1) Who is at risk? In 3-5 sentences, describe what groups (besides Farmer Jones herself) might be at risk of loss regarding farming corn? Identifying the scope (boundaries on size) and scale (potential severity or impact) that the risks have is important for understanding what needs to be characterized. Identify 2-3 other groups at different levels (e.g., local, state, national, and international levels) within your response who may have a loss related to corn crops.

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2) Defining the Risks? In 3-5 sentences, describe the risk to Farmer Jones and her farm itself. What kind of quantified values can you identify that could be valuable numerical ways of characterizing the risks of crop loss? You may refer to the available datasets and prompts for ideas, but also consider what kind of data or numbers you would think would be the most helpful (even if that data does not exist in the provided datasets–sometimes you have to dream about what data you would like to find to drive you to fruitful data searches in your own project).

- Farmer Jones has the risk of a reduced income, a sudden loss of funds, incurring debts from commercial insurance and needs, loss of crop quality, loss of customer trust, and an increase in customer turnover. A reduced income and losses in funds can be measured alongside debts, through not only a static quantitative monetary figure but a change in value over time, etc. dollars lost/month. A loss in crop quality can be measured through many factors, specifically the deviation from expected protein:fiber:carb proportions corn usually has, any loss or unhealthy increase in biomass, and the scale of microbial and bacterial diversity. Finally, loss of customer trust and increase in customer turnover can be identified by the changes in tipping rates, customer return rates, and frequency of customer visits (per customer).

3) Identify Risk Mitigation Strategies? In 3-5 sentences, identify a risk mitigation strategy that Farmer Jones may choose to mitigate risk for her farm in each of the three categories and describe how you think each of these three strategies might be able to help mitigate those losses. Is there a strategy category that seems to be more or less feasible than another category to pursue? No calculations needed.

- A risk mitigation strategy in the insurance category that Farmer Jones may choose to use is selling her corn over the course of the year, as long as she is confident that it won't go bad or lose quality. If she sells her corn at the current price in the future, she will make a profit if the price of corn goes down. A risk mitigation strategy related to modifying outcomes that she may choose to employ could be to warn consumers ahead of time that corn may go bad - this would decrease their negative reactions. She could also stockpile corn in multiple places, which would decrease the loss from all corn going bad from one contaminated location. A behavior change that Farmer Jones could employ would be to make sure that the corn is stored in a secure place, which would decrease the risk of it going bad. Beyond caring corn harvested, Farmer Jones can actively employ

drought-preventative methods and invest in more water to care for their crops in potentially arid weather.

4) In 2-3 sentences each, identify which of the three categories of data identified in the Actuarial Process Guides are provided in each of the tabs of the scenario's attached dataset. Be specific in identifying the column (or description) from the dataset or the scenario description in your response. Explain (at a high level) what information and insights these datasets can provide.

- Cause of Loss Smith Co tab - The cause of Loss Smith Co tab shows data that helps categorize risk and potential outcomes. This is because the data shows the causes of the loss, when the loss accrued, and what type of loss it is. This allows insurance companies to categorize the risks and predict potential outcomes.
- Corn Planting Costs tab - The corn planting cost table defines the historical range of severity of potential loss. This is seen through the 9-year layout of varying price ranges.
- Corn Harvest Costs tab - This tab explores Historical Frequency. However, it also measures the range of the loss- but it doesn't specify loss ranges per category. The data overall mostly shows historical data about net losses apart from category.

5) What is the average total cost per acre for corn production (2016-2025) and average total cost per bushel (2016-2025)?

- The average total cost per acre for corn production between the years 2016 and 2025 is $548.11. We reached this average total cost by summing the average costs/acre of each year within each category
- The average cost per bushel of corn was $3.06, which was identified through the average bushel cost (total cost/expected bushel count) for each year 2016 through 2025

6) What is the average assumed yield (bushels per acre) for 2016-2025?

The average assumed yield from 2016-2025 was 178.5 bushels per acre. Extending this to all 345 acres, we also know that she could harvest up to 61582.5 bushels in one season.

7) **Planting Costs for Farmer Jones.** For Farmer Jones, if all 345 of her farm's acres are planted, using the average cost per acre found above in #5, what is the anticipated total cost for planting in the next season?

- If Farmer Jones planted and used all 345 of her farm's acres, she would have to pay costs of $194,030.94.

