Economic Impact Analysis and Regional Activity Tool for Alternative Irrigated Cropping in the San Luis Valley

Rebecca Hill
James Pritchett

Agriculture and Resource Economics
Colorado State University

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SAN LUIS VALLEY DEVELOPMENT RESOURCES GROUP
SAN LUIS VALLEY COUNCIL OF GOVERNMENTS

610 State Avenue, Suite 200 ~ P.O. Box 300 ~ Alamosa, CO 81101
719-589-6099 ~ Fax 719-589-6299
www.slvdrg.org

Contact: Rebecca Hill, Agriculture and Resource Economics, Colorado State University, email: Rebec.L.Hill@gmail.com, PH: 970-491-7119 or James Pritchett, Agriculture and Resource Economics, Colorado State University, email: james.pritchett@colostate.edu, PH: 970-491-5496

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Introduction

The San Luis Valley has a rich heritage and is a vibrant region located in southern Colorado. This high altitude valley is culturally and geographically distinct from its neighbors with nearly 8,200 square miles of semi-arid lands enfolded by the San Juan Mountains and Continental Divide on the west, and the Sangre de Cristo and the Culebra mountains on the east, the Colorado–New Mexico state line on the south, and the La Garita range on the north. Six counties lie within the San Luis Valley and include Alamosa, Conejos, Costilla, Mineral, Rio Grande, and Saguache.

The economy in the San Luis Valley is firmly connected to agriculture with a significant share of its gross domestic product coming from agricultural sales and associated income. Important agricultural goods include the Valley's premier potato production and its high quality alfalfa, barley, and cattle. Agriculture is tightly woven with other industry sectors because of the local purchase of inputs and the local spending of wages. Irrigation is the lifeblood of the agricultural engine, as seldom is more than eight inches of precipitation received each year.

Snowmelt is the primary source of water for surface irrigation in the San Luis Valley, and centuries of the ensuing runoff have filled the aquifer that lies beneath the surface of farmland acres. Irrigation wells have tapped this rich water resource. However, persistent drought conditions in the last decade reduced the recharge that occurs from natural runoff or diverted irrigation flows from the Rio Grande causing underground aquifers to be depleted at an unsustainable rate.

The communities, governments, and citizens of the San Luis Valley are mobilizing positive approaches for maintaining the sustainability of underground water supplies and the economic base of local communities. One approach is the reduction of irrigated agriculture's aquifer depletions through a mix of conservation strategies, alternative crop rotations, and the fallowing of agricultural lands.

An important set of questions centers on the overall economic ripple effects that occur when irrigated cropping changes in the San Luis Valley. These questions include:

- What is the benchmark level of irrigated agriculture in the San Luis Valley?
- How are final product sales, input purchases and wages for irrigated agriculture connected to allied industries and employment in local communities?
- In what way does irrigated agriculture and allied industries contribute to government revenues that are then spent on local infrastructure and services?
- How will the economic adaptations from reduced groundwater depletions be distributed among stakeholders (e.g., businesses, households and government) in the local economy?

The San Luis Valley Council of Governments, Colorado Water Institute and CSU Extension partnered to provide insights into these key questions, and a local engagement process provides important advice. An advisory committee of local stakeholders helped to guide the research and engagement activities. Beginning in May 2015, the advisory committee met to define objectives for the research activities and to provide needed feedback on the project's progress, evaluate preliminary results, and to suggest alternative approaches. The advisory committee and research team developed the following objectives:

1. Identify sectors of the region's economy most closely aligned with the economic activity generated by irrigated crop production;

2. Create a tool that uses economic activity matrices for assessing future changes to economic activity in the region; and

3. Characterize the economic ripple effects of proposed strategies for reducing groundwater depletions such as changing the crop mix and conservation fallowing cropland.

