Bianchi, Chan, Hoang, Sanderfer

Project Title: The Comparison of Drip vs. Furrow Irrigation Systems and its Effects on California Agriculture

Group Members: Mia Bianchi, Grace Chan, Jennie Hoang, Larissa Sanderfer

Abstract:

This project addresses whether agriculture in Monterey, California has experienced a trend in significantly changing its irrigation practices to more efficient methods during the time period from 1996-2014. We compared trends between two different crop types: field crops and vegetable crops. This comparison will allow us to see whether there is a faster year-to-year switch from traditional furrow irrigation to efficient drip irrigation, due to differences in water requirements between the crop types. Through the graphical analysis, we evaluated the relationship between the numbers of acres used per irrigation method per each crop type, over time. We observed two clear trends. First, both graphs showed that over time more acres are watered via drip irrigation while less are being watered via furrows. Second, we observed that vegetable crops have a faster and more correlative change in trend compared to field crops. This illustrates that farmers are more readily switching irrigation methods from furrow to drip irrigation more so for vegetables, rather than for field crops. This observed trend could be due to the fact that vegetables require more water and are grown at higher quantities than field crops, forcing farmers to be more mindful of their water use with vegetable planting.

There are some limitations in our research study. We were unable to analyze individual farms due to the lack of available data. As a result, we do not know if the increased acres watered through drip irrigation are due to farmers purchasing more land.

However, we came to a confident conclusion that agricultural areas in Monterey County are being more mindful of their water use by switching from furrow irrigation methods to drip irrigation, with a faster observed change in vegetable crops than in field crops.

Introduction:

In the United States, California may be ranked third in size, but in agricultural production, it is ranked first (U.S. Department of Agriculture 2013). As the nation's largest agricultural producer, California generated $44.7 billion in revenue from its 80,000 farms and ranches in 2012, making it a larger agriculture producer than the mid-west states of Iowa and Nebraska (USDA 2013). Due to its prime location and mild Mediterranean climate, California has proven incredibly successful in the agriculture sector (Sandoval Solis 2015).

However in 2013, California entered a major drought period. A lack of precipitation has since led to severe drought issues, such as critical declines in lake and reservoir levels and intensified groundwater extraction and depletion without recharge (U.S. Geological Survey 2015). Despite the water shortage that California is experiencing, the state is adapting to its current drought conditions. With California's farmers, the utilization of better and more water-efficient technologies can efficiently maximize water usage, without compromising their crop yields (Texas A&M AgriLife Extension, n.d.).

Drip and furrow irrigation are two different methods used to water crops. Drip irrigation is a slow, steady system that slowly drips water on the surface or roots of plants (Texas A&M, n.d.). Drip irrigation is highly efficient and only waters the plant, not the surrounding surface. Little labor is needed once the system is set up. However, this method requires a high initial cost (Texas A&M, n.d.). The more traditional furrow irrigation method utilizes rows of water filled trenches to irrigate the surrounding plants. If it is not properly managed, there can be excessive waste (Natural Resources Management and Environment Department, n.d.). Furrows also carry a small initial cost, which seemingly poses as an advantage. However, despite any monetary expenses initially saved, furrows require intensive labor for continual maintenance and have lower application efficiency (Natural Resources Department, n.d.). Due to the high long-term costs of furrows, many farms throughout the country have switched their irrigation practices from furrows to drip irrigation. For instance, over the past 10 years, the farms throughout the state of Nebraska have decreased the use of furrow irrigation from 2.4 million to 1.5 million (Texas A&M, n.d.).

The following project analyzes water usage data from the vastly agricultural county of Monterey, California. From the data collected, we examine the watering practices of Monterey's agriculture sector, comparing the usage of furrow irrigation, a traditional farming water practice, to that of drip irrigation, a more efficient watering practice, over a time-span from 1996 to 2014 (Monterey County Water Resources Agency, n.d.). Ultimately, our project will highlight the importance of better water conservation farming techniques, as they can be utilized in place of traditional water practices without compromising crop yields. This becomes increasingly important as drought conditions intensify.

Objective:

The main goal for this project is to analyze whether there is a year-to-year trend of more efficient watering practices being applied to farm crops. The following illustrates the core tasks of our project:

1) Understand which methods of irrigation are most efficient in terms of water use efficiency. We will focus on the comparison between drip irrigation and less efficient water-use practices, such as furrow irrigation.

2) Research water usage data from the Monterey County Water Resources Board to gather year-to-year data on how many acres of farmland in Monterey County were applied with water from furrow vs. drip irrigation.

