IRRIGATION USING SURFACE WATER–AN ALTERNATIVE TO GROUND WATER OVERDRAFT

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INTRODUCTION

Irrigated acreage in Mississippi increased from 467,957 acres in 1980 to 639,561 acres in 1983 (1,2). Preliminary information for 1984 indicates that nearly 700,000 acres are presently being irrigated. These figures reflect a nearly 50 percent increase in irrigated acreage during a four-year period.

This evidence of significantly increased demand for irrigation water for cotton, soybeans, rice, and aquaculture indicates that adequate water supplies will be vital in coming years. Without proper conservation techniques and alternative water sources, the next generation of Delta farmers may face shortages of water for irrigation. These trends in Mississippi are also shared with adjacent states in the South Atlantic-Gulf Region. This region is blessed with abundant annual rainfall. The increased use of surface waters (as a supplement to ground water) for irrigation purposes in the region would be a desirable change, considering present and projected depletion rates of ground water in aquifers.

IRRIGATION PRACTICE

The emphasis of this research was to perform an analysis of the options to be considered when using surface water as an alternate to ground water for irrigation purposes. The purpose of the project was to identify problems that may hinder widespread use of surface water, evaluate equipment suitable to use surface water, provide an economic analysis comparing costs involved, and make recommendations concerning the use of surface water in place of ground water.

Present irrigation practices and equipment were examined during the course of this study. This study consisted of an extensive literature survey, attendance of workshops, discussion with farmers and equipment vendors, and site visits to irrigated farms and suppliers of equipment. General conclusions following this phase of the work were:

1. Well water is generally used for irrigation, in lieu of surface water, due to its present availability and because it is cheaper. Any encouragement to use surface water for irrigation will have to come (at least in the immediate future) because of economic advantages which its use may offer.
2. There are no generally acknowledged problems with surface water pumping equipment and this equipment is readily available from vendors.
3. Catfish farming operations do not generally provide appreciable quantities of water which may be used for irrigation.
4. Present rice growing practices may produce situations where excessive water use results. The reuse of such water in a center pivot system will be subsequently discussed.

The above factors indicated that any surface water irrigation system must be able to compete strictly on an economic basis with any system which it could be expected to replace. This should remain true until such time as water use patterns (surface versus ground) are more closely regulated by law. The following work will focus attention on the economics of delivery of a certain quantity of water to an irrigated crop. The study will not attempt to address problems associated with the development of canals or impoundments which may be needed to properly utilize surface water. The economic analysis will not treat the related area of increased crop yield due to irrigation since this factor (yield) is independent of the economics of the water delivery scheme. It is common knowledge, for example, that rice growth may be stunted and yields reduced in the vicinity of wells discharging relatively cool well water onto the crop. Such factors should be taken into account by the farmer in order to arrive at a total economic analysis of any proposed irrigation system.

The major emphasis of this report will be a treatment of the economics of ground water versus surface water irrigation systems.

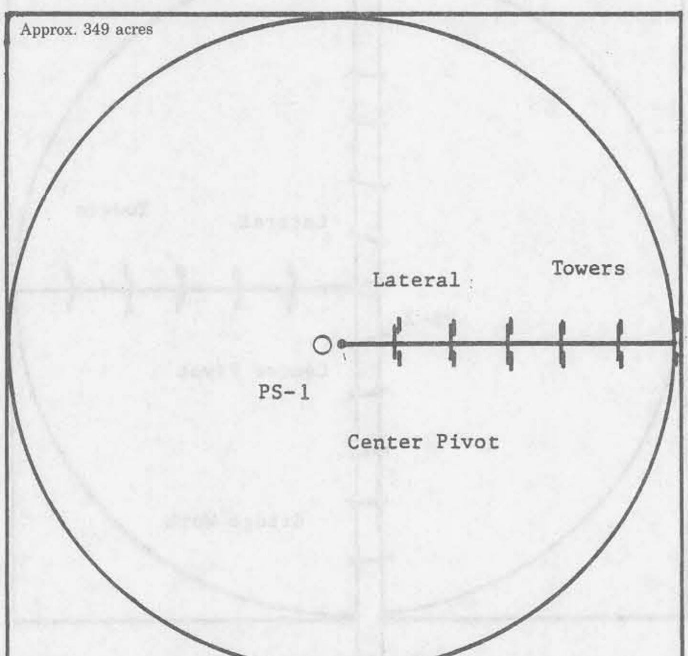

Figure 1. PS-1: Components; power source (Diesel engine, generator, water pump). Length of Lateral - 2200′

