDI were used in an earlier analysis submitted to the USDA-NRCS as part of the CIG.

farm manager and the SDI system manufacturer. The automation system, including the accessories, were eliminated. No replacements were needed for a non-automated conventional system, as they are solely to the benefit of automation. All other costs were kept the same.

2.3 Capital Costs Analysis and Discussion

The manure SDI system cost $1,169.56 more per acre to purchase and install than the conventional SDI system (Table 1). The capital costs for manure SDI were higher than conventional SDI in each category, with the main differences in pump materials, filter materials, and the installation of both.

Table 1. Capital costs per acre for a manure SDI system and a conventional SDI system, from quotes of a 144 acre field.

$/acre	Manure SDI, automated	Conventional SDI, no automation	Difference
Pump materials and installation	$ 657.40	$ 271.26	$ 386.14
Filter materials and installation	$ 1,061.10	$ 332.78	$ 728.32
Field materials and installation	$ 1,705.15	$ 1,650.05	$ 55.09
Total	**$ 3,423.65**	**$ 2,254.09**	**$ 1,169.56**

The cost for pump materials and installation is $386.14 higher per acre for manure SDI than conventional SDI. The difference is due to the Variable Frequency Drive (VFD) and equipment and infrastructure associated with the VFD, which are necessary to efficiently manage the flow of manure effluent.

The cost of filter materials and installation is $728.32 higher per acre for manure SDI than conventional SDI. The greatest difference is the doubled filter capacity. Ten sand media filters would be used for manure SDI versus five for conventional SDI for the 144 acre field. These additional media filters are needed to handle the greater solids contained in manure effluent compared to fresh water. The second largest cost difference was the automation systems in the manure SDI system, including the control system and the mixing valve.

The cost of field materials and installation is $55.09 more per acre for manure SDI than conventional SDI. The manure SDI system has an automatic control which was not needed for the non-automated conventional SDI system.

The use of automation affects both the capital cost and the operations and maintenance costs of the manure SDI system. Investing in automation increased capital costs, but reduced some operating costs (see the Operations and Maintenance section below). While not common on California dairy irrigation systems, automation may become more common as producers seek to reduce operational costs such as labor. Each farm will need to determine the right balance of automation and cost for their situation.

The life expectancy of the manure SDI system is 20 years for above ground components like pumps and filters; 15 years for manifolds and sub-mains; and 10 years for buried drip lines, all according to the manufacturer. The sand media in the filters is typically replaced every 5 years, depending on the fresh water and manure effluent pumped through the system. The life expectancy of the system will be strongly influenced by the quality of the original materials, the operating environment, and maintenance practices. Life expectancy is important for calculations of depreciation costs of the system (see the Change in Net Income section below).

3.0 Operations and Maintenance Analysis

This analysis compares the operating and maintenance costs of manure SDI to both flood system and conventional SDI.

3.1 Scope of Analysis

The operations and maintenance analysis only includes costs incurred during silage corn production because the irrigation systems were run substantially more – and more consistently – than for winter forage. Each year, some of the winter forage's water needs would be met through precipitation. However, the amount of precipitation is highly variable from year to year in the San Joaquin Valley, so the need for use of the manure SDI system for winter forage is also highly variable. Since irrigation system use – and the associated costs – for growing winter forage will vary quite a bit by location and year, it did not seem as helpful to analyze winter forage costs.

3.2 Methodology

3.2.1 Calculations of Costs

Data for the operations and maintenance analysis were collected from a combination of direct measurements from the field trials and farm records. The summary of total costs and the prices used to calculate those costs are listed in Table 2 and

Table 3.

The water applied cost for the flood system refers to costs associated with the volume of blend of fresh water and manure effluent applied to the field. The farm manager provided the total volume of water applied by flood irrigation and the cost per acre-foot volume of water[2], based on the irrigation district rates.

[2] The same cost per acre-foot was used for all of the cost of water applied calculations.

The total cost for the water applied per acre was calculated by multiplying the volume of water applied per acre and the cost per acre-foot volume of water.

The water applied cost for the conventional SDI system refers to costs associated with the volume of fresh water applied to the field with periodic injections of UN32 synthetic fertilizer. The conventional SDI system irrigated a field which is part of a 325 acre block, with both alfalfa and corn acres. The farm manager provided separate volumes of water applied to each crop, including germination by sprinklers. The total cost for the water applied per acre was calculated by multiplying the volume of water applied per acre and the cost per acre-foot volume of water.