3) Create line graphs showing the trend of acres of water used for either water-use type from the available data from 1996-2014. We will further analyze the R^2 value to determine how significant of a linear correlation is present for both individual lines. Additionally, we will compare and contrast the trends in irrigation uses for vegetable crops vs. field crops.

4) Place this data in perspective to California Vineyard Crop data for 2001 and 2010 to show that the results calculated have validity and are reproducible. This comparison between our sample size data of Monterey County and the California Vineyard Crop data allows us to reasonably assume that our results are accurate, if they fall within the expected range.

Hypothesis:

The hypothesis is broken down into two segments:

1. Due to increased water costs and intensified drought conditions, there should be an overall trend of more acres of farmland being applied with water via drip irrigation, rather than the traditional furrow irrigation.
2. Furthermore, there will be stronger trends of drip irrigation usage in vegetable crops versus field crops. This is due to the fact that 1) vegetable crops are often planted in larger acreage than field crops and 2) vegetable crops are more water intensive than field crops (cite almond tree problems in drought)

Data Sources:

We used the Groundwater Extraction Summaries from 1996 to 2014 collected by the Monterey County Water Resources Board. The summaries include data on the amount of acres per plant watered, and the method of irrigation (Monterey County Water Resources Agency, n.d.). From this data source, we created line graphs and calculated the R^2 values. The line graphs allow us to compare the trend lines of furrow vs. drip irrigation, further filtered by crop type (vegetable or field). To ensure that our graphs were accurate, we calculated the R^2 values to verify that there is a strong linear correlation in our data sets.

Further information was collected for vegetable vs. field crop types from the Texas A&M Agrilife Extension webpage detailing agricultural resources. Research from the Agrilife Extension on these crop types displays the differences in water consumption between field crops and vegetable crops. This research is critical to our report as it helps support our second hypothesis. Additional data on crop type characteristics and information was retrieved from the Department of Agriculture's report on "California

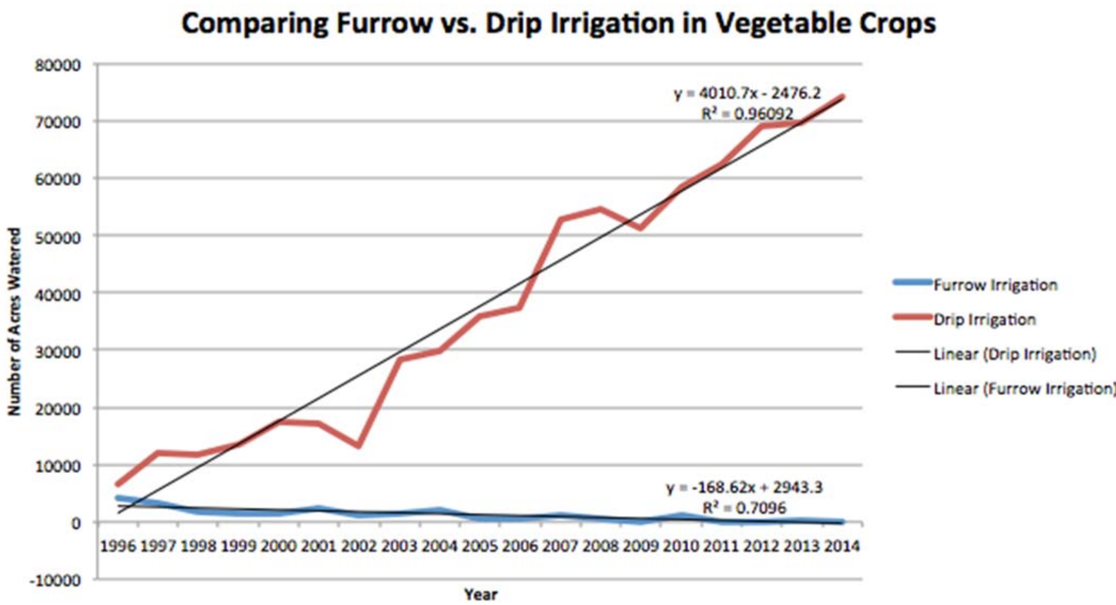
Agricultural Statistics: 2012 Crop Year." This data further supplements the research from Agrilife Extension.

To verify that our sample size data set from Monterey County is valid and reproducible, we gathered data from Professor Solis's California Vineyard Crop data for 2001 and 2010; this data can be found from his "Climate-Smart Agriculture Strategies for Water Management in California" presentation for the Global Science Conference. This comparison between the Monterey County data and the California Vineyard Crop data will allow us to determine if our results are accurate.

