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COST OF IRRIGATION OWNERSHIP AND OPERATING COSTS
through Irrigation Budgets for South Georgia

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These irrigation budgets, developed by University of Georgia Cooperative Extension, are estimates of the irrigation costs of a center pivot irrigation system located in southeast Georgia. Our intention is to provide flexible, user-friendly irrigation budgets with default values. That being said, the variation among different farm conditions can impact investment costs and annual costs associated with irrigation; users are suggested to modify these default values and customize their budgets according to their specific field conditions. Please consult your irrigation providers for properly designed center pivot systems that match well production to achieve your irrigation goals. This should serve as a generalized user guide for irrigation budgets and provide guidance for adjusting the default values in the budgets.

Overview

Irrigation is widely used for managing production risk in row crop production in south Georgia. While irrigation systems are likely to increase crop yield, there are additional costs associated with their ownership and operation. Irrigation budgets developed by UGA Extension help producers in estimating total investment costs, annual ownership costs, and annual operating costs. Four irrigation budgets were developed in Microsoft Office Excel: *65 Acres Electric Powered Center Pivot Irrigation Budget*, *65 Acres Diesel Powered Center Pivot Irrigation Budget*, *160 Acres Electric Powered Center Pivot Irrigation Budget*, and *160 Acres Diesel Powered Center Pivot Irrigation Budget*. The diesel powered center pivot has a gearhead system, while the electric powered center pivot has a power unit. These irrigation budgets are available to download at the UGA Department of Agricultural and Applied Economics Extension Budgets website (https://agecon.uga.edu/extension/budgets.html).

Inputs needed to tailor the budget to your farm

As shown in Figure 1, the irrigation budgets were created with default values for the type of crop, type of irrigation scheduling method, acreage covered, average time for full coverage, average application rate, and the annual acre-inch applied. Growers can replace these default values with their farm-specific information for each field to estimate their own irrigation costs. The acreage covered and the average time for full coverage depend upon the number of towers, the length of each span, and the pivot's travel speed. The average application rate is assumed to be 1 acre-inch for each application in our irrigation budget.

Figure 1. Breakdown of the basic information inside the irrigation budget. The example shown here is for *160 Acre Electric Powered Center Pivot Irrigation Budget*.

160 Acres Electric Powered Center Pivot Irrigation Budget
Georgia, 2021

Crop Type	Corn	
Irrigation Scheduling Method[1]	Checkbook	
Acreage Covered	160	Acres
Average Time for Full Coverage	73	Hours
Average Application Rate	1	Inches
Annual Acre Inch Applied	16	Inches

Investment costs, annual ownership costs, and annual operating costs change with the type of crops and the irrigation scheduling method selected. Figure 2 shows the drop-down menu for the selection of the type of crops, and Figure 3 shows the drop-down menu for the type of irrigation scheduling method available in the irrigation budgets. For each crop, users can choose the *Checkbook* method if they use a calendar-based irrigation method, the *SMS Plus* method if they use soil moisture sensors (SMS), and the *App-Based* method if they use an irrigation app on their smartphone to irrigate the field.

Figure 2: Drop-down menu for crop types, including corn, cotton, and peanuts.

Crop Type	Corn	
Irrigation Scheduling Method[1]	Corn Cotton Peanut	
Acreage Covered		
Average Time for Full Coverage	73	Hours
Average Application Rate	1	Inches
Annual Acre Inch Applied	16	Inches

Figure 3: Drop-down menu for irrigation scheduling method, including the *Checkbook* method, the *SMS Plus* method, and the *App-Based* method.

Crop Type	Corn	
Irrigation Scheduling Method[1]	Checkbook Checkbook SMS Plus App Based	
Acreage Covered		
Average Time for Full Coverage		
Average Application Rate	1	Inches
Annual Acre Inch Applied	16	Inches

The *Checkbook* method is a calendar-based method developed by UGA Extension (Porter, 2020a, 2020b, 2020c). This method recommends weekly water requirements as the guideline for irrigation. Growers are to record daily rainfall through rain gauges. Total weekly rainfall is subtracted the from the weekly water requirements to calculate the amount of irrigation needed for that week.

The *SMS Plus* method uses soil moisture sensors in the field. Soil moisture sensors detect the amount of soil moisture present in the field and send the data to the base station. The base station then converts the data into volumetric water content to determine the amount of irrigation water needed. Generally, each farm only needs one base station, and each pivot needs one soil moisture sensor.