The water applied cost for the manure SDI system refers to costs associated with the volume of fresh water and manure effluent that was applied to the field, as measured by the flowmeters built into the system. The volume of water back flushed from the manure SDI system was sent to the lagoon for later use and was not included in the water applied metric. The total cost for the water applied per acre was calculated by multiplying the volume of water applied per acre and the cost per acre-foot volume of water.

The energy cost for the flood system refers to costs associated with the energy used by the pumps to move water onto the field. The farm manager selected a representative pump for the flood field and provided the pump's gallons per minute rate and the energy utilization costs. The acre-inches pumped was calculated multiplying the gallons per minute and the number of minutes the pump was run. The energy cost per acre-inch pumped for the flood field was calculated by dividing the acre-inches pumped by the total energy utilization costs. Total per acre energy cost for the flood field was calculated by multiplying the energy cost per acre-inch by the acre-inches applied per acre in the conventional SDI field.

The energy cost for the conventional SDI system refers to costs associated with the energy used by the pumps to move water into the system, through the system, and onto the field as well as electricity needed to run other components of the conventional SDI system. Costs were calculated based on data provided by the farm manager. The conventional SDI field is part of a 325 acre block on a single electrical meter. The energy cost per acre-inch pumped was calculated by dividing the total electrical cost by the volume of water applied to the entire 325 acre block. Total per acre energy cost for the conventional SDI field was calculated by multiplying the energy cost per acre-inch by the acre-inches applied per acre in the conventional SDI field.[3]

The energy cost for the manure SDI system refers to costs associated with the energy used by the pumps to move water into the system, through the system, and onto the field as well as electricity needed to run other components of the manure SDI system. Costs were calculated based on data provided by the farm manager and data collected in the field. The energy cost per acre-inch was calculated by dividing the total energy cost from the manure SDI system by the volume of water applied. Total per acre energy cost for the manure SDI field was calculated by multiplying the energy cost per acre-inch by acre-inches applied per acre in the manure SDI field.

The labor costs include labor for operations, maintenance, and germination. The costs were provided on a per acre basis for each field by the farm manager.

The cost of materials applied included a variety of materials and the costs, provided by the farm manager. The cost per acre for the UN-32 synthetic fertilizers were calculated by multiplying the gallons of amendment applied per acre and the cost per gallon. The costs per acre for the pop-up fertilizer, the biological amendment, the peracetic acid (for line maintenance) and the sprinkler equipment rental were provided by the farm manager.

[3] Although water for germination was applied through diesel pumps, the same cost per acre-inch was used for germination water as was used for the rest of the water applied through the conventional SDI system.

Table 2. Calculated total costs for each operations and maintenance cost considered.

Type	Description	Unit	Flood	Conventional SDI	Manure SDI
Yield	Value of Replacement Forage	$/ton	$ 50.00	$ 50.00	$ 50.00
Capital Costs	Full Capital Cost of System	$/acre	$ -	$ 2,254.09	$3,423.65
	Depreciation Expense: Full Cost	$/acre	$ -	$ 225.41	$ 342.36
	EQIP Cost Share	$/acre	$ -	$ 1,050.00	$2,871.00
	Depreciation Expense: with EQIP	$/acre	$ -	$ 120.41	$ 55.26
Water	Cost of Water	$/acre ft	$ 75.00	$ 75.00	$ 75.00
	Cost of Water	$/acre in	$ 6.25	$ 6.25	$ 6.25
Energy	Pumping Cost	$/acre in	$ 1.60	$ 6.90	$ 6.19
Labor	Labor, germination	$/acre	$ -	$ 45.00	$ 45.00
	Labor, operation	$/acre	$ 93.50	$ 16.85	$ 9.50
	Labor, maintenance	$/acre	$ -	$ 58.67	$ 62.25
Materials	UN 32 Liquid Fertilizer	$/gal	$ 1.70	$ 1.70	$ -
	Pop-up Fertilizer	$/acre	$ 34.00	$ 34.00	$ -
	Biological Amendments	$/acre	$ 21.00	$ 21.00	$ 21.00
	Peracetic Acid	$/acre	$ -	$ 16.50	$ 20.00
	Equipment Rental (sprinklers)	$/acre	$ -	$ 50.00	$ 50.00

Table 3. Prices used in operations and maintenance calculations.

