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Cost Analysis of Micro-Irrigation Systems on Farms

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ABSTRACT

Water is considered by many to be the most important commodity available today. From being consumed to use in agriculture, water has a variety of uses and is of great importance in many aspects of life. Being such a widely used resource, it is also paramount that this resource is conserved and used in the most efficient way. Civil Engineering students at California State University, Northridge (CSUN) researched the efficiency and cost of modern-day agricultural irrigation systems and compared the cost to that of a more efficient micro-irrigation system. The purpose of this research was analytical, as it served to show the costs of both types of irrigation systems as well as the time it would take to recover the cost of a more efficient irrigation system and the annual savings of continued use.

Keywords: *Sustainability, agriculture, water, irrigation, efficiency*

INTRODUCTION

Agriculture is one of the main sources of water consumption within the United States. The United States Department of Agriculture (USDA) estimates that agriculture accounts for 80% of the country's water consumption and 90% in western states like California.

California is the nation's largest exporter of vegetables, providing more than half of some vegetables like carrots and artichokes as well as providing a vast majority of the nation's nuts. Needless to say, the demand for water is high.

California, at times, does not get enough rain to meet the demand. To make up for it, farmers often tend to dig wells and tap into groundwater reserves. These are not infinite sources of water however, and many wells run dry and another needs to be found elsewhere in the watershed. In order to prevent this for as long as possible, measures can be taken to preserve water during irrigation.

In this research project, normal irrigation methods and equipment were researched and compared to more efficient micro-irrigation methods. Both prices were estimated to a reasonable degree and the payoff time was calculated as well as projected annual savings for a farm located in the Central Valley of California.

Normal Irrigation System

In agriculture, there are several different types of irrigation systems. They all revolve around movement of an irrigation rig through the field, but each does this differently. The most used Irrigation system is the center pivot system shown in Figure 1.

Figure1. Center Pivot Irrigation System

It is the most popular irrigation system in the world for their high efficiency, and the most significant mechanical innovation in agriculture. In the United States (2012), the portion of farms that were using this irrigation system over other conventional methods was about 63%, probing the popularity of it. This system is made up of pumping stations which grab water from a resource such as a river, and deliver it through the pipes and water conduits to the pivot point per Coachella (2016). Water is driven through the span structure and distributed to the sprinkle which applies the right size of the water drops to maximize the absorption of the soils. It's powered with electric motors that allow it to move automatically.

The system is flexible to change demands and to be used in any kind of agriculture. It is customizable to the size and shape of the specific field and the equipment is forgiving. Center Pivot provides more developed remote monitoring to specify potential issues in the system that can be solved easily. Since the nozzles in the system are large, there is no need for filtration as there is rarely a clog. The system equipment is made of recycled materials. A well designed sprinkler system applies water uniformly to the soil surface, and is capable of applying enough water to meet the peak demands of the crop without producing excess runoff per Hill (2002). Good design considers such factors as pressure, nozzle size and spacing; wind, air temperature and humidity (day versus night); soil intake rate; crop rooting depth and water use rates.

In 2009, Porter and Marek studied the relationship between the holding capacity of the soil water and the application depth of the center pivot irrigation, and they found out that the key to optimize the center pivot irrigation is the management, which take in the account the soil's permeability, changing crop water requirement and water holding capacities. In 2004 a variable flow sprinkler was developed by King and Kincaid to control the irrigation water application.

Center pivot systems cost around $712 per acre, most of the cost in the Center pivot systems is from the water usage since it is very easy to maintain a center pivot system and can last long if properly maintained. Per Amosson, a properly maintained irrigation system can operate for as long as 25 years.

Micro-Irrigation System

Due to awareness of climate change, people started to use more controlled systems in order to conserve water. Micro-irrigation is a low volume irrigation that works with less flow and pressure compared to the normal irrigation system.

The efficiency can exceed 90% which is 15-20% more than the normal irrigation system. Thus, it's a major system to minimize wasting water and ensure that agriculture is getting the exact water it needs. This method has great aspects, it makes the soil absorb and supply water only to the plants without running off or vaporization, Porter (2009). Also the water only transferred to the areas that indeed need water such as the plants roots. It exposes the root by a direct supply of water.

The system components are made up of pre-filter and disc-filter. The filtration's level depends on the quality of the water and the emission size. In some cases regulating valves are required to control the system pressure to the wanted level and to switch from one section to another.

It has a controller that works with an automatic sensor for the soil moisture level, and rain shut-off sensor due to water conservation being the main reason for using this system, Kang (1999). It can be used in commercial, civic and private-landscape projects but is better suited for small fields. There are various types of Micro-Irrigation system such as drip, subsurface drip, and micro-spray irrigation.