ECONOMIC ANALYSIS: SURFACE VERSUS GROUND WATER

Many people interviewed during this research indicated a need for accurate predictive tools which used current costs and which could be used to compare costs of irrigation using various designs; some of which would employ surface water. The increasing use of center pivot systems indicated the desirability of using them as a central item in the designs. Discussion with farmers and suppliers indicated that useful information could be gained by performing an economic analysis of water delivery costs from three general configurations of center pivot systems. These are identified as PS-1, PS-2, and PS-3 and the general characteristics of each are as follows:

PS-1-Conventional center pivot system using ground water from well in alluvial aquifer. Center pivot has a lateral length of 2200 feet and pivot is powered from electric generator driven by Diesel prime mover which also powers the pump. Irrigated acreage is approximately 349 acres. The system delivers 1900 GPM at 60 psig at the center head which is 10 feet above the pump level. A plan view of PS-1 is shown in Figure 1. This is the reference system.

PS-2-Center pivot system generally configured as reference system PS-1. Surface water is provided to the system from a drainage ditch which the system straddles. Necessary bridge work is required to allow the towers of the center pivot system to cross the ditch. Pumping rate and supply pressure are identical to PS-1. It is anticipated that the surface water may originate as runoff from rice farms or from outflow from through-flow catfish ponds. Pump work will be reduced from that required by PS-1. A plan view of system PS-2 is shown in Figure 2.

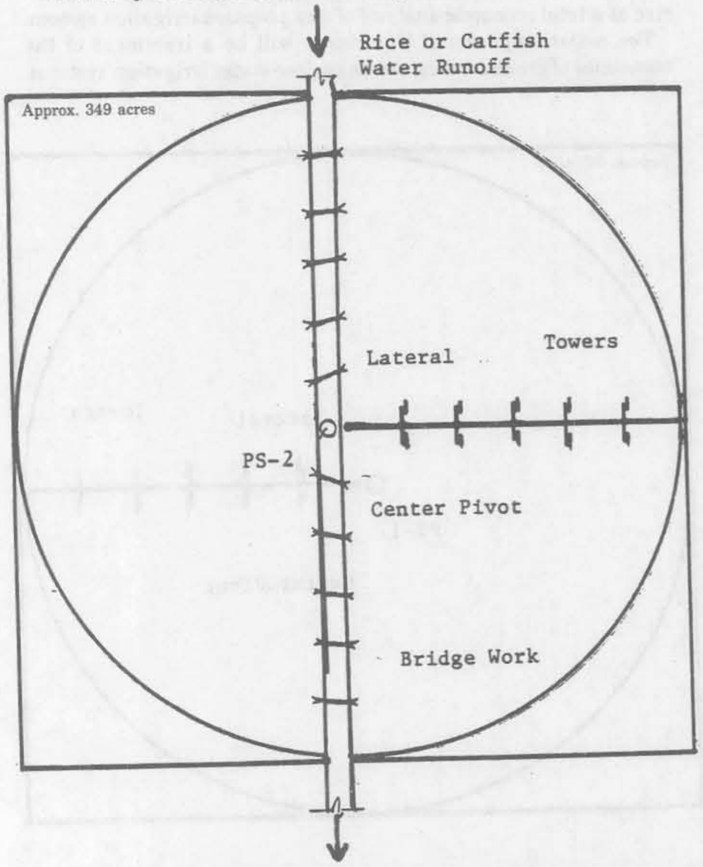

Figure 2 - PS-2: Components; power source (Diesel engine, generator, water pump).
Length of Lateral - 2200′

PS-3-This is a center pivot system generally configured as the reference system PS-1; however, water is remotely supplied from a reservoir or stream via a buried pipe. A power source at the pump location provides power for the pump as well as electricity which is carried to the center pivot in an underground cable. Supply GPM and pressure at the center pivot are identical to that provided in PS-1 and PS-2. A plan view of PS-3 is shown in Figure 3.