Type	Description	Unit	Flood	Conventional SDI	Manure SDI
Acres	Acres Tested	Acres/Field	70.00	75.00	74.00
Yield	Yield	Tons/acre	25.00	29.10	30.10
Water Applied	Germination	Acre-in per acre	-	4.10	4.10
	Backflush	Acre-in per acre	-	-	-
	Main Season Water Applied	Acre-in per acre	41.04	24.85	25.84
Fertilizer	Synthetic Fertilizer	Gallons/acre	12.00	80.00	-

3.2.2 Comparison of Costs

Each of the cost areas was compared to one another, both as absolute differences between systems and in terms of the percent of the total for the individual system. The absolute differences provide the quantitative differences between systems, identifying areas of major difference. The percent of the total provides context for the relative impact of each cost category to the total of a given system, helping identify major cost drivers of that system.

3.3 Results and Analysis

The cost differences between irrigation systems were analyzed. The major cost drivers and sources of differences were identified. The costs and the comparisons are listed in Table 4 and the relative contribution to costs are summarized in

Table 5.

Table 4. Operations and maintenance costs for each system and the cost differences.

		Flood	Conventional SDI	Manure SDI	Conventional SDI vs. Flood	Manure SDI vs. Flood	Manure SDI vs. Conventional SDI
Water	Water Applied	$ 256.50	$ 180.94	$ 187.13	$ (75.56)	$ (69.38)	$ 6.19
Energy	Electrical and Pumping	$ 65.66	$ 199.75	$ 185.37	$ 134.09	$ 119.71	$ (14.38)
Labor	Sprinkler Germination	$ -	$ 45.00	$ 45.00	$ 45.00	$ 45.00	$ -
	System Operations	$ 93.50	$ 16.85	$ 9.50	$ (76.65)	$ (84.00)	$ (7.35)
	System Maintenance	$ -	$ 58.67	$ 62.25	$ 58.67	$ 62.25	$ 3.58
	Total Labor	**$ 93.50**	**$ 120.52**	**$ 116.75**	**$ 27.02**	**$ 23.25**	**$ (3.77)**
Materials	UN 32 Liquid Fertilizer	$ 20.40	$ 136.00	$ -	$ 115.60	$ (20.40)	$ (136.00)
	Pop-up Fertilizer	$ 34.00	$ 34.00	$ -	$ -	$ (34.00)	$ (34.00)
	Biological Amendment	$ 21.00	$ 21.00	$ 21.00	$ -	$ -	$ -
	Peracetic Acid	$ -	$ 16.50	$ 20.00	$ 16.50	$ 20.00	$ 3.50
	Equipment Rental (sprinklers)	$ -	$ 50.00	$ 50.00	$ 50.00	$ 50.00	$ -
	Total Materials	**$ 75.40**	**$ 207.50**	**$ 41.00**	**$ 132.10**	**$ (34.40)**	**$ (166.50)**
Total Costs		**$491.06**	**$ 708.71**	**$530.25**	**$ 217.65**	**$ 39.18**	**$ (178.46)**

Table 5. Percent of total operations and maintenance cost for each system.

	Flood	Conventional SDI	Manure SDI
Water applied	52.23%	25.53%	35.29%
Energy costs	13.37%	28.19%	34.96%
Labor, total	19.04%	17.01%	22.02%
Labor, germination	0.00%	6.35%	8.49%
Labor, operation	19.04%	2.38%	1.79%
Labor, maintenance	0.00%	8.28%	11.74%
Materials	15.35%	29.28%	7.73%
Total	**100.00%**	**100.00%**	**100.00%**

3.3.1 Results and Analysis: Conventional SDI vs. Manure SDI

The total costs of operations and maintenance calculated for conventional SDI was $708.71 per acre versus $530.25 per acre for manure SDI. The $178.46 per acre difference in cost is primarily represented by the difference in synthetic fertilizer use. Small cost savings from manure SDI were also seen with energy costs and labor, attributed to automation features of the manure SDI system.

The water applied was similar for both systems: the conventional SDI field applied 28.95 acre-inches of water, similar to the 29.94 acre-inches applied for manure SDI. The associated costs per acre are similar as well: $180.94 per acre for conventional SDI and $187.13 per acre for manure SDI. Results were expected to be close given the similarity in technologies, varieties, soil type, and field setup. Though water applied may not differentiate the systems much from each other, it is a major cost driver for each system (25.53% of total costs studied for conventional SDI and 35.29% for manure SDI).

