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THE ARKANSAS VALLEY SUPER DITCH - A LOCAL RESPONSE TO "BUY AND DRY" IN COLORADO WATER MARKETS

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ABSTRACT: Across the West, water transfers generate controversy. In Colorado's Arkansas River basin urban growth and harsh farming conditions have led to water transfers from agricultural to urban uses. Much of this water left the Arkansas basin and was transferred north to the city of Aurora in the South Platte River basin. Several studies have shown that these transfers have had significant secondary economic impacts associated with the removal of irrigated land from production. In response, new methods of sharing water are being developed to allow water transfers that benefit both the farm and urban economies. One such project currently under study is the Arkansas Valley "Super Ditch", a rotational crop fallowing plan based long-term water leasing designed to provide an annual supply of 31.6 Mm^3. This paper analyzes the economic impacts of implementing the "Super Ditch" as a locally developed alternative to "buy and dry".

Key Terms: water transfer, rotational fallowing, rotational crop management strategy, IMPLAN, input-output analysis, water supply management, irrigation management

Running Head: Arkansas Valley Super Ditch Rotational Fallowing

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INTRODUCTION

Water sales from farms to cities have been controversial since the early 20th Century when the Metropolitan Water District succeeded in bringing water over 200 miles from the Owens Valley to the Los Angeles basin (Kahrl, 1983; Reisner, 1986). The first major water sale in Colorado's Arkansas Valley occurred in 1955 (Table 1). With cities growing along Front Range and sugar production declining, the basin became an attractive target for water purchases in the 1970's and 1980's. From 1971 to 1986 over 162Mm^3 of water was transferred from agricultural to urban uses in eight major sales.

Residents of the Arkansas Valley came to view water transfers with increasing alarm, fearing that the loss of water would lead to inevitable economic decline. Each new sale met with strong denunciation in the local papers. New groups formed to explore means to "keep water in the Valley." Nevertheless, the state's water interests, whether urban or rural, maintained a strong belief in the prior appropriations system. Water is private property. Arkansas Valley farmers have always resisted attempts by any entity to impose restrictions on their right to use or transfer water within the established framework of the state's water law. Thus any plan to sustain irrigated agriculture in the Arkansas Valley must be consistent with farmers' ability to freely exercise their water rights.

From the first transfer in 1971 over 30 years went by without a political body forming to represent voters' interests in the context of water transfers (www.lavwcd.org). Motivated by the severe drought of 2000-2002 as well as speculative interest in the Valley's largest ditch, the Ft. Lyon Canal, the citizens of 5 counties in the lower valley voted to create the Lower Arkansas Valley Water Conservancy District (LAVWCD) in 2002.[3] The mission of the District is "to acquire, retain and conserve water resources within the Lower Arkansas River Valley; to encourage the use of such water for the socio-economic benefit of the District citizens; to participate in water-related projects that will embody thoughtful conservation, responsible growth, and beneficial water usage

[3] These are Pueblo, Otero, Crowley, Bent and Prowers counties.

within the Lower Arkansas Valley…" (www.lavwcd.org). Clearly, a rotational fallowing agreement between the District's farmers and Front Range cities is one strategy to achieve these objectives.

The rotational fallowing agreement between the Metropolitan Water District of Southern California (MWD) and the Palo Verde Irrigation District (PVID) is often seen as the model for allowing cities to firm up their supplies while at the same time, allowing irrigators to retain ownership of their water rights and to keep farming. However, the PVID has a distinctively different institutional arrangement; it is a single entity created by an act of the California Legislative in 1923 (www.pvid.org). The LAVWCD, on the other hand, was created by a referendum of the citizens the five lower basin counties in 2002 as a means of creating an institution to help protect the interests of local citizens with respect to the Valley's water resources. Fundamentally the aim of a rotational fallowing agreement is to spread the economic impact of removing irrigated land from production over both time and space by implementing rotating leases with farmers across the ditch companies participating in the Super Ditch. No land is ever permanently removed from production. Moreover, revenues lost from crop production are replaced by lease payments that can maintain expenditures within the Valley's economy.

The Arkansas Valley Super Ditch is a local, basin-of-origin, devised solution to the external pressure for water transfers. Its aim is to respond to the market demand from cities on irrigated agriculture to put water to its highest value use, while maintaining local control by retaining ownership among farmers. The goal of this arrangement is to sustain agricultural communities in the lower Arkansas Valley. If the Super Ditch is to achieve this objective it must generate greater benefit from direct, indirect and induced economic activity within the valley than the permanent dry-up and transfer of water rights. Input-output analysis is a useful tool for assessing such multiplier effects within a region. We analyze the potential economic impact of the "Super Ditch" on the Lower Arkansas River Basin, based on the positive revenue from lease payments and possible dryland farming scenarios. We make no attempt to determine whether this approach is better than other possible alternatives. The Super Ditch is interesting because it was developed by the

District to address the broad, local, economic consequences of water transfers while operating within Colorado's established system of water rights.