Figure2. *Drip irrigation system*

Per Kishore (2019) since water is the key of life; preventing its depletion is crucial. A study concluded that micro-irrigation used in farms saved farmers 15% of groundwater resources, and it improved the net-income of farmers. One of the most popular types of micro-irrigation is drip irrigation shown in Figure 2.

The first drip system in the United States was called "Dew Hose" and developed by Richard Cappin in 1960. Water efficiency by avoiding over watering and evaporation is the primary virtue of this system, Solomon (2002). The design is able to supply the appropriate amount of water to the plant. However; It has some drawbacks that should be thought about before using it such as the tape depth of the drip must be selected carefully otherwise it can get damaged. Also, its performance will entirely depend on the skills of the designer, if it's done wrong it will be expensive to fix. One of the most frequent issues in the drip system is the clogging. Acid and chlorinate should be applied periodically to dissolve the concentrated minerals that plugs the emitters.

Filters should be changed or flush constantly. Drips have a limit when used in light and sandy soils. Per Burt (1998) the energy efficiency of the pumping system is increased with micro-irrigation in addition to efficiency in application of fertilizers, higher crop yields and decrease in the need of erosion abatement efforts.

It costs around $2.50 to $4.50 per square foot to install a drip irrigation system, and depending on location, labor costs could be a major contributor. Labor costs could also be exempted if done by self. Also, it costs around $1,412 to install per acre.

Cost Analysis

Per Luhach et al. (2004) there is a seven-year return on savings when micro-irrigation is installed where a normal surface irrigation was once employed. This covers the removal of existing systems and the installation of the micro-irrigation system.

Orchards and one crop farm areas (i.e. strawberries) utilize a permanent system whereas a rotational crop system uses a system that is rearranged at the conclusion of each harvest. The initial cost to install a pivot system is around $712 per acre whereas it costs twice as much to install a drip irrigation system which is $1,412. Moreover, in terms of water usage, Center Pivot Systems uses more water than Drip Irrigation systems as stated on Table 1.

The differences between Center Pivot Systems and Drip Irrigation systems are major economically and efficiently. What is not included are the labor costs of maintaining a farm. Because of the variety of factors in farm work (pest abatement, soil conditions, severe weather) are not dependent on irrigation strategy and are thus not pertinent to this analysis.

Subsurface systems require 35-40% additional cost in time in the first season due to optimizing heads and rectifying design weaknesses (known as the initial trial). Both center pivot and drip irrigation systems have benefits, but in general, cost analysis shows center pivots are the right option for large-scale agriculture.

Table1. *Normal vs. Micro-Irrigation*

Irrigation	Normal Irrigation System	Micro-Irrigation System
Type	Center Pivot System	Drip Irrigation
Water Usage/Month*	15,360 Gallons per acre	12,240 Gallons per acre
Cost	$712 per acre	$1,412 per acre

**Depending on how many times per week. Estimate is for using systems twice weekly.*

Educational Objectives

In this educational research, students managed to expand their knowledge in the irrigation and cost analysis of it. As a team, the students were able to work in performing this research successfully with great leadership. Students were able to learn about the technique of both Normal and Micro-irrigation systems and compare them together.

The students were enthusiastic to analyze the cost and understand each system's benefits and drawbacks. Hence, this knowledge was fundamental for the students to earn the ability to critically analyze.

The research helped the team to cultivate their professional ethics by devoting their effort on this project. The topic of the research was important to the students for their career as civil engineers, as sustainability is paramount to the longevity of society. By the end, the team was able to find out the best irrigation system for different scenarios. After completing this research, the students are eager to choose carefully in the future the type of the irrigations.

Conclusion

Water is one of the most important resources on this planet, and everyday everyone takes water for granted and overuses this resource. The purpose of this research is to find out the most effective way to irrigate our land whilst using the minimum amount of water effectively. In this research, Normal Irrigation is compared to micro-irrigation, specifically Center Pivot Systems (Normal Irrigation) to Drip Irrigation (Micro-Irrigation), to find out which type of irrigation is more environmental. As shown in Table 1.

Drip Irrigation uses about 3000 gallons per acre per month less than Center Pivot Systems, which makes the Micro-irrigation system more environmental, but it comes with a disadvantage, its cost. Drip Irrigation costs almost $750 per acre per month more than Center Pivot Systems, which makes Center Pivot Systems more economical. It's ironic how using more water can be cheaper, but the Drip Irrigation system costs too much to maintain because it's so specific plus it's very expensive to implement, which is also another disadvantage. This is why anyone would rather use Normal Irrigation, because it's cheaper and easier.

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