The energy costs were not much different, but were surprising. The costs for conventional SDI was $6.90 per acre-inch of water compared to $6.19 per acre-inch for manure SDI. The $0.71 lower cost for the manure SDI system was not expected. The manure SDI system was expected to have higher energy costs than the conventional SDI because of design differences: two pumps versus one, double the per acre filtration capacity of the conventional SDI to filter manure, and more frequent filter backflushing to avoid clogging.

The lower energy cost may be due to the manure SDI system using VFD control, which saves energy by adjusting the pump motor speed in order to meet irrigation demand. The conventional SDI pumps which do not have the VFD controls on the other hand, run continuously at maximum speed. The relatively small differences in energy cost per acre inch therefore appear to be the combined effects of manure SDI VFD controls and the conventional SDI's inefficient pumping design.

Overall, the energy costs are a major cost driver for each system: conventional SDI at $199.75 per acre and manure SDI at $185.37 per acre (28.19% and 34.96% of total costs studied, respectively). Given that they are relatively close, however, energy costs do not differentiate the two systems.

The labor costs were $120.52 per acre for conventional SDI (17.01% of total costs) compared with $116.75 per acre for manure SDI (22.02% of total costs). The $3.77 per acre lower cost of manure SDI probably reflects the labor-saving features incorporated into the manure SDI design (e.g. automation). To better understand the differences, labor was separated for further analysis: pre-sprinkler labor, irrigation labor and maintenance labor.

Both the conventional SDI and manure SDI systems used sprinklers for germination, so the labor costs ($45.00 per acre) were the same for germination labor (conventional SDI 6.35% of total costs; manure SDI 8.49% of total costs). Germination with a flood pre-irrigation is possible with either system, which may reduce costs compared to sprinkler germination; data were not available to make that assessment.

The cost per acre for labor to operate the system was $16.85 per acre for the conventional SDI (2.38% of total costs) versus $9.50 per acre for manure SDI (1.79% of total costs). The $7.35 per acre lower cost for the manure SDI system can be attributed primarily to automation of field valves needed to irrigate different sections of the field for the manure SDI system. Irrigation labor for the manually operated conventional SDI, by contrast, requires numerous field trips and thus a higher irrigation labor cost.

The cost per acre of labor to maintain the system was $58.67 per acre for conventional SDI (8.28% of total costs) and $62.25 per acre for manure SDI (11.74% of total costs). The main activities for both were leak repairs and line flushing. The lower maintenance cost for the conventional SDI may reflect maintenance being conducted while operating irrigation manually, so some of those costs were counted as operational labor. It may also reflect additional maintenance trips required for the manure SDI system to keep the lines clear from clogging due to the higher biological activity of manure effluent.

Automation appears to be the main reason for labor savings of the manure SDI system. Overall, labor does not represent a major difference between the two systems.

The cost of materials differed between conventional SDI ($207.50 per acre) and manure SDI ($41.00 per acre). The conventional SDI field had a synthetic liquid fertilizer applied at a cost of $136.00 per acre. The manure SDI field fertilized with manure effluent instead of synthetic fertilizer. The manure effluent was assumed to be available at no cost since it is readily available at the dairy. A biological amendment was used in the both the conventional SDI and manure SDI fields at a cost of $21.00 per acre to increase the rate of manure nitrogen mineralization. The farm manager noted that using biological amendments was a farm-specific practice and not all dairies use them.

The farm manager reported one additional application of peracetic acid for line maintenance in the manure SDI system compared to the conventional SDI system. The introduction of manure effluent in drip irrigation lines was expected to result in a higher than normal biological activity, requiring additional drip line cleaning compared to conventional SDI systems.

The $166.50 lower cost difference of materials between conventional SDI and manure SDI systems accounted for the largest share of the total difference in cost per acre between both systems. The difference in cost was expected to be large, because the manure SDI system doesn’t require synthetic fertilizer, a costly commodity. Materials represent 29.28% of total costs for the conventional SDI system while representing only 7.73% of total costs for the manure SDI system. Synthetic fertilizer represents a major difference between a conventional SDI and manure SDI system and could be considered a major cost driver for conventional SDI.

3.3.2 Results and analysis: Flood irrigation vs. Manure SDI

The total cost of operations and maintenance calculated for the flood system was $491.06 per acre compared to $530.25 per acre for manure SDI system. Manure SDI was $39.18 per acre more costly to operate than the flood system. The main savings from the manure SDI system are from the reduced water applied; however, the manure SDI requires more energy and labor. Using flood instead of sprinklers to germinate could reduce labor costs for manure SDI.

