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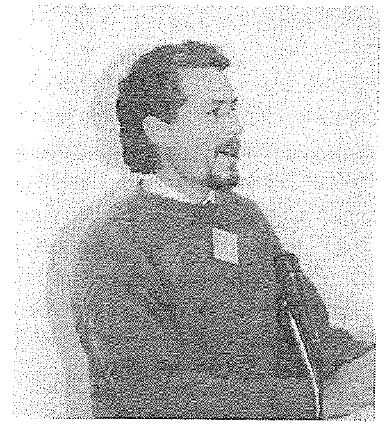

AGRICULTURAL WATER CONSERVATION

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INTRODUCTION

This paper looks at conservation from the point of view of production agriculture. Agriculture is the largest manufacturing industry in the world. Worldwide and in the United States it is number one. Agriculture manufactures products used by every person in the world. It produces food, fiber, and renewable energy. Agriculture takes two basic inputs, water and sunlight, and makes something out of it. No other industry can work with that primitive of a raw product and yet produce the high quality and usable products that the agricultural industry does.

What's the outcome of agricultural production? Figure 1 depicts a simplification of production agriculture's inputs and outputs. Society is impacted by production agriculture in three ways:

- Jobs - labor needs are significant especially with vegetable crops such as chile. Much of the money used by agriculture to finance crop production is returned to individuals through wages.
- Energy use - agriculture is a significant user of energy.
- Consumption of durable goods - farmers purchase high-dollar-value equipment like trucks and tractors (and today a reasonably sized tractor costs about $50,000) thus providing midwesterners with high-paying jobs. John Deere would go out of business without agriculture.

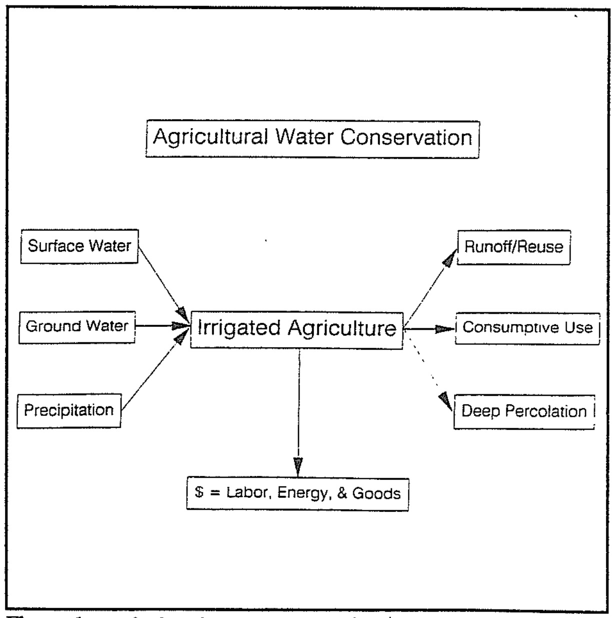

Figure 1. Agricultural water conservation.

Agriculture takes sunlight and water to produce what the nation can run on, ranging from the simplest things such as your cotton shirt to the very sophisticated tractor that has a tremendous amount of engineering and high quality labor put into it.

Irrigated agriculture in New Mexico uses three sources of water: groundwater, surface water and precipitation. The Deming area receives little precipitation or surface water, so most irrigation water comes from groundwater sources. Agricultural land located in the Elephant Butte Irrigation District and the Middle Rio Grande Conservancy District receives most of its water from the Rio Grande except during times of drought. Finally, agriculture in the High Plains region uses precipitation productively. For the last ten to fourteen years, precipitation in New Mexico has been significantly greater than usual and farmers have taken advantage of the extra rainfall, although at times it can be an irritation. Generally farmers hope for clear skies so they can perform field operations.

Agriculture receives its water from three sources and after using the water productively, it ends up in three places—runoff, consumptive use and deep percolation. Water which runs off the field may be captured and reused for other purposes. Consumptive use produces food and fiber through biological processes, and water is vented back to the atmosphere through evapotranspiration. Water may also percolate past the crop rootzone and recharge the groundwater. This water balance occurs in almost all irrigated agriculture. Neither runoff, consumptive use, nor deep percolation are water losses.

If the agricultural sector is going to conserve water, it must conserve runoff or reduce deep percolation. However, the water used by agriculture is merely transported elsewhere in the hydrologic cycle to be used for other purposes or to be reused by agriculture. Only the consumptive use of water is lost to the atmosphere and in doing so is used productively. Agricultural producers are trying to reduce consumptive use without reducing yield, but genetic engineers and plant breeders have a long way to go in developing more water-efficient plants.

Agricultural water conservation is complicated in that every irrigated field is different and many are considerably different from each other even within the same irrigation district, and definitely between irrigation districts. Having worked with about twenty irrigation districts in my career, I can say that in every single district, although there may be similarities in hydraulic characteristics, crops, and soil types, there are different attitudes or philosophies or mechanizations by which the land is farmed. Sometimes the differences are subtle, othertimes they are not.