8) **Range for Anticipated Costs.** Critical Thinking: Realistically, is this value found in #7 higher, lower, or "about right" for the actual anticipated costs? What might be a realistic "range" (i.e., reasonable minimum and maximum values for the planting costs)? Why? Explain in 1-2 sentences (additional computations are optional).

- The value found in #7 depicts the average value for the anticipated cost per acre seems "about right". Even though the standard deviation of some categories, such as machinery cost per acre and seed/chemical cost per acre, is higher, the magnitude of the numbers is also higher, concluding that the average is " about right" with an anticipated range of $ 430.532 to $665.69 or 548.11 $\pm$ $117.58 (the sum of all the individual characteristic deviations).

9) **HARVEST EXPECTATIONS FOR FARMER JONES.** For Farmer Jones, if all 345 acres of her farm are harvested with the average yield found above in #6, what is the projected total yield (in bushels)?

- The projected total yield in bushels is equal to 61,582.5. This is found by multiplying the average number of bushels per year per acre by the total number of acres in the farm that are harvested.

10) **CORN SALE PRICES EXPECTATIONS.** Find the average cash corn prices for each month (Jan - Dec) for 2016-2025 and note them in a table (shown below).

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
$4.35	$4.43	$4.47	$4.55	$4.65	$4.73	$4.66	$4.46	$4.34	$4.21	$4.20	$4.35

11) **TRENDS IN CORN PRICES.** Identify 2-3 trend(s) that you notice regarding cash corn prices (i.e., over the years, within a calendar year, or within a marketing year) in the Corn Harvest Prices tab that may impact when a farmer wishes to sell their crop. Explain why you believe the trend is noteworthy or why it occurs in 1-2 sentences each (no new computations required)

- The highest average corn prices are in July, and the lowest average prices are in November. Additionally years 2022-23 had a spike in prices, which could indicate a lack in corn harvests at the time. This implies that farmers should sell more in July to get more money, but they might be harder to sell then as well.

12) **HARVEST EXPECTATIONS WITH OCTOBER SALE.** If Farmer Jones harvests and sells her entire harvest (found in #9) using the 2016-2025 average corn sale price for October (as found above in #10), what would her revenue be? What would her profit be (using planting costs found in #7)?

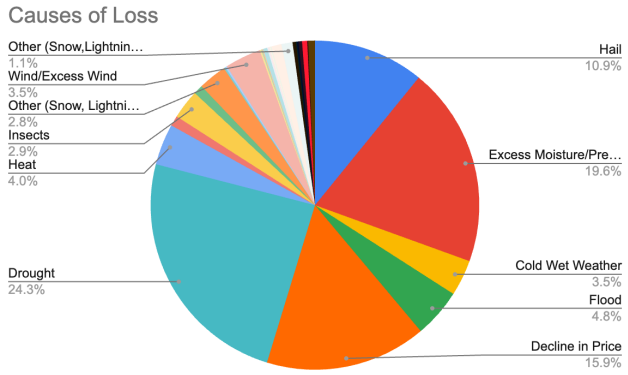
The revenue would be $259,262.33. The planting cost would be $194,030.94.
Given this, the total profit would be $65,201.39. The October sale price is significantly lower compared to the midsummer values, which shows selling trends after harvest hurting families by decreasing their monthly profit.

13) **HARVEST EXPECTATIONS WITH OPTIMAL SALE.** If Farmer Jones can store her harvested corn and wait for the optimal sale (using the 2016-2025 averages found in #10), what could she anticipate for maximum revenue? Identify the month and revenue amount.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
$4.35	$4.43	$4.47	$4.55	$4.65	$4.73	$4.66	$4.46	$4.34	$4.21	$4.20	$4.35

The best month to sell for maximum revenue would be June, and the revenue amount would be $291,285.23. The difference between the best-selling month (June) and the October sale shows a loss of $32,000, showing how timing alone substantially affects the profit.

14) **Creation of a data visual.** Create a chart (e.g., pie chart, bar chart, etc.) that summarizes, labels, and categorizes the causes of loss for claims for 1994-2024. Include the chart in your response.