Figure 4: Smart irrigation cotton app developed by UGA Extension.

Photo: Dr. Vasileios Liakos

The *App-Based* method refers to a crop-specific app that can be downloaded to smartphones. Figure 4 shows the smart irrigation cotton app developed by the UGA Extension (Vellidis et al., 2016). Users can enter information regarding the location of the field and the soil types present in each field prior to the first use of the app. The app then estimates the amount of irrigation water needed for the field based on the corresponding meteorological data, crop phenology, and crop coefficient. Soil-water balance is calculated daily by the *App-Based* method to provide irrigation recommendations.

The irrigation budgets automatically adjust the values of the annual acre-inch applied based on the crop and irrigation scheduling method selected by the grower. Table 1 lists the default values of annual acre-inch applied during the growing season for each specific crop and irrigation scheduling method. These values are based on the average irrigation depth values from field experiments conducted by agricultural engineers at UGA. Users can input their own irrigation amount (annual acre-inch applied) into the irrigation budget based on their farming records.

Table 1. Default values of irrigation depth for each crop and each irrigation scheduling method during the growing season in irrigation budgets.

Irrigation Scheduling Methods	Corn	Cotton	Peanut
Checkbook	16	11	10
SMS Plus	10	5	6
App Based	10	6	6
Units: acre-inch			

Components of an irrigation budget

There are three major components of the irrigation budgets: investment costs, annual ownership costs, and annual operating costs. These costs can change depending on the type of crops and irrigation scheduling method used.

Investment costs

Figure 5 lists the breakdown of the investment costs for a pivot irrigation system. The major investment costs are the costs of the pipe and fittings, the pivot system, the power unit or gearhead system, the well, and the pump. If users select the *SMS Plus* irrigation scheduling method, the costs of soil moisture sensors and a base station are added to the budget.

Salvage value is defined as the expected market value of the asset at the end of its assigned useful life. Useful life is the number of years the asset is expected to be used. The total depreciation, or loss in value expected over the useful life, can be found by calculating the difference between the investment cost and the salvage value. Users can adjust the default values for useful life, salvage value, quantity, and cost per unit of the asset. The default salvage values of the equipment are assumed to be zero in the irrigation budgets.

Figure 5: Breakdown of investment costs from the *160 Acre Electric Powered Center Pivot Irrigation Budget* (top) and the *160 Acre Diesel Powered Center Pivot Irrigation Budget* (bottom). The example shown here is for the SMS Plus irrigation method.

Investment Costs	Useful Life	Salvage Value	Quantity	Cost/Unit	Investment Cost	Investment Costs Per Acre
Pipe and Fittings (Feet)	20	0	500	$7.75	$3,875.00	$24.22
Pivot System (8 Towers)[2]	20	0	1	$105,500.00	$105,500.00	$659.38
Pump	15	0	1	$33,000.00	$33,000.00	$206.25
Power Unit	15	0	1	$17,000.00	$17,000.00	$106.25
Well[3]	20	0	1	$53,000.00	$53,000.00	$331.25
Soil Moisture Sensors	6	0	1	$600.00	$600.00	$3.75
Base Station	6	0	1	$2,000.00	$1,000.00	$6.25
Total Investment Costs					**$213,975.00**	**$1,337.34**

Investment Costs	Useful Life	Salvage Value	Quantity	Cost/Unit	Investment Cost	Investment Costs Per Acre
Pipe and Fittings (Feet)	20	0	500	$7.75	$3,875.00	$24.22
Pivot System (8 Towers)[2]	20	0	1	$105,500.00	$105,500.00	$659.38
Pump	15	0	1	$33,000.00	$33,000.00	$206.25
Gearhead System	15	0	1	$20,000.00	$20,000.00	$125.00
Well[3]	20	0	1	$53,000.00	$53,000.00	$331.25
Soil Moisture Sensors	6	0	1	$600.00	$600.00	$3.75
Base Station	6	0	1	$2,000.00	$1,000.00	$6.25
Total Investment Costs					**$216,975.00**	**$1,356.09**

It is assumed that the center pivot is not located directly above the well, and that pipe and fittings are used to transport water from the well to the center pivot. The center pivot system includes a central tower with a pivot mechanism and a main electric control panel. A single long, irrigating pipeline attaches to the central tower with sprayers or sprinklers. The system also includes frame towers to move wheels, long spans, steel trusses, and/or cables supporting the irrigating pipeline, and a sprinkler gun at the end of the pipe. More information about the main components of a pivot irrigation system can be found at Phocaides' *Handbook on Pressurized Irrigation Techniques* (Phocaides, 2007).