The water applied differed for flood and manure SDI. The flood irrigated field applied 41.04 acre-inches of water compared to 29.94 acre-inches for the manure SDI system. The 11.10 acre-inch difference in water applied was expected and is characteristic of the higher water use efficiency of manure SDI systems. Therefore, the associated costs per acre were also quite different: $256.50 per acre for flood (52.23% of total costs) and $187.13 per acre for manure SDI (35.29% of total costs). The cost of water is an important cost driver, especially for the flood system, and the $69.38 per acre difference is important for deciding between the two systems. If the cost of water continues to increase, water-efficient irrigation systems such as manure SDI could become more attractive investments.

The energy cost was $1.60 per acre-inch for the flood system and $6.19 per acre-inch for the manure SDI system. The difference was expected, as the energy needed to lift water for flood is lower than the energy need to pressurize and pump fluid through manure SDI. Overall, energy costs were $65.66 per acre for flood (13.37% of the total costs) compared to $185.37 per acre for manure SDI (34.96% of the total costs). Energy costs are a major driver for the manure SDI system but not for the flood system, and energy is a major source of cost differences between the two systems.

The labor costs were $93.50 per acre for the flood system and $116.75 per acre for the manure SDI system. The $23.25 per acre difference includes the labor used for sprinkler irrigation to germinate corn with the manure SDI system. During the project, growers had experimented with pre-plant irrigation using the drip lines, which did not work well. The alternative that did work was either flood pre-irrigation or sprinkler germination; if flood pre-irrigation is used instead of sprinkler germination, that could reduce labor costs for manure SDI.

Flood irrigation involves a labor-intensive ditch tending process that requires extensive field travel in order to open and close berms using a shovel. Flood systems reported no maintenance labor, because the process of ditch tending also involves irrigation maintenance. Maintenance labor of the manure SDI system is mostly gopher control and line flushing, an activity not incurred in flood irrigation.

Overall, labor was a smaller cost driver for the flood system (19.04%) than for the manure SDI system (22.02%) and was not a major cost difference between the systems.

The cost for materials were $34.40 per acre different for flood and manure SDI. Overall, the cost of materials for the flood system was $75.40 per acre (15.35%) compared to $41.00 per acre (7.73%) for the manure SDI system.

The flood field received manure effluent, small amounts of two types of synthetic fertilizer, and a biological amendment to improve plant availability of manure effluent nutrients. The manure SDI field only received the biological amendment. The biological amendment is a farm management decision that other dairies may not choose to make; the analyses included the costs of that biological amendment because they were relevant for the dairy studied. Overall, the cost of materials was not a major cost difference between flood and manure SDI.

3.4 Summary and Conclusions of Operations & Maintenance Cost Analysis

The manure SDI system was compared with conventional SDI and flood irrigation systems. The key differences identified were:

1. Manure SDI utilized manure effluent as an alternative to synthetic fertilizer, contributing largely to an overall $178.46 per acre reduction in operations and maintenance costs studied compared to conventional SDI.
2. Overall manure SDI cost $39.18 per acre more compared to flood irrigation, with manure SDI requiring substantially more energy than flood.
3. When comparing flood to manure SDI, the reduced water applied represents an impressive savings of water and the associated costs of purchasing that water.

Changes in water, energy and labor costs will each be important factors for growers considering a switch from flood to manure SDI. In California, both water and labor prices are likely to increase over time. Water scarcity and groundwater regulation is driving water prices up. And labor costs are expected to increase due to a combination of new minimum wage regulations and current labor shortages.

For the producer considering a switch from flood to manure SDI or conventional SDI, the primary driver is likely increased water efficiency. There are advantages to switching, but it's a decision that each grower needs to evaluate for their specific dairy. One consideration is the change in net income, including under different water prices.

4.0 Change in Net Income Analysis

4.1 Scope of Analysis

While most dairies currently use flood irrigation, a growing number are assessing whether they should switch to more efficient irrigation to respond to reductions in water allocations and increase in water costs. The capital costs and operations and maintenance costs were combined in a change in net income analysis to help producers compare the systems. A positive change in net income indicates that the financial benefits of switching systems outweigh the costs, while a negative change in net income indicates that the costs outweigh the financial benefits. It is important to note that this analysis is based solely on the costs and fields studied and that there are also non-financial aspects that should be considered. Dairies should complete their own investment analyses, using the information provided as a reference.

The change in net income analysis focused primarily on the differences expected directly as a result from a switch from flood to manure SDI, although switching from flood to conventional SDI was also assessed. In both situations, the analysis included a comparison with and without EQIP cost share support.