THEORY

Incentives to exploit differences in resource endowments have motivated trade throughout history whether in spices, silks, tea or water (Bernstein, 2008). While commercial exchange is driven by the desire for profits, public sector projects for interbasin water transfers must take a boarder perspective. In their seminal book on water transfers, Howe and Easter (1971) note that secondary costs are ignored in standard cost-benefit analysis. Standard theory on benefit-cost analysis (Sudgen and Williams, 1978) ignores such costs (and benefits) under the assumption that factors of production are mobile. However, land and other investments related to irrigated agriculture are not, so that their value will fall below the depreciated value they could obtain if they could be reallocated and reemployed in an alternative use. The prospect of both "stranded" farm-related investments as well as the prospect of high transactions costs has motivated much research on water transfers. Moreover, The extent of water transfer activity in the past, and its likelihood to continue, drives the desire to find strategies to mitigate negative impacts in the future.

Brewer et al (2007) identify over 300 water transfers in the western United States from 1987 to 2005, with the most active markets in the South Platte Basin of Colorado, the Colorado River basin in Texas, and the Central Valley (Sacramento/San Joaquin Rivers) of California. Of these transfers 48% were permanent sales of water rights with the remaining being short-term leases. Municipalities are the most common buyers of water rights, accounting for 37% of purchases and irrigators are the most common sellers at 55% of sales (Brown, 2006). These sales and leases have been made from a willing seller to a willing buyer making each better off. Pareto efficiency is satisfied. However, the question of what some call, "Owens Valley Effect", i.e., the harm to third parties in the basin of origin, still lingers.

Observing what appeared to be opportunity for economic gain from moving water from farms to cities, Young (1986) posed the question, "Why are there so few water transfers?" He concluded that there are significant institutional barriers and high transaction costs in transferring water rights and recommended addressing these issues to make the market more fluid. MacDonnell and Rice (1993) conducted a comprehensive study of water transfers in the western states. They concluded that transactions costs are high, the process often slow, and impacts on those other than other water rights owners, who must be kept whole, are not formally considered in the transfer process. Given their lack of legal standing in the transfer process, farming communities across the West are taking action to restrict water transfers out of agriculture. MacDonnell (2008) provides a comprehensive survey of the actions that have been taken or proposed in states across the West to address basin-of-origin concerns. Hanak (2005) shows that *ad hoc* approaches, where individual counties seek to prevent transfers, lead to inefficient use of available supplies. Michelson and Young (1993) use an integrated analysis to surmise that optioning agricultural water supplies during drought is a viable alternative to other methods, such as the permanent purchase of a water right.

How significant are third-party costs? Estimating these costs is not easy as many factors affect yearly net revenue in farming – prices, energy costs, drought, a salmonella scare, to name only a few. Even leading economists can disagree. At the 2004 Universities Council On Water Resources (UCOWR) Annual meeting in Porland, Oregon, Robert Young (who was receiving the Warren A. Hall medal for contributions to water resources research), observed that, in his experience, the farm sector is highly dynamic where factors readily move in and out. Charles Howe (the previous year's recipient of the Hall medal), reflecting on his research in Colorado's lower Arkansas Valley (Howe et al. 1990), countered that there has been significant economic dislocation and that such impacts need to be more fully addressed in the transfer process. Observing water transfers in California's Central Valley, Mitchell (1993) observes that other factors, such as crop prices, weather, and government programs, impact farm communities more significantly than water transfers. In our 2008 survey of the literature on third party impacts, we concluded that there are fewer negative impacts where there are flexible leasing arrangements as opposed to permanent transfers. Moreover, counties with diversified economies experience a smaller negative effect (Smith and McMahon, 2008).

How are these impacts measured? Input-output analysis and IMPLAN, specifically, has been used in previous studies to measure the impacts of water transfers on agricultural communities. Howe and Goemans (2003) analyzed the historical effects of water transfers in Colorado's South Platte and Arkansas River basins. Estimating the impact on a per acre-foot basis, they concluded that, due to the depressed nature of the agricultural economy in the lower Arkansas Valley, it would take ten years for the economy to adjust versus five years in the South Platte basin. They recommended assistance in the form of a transfer fee per acre-foot or a more gradual removal of water out of farming. In their IMPLAN study of four Colorado River Basins, the lower South Platte, the lower Arkansas, the Rio Grande and the Republican, Thorvaldson and Pritchett (2006) estimated the direct and secondary impacts of water transfers on a per acre rather than per acre-foot basis. Like Howe and Goemans, they raised concerns about uncompensated impacts on the basin of origin and recommend compensation/mitigation programs tailored to each specific basin. They further speculate that there may be a tipping point beyond which a community cannot recover.

The IMPLAN studies described above all showed that permanent water transfers out of agriculture have significant, short-run economic impacts on the location of origin with the potential for lasting negative effects. This study examines rotational fallowing as an alternative to permanent transfers of water rights, extending the work of Howe, Lazo, Weber (1990), Michelson and Young (1993), Howe and Goemans (2003), and Thorvaldson and Pritchett (2006) by evaluating long-term leasing.

BACKGROUND

The Arkansas drains Colorado's largest river basin but by the mid 1880's, it was fully appropriated (Figure 1) (Abbot, 1985). The basin has seen a number of large agriculture-to-urban water transfers, mostly out of basin, and these are expected to continue in the future. The Colorado Statewide Water Supply Initiative (SWSI) estimated that 29,000 more hectares would be removed from agriculture to provide water to growing municipalities (Colorado Water Conservation Board, 2004). While municipal and agriculture are the largest interests in the basin, other stakeholders are becoming more important and active in river management. For example, recreational boating days have increased exponentially during the past three decades making the upper Arkansas one of the most rafted rivers in the country. (Naeser and Smith, 1995).