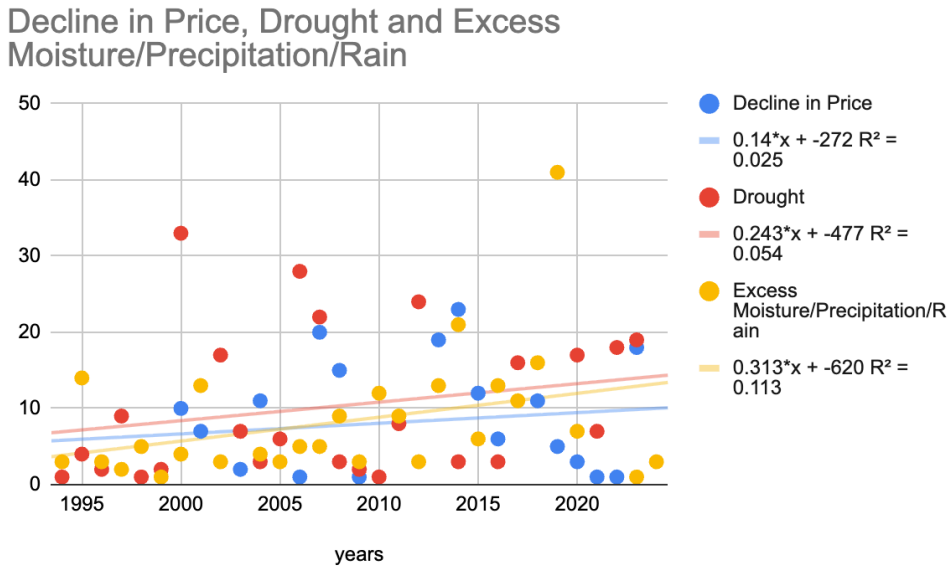


15) **Top causes of loss and their impacts.** Based on the data visual you created, what appear to be the top 3 leading causes for a loss claim? Why? Explain in 1-2 sentences (include the frequency of these claims in your response). How does this information on the top 3 causes of loss inform Farmer Jones as she plans for future risks to her farm in Smith County? Explain in 2-3 sentences.

- The top three leading causes of loss are excess rain, drought, and price decline. This is because, based on the season, farms in the Midwest are threatened by both bouts of drought, while very quickly killing crops and overwatering, which can do the same. Declines in investments and prices caused by economic depressions accelerate these

damages by reducing a farm's capability to maintain itself. From the year 1984-2024, the data even showed that drought accounted for 288 cases, decline in price 188, and excess moisture 233. This informs Farmer Jones that preventative measures must be put in place towards these three risks, and efforts must be made to save money in the event of an economic depression. Examples of preventative measures can include larger greenhouses, reserve water supplies, and crop shades.

16) **LINEAR REGRESSION:** Conduct a linear regression on the frequency of loss claims for the top 3 causes of loss claims identified in prompt #15 for 1994-2024. Provide the plot (plot all 3 on the same chart), regression equations, and correlation coefficients in your response.



17) **Cause of loss trends and patterns:** Referring to your regression conducted above in #16, describe 2-3 trends or patterns you observe in causes of loss over the historical timeframe (e.g., maximums, minimums, patterns, co-occurrence of causes of loss, etc.). Offer a short, plausible explanation for why you believe the trend occurs (1-2 sentences each).

- Excess moisture/rain, drought, and decline in price as causes of consistently increasing over the course from 1994 to 2024. While there is little linear correlation strength, as indicated by the R^2 values, the average figures generally increase, allowing us to make this observation. This can be because of an increase in farms resulting in an increase of losses, as the total number of agricultural assets grows
- Variability greatly increases as the years increase from 1994 to 2024. This can be attributable to an increase in crop concentration, causing local events to have greater spreading damages
- Minimum values generally increased over time, which may be a result of both a greater concentration and a greater number of crops. With more crops, the probability of any loss is increased. With greater concentrations, those few disasters will spread to nearby crops

quickly, specifically occurrences of drought or overwatering. These two factors combined increase the minimum number of crop losses over time.

18) **ASSUMPTION EVALUATION**. In 1-2 sentences, evaluate and assess the reasonableness and rational basis for the assumption below. Note why the assumption is necessary or reasonable to simplify the topic to model, or if the assumption goes beyond what is reasonable. Assumption: "Nationally, approximately 91% of farm producers have farm insurance. We assume that the rate of farm producers who have farm insurance is the same for Smith County, Iowa. "

The assumption is reasonable, although it does not account for the change in risks local to Smith Country versus the entire national farming industry, which motivates the acquisition of farm insurance. This assumption, however, is key in the development of a fruitful model, as it allows national farmer insurance data to be used in our local context, increasing the width of further decisions and assumptions we can make.