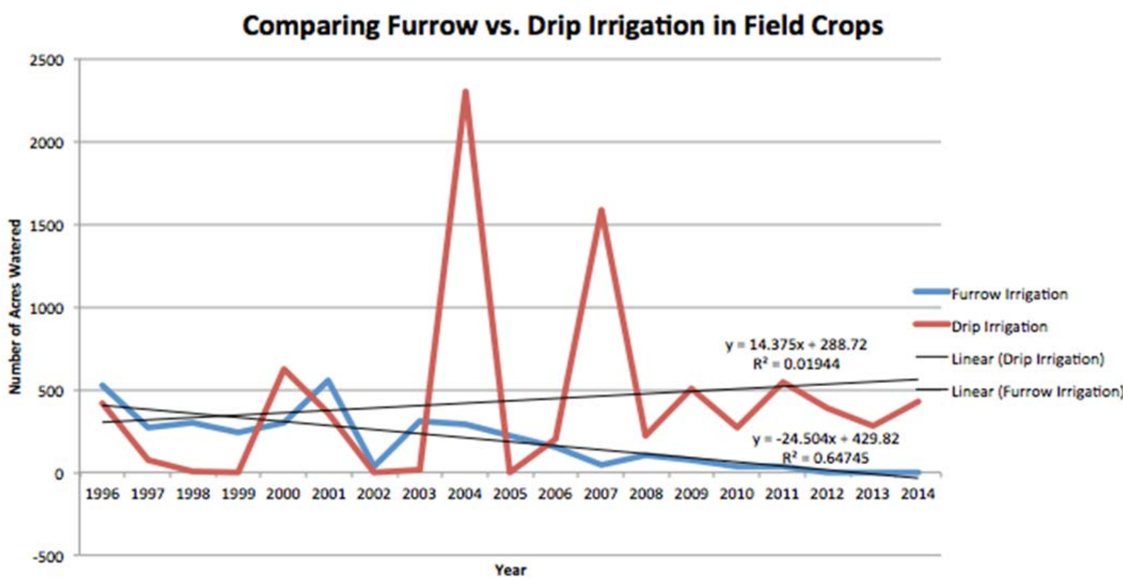
Methods and Assumption:

For simplification of our project, we made a few assumptions to streamline our research. First, we did not take into account the exact precipitation of each year. We also classified years as either a normal year or a drought year, according to broader precipitation classifications. Under the normal years, we assumed that the variation was negligible. However, this may not be the case as normal years may have large variations between them. Furthermore, we also assumed that the amount of vegetables and field crops grown were constant each year. In reality, one year may have returned a higher yield of vegetables than another, which would result in more water being used in that specific year.

Calculation/Results:



Graph 1: data collected from Monterey County Water Resources Agency



Graph 2: data collected from Monterey County Water Resources Agency

In our analysis, we graphed the number of acres watered over time for each type of crop using each irrigation method (Monterey County Water Resources Agency, N.d.). We compared these results using R-squared values and the slopes of best-fit lines to analyze the validity of our results.

Graph 1 illustrates the number of acres watered with drip vs. furrow irrigation where vegetable crops were grown between the years 1996-2014. Using Microsoft Excel, we calculated the slope of the best fit lines and R-squared values. The slope of crops watered with drip irrigation was *4010.7* and the R-squared value was *.96*. This means that there were, on average, about 4,000 acres converted to drip irrigation annually during that time period (Monterey, n.d.). Since the R-squared value is .96, which closely approaches 1, it signifies the strong correlation between the actual data and our best-fit line (Monterey, n.d.). For the crops watered with furrow irrigation, the slope was *-168.62* and the R-squared value was *.71*. The slope shows there is a decline in acres watered with furrow irrigation, illustrating the farmers' move toward the more efficient drip irrigation methods. Additionally, the R-squared value, .71, illustrates a weaker correlation between the best-fit line and our actual data.

Graph 2 demonstrates the number of acres watered with drip vs. furrow irrigation where field crops were grown between the years 1996-2014 (Monterey, n.d.). Using the same methods as above in Microsoft Excel, we calculated the slope of best-fit lines and R-squared values. The slope of field crops watered using furrow irrigation was *-24.5* and the R-squared value was *.64*. This demonstrates that there was, on average, a 24-acre decline in acres using furrow irrigation per year. Since the R-squared value is .64, it illustrates a somewhat weak correlation between the actual data and the best-fit line. The slope of field crops watered using drip irrigation was *14.375* and the R-squared value was *.0194*. This illustrates that there was an overall growth in number of acres watered using drip irrigation. The R-squared value, being so low at .0194, illustrates a very weak correlation between the best-fit line and the actual data (Monterey, n.d.). The very low R-squared values for field crops graph in relation to the higher R-squared values for vegetable crops demonstrate the higher variation in field crops acreage. This fits with the data that field crops are more susceptible to the market variation than vegetable crops (United States Department of Agriculture 2014). Overall, these graphs we have created based on the data collected illustrates that our hypotheses are correct.