Figure 2 shows the three major types of agricultural irrigation systems. Flood or gravity irrigation is the most prevalent type of irrigation in the U.S. and worldwide. It is an economical method and can be a very water-efficient method.

MAJOR TYPES OF IRRIGATION

Flood or Gravity

Furrow, Basin, Border

Sprinkler

Center Pivot, Turf

Micro

Drip, Landscape, Greenhouse

Figure 2. Major types of irrigation.

Sprinkler irrigation is limited in applicability and by cost. Two types of sprinkler irrigation have been adopted on a large scale: center pivot and turf irrigation. Center pivot irrigation is used on the High Plains of Texas, Nebraska and California and a little bit in New Mexico. Nearly all turf irrigation uses sprinkler irrigation. Sprinkler irrigation results in an increase in evaporation caused by propelling the water droplets through the air. From the time the water leaves the sprinkler until it hits the ground, water is lost to evaporation, and that water is not used productively other than for evaporative cooling in the nearby area. This water is lost to the atmosphere. In flood or gravity irrigation, there is very little evaporation because the water is close to the ground. Typically evaporation water loss through flood irrigation is less than 5 percent, often only 2 percent. Sprinkler evaporative loss can be as high as 20 percent.

Micro-irrigation in agriculture is limited to drip irrigation and is mainly successful on orchard crops such as grapes and to a limited degree on some trees, mainly when the trees are young. Eventually because of the large consumptive rate of mature orchard crops, drip irrigation cannot apply an adequate amount of water in a timely manner. Drip irrigation is very popular for use in greenhouses and for landscape, but accounts for only a fraction of a percent of the production of agricultural land worldwide, and will remain so for a long time. Drip irrigation is expensive to install and requires a great deal of management. The cost is so great that drip irrigation won't be implemented widely until the cost of water increases sufficiently. If the cost of water reaches that point, there will be a lot of people put out of business in the agricultural industry.

A FARMER'S VIEW OF WATER CONSERVATION

The bottom line for farmers as for most business people is the balance in their checkbook. That's not to say that producers don't think about other things, but their net profit is a critical determinant of whether and how they will farm. In dealing with a metropolitan water district for example, producers will ask themselves, "What will the water district pay me not to farm with this water?" Producers weigh the answer to that question against the value of the crop they could produce. If the crop values increase, farmers can afford to pay more for raw inputs such as water. If prices decrease, farmers must reduce initial outlays for raw input.

Producers also assess the risks involved in farming and risks play an important role in terms of conservation.

For example, if a farmer has a chile crop with $1000 per acre invested at the end of the year, he may contemplate whether to irrigate one last time. It may cost the farmer $2 an acre to irrigate once more, but he is concerned about his yield. The farmer may take some soil moisture measurements to help him decide whether to irrigate, but often the farmer decides it isn't worth the risk of a yield reduction to not spend the $2 per acre to irrigate. He will go ahead and irrigate, many times when it may not be necessary, but there may be some uncertainty in it and they'll minimize the risk by irrigating.

The effort required to implement a conservation practice is critical. Anyone who has tried to farm understands this. I was a bit naive when I first started farming. I had 40-50 acres of chile and thought of hiring two people to hoe weeds. Then I calculated how many linear miles you have to walk to weed that field. It's about 140 miles, the distance from Las Cruces to Socorro. I wanted the field weeded in two weeks. It would take quite a bit of effort for two people to walk that distance, all the while swinging a nine-pound hoe. So you get a little better view of what effort is involved and the benefit of my spending time instead of conserving water instead of not doing that last $2 irrigation per acre is a lot of other things going on that I'm going to make a lot more than $2 per acre, if I'm paying attention to them. You've got fertility management, you've got insect management, and cash flows are low at that time of the year; there are a lot of things going on that I can benefit from much more than maybe putting the time into water conservation.

A FARMER'S VIEW OF WATER CONSERVATION

Economics

Dollar per acre-foot vs. value of crop

Risk - Marginal costs of water vs. yield

Effort

Benefit of time spent scheduling vs. other activities

Validity and interpretation of data

Figure 3. A farmer's view of water conservation.

Another factor in conservation is the validity and interpretation of the data supporting conservation practices. Being an academic turned agriculturalist, I should be touting high-tech methods for agricultural water conservation. As a result of trying to apply my research as well as the research of others to farming practices, I have questions concerning how to interpret the research data and the validity of the research.

A typical farmer is extremely intelligent and has learned a lot through experience. Each day farmers are required to make many decisions requiring intelligence and experience. As an academic, one is tempted to tell farmers, "Hey, I've done this analysis, you've got to adopt these computer programs and these best management practices. I know these data will help you operate more efficiently, I did a research paper on it." Researchers are up against farmers who know quite a bit more than they do about farming, and the reason they know so much is that they live it everyday. And they think about it everyday.