The cost of the well depends on its depth and size. The size of the pivot, the acreage covered, the rate of gallons per minute, and pressure dictates the size of the well. In south Georgia, depending on the location, water can be pumped from either the Floridan Aquifer (60-600 ft) or the Claiborne Aquifer (700+ ft). Most farmers draw water from the Floridan aquifer. However, in certain regions, new wells must be installed to pump water from the Claiborne Aquifer due to current water regulations. The well, for the sake of the irrigation budgets, is assumed to be a 12-in. wide, 500-ft deep open-hole well with casing up to 300 ft deep. It is also assumed that a single well provides irrigation water for a single pivot. In situations where a single well supports multiple pivots, users can adjust the investment costs of the well based on the proportion of the well used for a specific pivot.

Figure 6: Turbine pump (top) and submersible pump (bottom) for agricultural irrigation in the field.

Photo: David Hall

Two different types of pumps are available for farmers to use: *turbine pumps* and *submersible pumps* (Figure 6). Turbine pumps usually require a larger sized well than submersible pumps. In turbine pumps, the motor for the pump is above the ground and the pump is below the water level. Turbine pumps can pump water at a rate of 800 gal per minute or higher. In submersible pumps, both the motor and the pump are below the waterline. Submersible pumps can pump water at 600 gal per minute or lower. The costs for the pump, the power unit, and the well are obtained from drilling companies in south Georgia. In our irrigation budgets, we assume the pump is a submersible pump.

If the user chooses the *SMS Plus* option, the budget will automatically add the extra costs for the soil moisture sensors and the base station. A base station can control and process soil moisture data from multiple pivots on a farm simultaneously. Thus, the investment cost for the base station is adjusted according to the number of pivots on the farm in order to reflect the proportional cost of the base station to that specific pivot. The irrigation budgets assume that a farm has either four 65-acre center pivots or two 160-acre center pivots, and that each farm only needs one base station for the *SMS Plus* irrigation scheduling method. The number of pivots needed on a farm is estimated by dividing the average irrigated acreage on a farm by the acreage covered by the pivot in the budget. The data and calculations for average irrigated acreages on a farm in Georgia are listed in Table 2. Users can change this value according to the number of pivots they own on their farm.

Table 2. Average farm size for irrigated acreage in Georgia.

Row Crops	Number of farms	Total Irrigated Acre	Irrigated Acre Per Farm
Corn	891	146,480	164
Cotton	1,371	434,548	317
Peanut	1,558	364,427	234
Total	**3,820**	**945,455**	**248**
Source: 2017 Census of Agriculture. Volume 1, Chapter 2: State Level Data, Table 25			

There are two types of soil moisture sensors available in the market: tensiometric sensors and capacitance sensors (Figure 7). Tensiometric sensors use soil moisture tension, also known as matric water potential. These sensors require a longer time to provide the soil moisture content reading. Capacitance sensors use probes to measure soil moisture. Sensors are distributed inside the probe, which determines the changes in the soil water content. These sensors can precisely measure the soil water content within a short period to guide more precise irrigation scheduling decisions. Tensiometric sensors are less costly than capacitance sensors, and are therefore more widely adopted by farmers than the capacitance sensor. Thus, in our irrigation budget, we assume that farmers use the tensiometric sensor.

Figure 7: Sensor-based system, including tensiometric sensors (top) and capacitance sensors (bottom).

Ownership costs

Ownership costs are the annual fixed costs associated with investment costs, as shown in Figure 8. These include the depreciation costs, intermediate interest costs, as well as the tax and insurance costs for the pipe and fittings, the pivot system, the pump, the power unit or gearhead system, the well, the soil moisture sensors, and the base station.

Figure 8: Breakdown of ownership costs from the *160 Acre Electric Powered Center Pivot Irrigation Budget* (top) and the *160 Acre Diesel Powered Center Pivot Irrigation Budget* (bottom). The example shown here is for the *SMS Plus* irrigation method.