In particular, this research project describes the economic activity in the San Luis Valley and considers the likely distribution of economic changes that come from scenarios that include:

- Reducing cropping acres for the four primary irrigated crops of the San Luis Valley—alfalfa hay, potatoes, barley and wheat.
- Reducing irrigated production of alfalfa.
- Substituting a less water-using crop, wheat, in favor of alfalfa.
- Enrolling irrigated cropland in a Conservation Reserve Enhancement Program (CREP).

An economic activity matrix has been created for the San Luis Valley and is being created for each of the six individual counties in the region. The activity matrix proxies the economic linkages among sectors of the economy based on the purchases and sales of goods as measured in 2013, which is the most recent year of available data. The matrix is placed in a spreadsheet and modified so community members can use it as a planning and discussion tool. The tool provides a snapshot of how economic activity is altered when the value of goods produced by economic sectors, such as irrigated cropping, is altered.

This executive summary provides key findings related to these objectives. In the following text, basic economic demographics of the San Luis Valley are described, followed by an explanation of the economic activity matrix and the 'what-if' scenario analysis tool. A hypothetical scenario for creating water savings is considered in order to demonstrate how the tool can be used by local stakeholders.

San Luis Valley Economic Demographics

The San Luis Valley is a geographically defined region in south-central Colorado with nearly 8,200 square miles of land and a population of just over 46,000 individuals. The population of the area is relatively stable with anticipated annual growth of 0.9% in the coming years. In the San Luis Valley, business activity is centered on more than 825 establishments and 28,000 employees. The region is home to 14 school districts, and the high school graduation rate is 85% of the student population (DOLA, 2014).

Agriculture is vibrant industry in the San Luis Valley and is the region's primary economic driver. As reported by the US Census and the Bureau of Labor Statistics for 2013, the gross domestic product of the counties in the San Luis Valley totaled more than $3.3 billion and the equivalent of slightly more than 28,000 full time employees earn wages. Agriculture accounts for a significant portion of the top 10 sectors of the economy as measured by output as reported in Table 1 below. Agriculture's influence is evident in the farm gate sales of potatoes, alfalfa, and a portion of the wholesale trade as well as in agriculture production support industries and trucking.

Table 1. Top 10 Sectors of San Luis Valley Economy for 2013 (IMPLAN).

Rank	Sector	Employment	Output (Mill. $)	Output Multiplier
1	Potato Farming	1,141	$179.2	1.47
2	Wholesale Trade	717	$161.1	1.46
3	Electric Power	121	$151.6	1.22
4	Alfalfa Farming	886	$117.3	1.52
5	Agriculture Production Support Industry	2,694	$100.2	1.44
6	Hospitals	772	$96.2	1.50
7	Beef Cattle	411	$93.9	1.60
8	Local Gov./ Educ.	1,321	$67.8	1.43
9	Trucking	402	$57.1	1.58
10	Real Estate	394	$56.6	1.20

As an example, potato production is the sector generating the greatest economic activity measuring nearly $180 million in sales in 2013 and an employment equivalent of more than 1,100 individuals in the San Luis Valley. Every dollar of sales generates 47 cents of local economic activity as indicated by the column summarizing the potato output multiplier (1.47). The multiplier calculates the local economic activity that includes the direct sale of potatoes, the purchase of inputs needed in potato production and the activity generated by wages spent locally. The size of the multiplier will depend on the basic demographics of the region, the diversity of the regional economy, the relative importance of irrigated agriculture in the regional economy, and the strength of the backward and forward linkages between irrigated agriculture and supplying and processing sectors. The magnitude of the potato multiplier is similar to other agricultural commodities produced in Colorado.

Potatoes are a significant crop for the San Luis Valley and depending on the associated prices and yields, potatoes can be the largest generator of revenues to the area. Potato's influence on the local economy is somewhat rivaled by alfalfa production, which includes more than 137,000 acres (Table 2). The value of annual output can be interpreted as crop revenues and this depends importantly on market prices and yields.