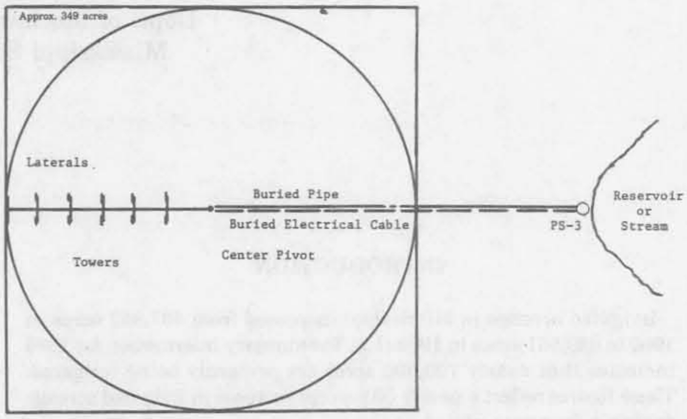

Figure 3. PS-3: Components; power source (Diesel engine, generator, water pump).
Length of Lateral - 2200′

The detailed characteristics of system PS-1 are as follows:

Center Pivot-2200 foot length of lateral, 349 acre coverage, water requirements are 1900 GPM at 60 psig delivered 10 feet above pump outlet, Caterpillar 3208 Diesel irrigation power unit. Major items in total cost are $56,406 for center pivot, $15,750 for power unit, and allowances for freight, erection, concrete pads, shed, and plumbing and miscellaneous. Total installed cost (TIC) - $85,000.

Well-Various depths (water surface from 80 to 150 feet below pump), uses Gould 14JHO pump (or equivalent) with two or three stages depending on depth. Total installed cost of well (including pump) - $13,000.

Fuel Costs -Annual fuel costs are based on 1000 hours of operation per year, brake specific fuel consumption for the engine is 0.365 pounds per horsepower hour. Current fuel price - $0.90 per gallon.

Maintenance Costs -Maintenance costs are estimated to be $850 for the second year of operation (1 year warranty) and will increase yearly as determined by the inflation rate.

For system PS-1, the depth to water level must be added to the outlet head at the pump (150 feet of water) to determine total head across the pump. Total head across the pump and pump efficiency may be used to determine required horsepower output of the Diesel prime mover. The horsepower of the engine and the brake specific fuel consumption may be used to determine fuel consumption per hour of operation. Fuel unit cost and consumption can finally be used to determine seasonal fuel cost for a given well depth. Annual operating time is assumed to be 1000 hours for all three systems considered in this research.

Table 1 presents the annual fuel and maintenance costs for system PS-1 which will be experienced throughout the 15-year life of the system where both fuel and maintenance costs have been assumed to increase at 5 percent per year. Fuel costs are shown for 80, 100, 120, 150-foot depth to water.

Table 1. PS-1: Annual Costs

Year	Fuel Cost ($)				Maintenance Costs ($)	System Cost ($)
	80	100	120	150		(12% Loan)
1	6335	7039	7790	8213	0 (warranty)	14,406
2	6652	7391	8180	8624	850	-
3	6969	7743	8569	9034	893	-
4	7349	8165	9036	9527	935	-
5	7729	8588	9504	10020	986	-
6	8109	9010	9971	10513	1037	-
7	8489	9432	10439	11005	1088	-
8	8932	9925	10984	11580	1139	-
9	9376	10418	11529	12155	1198	-
10	9819	10910	12075	12730	1258	-
11	10326	11474	12698	13387	1318	-
12	10833	12037	13320	14044	1386	-
13	11403	12670	14022	14783	1454	-
14	11973	13304	14723	15523	1530	-
15	12543	13937	15424	16262	1607	14,406

Fuel and maintenance costs are seen to approximately double during the life of the system if an annual increase of 5 percent is assumed.