Water transfers in the lower basin are driven by a number of factors. Irrigated crops need more than 6,091 m^3 per hectare to produce consistent yields (Weber, 1989); yet two of the largest ditches, the Colorado Canal and the Ft. Lyon, hardly meet this requirement, annually delivering an average of 5,144 (Weber,1989) and 7,092 (Sherow, 1990) m^3 per hectare, respectively. The area also faced the demise of the Valley's main cash crop, sugar beets. By 1979, the original six sugar factories had all closed (Hartman, 2003). This forced the sale of the Valley's most senior ditch, the Rocky Ford, which had delivered an average of nearly 15,220 m^3 per hectare. Between the Rocky Ford and the 1985 sale of 123 Mm^3 from the Colorado Canal, much water left the lower basin. And the "cruel economics of agriculture" are still at work. The Denver-based company, Pure Cycle, holds a 20% speculative interest in the Ft. Lyon Canal, the basin's largest ditch for a total of 7,100 hectares or 49.3 Mm^3 of water (Woodka, 2006b). Table 1 shows the historical water transfers in the basin**.**

The "Cruel Economics of Agriculture" extend well beyond the reliability of the basin's water supply to the farms themselves. Thirty-two percent of farms in the lower basin counties that are most reliant on agriculture generate a net loss, most with losses over 45% (United States Department of Agriculture, 2006). Farm income makes up 10% of these counties' total personal income receipts compared to just 0.41% for the state as a whole (Bureau of Economic Analysis, 2004). This significant reliance on agriculture leads local entities, especially the Lower Arkansas Valley Water Conservancy District (LAVWCD), to look for alternatives to permanent water sales to keep the socio-economic benefits of irrigated agriculture in the basin. LAVWCD has designed the Super Ditch to be this alternative.

The "Super Ditch"

LAVWCD formally announced the Super Ditch Corporation in November 2006. This proposal aims to keep the economic benefits and ownership of water in the Arkansas basin to avoid the permanent dry-up of land and enhance the socio-economic base in the Lower Arkansas Valley (Woodka, 2006a). The concept of the Super Ditch was born out of the need to both keep the farmers on their land while also providing a consistent water supply to purchasing entities. It is designed to provide a longer-term water supply that is nearly equivalent to what would be delivered by a permanent sale of the same water; this should keep the benefits of the water local as well as provide the assurances that the buyer of water needs to add to their long-term water supply. Moreover, a rotational fallowing agreement creates the opportunity to spread the impact of fallowing over the ditches and counties involved in the program. Permanent transfers where a majority of shares are transferred from a single ditch, such as the majority sale of the Colorado Canal in Crowley country, concentrate the effects of the loss of agriculture activity in a localized area.

To estimate the economic impact of this proposal, this paper follows the assumptions of the initial feasibility studies done by HDR engineering. This study included the following eight ditches: the Bessemer Ditch, the Rocky Ford Highline Canals, the Oxford Farmer's Ditch, the Otero Canal, the Catlin Canal, the Holbrook Canal, the Ft. Lyon Storage Canal, and the Ft. Lyon Canal that are in Pueblo, Otero, Crowley, Bent, and Prowers counties (Figure 2)(HDR Engineering, 2006). Taking into account the amount of water adjudicated to each canal and the priority dates of these associated rights, the study then develops scenarios for water availability to these canal companies in four different water years, based on 30 years of historical water deliveries:

wet year:	383 Mm3,
average year:	262 Mm3,
dry year:	220 Mm3,
extreme dry year:	92 Mm3 (2002).

Based on these water years a rotational fallowing arrangement in which every farmer is eligible to fallow their land and lease water three of every ten years, the HDR study estimated how much water will be available for leasing. Assuming a 40% participation rate, HDR's study calculated that during an average year 31.6 Mm^3 will be available, during a dry year 26.5 Mm^3, but only 11.1 Mm^3 during an extremely dry year (HDR Engineering, 2006).

Previous Experience: The Rocky Ford-Highline Canal Leasing Arrangement:

Motivated by the extreme drought in 2002 the city of Aurora and the Rocky Ford-Highline Canal agreed to the largest leasing arrangement in Colorado history between 2003 and 2005 (MacArthur, 2004). As terms of the lease, the Canal received $250,000 for repairs, and $1307 per fallowed hectare. In total, 833 of the canal shares were leased, providing 15.5 Mm^3 each year of 2004 and 2005. No leasing occurred in 2003, which was spent finalizing the agreement and improving the canal system to make the lease possible (Personal Communication to Author by Dan Hendrichs Rocky Ford-Highline Canal Superintendent, November 20, 2006).