Table 2. Four primary irrigated crops in the San Luis Valley for 2013 (USDA and IMPLAN).

Crop	Acres	Annual Output (Million $)	Labor (hours/ac)
Barley	46,000	$38.8	1.2
Alfalfa	137,000	$117.3	3.7
Potatoes	46,600	$179.2	14.0
Wheat	5,900	$6.1	1.3
San Luis Valley Total	***235,500***	***$341.4***	**XXX**

Notable in the table above, the vast majority of irrigated cropping is directed to alfalfa production followed by nearly equal amounts of barley and potato farming. If irrigated cropping is reduced in the San Luis Valley, it may be that alfalfa acres will be impacted the most and associated ripple effects will be transmitted throughout the economy. Historically, alfalfa acres and overall alfalfa production has increased in the period 2010-14 with some easing recently. Potato production has decreased by 10% over the 2010-14 period while barley acres have increased slightly. Potatoes tend to be the most labor intensive crop with 14 labor hours expended per acre of production, which leads to a greater impact on local wage income when additional acres of potatoes are grown or taken out of production relative to other crops.

Table 3 reflects the interrelationship between the primary irrigated crops in the San Luis Valley and the remainder of the economy. Output multipliers for each crop are listed in the second column of Table 3, and these multipliers reflect the overall economic impact of a dollar received for a crop; that is, an additional dollar of sales of barley generates a total impact of $1.43 to the economy because of the direct sale of the barley, the indirect purchases of inputs for growing barley and the induced spending of barley based wages in the economy.

Table 3. Multipliers and economic activity per acre for four irrigated crops in the SLV using 2013 information (USDA, IMPLAN).

Crop	Output Multiplier	Economic Activity ($/ac)	Employment Multiplier
Barley	1.43	$844	6.1
Alfalfa	1.52	$856	12.1
Potatoes	1.47	$3,846	10.4
Wheat	1.43	$1,035	5.7

Irrigated agriculture is intertwined in the local economy through several channels: the most obvious are sales of irrigated crops that directly influence the economy as they are purchased by consumers or processors, but these crops in turn generate demand for intermediate goods (indirect purchases) and services from other, related sectors of the economy. In addition, the direct and indirect purchases increase employment and income, enhancing the overall economy's purchasing power, thereby inducing further spending on goods and services. This cycle continues until the spending eventually leaks out of the local economy as a result of taxes, savings, or purchases of non-locally produced goods and services.

The third column of Table 3 measures the economic activity generated by an irrigated acre of the crop. The greatest economic activity is found for potatoes at $3,846 per acre. This value is not a measure of profit, rather it is the summed value of potato revenues, the costs of the inputs purchased to grow potatoes and the amount of wages paid for the year 2013. The combination of these economic activities generates the highest level of overall economic activity – but not necessarily the greatest profits to the producer. Indeed, high cost crops may generate large economic activity via input purchases, but yield meager profits. The last column of the table indicates the additional full time equivalent jobs generated by an additional million dollars of sales of the crop. In the case of wheat, a less labor intensive crop, selling $1 million more wheat would generate almost 6 full time equivalent labor positions in the local economy.

Care should be taken when interpreting the values listed in Table 3. First, these values represent a snapshot of the local economy in 2013, rather than a forecast of what will happen if irrigated cropping acres were altered. More specifically, these values fail to reflect the adaptations of farmers and agribusinesses who observe the change in irrigated acres and develop business strategies to compensate for lost opportunities. Adaption is likely to mitigate some of the lost economic activity. In addition, the estimates are specific to the year 2013, so local commodity prices and local yields influence the value of crops produced. Lastly, the values do not capture the notion of a “tipping point,” in which lost irrigated acres might cause the economy to cross a critical threshold so that supporting businesses are no longer viable. For this reason, these estimates are better approximations of smaller changes in irrigated acres rather than large scale changes.