The annual payment on the center pivot and well ($98,000) will be dictated by the interest rate assumed on the loan. A reasonable value for the interest rate, considering current economics, is 12 percent. The annual payment on a $98,000 loan for 15 years at an annual interest rate of 12 percent is $14,406.

Total annual operating expenses for system PS-1 may be determined for any year of its 15-year life by summing the annual loan payment and the fuel and maintenance costs.

The detailed characteristics of system PS-2 are as follows:

Center Pivot-These items and costs are identical to those for PS-1. Additional cost of bridging for ditch bridges on this configuration is approximately $1000. Total installed cost - $86,000.

Well-Water pumped from drainage ditch either 5 or 10 feet below pump inlet, pump is Berkeley B6EXRBL (or equivalent). Total installed pump price is approximately $8,000. There is no well cost for PS-2; however, $1500 is included in the pump price for construction of appropriate pump inlet structure (canal, etc.).

Fuel Costs -Same as PS-1.

Maintenance Costs-Same as PS-1.

The operating characteristics of system PS-2 are shown in Table 2. Since system PS-2 utilizes water from a ditch or channel, the depth from the pump inlet to the available water has been assumed to be either 5 or 10 feet.

Table 2. PS-2: Annual Costs

Year	Fuel Cost ($)		Maintenance Costs ($)	System Cost ($)
	(5 ft.)	(10 ft.)		(12% Loan)
1	4256	4272	0	13,801
2	4469	4486	850	-
3	4682	4699	893	-
4	4937	4955	935	-
5	5192	5212	986	-
6	5448	5468	1037	-
7	5703	5724	1088	-
8	6000	6023	1139	-
9	6299	6322	1198	-
10	6597	6622	1258	-
11	6937	6963	1318	-
12	7278	7305	1386	-
13	7661	7690	1454	-
14	8044	8074	1530	-
15	8427	8459	1607	13,801

Annual costs for system PS-2 are presented in Table 2 where both fuel and maintenance costs have been assumed to inflate at 5 percent per year for the 15 year life of the system. Tables 2 and 1 may be used directly to compare future savings of one system versus the other.

The detailed characteristics of system PS-3 are as follows:

Center Pivot-These items and costs are identical to those for systems PS-1 and PS-2. Additive costs for this system will be PVC pipe to transport water from a remote stream or reservoir and buried electrical cable to conduct power for the center pivot drive from the generator mounted at the pump. These costs are $4,750 per 1000 installed feet of 12 inch, 80 psi SDR51 PVC pipe and $1,250 per 1000 installed feet of aluminum wire. Total installed costs are:
$103,000 (3000 foot pipe length),
$109,000 (4000 foot pipe length),
$115,000 (5000 foot pipe length).

Well-Water pumped from stream or reservoir and supplied to center pivot at appropriate flow and pressure through a 12-inch buried PVC pipe, pump is Berkeley B6EXRBL (or equivalent). Total installed pump price is approximately $8,000. There is no well cost for PS-2; however, $1,500 is included in the pump price for construction of appropriate pump inlet structure (canal, etc.).

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For system PS-1, the depth to water level must be added to the outlet head at the pump (150 feet of water) to determine total head across the pump. Total head across the pump and pump efficiency may be used to determine required horsepower output of the Diesel prime mover. The horsepower of the engine and the brake specific fuel consumption may be used to determine fuel consumption per hour of operation. Fuel unit cost and consumption can finally be used to determine seasonal fuel cost for a given well depth. Annual operating time is assumed to be 1000 hours for all three systems considered in this research.

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Center Pivot-These items and costs are identical to those for PS-1. Additional cost of bridging for ditch bridges on this configuration is approximately $1000. Total installed cost - $86,000.

Well-Water pumped from drainage ditch either 5 or 10 feet below pump inlet, pump is Berkeley B6EXRBL (or equivalent). Total installed pump price is approximately $8,000. There is no well cost for PS-2; however, $1500 is included in the pump price for construction of appropriate pump inlet structure (canal, etc.).

Fuel Costs -Same as PS-1.

Maintenance Costs-Same as PS-1.

The operating characteristics of system PS-2 are shown in Table 2. Since system PS-2 utilizes water from a ditch or channel, the depth from the pump inlet to the available water has been assumed to be either 5 or 10 feet.