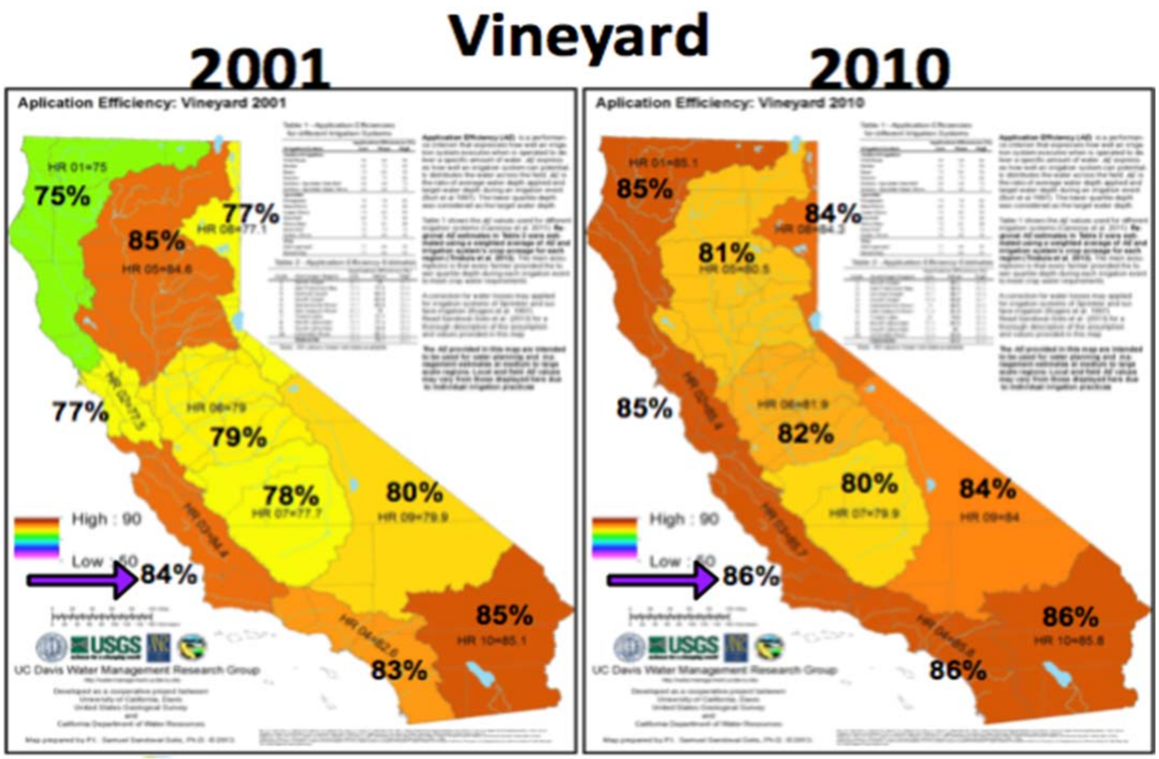


Figure 1: Sandoval Solis, S. "Application Efficiency: Vineyard 2001" and "Application Efficiency: Vineyard 2010" UC Davis Water Management Research Group.

To supplement our analysis and bring it into context with an example, we compared the differences in irrigation efficiency between 2001 and 2010 for vineyard crops within different regions of California. In Figure 1, we are specifically comparing the application efficiencies of the Monterey region, which are highlighted with the purple arrow.

Hypothesis:

Our overall results prove our hypotheses were correct. The data we gathered for Monterey County illustrates that as droughts intensify, farmers move towards drip irrigation, which is a more efficient irrigation system (Monterey County Water Resources Agency, n.d.). Furthermore, analysis of the data collected on market prices and crop acreage illustrates that vegetable crops have a stronger tendency than field crops to be watered with drip irrigation (USDA 2014).

Recommendations/Limitations:

Overall, we were very limited with the data we were able to collect for this project as irrigation data is very selectively chosen and presented for public use. Our group had to rely on data from the Monterey County Water Resources Board, which contained reported data from 1996 to 2014. Current data from 2015 is not present for public view on their website. The Water Resources Board only allows certain data to be released, as private farms are not legally bound to release any of their water usage information; this “no disclosure” policy makes it even more challenging to study and break down water usage of agricultural counties in California. Overall, the recommendations for Monterey County would be to continue to convert their water use techniques to drip irrigation. By converting irrigation measures to drip irrigation, this better ensures that the plants can efficiently absorb the water, eliminating excess water waste.

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