The previous discussion indicates the importance of irrigated cropping to the local economy – farm gate sales account for a significant portion of the San Luis Valley’s regional economic activity and employment. The cropping activity is almost entirely sourced from four irrigated crops – potatoes, alfalfa, barley and wheat – which have varying contributions to regional economic output due to the value of their sales, the costs of locally sold inputs and the payment of wages to local labor. The synergies between sectors of the economy can be captured through the use of economic output and labor multipliers as are represented in Table 3. In fact, every sector of the San Luis Valley economy can be interrelated with the others via multipliers.

Defining multipliers for the San Luis Valley is a useful teaching and planning exercise. Indeed these multipliers and underlying relationships can be combined to create an economic activity matrix that reveals the likely economy wide impacts of changing irrigated cropping and/or associated re-investment meant to mitigate these changes. The matrix may then be adapted to a form that allows decision makers and stakeholders to alter sector outputs and trace how the impacts are transmitted through the economy.

Economic Activity Matrix and 'What-If' Regional Economic Tool

The multipliers in Table 3 of the previous section represent economic activity and are created using a tool that economists labelled input-output (I-O) models. I-O models provide an empirical representation of the economy and its inter-sectoral relationships keeping track of the purchases and sales of every sector. When the multipliers are embedded in a planning tool, a user can determine the economy-wide effects resulting from a change in the production of one sector, such as changes to irrigated cropping in the San Luis Valley. An I-O model has an economic activity matrix at its core, and it is this economic activity matrix that describes how transactions in one economic sector influence the sales and purchases of another sector. For example, the economic activity matrix for the San Lis Valley can suggest how an additional dollar of potato sales will influence the amount of fertilizer that is purchased and sold in the local economy.

I-O analysis is comprised of two phases: descriptive modeling and predictive modeling. The descriptive model includes information about local economic interactions known as regional economic accounts. The regional account tables describe a local economy in terms of the flow of dollars from purchasers to producers within the region. In the predictive phase, these regional economic accounts are used to construct local-level multipliers, which express the response of the economy to an impact such as a change in demand or production.

In agriculture, crop enterprise budgets describe how farmers spend revenues on particular inputs such as fuel, fertilizer and labor. These enterprise budgets serve two purposes in this study. First, they are used to adjust the basic I-O model, which is derived from a national model, to make it specific to the San Luis Valley and its crops. The national model represents the "average" condition for a particular industry. Without adjustments for regional differences, the national statistics do not necessarily represent industries comprising the San Luis Valley. Second, these enterprise budgets are used to create a new sector for each irrigated crop in that region. Having a separate sector for each irrigated crop creates a more accurate calculation of the output multiplier, and thus a more accurate portrayal of the size and distribution of the impact of changing irrigated cropping acres.

For this study, crop prices and enterprise budgets are provided by Colorado State University Extension with validation from local producers and agribusinesses. The enterprise budgets reflect the 2013 costs of production, although prices and yields can be changed to reflect various economic impacts.

Using I-O Models to Perform Economic Analysis

The economic activity that is generated by an industry does not end simply at its sale in the marketplace. In order to more fully describe the economic contributions of specific industries in a regional economy, the indirect and induced effects must also be explored. For example, if an analyst studies the economy of a rural farming region and adds together only the direct impacts of each sector in the economy, the omission of indirect and induced activity may skew the results. Farming in the region is not only responsible for generating direct revenues, it also is responsible for demanding fertilizer and seed from the local farm supply store, and tractors from the local dealer, all of which are indirect effects. The farmers also spend their income at the local diner and provide tax revenues to county services, which are induced effects. Therefore, a one-dollar decline in agriculture revenue would have a greater than one-dollar effect on the regional economy because of these linkages. This is the fundamental rationale behind looking at indirect and induced effects in addition to direct effects when conducting regional economic impact analysis. The total effect of a change in the economy is the sum of the direct, indirect, and induced effects, and the multiplier is calculated by dividing the total effect by the direct effect.