19) **ASSUMPTION DEVELOPMENT.** Write your own 1-2 sentence assumption that would pertain to this real-world scenario for math model creation (it may be an assumption about the scenario's data, problem statement, possible outcomes, math model structure, or other pertinent factor). Provide a 1-2 sentence justification explanation as to why the assumption is needed and reasonable.

The environmental causes of crop loss will increase each year in variability, developing a stronger need for environmental protection as a risk-preventative tactic. This assumption is strongly validated by the data pertaining to the three main causes of loss (overwatering, drought, and price decrease) over the years 1984-2024, which displayed an average increase in losses for each variable over time.

20) **FREQUENCY OF CLAIMS DUE TO DROUGHT.** From the Cause of Loss tab (1994-2024), what is the annual average frequency of claims made for drought for farmers in Smith County, Iowa?

The annual average frequency of claims made for drought for farmers in Smith County, Iowa, is 10.28 claims per year. The average shows that while the drought is not a frequent event over a year, its severity makes it economically significant.

21) **EXPECTED VALUE OF LOSS DUE TO DROUGHT.** For Farmer Jones, what is the expected value of crop loss due to drought in a given year (based only on the actual cost for Farmer Jones to plant)? Refer to the planting costs found in #7 for Farmer Jones' severity of

Loss.

- Given that the expected probability that any given farmer in Iowa will experience a drought is 0.00350, and the planting cost for farmer Jones (severity) is $194,030.94, the expected value of loss is $679.11

22) **AVERAGE ANNUAL INSURANCE PAYOUT DUE TO DROUGHT.** What is the average annual insurance payout per policy for farmers in Smith County due to drought (use the Cause of Loss tab)? What could this mean for Farmer Jones as she considers her risks due to drought? Explain in 2-3 sentences

- The average annual insurance payout due to drought would be $36.94, because when you multiply the average annual drought claims per year by the average payout per drought claim, you obtain the annual payout. Then, to find the payout per policy, we would divide by 2936, giving us $36.94.

23) Farmer Jones is considering purchasing and installing a grain silo to store harvested corn for long periods of time. She is considering a 100,000 bushel grain storage silo that would cost $250,000 to purchase and install (labor included).

- What risk(s) might Farmer Jones mitigate by installing a grain silo? What kind of risk mitigation strategy is this (behavior change, modifying the outcomes, insurance)? Explain in 1-2 sentences.
    - Weather damage, pest and insect damage, spoilage, mold, and reduced handling costs. These are modifying the outcome strategies, changing what happens to the corn after harvest.
- Identify 2-3 advantages or "pros" of installing a grain silo as a risk mitigation strategy. Explain and justify your response in 2-3 sentences (no new computations necessary).
    - The silos are sturdy, airtight structures that prevent loss of crops. Furthermore more the modern gilo has aeration, ventilation, temperature, and humidity regulation that prevent mold from growing, protecting the crops. Additionally, also protects the crops from rodents and animals.
- Identify 2-3 disadvantages or "cons" to installing a grain silo as a risk mitigation strategy. Explain and justify your response in 2-3 sentences (no new computations necessary).
    - Silos can pose multiple safety hazards, including machinery failures and accidents, dust explosions, and exposure to toxic gases. Owning a silo can also be very expensive, with all the operational costs and maintenance fees.

24) Based on the fact that drought seems to be a major cause of loss, Farmer Jones is exploring the option to install an irrigation system for her entire farm. Details for the system she is

exploring are included below. For this scenario, we assume that she has ample groundwater access for the pumps and does not have to purchase water access rights.

- Installation Cost: The system would require pumps and permanent piping, which is anticipated to be $1,500 per acre for labor and materials.
- Usage Cost: Once installed, per-acre pumping costs are projected to be $58 per acre for energy usage for the season and an additional $30 per acre per season for maintenance and repairs.
- Projected impact: Based on conversations with neighboring farmers who have installed irrigation systems on their corn farms, also in Smith County, it is projected that Farmer Jones could anticipate a yield of 270 bushels of corn per acre by using the irrigation system.