Farmers get most of their information through informal networks. At the field level, it's not an overly competitive industry. Most farmers do not compete to put their neighbors out of business. Farmers cooperate with each other and network. A tremendous amount of information is transferred among farmers.

There's an intuitive optimization process that occurs with farming as in other industries. It is not understood exactly how farmers leap from an inference to making a decision without having significant or sufficient information to make that decision. This is something that artificial intelligence researchers are trying to a get grasp on right now. Farmers often seem to have the right answer, but don't know how they arrived on that answer. Their answers may not be 100 percent correct initially, but the trial-and-error process and hands-on experience helps generate the optimization and intuitive process.

EXPERIENCE VS. ANALYTICS
Day-to-Day Basis
Networking
Extrapolation - Intuitive Optimization
Hands-On/Trial and Error
Natural Selection of Best Farmers via Economics
Life Long Farmer - 40 to 50 experiments
Generational Transfer of Information

Figure 4. Experience vs. analytics.

Also, there is a natural economic selection process which operates in most businesses. We saw it working to a great degree in agriculture during the 1980s. Farmers who couldn't produce at the maximum economic efficiency went bankrupt. To some extent, economics eliminated a lot of farmers who didn't know what they were doing. Those left were often farmers with the best farming and financial instincts.

A farmer only gets to conduct 40 to 50 experiments and then he's dead. He has a limited time to optimize his farming process. Hopefully during the learning process there is ongoing generational transfer of information. Not only from parent to son or daughter, but from one group to another. Even so, things change quickly in farming.

WHAT WORKS IN AGRICULTURAL WATER CONSERVATION

Previous water conservation efforts can be categorized as either efforts that worked well and those that did not. Each technology has restrictions on applicability and drawbacks on use.

Laser-land grading, precision grading of land down to a fraction of an inch so that water can be spread evenly during flood irrigation is an important and very common practice. Laser leveling is done with an instrument that is more of a surveying instrument than anything having to do with land-leveling machines. A laser reference system is used to provide the information necessary to adjust the land-leveling equipment so that farmers get a very precise, graded field. The uniform grade allows uniform application of water.

Surge-flow irrigation has limited applicability for surface irrigation although it has been very successful in specific geographic areas. Surge-flow irrigation uses an automated valve that alternates the flow of water in furrows from one set of furrows to another controlled by computer program. It is very affordable and easy to use. The Soil Conservation Service and others are enthusiastically encouraging its use, and it is an excellent example of technology transfer. Surge-flow is an innovation that made farmers pay attention to things they had not paid attention to before and part of its success is due to farmers networking.

Low pressure precision application is a method whereby agriculture has been able to reduce energy costs and evaporation losses experienced when using center pivots. Low-pressure precision application has been implemented primarily in the High Plains with great success.

Automation and use of remote control are being applied increasingly to improve irrigation efficiency and reduce labor costs. Farmers will buy into electronics as long as they are economically, very reliable, and make the job simpler.

The last point may be the most important. Eighty cents a pound cotton will do the most for agricultural water quality conservation and preservation. You must have money to make system capital improvements. You may think 80 cents a pound doesn't sound like much, but it is a world of difference from where agriculture is now. Eighty cents a pound would provide capital resources to the farmer that no federal agency could match. However, the world market has not supported this price and may not for quite a while.

Figure 5 lists several things which have limited success in conserving irrigation water. Irrigation scheduling is important, but there are problems with the validity and interpretation of data. Drip irrigation is difficult to implement on a large-scale for production crops, such as cotton and chile. It requires intensive management, resources, and capital. There always seems to be someone developing a new application of a soil additive, plant hormone or different fertilizer. If it costs less than $20 an acre, or sometimes only a few dollars an acre for aerial applications, farmers might try it. However, often the efficacy of the substance is unproven. Often it's just something to sell the farmer with the promise that it will reduce consumptive use by 10 percent, but in reality, there is no way to evaluate whether it did anything at all.

WHAT IS DIFFICULT TO USE IN PRODUCTION AGRICULTURE

Irrigation Scheduling

Drip Irrigation

Soil and Plant Treatments

$0.50 a Pound Cotton

Figure 5. What is difficult to use in production agriculture.

Last and most significant is the price a farmer receives for his product. Using the example of cotton at 50 cents a pound, it will be difficult for a farmer to reinvest next year with this year's cotton money and install an automated irrigation system or surge irrigation system or laser level as conservation efforts. Farmers will not have the capital to make these improvements.

In summary, water is a raw input into the manufacture of food and fiber. No one would think of telling the automotive industry that they must limit the amount of iron they use in manufacturing a car. As long as agriculture uses water productively it benefits everyone. And agricultural conservation is not as easy as it may seem. First, from a hydrologic point of view, agricultural water use efficiency is high. Second, farming is a complex and risk-oriented business with the marginal cost of water being relatively low. And third, many of the water conservation programs and technologies are of limited applicability and benefit.