I-O modeling is based on several economic assumptions about technical relationships and business behavior:

- Constant returns to scale: This implies that the production of goods and services are scalable and linear in the scaling --if additional output is required, all of the necessary inputs increase proportionately. This assumption generally holds in economic analysis for short run periods and for incremental changes.

- No supply constraints: With this assumption, an industry has limitless access raw materials at a fixed price, and industry output is limited only by the demand for its products. This assumption is generally reasonable for agriculture, with the exception of water, which can certainly be a limiting factor in production. Because this study looks at industry contraction, rather than expansion, limiting inputs is of less concern.

- Fixed commodity input structure: This implies that price changes do not because a firm to buy substitute goods--changes in the economy will affect the industry's output but not the mix of commodities and services it requires to make its product. This is the most troubling assumption and is the reason that the model is static and should not be used to forecast much beyond one year.

- Homogenous sector output: This implies that the proportions of all the commodities produced by that industry remain the same, regardless of total output--an industry won't increase the output of one product without proportionately increasing the output of all its other products. This is a reasonable assumption for the agricultural sector.

- Homogenous industry technology: This implies that an industry uses the same technology to produce all of its products. This is a reasonable assumption for the agricultural sector.

IMPLAN is the I-O modeling system used in this study. IMPLAN (Impact Analysis for Planning) was originally developed by the USDA Forest Service in cooperation with the Federal Emergency Management Agency and the Bureau of Land Management to assist the Forest Service in land and resource management planning. IMPLAN is now widely used by many state /federal agencies, universities and private consulting firms, and is the modeling system employed for this study. The following section describes how the IMPLAN software is used to create individualized I-O models and how impact analysis is then performed on those models.

I-O Models and IMPLAN

To create a regional I-O model, the regional data is combined with the national structural matrices to form regional multipliers. In the first step, the IMPLAN software creates the regional study area file by combining the counties selected by the user. From the initial study area data, the software regionalizes the national structural matrices by eliminating industries that do not exist in the region. Imports are then estimated via the regional purchase coefficients (RPC's). An RPC represents the proportion of total supply of a good or service required to meet a particular industry's demands that are produced locally. For example, an RPC value of 0.8 for the commodity "potatoes" means that 80 percent of the demand for potatoes is provided by local farmers. The RPC's for this study are revised when appropriate to reflect conditions in the San Luis Valley. Once RPC's are derived, imports are calculated using the minimum of the RPC or supply/demand pool ratio. Local demands are multiplied by the RPC's to create set of net local demands (total demand minus imports). This creates a set of matrices and final demands that are free of imports. Domestic exports are the residual of regional production not locally consumed. The result is a balanced set of regional economic accounts.

The I-O accounts are developed next. The regional use matrix and final demands are converted from commodity to an industry basis. The subsequent inversion of the I-O accounts provides an import-free matrix of multipliers, which are used to calculate the indirect and induced impacts that result from the direct impact. This matrix is an economic activity matrix that can be used to proxy changes to the San Luis Valley economy of different irrigated cropping patterns.

'What-If' Spreadsheet Tool

An objective of this study is to create a user-friendly tool with which stakeholders can perform "what-if" analysis when examining changes to the local economy, such as when the crop mix shifts from more water intensive crops to less water intensive crops. In order to do this, the economic activity matrix is embedded in an Excel® spreadsheet. Next, an input page is created that lists important economic sectors, and the level of sales (measured in dollars) for any of the region's economic sectors can be adjusted depending on the scenario of interest. As an example, alfalfa hay sales can be decreased and barley acres increased to proxy a shifting crop mix. The input levels are multiplied by the appropriate economic activity multipliers to create a set of changes to regional economic output. The output changes are displayed within the spreadsheet.