While this lease was more of an Interruptible Supply Agreement (ISA) than an RFA, it provides a picture of possible lease prices as well as farmer behavior during a lease. An ISA is an agreement between seller (Highline Canal Farmers) and buyer (Aurora) to provide the water when the buyer needs it. In an RFA, a group of farmers each fallow an agreed amount of acreage every year, ideally providing a consistent yearly supply of water to the purchaser(s). Farmers who are not farming during the fallow years can pay back debts and make repairs with lease payments. They might also dryland farm or engage in off-farm activities to generate additional income. One farmer was creative enough with a combination of dryland farming and cattle grazing to net $2,475 per hectare (Personal Communication to Author by Hans Fedde, Farmer, Rocky Ford-Highline Canal November 20, 2006). Such production is not possible for all farmers. For example, alfalfa is a phreatrophitic crop that, in some areas, reaches the water table, thus violating the Colorado-Kansas Compact (Personal Communication to Author by Burt and Ellen Nesselhuf, Farmers, Rocky Ford-Highline Canal, November 20, 2006).

Nevertheless other crops are possible, especially wheat and barley, which are fairly common dryland crops in the area. An estimated fifty percent of the shareholders dryland farmed during the two-year lease (Email Correspondence with Author, Ina Bernard, Division 2 State Engineer's Office, January-February 2007).

We use both the lease price and dryland farming habits of farmers on the canal in our model. The two dryland crops (wheat and barley) and their typical percentages (70% wheat, 30% barley) of total farmland are calculated using NASS. These percentages were incorporated into the various scenarios below, all of which use $1,307 per fallowed hectare as the base lease price.

We have not tried to model particular leasing patterns among the ditch companies included in the HDR feasibility study. Disaggregation of impacts to particular ditches is beyond the scope of this analysis and the resolution of our model. However, the first step is to ask the questions, can such a leasing arrangement maintain farm incomes within the area; and, how will the associated change in expenditure patterns affect the area's economy?

METHODOLOGY

This paper uses input-output models to predict the economic impact of the Super Ditch. Leotief (1986) developed the concept of input-output tables for analyzing the relationship between outputs and use of production factors. Our paper uses IMPLAN (IMPact Analysis for PLANning), which was originally developed by the University of Minnesota and the U.S. Forest Service to examine the impacts of regional forest policies (Minnesota IMPLAN Group, 1999). IMPLAN has previously been used by other authors to analyze transfers though permanent sales (see Howe, Lazo, and Weber, 1990; Howe and Goemans, 2003; Thorvaldson and Pritchett, 2006). Here we use it to predict the impacts of the Super Ditch as a case study of long-term water leasing, as an alternative to the permanent water transfer. While the fixed coefficient assumption of input-output analysis tends to overestimate impacts, as noted above, the previous work with IMPLAN on the lower Arkansas River basin makes our results comparable to these previous studies.

Assessing the impacts of the 'Super Ditch' began by disaggregating 2001 IMPLAN data into irrigated and non-irrigated farm sectors using calculations based on 2001 National Agricultural Statistics Service crop data. This technique follows the procedures of Thorvaldson and Pritchett (2006). Due to the weaknesses in IMPLAN's ability to reflect the local farm economy, especially with respect to employment, sales, and inputs (McKean et, al., 1998), crop enterprise budgets were obtained from Jennifer Thorvaldson at Colorado State University the same used by her for a 2006 study (Thorvaldson and Pritchett, 2006). A crop enterprise budget explains the inputs, their corresponding IMPLAN sector, and the percentage of each dollar spent on that crop production for that input. This percentage is presented as an absorption coefficient. These coefficients are calculated by taking the total inputs per hectare and calculating the percentage of each input 's cost that is required. For example, the purchase of nitrogen fertilizer has an absorption coefficient of 0.085. These enterprise budgets are specific to eastern Colorado, as well as to its northern or southern regions depending on the crop, and contain inputs per hectare of production and the corresponding IMPLAN industry sector. Crop enterprise budgets also calculate absorption coefficients. These are the production functions that show "where an industry spends [inputs], and in what proportions, to generate each dollar of output" (IMPLAN). Production functions for IMPLAN are usually calculated on a national average basis. IMPLAN recommends modifying them if they do not reflect the conditions of the local study area (IMPLAN). Thus, local crop enterprise budgets are used to reflect the expenditure patterns of southeastern Colorado.

For the purpose of this analysis, sectors in IMPLAN have been modified to reflect the difference between irrigated and non-irrigated crops. Using yield and price data from 2001, output values are created for each crop and, along with the production functions from the above crop enterprise budgets, are inputted into IMPLAN into new irrigated crop sectors. These values are then subtracted from the original farming sectors in IMPLAN, thus creating irrigated and dryland farming sectors. This allows for the analysis of the removal, or addition, of specific types of crop production necessary for the model.

Minnesota IMPLAN Group's IMPLAN software and data from 2001 are used for the analysis. County data is customized to represent the Arkansas Basin following procedures employed by Thorvaldson and Pritchett (2006). Data from the Colorado Agricultural Statistics Service, 2003 Colorado Agricultural Census, and the National Agricultural Statistics Service (NASS), are used to calculate crop acreage breakdowns and initial impact values based on the crop conditions in the study area. Other data sources, including the United States Geological Service and Colorado Decision Support Systems (CDSS), are used to derive many of the tables and the maps used in this paper. Finally, for the information on the Rocky Ford-Highline lease and prices, interviews with canal farmers and the Arkansas Valley Range Project were conducted. The Division 2 State Engineer's Office and Otero County Assessor's Office were also contacted for both crop and property tax information.