Water is a key cost driver that is projected to become more scarce and expensive, both due to changing weather patterns and water policies. Plus, there are a wide range of prices for water, depending on geography, water rights, etc. In order to consider a range of water prices, current or projected, the analysis also looked at how a range of water prices could affect change in net income between a flood and a manure SDI system.

4.2 Methodology

4.2.1 Change in Net Income

The costs are the same as described in the capital costs and operations and maintenance analyses. The depreciation of the equipment needed for each system was calculated as a straight line depreciation, without any salvage value, over a ten year period. The specific lifespan on the system varies, so ten years was a middle ground between estimated twenty year life expectancy of the hardware manifolds and the shorter-lived pumps and electrical components.

Yield value was included for the revenue. Yields on all fields refers to tons of crop harvested, adjusted to 70% moisture, and were provided by the farm manager. The average value of $50 per ton for the region was used, based on data provided by the growers. The revenue per acre was calculated by multiplying the yield per acre by the price per ton.

The difference for each cost per acre were calculated between manure SDI and flood. The sources of increases and decreases in net income were noted and the total change in net income for each comparison was calculated.

4.2.2 Scenario Analyses: Increasing Price of Water

Scenarios were created by substituting different costs of water to calculate how they impacted change in net income between a flood and manure SDI system. A cost range of $0 to $1,000 per acre-foot was set to represent a wide range of potential water costs, including future extreme costs that may arise due to droughts and regulations. In the scenarios, only water costs were varied and all other costs held constant. For simplicity sake, the scenarios also held the price per ton of corn constant, although it would be expected that the price of corn would increase to some degree as water costs increase.

4.3 Results and Analysis

4.3.1 Yields

Yield for the flood system was 25.00 tons per acre ($1,250.00 per acre) compared with 30.10 tons per acre ($1,505.00 per acre) for the manure SDI system. The 5.00 ton per acre higher yield for the manure SDI system was expected and can be attributed to the "yield bump" observed in conventional SDI systems on other crops. With SDI systems, the plant receives a continuous supply of water and nutrients, which optimizes plant development. Plants in the flood irrigated system, on the other hand, are adversely impacted by the continuous cycles of moisture stress and water logging associated with periodic irrigation events. The higher yields for manure SDI system resulted in a $255.00 per acre revenue increase compared to flood irrigation.

The yields of the conventional SDI and manure SDI fields were comparable at 29.10 and 30.10 tons per acre. Revenue is therefore similar: conventional SDI $1,455.00 per acre and $1,505.00 per acre. The result was expected given that the precision application of water and nutrients associated with SDI systems generally result in consistent yields regardless of the nutrient source.

4.3.2 Change in net income – Flood to Manure SDI

The change in net analysis focused on costs that are different as a result of switching irrigation systems. Overall, a switch from flood to manure SDI results in a $176.55 per acre decrease in net income (Table 6). The increased revenue from improved yields and the decreased costs – including those due to lower water applied – do not compensate for the cost increases. Energy and sprinkler germination-related costs represent the major increases in operations and maintenance costs. However, the main source of the decreased change in net income is depreciation, representing the capital costs of the system spread out over a ten year period.

With the availability of cost-share support with EQIP, switching from flood to manure SDI becomes a favorable investment (Table 7). The cost-share funding of $2,871.00 per acre for manure SDI decreases the depreciation of the system greatly, such that manure SDI has a $110.55 per acre increase in net income as compared to flood.

Table 6. Comparison of changes in net income for switching from flood to manure SDI, without cost-share support from NRCS EQIP.

Flood -> Manure SDI (without EQIP)			
Increases in Net Income		**Decreases in Net Income**	
Increases in Revenue		**Increases in Costs**	
ITEM	AMOUNT	ITEM	AMOUNT
Yield	$ 255.00	Energy for system and pumping	$ 119.71
Total Increased Revenue	$ 255.00	Labor for sprinkler germination	$ 45.00
Decreases in Costs		Labor for system maintenance	$ 62.25
ITEM	AMOUNT	System maintenance materials	$ 20.00
Water applied	$ 69.38	Equipment rental (sprinklers)	$ 50.00
Labor to operate system	$ 84.00	Depreciation	$ 342.36
UN 32 Liquid Fertilizer	$ 20.40		
Pop-up Fertilizer	$ 34.00		
Total Decreased Costs	$ 207.78	Total Increased Costs	$ 639.32
Total Increased Net Income	**$ 462.78**	**Total Decreased Net Income**	**$ 639.32**
Annual Per Acre Increase (Decrease) in Net Income =	**($176.55)**		

Table 7. Comparison of changes in net income for switching from flood to manure SDI, with cost-share support from NRCS EQIP.