The economic activity matrix is the heart of a spreadsheet tool that permits stakeholders to approximate the impact of changing irrigated cropping scenarios, or to examine other mitigating investments in the economy. The following section describes a series of 'what-if' scenarios that are examined using the tool. ***Importantly, the scenarios are treated as hypothetical changes for demonstrating the tool rather than actual policies or predictions of changes to the San Luis Valley economy.***

Using the 'What-If' Spreadsheet Tool to Examine Water Saving Approaches

The following examples illustrates the use of the 'what-if' spreadsheet tool in describing the one-time changes to the San Luis Valley economy when an economic disruption, such as a changing crop mix, occurs. In the following **hypothetical** examples, the economic disruption involves four different approaches for reducing the consumptive use of groundwater irrigation by 24,500 acre feet. The four potential strategies are:

- Spreading water reductions equally among different crops to meet goals
- Reducing irrigation only in alfalfa cropping to meet water savings goals
- Shifting acres from alfalfa to wheat to meet a water savings goal
- Reducing irrigation in alfalfa cropping combined with participation in a conservation reservation enhancement program (CREP) to meet the water savings goal.

The first scenario considers reduction in the overall production of four crops so that each crop saves an equal amount of water withdrawals. The total savings goal is 24,500 acre feet (AF) which is distributed equally as 6,125 (AF) for each of the SLV's principal crops. In this scenario, we assume that acres are fallowed for each crop rather than pursuing a limited irrigation strategy. The fallowed acreage varies by crop as individual requirements differ when meeting plant growth needs. Fallowing necessarily reduces crop sales because fewer acres are grown and sold. If fewer acres are grown, then fewer inputs and labor are needed, so an economic ripple effect is transmitted through the economy.

The economic impact calculation begins when the reduced sales are entered into the input page of the what-if spreadsheet tool. The reduced sales are then multiplied by the economic activity matrix to develop measures of economic output changes. In the current scenario, the crop is assumed to generate revenues per acre that are equivalent to the revenues generated in 2013. Table 4 indicates the changes in acreage and output under this scenario.

Table 4. Equal water savings scenario and associated crop acreage and output reductions.

Crop	Acreage Change	Total Economic Output Change	Percent Change in Economic Output
Barley	-4,224	$ (3,565,926)	-9%
Alfalfa	-2,500	$ (2,140,000)	-2%
Potatoes	-5,104	$ (19,631,282)	-11%
Wheat	-4,224	$ (4,372,341)	-72%
San Luis Valley Total	**-16,052**	**$ (29,709,549)**	**-9%**

As might be expected, the acreage reductions vary by crop because some crops are more water intensive when compared to others. The total reduction in crop acres is 16,052 acres of which wheat has the greatest percentage share (only 5,900 acres of wheat are grown so the reduction of 4,224 acres is quite large) and alfalfa has the lowest proportion. The total reduction in economic output is more than $29 million of which potatoes accounts for $19 million. Each acre of potatoes generates significant economic activity, hence the large decrease in economic output.

An alternative hypothetical water savings approach might be to seek reductions in alfalfa hay alone, which is grown widely throughout the San Luis Valley and is a more intensive water using crop. The reductions in economic activity for this approach are found in Table 5.

Table 5. Achieving 24,500 AF of water savings by reducing hay production.

Crop	Acreage Reduction	Total Economic Output Change	Percent Change in Economic Output
Barley	0	0	0
Alfalfa	-10,000	$ (8,560,000)	-7%
Potatoes	0	0	0
Wheat	0	0	0
San Luis Valley Total	**-10,000**	**$ (8,560,000)**	**-3%**

As indicated in Table 5, fewer acres are fallowed when hay is the only crop that is part of the water savings approach, and the total economic impact is but $8.5 million rather than the $29 million that is reported in the previous table. It would seem that focusing fallowing approaches on water intensive crops that generate less economic activity per acre is beneficial to the regional economy relative to other approaches, although care must be taken as this may not be the best strategy for individual farmers, particular industries or particular areas.