Identify the installation costs and annual operating costs of the irrigation system for Farmer Jones' farm. What is the anticipated annual corn harvest yield (in bushels) with the irrigation system? If Farmer Jones were to sell her entire crop upon harvesting in October, what is the anticipated revenue for this anticipated harvest with the irrigation system (use the 2016-2025 average corn sale price for October as found above in #10)?

The irrigation costs $1500/acre to install, and costs $88/acre annually to maintain. If Farmer Jones were to sell her entire crop upon harvesting in October, she would make $389,999.1 in revenue, not profit, from the corn alone (assuming she used all 343 acres of farmland).

The U.S. The Department of Agriculture's Risk Management Agency offers a variety of insurance plans available for specific commodities, including corn. Farmer Jones is considering purchasing a Revenue Protection crop insurance policy. This type of policy would provide a guarantee against the undesirable outcome in which anticipated crop yields are lower than projected (due to natural causes), as well as a guarantee against the undesirable outcome in which the sale price at harvest is lower than the projected sale price when the policy was purchased earlier in the year (thus protecting against a drop in revenue). Several types of insurance policies exist, and the premiums (payments that the farmer would need to make to the insurance company) would be cheaper or more expensive depending on what is included in the coverage of the policy. Equations

Guarantee per acre = (projected yield) x (coverage percentage) x (higher of projected or harvest price)

Actual Revenue per acre = (actual yield) x harvest price

Insurance Payout (only triggered if the guarantee is greater than the actual) = guarantee per acre – actual revenue per acre

Conditions Farmer Jones is considering for a scenario outlining a price decline:

- Farmer Jones is considering a policy with 85% coverage that has a premium cost of $25 per acre. For the scenario that Farmer Jones is considering: the approved yield is the same

as the actual yield (computed by you in #6), the agreed-upon projected price is $5.20 per bushel of corn, and At harvest, the actual price was $4.39 per bushel of corn.

25) Using the equations and conditions outlined above: Find the revenue "guarantee per acre" with 85% coverage. Find the "actual revenue per acre." Use the values found above. If the insurance payout is triggered, compute the insurance payout per acre and total insurance payout. If the insurance payment is not triggered, explain why not (in 1-2 sentences).

Revenue "guarantee per acre"=(projected yield) x (coverage percentage) x (higher of projected or harvest price)=(178.5)*(0.85)(5.2)*=788.97 dollars/acre

Revenue "Actual revenue"=(actual yield) x harvest price=178.5*4.39=783.62 dollars/acre

Because the actual revenue is lower than the guarantee per acre, insurance is triggered. The insurance payout=guarantee-actual revenue=788.97-783.62=5.35 dollars/acre

26) While Revenue Protection can address the risk of lower yields than anticipated, Farmer Jones is specifically interested in exploring how Revenue Protection can be used to mitigate the risk of a drop in price (if she was only interested in mitigating risk of lower yields, she could purchase the cheaper Yield Protection insurance). Identify the total cost of the annual premium for Farmer Jones' farm for the Revenue Protection plan outlined above. Based on the analysis conducted here on Revenue Protection, would you recommend that Farmer Jones purchase revenue protection crop insurance to protect against a drop in price or potentially rely on Yield Protection insurance only? Why or why not? Explain in 2-3 sentences (additional computations optional).

The total cost of the annual premium for Farmer Jones' farm for the revenue protection plan=dollars/acre*total acres=25*345=$8625 annually

However, the total payout is expected to be 1845.75

So the real cost of Revenue Protection is $6779.25 to the farmer. Based on the data concerning all protections, we know that in the past, the average annual premium for yield protection was $1298.15/policy for an average of 2.26 policies, indicating a total annual cost of $2932.85. Since this is much lower than the real cost of the annual premium to the farmer, and the total expected insurance payout from Revenue protection is lower than this, we can logically conclude that using Yield protection is the best choice.

27) Irrigation System Impact: Based on the data available to Farmer Jones, other corn farmers in Smith County who have installed an irrigation system like the one she is considering have found that their chance of loss due to drought has dropped to 0.2% in any given year. If Farmer Jones installs the irrigation system as outlined in Prompt #24 above, what is her expected value of loss due to drought (with severity of loss being the cost of planting found in #7)?