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Well-Water pumped from stream or reservoir and supplied to center pivot at appropriate flow and pressure through a 12-inch buried PVC pipe, pump is Berkeley B6EXRBL (or equivalent). Total installed pump price is approximately $8,000. There is no well cost for PS-2; however, $1,500 is included in the pump price for construction of appropriate pump inlet structure (canal, etc.).

Fuel Costs -Same as PS-1.

Maintenance Costs-Same as PS-1.

Table 3 shows the annual costs for PS-3 considering an annual fuel and maintenance inflation rate of 5 percent. Direct comparison of Tables 1, 2, and 3 indicates the relative fuel, maintenance, and system costs for the three systems.

Table 3. PS-3: Annual Costs

Year	Fuel Cost ($) 3000	4000	5000	Maintenance Costs($)	System Cost ($) (12% Loan)
1	5613	6091	6656	0	18,081
2	5894	6396	6989	850	-
3	6174	6700	7322	893	-
4	6511	7066	7721	935	-
5	6848	7431	8120	986	-
6	7185	7796	8520	1037	-
7	7521	8162	8919	1088	-
8	7914	8588	9385	1139	-
9	8307	9015	9851	1198	-
10	8700	9441	10317	1258	-
11	9149	9928	10849	1318	-
12	9598	10416	11382	1386	-
13	10103	10964	11981	1454	-
14	10609	11512	12580	1530	-
15	11114	12060	13179	1607	18,081

Previous calculations have also not included depreciation on the irrigation system as this would, again, be highly dependent on the particular system and the depreciation method employed for the calculations. Traditional accounting practices may be used to determine the particulars of savings due to interest payments and depreciation once the irrigation system is configured.

This work has also not included economic factors concerned with increased crop yields which must be considered in an overall economic analysis when using irrigation systems. Williams (10) has considered such an analysis for a typical well fed center pivot system. The results are presented in the form of required increased yield needed to offset the cost of the irrigation system.

The major emphasis of previous discussion has been to present current economic factors concerning the installation and operating expenses of typical surface water based irrigation systems which should be considered prior to final selection of an irrigation system. Sufficient information has been included to allow one to critically examine the economics associated with the requirement to deliver a fixed quantity of water where alternate delivery techniques are used.

ANALYSIS OF RESULTS

Considering current trends toward increased irrigated acreage in the Mississippi Delta area of the South Atlantic-Gulf Region it is reasonable to anticipate that the projected drawdown levels of the Mississippi River Alluvial Aquifer will be experienced during the next 20 years. Farmers experiencing the predicted drawdown levels exceeding 80 feet will see an increasing trend toward reduced pumping rates from presently installed wells along with increased maintenance costs, equipment failure, and the need to reconfigure wells. Pumping costs will be increased due to the necessity to draw the water from deeper levels and the need to run longer hours to pump a fixed amount of water from the dropping water table with present equipment.

An economically attractive alternative to the continued expansion of the use of well water for irrigation has been presented here in the form of the two proposed systems which use surface water. Proposed system PS-2 which relifts water from a drainage ditch to the center pivot system is cheaper to install and will always experience significant annual operating savings even when compared to well systems presently being installed in the Mississippi Delta. The components proposed in its design are "off the shelf" items which are currently being used in operating systems. The same is true for some configurations of the proposed system PS-3 which uses water remotely pumped to the center pivot via a buried pipe.

Prospective irrigators should seriously evaluate the use of surface water when considering the installation of new systems. The models presented here allow the direct comparison of systems using surface water with the typically installed system which uses ground water from aquifers which already are experiencing drawdown. The prudent and efficient use of our water resources must be based on an integrated system which emphasizes use of both ground and surface waters. The selection of an irrigation system should be based on both the economics and hydrology of the local area. This research has been performed in response to the need to develop and present economic data which can be used as input into the selection process for irrigation systems. The figures have shown that, in many cases, it is cheaper to use surface water than ground water for irrigation purposes. Future research should be aimed at developing appropriate techniques which could be used to help ensure the coordinated development of both surface and ground water resources.

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