ANALYSIS

The proposed Super Ditch RFA will have three impacts on the local economy: (1) the annual loss of 4,000 hectares from crop production: (2) expenditures resulting from lease payments on those lands, and (3) production from dry-land farming. These impacts are estimated separately below then aggregated to determine the overall impact of the Super Ditch on the region.

Rotational Fallowing - Impact of Removing of 4,000 Hectares from Production:

We assume that the direct effect of rotational fallowing will be the yearly removal of 4,000 hectares from irrigated production. Thus, before adaptations and yearly lease payments can be taken into account, the impact of the reduction of 4,000 hectares of irrigated crops is analyzed using IMPLAN. To calculate the amount of crops removed from production, irrigated acreage data from NASS is used to calculate the percentage of total irrigated acreage that each crop made up across the study area: grain corn (24%), silage corn (2%), hay (48%), sorghum (9%), and wheat (16%). These percentages are then divided among the 4,000 hectares, multiplied by the 2001 yield and price (the year of IMPLAN's parameters) resulting in a reduction (Table 2) of $3,560,000 that is then analyzed in IMPLAN.

The initial impact of the reduced irrigated acreage reveals significant direct, indirect, and induced effects, for every $1 decrease in crop production an additional $0.34 is lost to the economy as a whole. This includes output, income, and tax impacts. The output multiplier for the initial impact is 1.34. In addition, spreading the impact over the acreage involved in the RFA, the reduced economic activity is $1,172 per hectare. The reduction in value-added (income and taxes) equals $475 per hectare removed from production. Table 3 illustrates the results of this analysis in IMPLAN.

Leasing Benefits - Annual Payments of $1,307 per Hectare:

The next step in the analysis is to analyze the positive impacts of the lease payments. This is done by increasing the 'household income' sector in IMPLAN. The amount used was $1,307 per hectare ($5,280,000), the same paid by Aurora during the Rocky Ford-Highline Canal water lease. A similar amount, $1,490 per hectare, was paid to farmers by the Metropolitan Water District during the Palo Verde Agreement.

One key difference is that the output multiplier of the household income sector is much lower than that of irrigated agriculture. That is, for every dollar increase in income only $0.16 accrues to the local economy (multiplier=1.16). The total impact per hectare of the lease payments equals $1,510, while the impact per capita is $114. Taking into account the reduction in economic activity per hectare ($1,178) calculated previously, the net gain to the economy from the lease payments is $332 ($1,510-1,178). Table 5 shows the results of analyzing the lease payments in IMPLAN.

Adaptation - Dry-land Farming:

Dry-land farming is one adaptation that is likely to occur on fallowed land each year. This is illustrated by the example of profitable dry-land farming during the Rocky-Ford Highline Canal lease. An estimated 50% of the farmers grew some combination of dry-land crops during the two-year lease (Email Correspondence with Author, Ina Bernard, Division 2 State Engineer's Office, January-February 2007). There are two reasons that we assume dryland farming will occur. First, it actually occurred during the Highland Canal lease; and second, the nature of RFA's (also called rotational crop management strategies) means that many farmers will only choose to fallow a portion of their land and thus are able to incorporate the lease as an additional crop management strategy. One way for them to manage fallowed land and help restore soil productivity is dryland farming of certain fallow crops. The potential for dryland farming depends on both factors that can be controlled, such as crop choice and management practices, and some that cannot, i.e, those related to climate. An additional constraint in the Arkansas Valley is the prohibition against growing dryland alfalfa due to its phreatrophytic character.

The aforementioned controllable (management decisions) and non-controllable (climate, disease) factors are taken into account by setting nine combinations of wheat and barley as the scenarios to input into IMPLAN. Relying on the assumption that alfalfa will not be farmed, wheat and barley would be the most common dryland crops in the area. The acreage of these dryland crops is calculated from NASS data and the percentages used to determine the breakdown of dryland crops. Then three management decisions are considered; 30%, 50%, and 70% of the land farmed. Finally, 3 possible climate scenarios are considered based on historical yields: An extremely dry year (598 kilograms per hectare wheat: 539 per hectare barley), average (27:32), and wet (41:57) (Table 5). Table 6 shows the resultant impacts per hectare (4,000 hectares) of the increase in dryland farming as an adaptation strategy. The impacts are spread out over 4,000 hectares for comparison with the decrease in irrigated crop production no matter how much acreage is farmed.

In the best-case scenario (high yields, high dryland farming participation), 20% of the losses of crop revenues are offset by the positive impacts from the increase in dryland farming. However in the worst case only 1% is offset. This obviously could change by farmers using different methods and being more productive as illustrated by the example of Hans Fedde during the lease, but these conservative scenarios provide a picture of some possibilities.