Guarantee per acre = (projected yield) x (coverage percentage) x (higher of projected or harvest price)
Actual Revenue per acre = (actual yield) x harvest price
Insurance Payout (only triggered if the guarantee is greater than the actual) = guarantee per acre – actual revenue per acre
0.002*avg drought costs:194,030.94.
=**388 dollars**

28) **COMPARISON OF EXPECTED VALUE OF LOSS.** Compare the expected value of loss with the irrigation mitigation strategy (what you just found in #27 above) to the expected value of loss without mitigation measures that you computed in #21. Is this expected value of loss a noteworthy improvement or not? Explain in 1-2 sentences and justify your answer with relevant supporting computations.

Expected Value without mitigation
EV = frequency x severity
EV = 0.00350 x 194,030.94 = $679.11
EV with irrigation (probability drop to 0.2%)
EV = 0.002 x 194,030.94 = $388.06
The irrigation system lowers the expected drought loss from $679.11 to $388.06, which is a significant reduction of $291.05 or a 42.9% decrease. The irrigation system allows for the mitigation of drought loss, ensuring the safety of crops and profit.

Total insurance payout: $1,845.75 (Question 25)

Expected Insurance payout without irrigation:
0.0035 x 1,845.75 = $6.46
Expected insurance payout with irrigation
0.002 x 1,845.75 = $3.69
The EV of actual planting loss without insurance is $679.11, which is reduced to $388.06 when the irrigation system is added. The EV of the insurance payout (what the insurance

company is expected to pay) is only $6.46, which is further reduced to $3.69 with the irrigation system.

Net expected loss for Farmer Jones if she had insurance:
No irrigation: 676.11 - 6.46 = $672.65
With irrigation: 388.06 - 3.69 = $ 384.37

This exemplifies why the expected insurance payout is small relative to the full planting severity expected value. It is due to the insurance payout per event being small in this scenario, so the insurance doesn't cover the planting costs' expected value.

29) **PROFIT TRAJECTORY WITH IRRIGATION** What is the anticipated profit for the first year after utilizing the described irrigation system (assuming the planting costs as found in #7)? What implication does this have for a timeframe projection of profitability with an irrigation system? Explain and justify your response in 3-5 sentences with any supporting computations necessary.
profit=revenue-costs=
acrs(acral revenue-(plan rate+setup+irrigation rate))-other constant costs(if any)
=270*(178.5*(4.6)-(548.112+88)-270(1500)=-355053.24

=270*178.5*4.6 - 345(548.112+88+1500)=221697-

When including installation costs, the farm loses 355053.24 dollars in its first year. From that point, they can profit 49946.76 dollars annually, making them take 8 years to break even and continue profiting at that point. So while it is profitable, even in a minimum loss scenario, it takes close to a decade to break even a moderate amount of profit.

30) **SHOULD THE IRRIGATION SYSTEM BE RECOMMENDED?** Identify 1-2 advantages or compelling reasons to install the irrigation system and 1-2 drawbacks or possible consequences of installing the irrigation system. Based on your analysis, would you recommend that Farmer Jones invest in the irrigation system for her farm? Why or why not? Explain in 3-5 sentences and justify with any relevant computations and values.

Advantages:
With the irrigation system recommendation, there is a larger lift in yield with much higher annual operating profit. The irrigatied yield (270 bushels per acre) increases the total revenue to about $392,161.50 and yields a yearly profit of 167,770.56 which is higher compared to the baseline profit of $65, 231.39 without the irrigation system.

Additionally the irrigation system reduced the drought EV in terms of loss, with the EV dropping from $679.11 to $388.06, saving around $291 for the expected value of loss, and the net expected loss after the expected insurance payout would further drop $388.06 to $384.37 per event which reduces the downside risk.

Disadvantages:
The high upfront cost of the installation would be $517,500, which creates a large negative cash flow in year 1 if paid upfront (around -349,729.44 within the first year of installation). Additionally, the annual operating cost of the system would add $30,360 per year, which must be paid regardless of the market price and the yield outcome. So, if the market prices fall, the operating cost will reduce the profit made for Farmer Jones in a given year.

Recommendations
The Better Call Us All team recommends that Farmer Jones invest in an irrigation system if 1. She can finance the installation at reasonable terms, including loans, subsidy, or cost-share, so the high upfront cost does not create an absurd short-term cash stress, and 2. She expects yields and prices to stay near the averages assumed in the scenario. Under these two conditions, the irrigation yields an incremental annual profit of around $102,539, breaking even in approximately 5 years, which is very reasonable for a multi-year investment for capital agricultural assets.