Ownership Costs						
		Depreciation	Intermediate Interest	Tax & Insurance	Ownership Costs	Ownership Costs
			8.00%	2.50%		Per acre
Pipe and Fittings		$193.75	$155.00	$48.44	$397.19	$2.48
Pivot System		$5,275.00	$4,220.00	$1,318.75	$10,813.75	$67.59
Pump		$2,200.00	$1,320.00	$412.50	$3,932.50	$24.58
Power Unit		$1,133.33	$680.00	$212.50	$2,025.83	$12.66
Well		$2,650.00	$2,120.00	$662.50	$5,432.50	$33.95
Soil Moisture Sensors		$100.00	$24.00	$7.50	$131.50	$0.82
Base Station		$166.67	$40.00	$12.50	$219.17	$1.37
Total Ownership Costs					$22,952.44	$143.45

Ownership Costs						
		Depreciation	Intermediate Interest	Tax & Insurance	Ownership Costs	Ownership Costs
			8.00%	2.50%		Per acre
Pipe and Fittings		$193.75	$155.00	$48.44	$397.19	$2.48
Pivot System		$5,275.00	$4,220.00	$1,318.75	$10,813.75	$67.59
Pump		$2,200.00	$1,320.00	$412.50	$3,932.50	$24.58
Gearhead System		$1,333.33	$800.00	$250.00	$2,383.33	$14.90
Well		$2,650.00	$2,120.00	$662.50	$5,432.50	$33.95
Soil Moisture Sensors		$100.00	$24.00	$7.50	$131.50	$0.82
Base Station		$166.67	$40.00	$12.50	$219.17	$1.37
Total Ownership Costs					$23,309.94	$145.69

Depreciation is the annual, non-cash expense that recognizes the amount by which an asset loses value due to use, age, and obsolescence. It spreads the asset's loss in value over the course of its useful life. The annual depreciation is calculated with investment cost, salvage value, and the useful life of the equipment using the following equation:

$$\text{Depreciation} = \frac{\text{investment cost} - \text{salvage value}}{\text{useful life}}$$

Intermediate interest is an opportunity cost associated with the investment tight up with the irrigation system. Interest is charged to the initial investment and salvage value of the equipment each year throughout its useful life. The intermediate interest rate of the equipment is considered to be eight percent and is used in the calculation of intermediate interest in the following equation:

$$\text{Intermediate interest} = \frac{\text{investment cost} + \text{salvage value}}{2} \times \text{interest rate}$$

Producers have to pay annual taxes and insurance for owning the equipment. The rate for property taxes and insurance are estimated to be 2.5% and are used in the calculation of tax and insurance in the following equation:

$$\text{Tax and insurance} = \frac{\text{investment cost} + \text{salvage value}}{2} \times \text{tax and insurance rate}$$

Users can adjust the intermediate interest rate as well as the rate for the property taxes and insurances to reflect their own costs.

Operating costs

Operating costs (also called "variable costs") change with the amount of water usage. The operating costs in the irrigation budgets are shown in Figure 9. These costs include fuel or electricity costs, repairs and maintenance costs, and labor and management costs.

Figure 9: Breakdown of operating costs from the *160 Acre Electric Powered Center Pivot Irrigation Budget* (top) and the *160 Acre Diesel Powered Center Pivot Irrigation Budget* (bottom). The example shown here is for corn and the *SMS Plus* irrigation method.

Operating Costs						
				Operating Costs	Operating Costs Per Acre	Operating Costs Per Acre Inch
Repairs and Maintenance				$1,272.50	$7.95	$0.80
		Horse Power	Cost Per kWh			
Pump (Electricity)		60	$0.13	$4,332.68	$27.08	$2.71
		Hours	Cost Per Hour			
Labor		0.28	$13.25	$37.54	$0.23	$0.02
Management		15.00	$34.21	$513.15	$3.21	$0.32
Total Operating Costs				**$6,155.87**	**$38.47**	**$3.85**

Operating Costs						
				Operating Costs	Operating Costs Per Acre	Operating Costs Per Acre Inch
Repairs and Maintenance				$4,025.50	$25.16	$2.52
		Horse Power	Cost Per Gallon			
Pump (Fuel)		120	$3.05	$11,755.92	$73.47	$7.35
Generator (Fuel)		25	$3.05	$2,449.15	$15.31	$1.53
		Hours	Cost Per Hour			
Labor		0.28	$13.25	$37.54	$0.23	$0.02
Management		15.00	$34.21	$513.15	$3.21	$0.32
Total Operating Costs				**$18,781.26**	**$117.38**	**$11.74**