Long-Run Impacts:

Consistent with Howe and Goemans (2003), we assume that the economy will adapt and negative impacts will dissipate linearly over a ten-year period. The positive impacts will remain constant, as leasing prices will stay similar over the ten-year period (payments will likely account for inflation). Another assumption is that there are no improvements in dryland farming yields or significant changes among farming activities to increasingly maximize their economic return. Since this is designed as an analysis of possible scenarios, conservative estimates are used to better understand the impacts of the Super Ditch. Three positive scenarios are used:

- Worst Case Scenario: 30% of acreage is dry-land farmed with minimal yields
- Average Scenario: 50% dry-land farmed with average yields
- Best Case Scenario: 70% dry-land farmed with maximum yields

These scenarios are combined with the positive IMPLAN output values for the lease payments, extended over a 10-year period (assuming constant payments), and brought back to the present value. The negative impacts from the lost crop production discussed earlier are reduced linearly to zero over a ten-year period and discounted back to the present value. All of this is done using a 5% discount rate, similar to Howe and Goemans (2003). Table 7 shows the resulting net impact of 10 years of implementing the Super Ditch.

As illustrated, even the lowest dryland faming yields still show a net benefit to the community. The negative impact per hectare (-$5,700) is offset by the positive gains of $13,400 per hectare, a net benefit of $7,700 per hectare during the worst case scenario. No matter the scenario there is still a fair amount of economic return for the community.

Comparison Across Sectors:

Factors of production, especially labor, are mobile and can adapt. However this takes time, which is why it is important to look at the immediate impact of the positive lease payments and the negative reduction of irrigated acreage across sectors. Looking at the sectors that are either positively or negatively changed by more than $50,000 annually, there is only one sector in common, wholesale trade. This sector experiences an annual net loss of $10,000. Agriculture and Forestry Support suffers the largest loss outside of irrigated crops and benefits little from the leasing arrangement. This results in a net loss of $200,000 annually for the sector. Domestic Trade, Monetary Authorities and Depository Credit, Food Services and Drinking Places all benefit from the lease payments, but all are relatively unaffected by the negative impacts from the reduced acreage.

There are some limitations of using the household income sector to analyze the lease payments. IMPLAN uses the national average spending patterns to characterize the household sector. Farms, as households, especially ones with debts that plan to continue farming, would likely spend differently than the average American household. For example, during the Palo Verde Water Lease pilot arrangement from 1992-94, farmers were estimated to use 93% of the lease payments within the local economy mostly on "farm-related investments, purchases, and debt repayment" (Metropolitan Water District, 2002; Kuhn, 1993). Like Palo Verde, Arkansas Valley farmers may also spend their lease payments within the Valley. This influx of long-term stable disposable income will also allow new sectors of the economy to develop over time to compensate for the loss in agricultural income and production. Modeling such change and adaptation is beyond the scope of IMPLAN's rigid assumption that relationships among inputs and outputs remain constant within the modeling period. Moreover, IMPLAN is best suited for modeling how marginal changes in inputs affect outputs. A rotational fallowing program on the scale of the Super Ditch may go beyond what could be considered a marginal change.

Property Taxes:

In the arid Arkansas Valley, irrigated farm land is far more valuable than non-irrigated land. This is especially true for the Lower Arkansas Valley. For example, on the

Rocky Ford Canal after the transfers to Aurora, irrigated land was reclassified as grazing land reducing its Actual Value from $2,194.31/hectare to $300.74/hectare (Personal and Email Communication to Author, Melissa Walker, Otero Country Assessor's Office, February 13, 2007). The Assessed Value (29% of Actual Value) decreases from $636.36 to $80.50 per hectare with the re-designation. Since these values determine property taxes, the funding base for schools and public infrastructure project decreases if there is no compensation during a permanent sale of water. However, this is not the case during a lease such as the Super Ditch as no water is ever permanently separated from the land.

CONCLUSIONS

What are the potential impacts of the Super Ditch? The local economy loses $1178 of direct and indirect expenditures per hectare removed from production. However, given the higher value of water in M&I use, lease payments are estimated to exceed these losses. thus turning the farmer's water into a second cash crop. Because of this steady flow of long-term income, improvements to farmland can be made and many farmers would have incentives to adapt during their "fallow" years without water, possibly dryland farming some or all of their irrigated acreage.

We model two positive impacts with IMPLAN to reflect the changed conditions created by rotational fallowing – annual lease payments and an increase in dryland farming. These positive payments result in a significant net benefit, especially over time. While this benefit is primarily due to the lease payments, the possible economic activity under different dryland farming scenarios may offset as much as 20% of the negative impacts of the necessary land fallowing (Table 8).

It should be noted that those sectors positively affected by the lease payments are not the same as those negatively impacted. However, conclusions about the affected sectors cannot be relied on too much since the household spending sector used for the lease payments in IMPLAN reflects the spending habits of general households, not farm households that are likely to use the money locally and on improvements to their farms. This is a limitation of IMPLAN for this analysis.

The population density of the lower Arkansas Valley is also a consideration in planning the Super Ditch. An advantage of the Super Ditch presents over a “buy and dry” approach is that the impact is spread over a number of canals. Nevertheless, the lack of economic diversity in the lower Valley will affect the economy of the region over time regardless of the success of the Super Ditch. The lower basin has a population of 53,731, and an employed workforce of 28,023. This low population density and lack of alternative economic activity make it likely that this economy will take time to recover from negative shocks (Howe and Goemans, 2003; Thorvaldson and Pritchett, 2006).