Flood -> Manure SDI (with EQIP)			
Increases in Net Income		**Decreases in Net Income**	
Increases in Revenue		Increases in Costs	
ITEM	AMOUNT	ITEM	AMOUNT
Yield	$ 255.00	Energy for system and pumping	$ 119.71
Total Increased Revenue	$ 255.00	Labor for sprinkler germination	$ 45.00
Decreases in Costs		Labor for system maintenance	$ 62.25
ITEM	AMOUNT	System maintenance materials	$ 20.00
Water applied	$ 69.38	Equipment rental (sprinklers)	$ 50.00
Labor to operate system	$ 84.00	Depreciation	$ 55.26
UN 32 Liquid Fertilizer	$ 20.40		
Pop-up Fertilizer	$ 34.00		
Total Decreased Costs	$ 207.78	Total Increased Costs	$ 352.22
Total Increased Net Income	**$ 462.78**		**$ 352.22**
Annual Per Acre Increase (Decrease) in Net Income =	**$110.55**		

4.3.3 Change in Net Income – Flood to Conventional SDI

Another option for dairies considering switching to more precise irrigation is conventional SDI. Like manure SDI, a switch from flood to conventional SDI without EQIP support is not a favorable investment (Table 8). Compared to flood to manure SDI, switching from flood to conventional SDI has a greater decrease in net income ($288.06 per acre). Even with cost-share support with EQIP, the flood to conventional SDI switch still shows a decrease in net income of $183.06 (Table 9).

Table 8. Comparison of changes in net income for switching from flood to conventional SDI, without cost-share support from NRCS EQIP.

Flood -> Conventional SDI (without EQIP)			
Increases in Net Income		**Decreases in Net Income**	
Increases in Revenue		**Increases in Costs**	
ITEM	AMOUNT	ITEM	AMOUNT
Yield	$ 205.00	Energy for system and pumping	$ 134.09
Total Increased Revenue	$ 205.00	Labor for sprinkler germination	$ 45.00
Decreases in Costs		Labor for system maintenance	$ 58.67
ITEM	AMOUNT	UN 32 Liquid Fertilizer	$ 115.60
Water applied	$ 75.56	System maintenance materials	$ 16.50
Labor to operate system	$ 76.65	Equipment rental (sprinklers)	$ 50.00
		Depreciation	$ 225.41
Total Decreased Costs	$ 152.21	Total Increased Costs	$ 645.27
Total Increased Net Income	**$ 357.21**	**Total Decreased Net Income**	**$ 645.27**
Annual Per Acre Increase (Decrease) in Net Income =	**($288.06)**		

Table 9. Comparison of changes in net income for switching from flood to conventional SDI, with cost-share support from NRCS EQIP.

Flood -> Conventional SDI (with EQIP)			
Increases in Net Income		**Decreases in Net Income**	
Increases in Revenue		Increases in Costs	
ITEM	AMOUNT	ITEM	AMOUNT
Yield	$ 205.00	Energy for system and pumping	$ 134.09
Total Increased Revenue	$ 205.00	Labor for sprinkler germination	$ 45.00
Decreases in Costs		Labor for system maintenance	$ 58.67
ITEM	AMOUNT	UN 32 liquid fertilizer	$ 115.60
Water applied	$ 75.56	Peracetic acid	$ 16.50
Labor to operate system	$ 76.65	Equipment rental (sprinklers)	$ 50.00
		Depreciation	$ 120.41
Total Decreased Costs	$ 152.21	Total Increased Costs	$ 540.27
Total Increased Net Income	**$ 357.21**	**Total Decreased Net Income**	**$ 540.27**
Annual Per Acre Increase (Decrease) in Net Income =	**($183.06)**		

4.3.4 Change in Net Income – Summary

The costs of switching means that, based purely on costs collected for this analysis, it is not a favorable investment to switch to manure SDI without EQIP support. The business case to switch from flood to conventional SDI is even weaker, regardless of EQIP support. However, producers likely have costs that vary from those collected for this analysis, and there are other considerations – such as water availability and expected future costs of water – which could impact producer investment decisions. Current EQIP support makes the switch from flood to manure SDI a more favorable investment.