Energy costs depend upon several factors, including the horsepower of the pumps and motors, the cost of fuel or electricity per unit, the total amount of irrigation during the season, and the hours needed for full coverage. The horsepower of the pump increases with the size of the center pivot system and the field. The cost of fuel or electricity per unit depends on the system. For diesel-operated systems, fuel cost is calculated. For electricity-operated systems, electricity cost is calculated. Fuel and electricity consumption varies based on the engine manufacturer. The total number of irrigation during the season is calculated as the annual acre-inch applied divided by the average application rate. The annual depth of irrigation varies from season to season based on soil types. The equations to calculate the energy costs are adapted from the irrigation budget developed by NC State as follows:

$$\text{Fuel cost} = 0.044 \times \text{horsepower} \times \text{cost of fuel per gallon} \times \text{average time for a full coverage} \times \frac{\text{annual acre-inch applied}}{\text{average application rate}}$$

Where 0.044 x horsepower is the fuel consumption per hour, which might vary with the different engine manufacturers. The unit for 0.044 is gallons/horsepower/hour (Bullen & Benson, 2007).

$$\textbf{Electric cost} = 0.746 \times \text{horsepower} \times \text{cost of electricity per kWh}$$

$$\times \text{ average time for a full coverage} \times \frac{\text{annual acre inch applied}}{\text{average application rate}}$$

Where 0.746 x horsepower is the power consumption by the equipment per hour, which might vary with the different engine manufacturers. The unit for 0.746 is kilowatt/horsepower/hour (Bullen & Benson, 2007).

The cost for repairs and maintenance of the equipment is estimated by multiplying the cost factor of the equipment with its investment cost. The cost factor for the pump in diesel-operated system and electricity-operated system is assumed to be 6.6% and 2%, respectively (Bullen & Benson, 2007). The cost factors for all equipment are listed in the cost factor sheet of the irrigation budget. Users can modify these cost factors to fit their production practice. The repairs and maintenance costs for equipment is calculated as follows:

Repairs and maintenance costs = initial costs × cost factors

In the irrigation budget, total repairs and maintenance costs are calculated by adding the repairs and maintenance costs for all the equipment used.

Labor cost depends upon the labor hours needed for each acre-inch of water applied (labor hours per acre-inch), the annual depth of irrigation (acre-inch applied), and the cost of labor per hour. The value for the number of labor hours per acre-inch is assumed to be 0.28 hours or 17 minutes. The labor cost is calculated with the following equation:

Labor cost = labor hours per acre-inch × acre-inch applied × cost of labor per hour

Management cost estimates the cost for the amount of time spent by the farm manager in using each of the irrigation systems. This depends upon the number of management hours that a manager spends during the growing season for each pivot and the cost of the manager per hour. The management hours per pivot for different crops and irrigation systems are listed in Table 3. The cost of the manager per hour is assumed to be $34.21, which was the 2019 median pay for farmers, ranchers, and other agricultural managers from the U.S. Bureau of Labor Statistics (Bureau of Labor Statistics, 2020). The management cost is calculated as follows:

Management cost = management hours × cost of manager per hour

Table 3. Management hours per pivot for different crops and irrigation scheduling methods during the growing season.

Irrigation Scheduling Methods	Corn	Cotton	Peanut
Checkbook	10	12.50	11.67
SMS Plus	15	18.75	17.50
App Based	10	12.50	11.67
Data from Wesley Porter (personal communication, May 20, 2020).			

Annual costs

Figure 10 summarizes the annual costs in the irrigation budget. This includes the total ownership costs, the total operating costs, and the total costs on a per pivot basis, per acre basis, and per acre-inch basis. The total cost of the irrigation system is calculated as follows:

Total costs = total ownership costs + total operating costs

Figure 10. Total annual costs from the Budget for *160 Acre Electric Powered Center Pivot Irrigation Budget*. The example shown here is for corn and the *SMS Plus* irrigation method.

Annual Costs			
	Cost Per Pivot	Cost Per Acre	Cost Per Acre Inch
Total Ownership Costs	$22,952.44	$143.45	
Total Operating Costs	$6,155.87	$38.47	$3.85
Total Costs	$29,108.31	$181.93	

Summary

Irrigation budgets help producers to estimate the annual ownership and operating costs of their irrigation systems. This publication shows how these budgets are constructed and how to customize these budgets to reflect the irrigation costs for a center pivot irrigation system at a specific farm. Producers can choose the type of irrigation method (*Checkbook*, *SMS Plus*, or *App-Based*) and the crop grown (corn, cotton, or peanuts) within these irrigation budgets. Producers can also alter the default values in the budgets and tailor them based on their specific farm records or operations.

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