The Super Ditch continues to move ahead. As of the summer of 2011 the LAVWCD has filed an exchange case and there is work underway related to process improvements aimed at streamlining quantification of historic consumptive use. Thus not insignificant legal hurdles remain (Curtis Mitchell, City of Fountain Utilities, Email Communication with Author, July 14, 2011). Moreover 8000 shares of the Catlin Canal recently signed on for a pilot project to 'sell' 500 acre-feet of water to the Pikes Peak Regional Water Authority. In addition, others are intently watching the progress of the Super Ditch as several groups in the South Platte Basin are looking at similar water sharing arrangements (Woodka 2011).

As noted by McDonald and Rice (1993), transactions cost including time, legal and engineering expenses create incentives to do large transfers where these fixed costs can be spread over a larger amount of water. If the cost of leasing through a rotational fallowing agreement increases water costs to the point that buyers balk, RFA as an alternative to permanent transfers will fail. A solution such as the “Cosmic Agreement” on Clear Creek, that flows into Denver from the west, involving all potential buyers and sellers in establishing the transferrable, consumptive use and resolving other related issues is needed to facilitate long term leasing.

The net benefits to the local community from the Super Ditch help justify the concept. The Super Ditch, or something similar, can provide a flexible water management solution that also can increase farmer's incomes. Water supply can be provided to municipalities on a long-term basis consistent to that which would be provided by a sale, yet the benefits remain with the farmers who also remain on the land. The Super Ditch will likely have a positive impact on the local economy. It is an idea worth exploring as part of the solution for the water crisis in the western United States.

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Figure 1: Arkansas Valley Map[4]

[4] Ibid

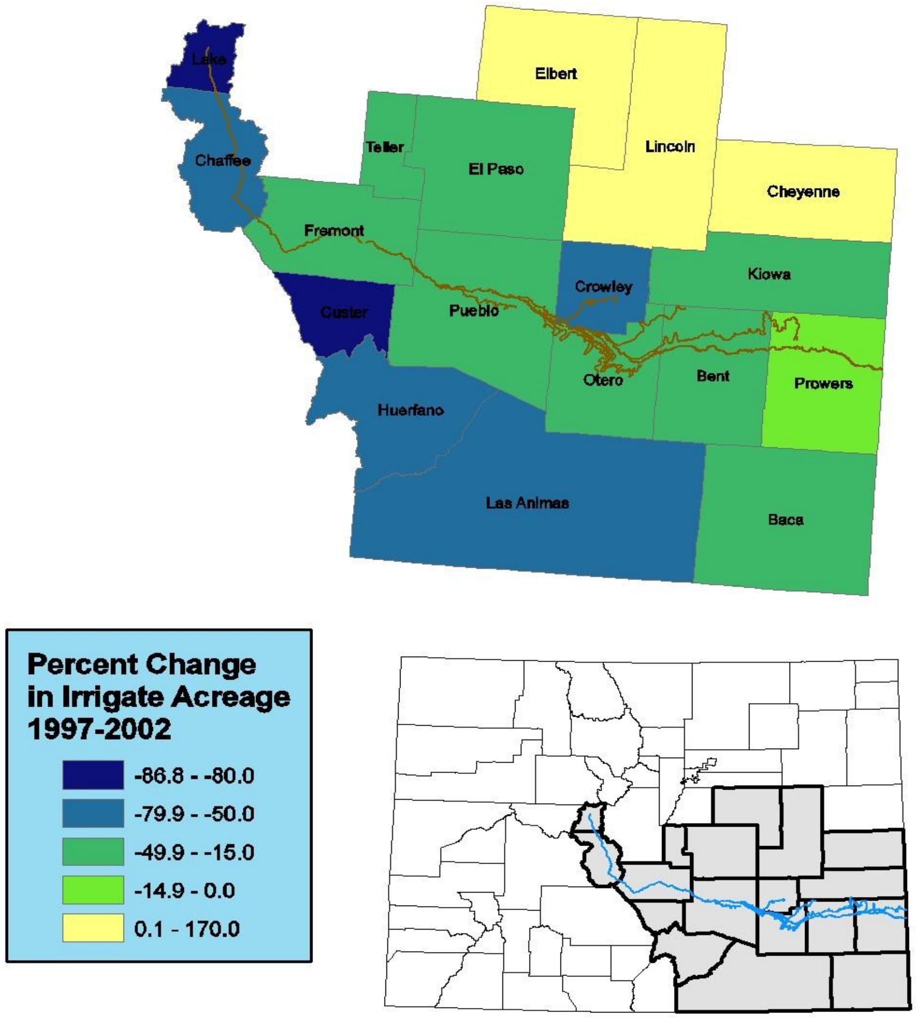
Lake
Chaffee
Teller
El Paso
Elbert
Lincoln
Cheyenne
Fremont
Custer
Pueblo
Crowley
Kiowa
Otero
Bent
Prowers
Huerfano
Las Animas
Baca
Percent Change in Irrigate Acreage 1997-2002
-86.8 - -80.0
-79.9 - -50.0
-49.9 - -15.0
-14.9 - 0.0
0.1 - 170.0

Table 1 – Water Transfers in the Arkansas Basin:

Water Transfers in the Arkansas Basin[5]			
Year	Transfer	Hectares Lost	Mm[6]
1955	Otero Ditch - Clear Creek Reservoir	2226	11.1
1971	Las Animas Town Ditch to Highline Canal	769	7.2
1971	Highline Canal (Busk Ivanhoe) to City of Pueblo	486	???
1972	Booth-Orchard to City of Pueblo	580	3.6
1973	Hobson Ditch to City of Pueblo	111	1.8
1984	Las Animas Consolidated Extension to Public Service	2358	16.3[7]
1985	Colorado Canal (incl. Twin Lakes Shares) to Pueblo, Springs, Aurora	19,020	123.6[8]
1986	Rocky Ford (majority) to Aurora	1659	14.7
1986	Highline (Busk Ivanhoe) to Aurora	405	???
2002	Rocky Ford (minority) to Aurora	1027	5.1[9]
	Totals	25,900	183.3

[5] Source: Division 2 State Engineer's Office (Unless Otherwise Indicated)

[6] Charles W. Howe, Jeffrey K. Lazo, and Kenneth R. Weber, "The Economic Impacts of Agriculture-to-Urban Water Transfers on the Area of Origin: A Case Study of the Arkansas River Valley in Colorado," *American Journal of Agricultural Economics* 72 (1990): 1202.

[7] This water has not been transferred yet.

[8] Howe and Goemans, p. 1060-61.

[9] Calculation 5,394 m^3/hectare * 728 hectares + 3,901m^3/hectares * 299 hectares

Figure 2 - The Arkansas Valley Super Ditch

Table 2 – Annual Crop Production Lost ($) from a Rotating Water Lease Resulting in the Reduction of 4,000 Irrigated Hectares:

Crop	Percentage of Total Irrigated Acreage by Crop	Hectares Lost	Yield per Hectare (metric tons)	Price per Unit($)	Output Impact($)
Corn Grain	24%	1000	10.5	78.30	820,000
Corn Silage	2%	77	47.3	24.20	85,000
Hay	48%	1938	11.3	110.90	2,271,000
Sorghum	9%	368	5.0	67.30	124,000
Wheat	16%	664	4.0	100.00	264,000
	100%	4,000			$3,564,000

Table 3 - IMPLAN Estimates of Reduced Economic Activity from Annual Fallow of 4000 Hectares:

	Direct	Indirect	Induced	**Total**
Total Value-Added($)	-1,271,669	-400,819	-248,126	**-1,920,614**
Output ($)	-3564,259	-765,118	-430,590	**-4,759,967**
Employment (jobs)	-13	-15	-6	**-34**
Per Capita ($)	-66	-14	-8	**-89**
Per Hectare ($)	-881	-190	-106	**-1,178**
Output Multiplier: 1.34				

Table 4 - Impacts of the lease payments on the economy:

Lease Payments - $1,307 per hectare	Direct	Indirect	Induced	Total
Total Value-Added ($)	1,389,000	193,000	253,000	1,835,000
Output ($)	5,280,000	385,000	439,000	6,104,000
Employment (jobs)	34	6	6	**46**
Per Capita ($)	98	7	8	**114**
Per hectare ($)	1,307	96	109	**1,510**
Output Multiplier - 1.16				

Table 5 - Dryland Scenarios and Associated Crop Revenues:

			Water Availability		
			Dry	Average	Wet
		Wheat/Sorghum	Yield – metric tons/hectare		
	Hectares Dryland Farmed (%)	Acres	0.60/0.54	1.81/2.51	2.75/3.83
Management Decision	30%	850/364	$52,725	$206,928	$328,071
	50%	1416/607	$107,640	$344,880	$546,785
	70%	1983/850	$150,696	$482,832	$765,499

Table 6 - Positive Impacts Generated by the Increase in Dryland Farming:

			Water Availability		
			Dry	Average	Wet
		Wheat:Sorghum	Yield - Bushels/Hectare		
Management Decision	Dryland	Acreage	0.60:0.54	1.81:2.51	2.75:3.83
Hectares Farmed (%)	30%	850:364	$65,000	$256,000	$405,000
	50%	1416:607	$133,000	$426,000	$676,000
	70%	1983:850	$186,000	$597,000	$946,000[10]

[10] The output multiplier for the increase in dryland farming was 1.26, so for every dollar of increased dryland production $1.26 was generated in the economy.

Table 7 - Total Impacts Per Hectare over 10 Years:[11]

	Impacts of Lost Crop Production	Worst-Case Dryland Scenario	Average Dryland Scenario	Best-Case Dryland Scenario
Per Hectare	-$5,693	$13,366	$14,109	$15,099
Net Benefits (Present Value)	----------------	$7,673	$8,416	$9,653

[11] Rounded to nearest hundred

Table 8 - Net Benefits of the Super Ditch:

	Summary of Findings - Impacts per Hectare	
		Per Hectare Impact
	Base Case - 4,000 Irrigated Hectares Lost	($1,178)
	Lease Payments	$1,510
	Worst Case (Dry Year)	$15
	Average	$106
	Best Case (Wet Year)	$235
Impacts By Year	Net Impacts (Lease + Dryland - Irrigated Hectares Lost)	
	Worst Case (Dry Year)	$346
	Average	$438
	Best Case (Wet Year)	$567
Long-Run	Present Value of Net Impacts Over 10 Years	
	Worst Case (Dry Year)	$7,673
	Average	$8,416
	Best Case (Wet Year)	$9,653