4.3.5 Different Prices of Water

The purpose of this analysis is to provide a range of possible scenarios for growers to use when evaluating their specific situation. While yields and costs vary year-to-year and grower-to-grower, the scenarios modeled assumed that yields and corn prices would be the same for each system as seen in the 2019 season, as well as all costs except water. Individual growers can take these analyses and substitute data from their operations to support decisions they make about whether or not they should switch to manure SDI.

As the price of water reaches about $211.81 per acre-foot, the change in net income from switching from flood to manure SDI without EQIP support becomes zero (Figure 1). That is, after that price point, manure SDI is a cost-effective investment as compared to flood. As discussed above, switching from flood to manure SDI with EQIP support is already a cost-effective investment at the current cost of water at the dairy studied ($75.00 per acre-foot).

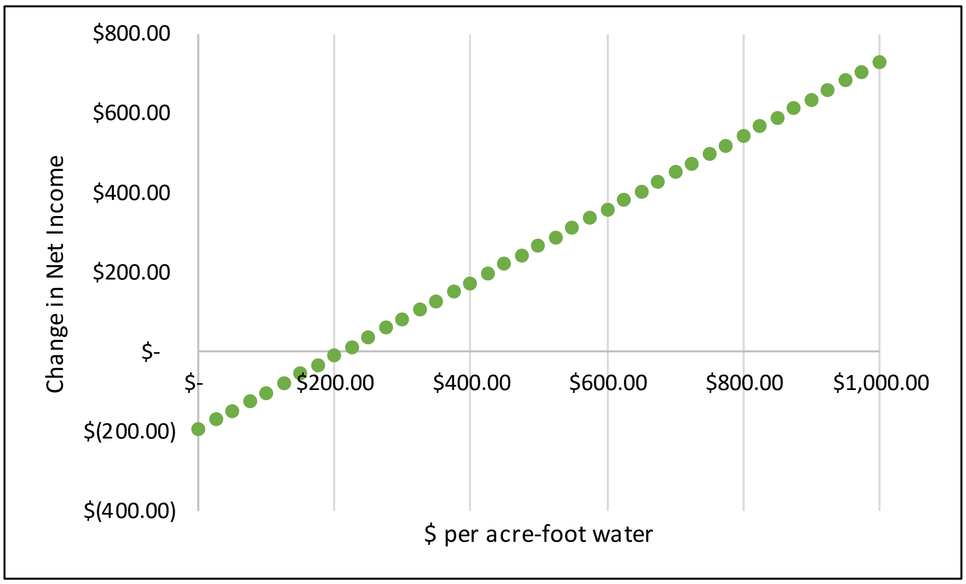

Figure 1. Change in net income for a switch from flood to manure SDI at different prices per acre-foot of water.

4.4 Other costs and scenarios not considered

Yield variation was not included in the analysis. Yields will vary, of course, dairy by dairy and year to year. The 25 tons per acre yield in flood and 30 tons per acre yield in the conventional SDI and manure SDI seemed fairly typical for dairies in California. Some dairies will aim for a higher yield or some seasons may produce lower yields than these, which would affect the change in net income. Similarly, the value of replacement forage will also vary year to year as well as dairy by dairy, depending on a variety of factors.

The analyses suggests synthetic fertilizer and other amendment costs would have small impact on change in net income of switching from flood to manure SDI. Still, similar to yields, the costs of materials may change over time and vary by dairy. The data needed to model fluctuations in synthetic fertilizer and other amendment prices were not readily available, so they were not included as a scenario. Each dairy has their own approach to synthetic fertilizers and other amendments; some may not supplement manure effluent at all and others might use more supplements than the model dairy presented.

Based on the relatively small differences in labor costs between flood and manure SDI, labor costs would have to increase dramatically before they were a major driver of costs when considering a switch from flood to manure SDI.

5.0 Overall Conclusions

Based on change in net income, a switch from flood to manure SDI results in a negative change in net income; however, if EQIP cost-share support is available and utilized, a switch from flood to manure SDI does result in positive change in net income. A switch from flood to conventional SDI, on the other hand, has a negative change in net income regardless of EQIP support. As the price of water increases, the change in net income from switching from flood to manure SDI eventually becomes positive, even without EQIP support.

Several costs were purposely excluded from the analysis, due to limited available data and to reduce the complexity of the analysis. Growers are encouraged to take the analyses and apply their specific context to evaluate whether a switch from flood to manure SDI is a good investment for their operation.