A third strategy involves shifting the production of alfalfa acres into a wheat crop, and this approach assumes that wheat contracts are available for the marketing of the addition wheat. Table 6 illustrates the economic impacts of the third scenario which represents a shifting crop mix rather than a fallowing program.

Table 6. Shifting Crop Acres from Alfalfa Production to Wheat Production.

Crop	Acreage Reduction	Total Economic Output Change	Percent Change in Economic Output
Barley	0	0	0
Alfalfa	-24,500	$ (20,972,000)	-17%
Potatoes	0	0	0
Wheat	24,500	$ 25,359,576	315%
San Luis Valley Total	**0**	**$ 4,387,576**	**2%**

In this scenario, reducing alfalfa by one acre and replacing with one acre of wheat production saves one AF of water per acre and a total of 24,500 AF needs to be saved. For every acre of alfalfa lost, an additional acre of wheat is grown. In this case, economic outputs from increasing wheat acres more than offsets the loss of alfalfa acres, so economic output increases by $4.3 million. Of course, this result is heavily dependent on how realistic a 315% increase in wheat production is, as well as 2013 price and cost relationships in the San Luis Valley.

One last scenario is considered in which farmers may fallow alfalfa acres and establish native grasses in order to receive a $175 per acre payment to enroll in a CREP program. For this scenario a total of 10,000 acres are enrolled to meet the 24,500 AF savings. In this scenario, it is assumed that the payment is used as household spending in the local economy, rather than to start a new enterprise or to invest in operating inputs that enhance production. Table 7 represents the potential economic effect of the program in which $175 million of CREP payments partially offsets the lost economic activity associated with foregone alfalfa production.

Table 7. Reducing economic activity for alfalfa hay production.

Crop	Acreage Reduction	Total Economic Output Change	Percent Change in Economic Output
Barley	0	0	0
Alfalfa	-10,000	$ (8,560,000)	-7%
Potatoes	0	0	0
Wheat	0	0	0
CREP Payment	NA	$ 1,750,000	NA
San Luis Valley Total	**-10,000**	**$ (8,560,000)**	**-3%**

Out outlined scenarios contain a fundamental assumption – the four crops are generating revenue values equivalent to 2013 values. But what if this assumption is relaxed? The 'what-if' tool can also be used to consider the same scenarios under circumstances in which high revenue years or low revenue years prevail.

Concluding Remarks

Irrigated cropping is an important base industry in the San Luis Valley generating significant direct sales in the local regional economy, creating important demands for the suppliers of agricultural inputs and generating significant wage income for workers that drives household demand for local goods. Indeed, an additional dollar of irrigated crop sales results in an additional 43-52 cents of additional economic activity in the San Luis Valley. These complex interrelationships can be explored, albeit imperfectly, by using economic multipliers and organizing them in an economic activity matrix. The foundation for matrix development is an input-output economic model, and in this study the IMPLAN software is used to create the matrix. An economic matrix for the San Luis Valley is developed using specific cropping information and locally relevant modifications to the standard IMPLAN model.

Regional economic issues often involve many stakeholders, and thoughtful deliberation of these issues often entails measuring the economic ripple effects of different policy scenarios. To this end, a spreadsheet tool was created that houses the San Luis Valley economic activity matrix, and four irrigated cropping scenarios demonstrate how such a matrix might be used. Rules of thumb suggest that including high value crops in acreage reductions may create larger economic impacts vis a vis lower value crops, that prevailing prices and yields play an important role in the determining overall impacts, and that CREP payments may not be sufficient to offset losses to economic activity, as well as the fact that payments may not be distributed to all those impacted by reduced irrigated cropping.

Introduction

The San Luis Valley is a vibrant region located in southern Colorado with a rich heritage. This high altitude valley is culturally and geographically distinct from its neighbors with nearly 8,200 square miles of semi-arid lands enfolded by the San Juan Mountains and Continental Divide on the west, and the Sangre de Cristo and the Culebra mountains on the east, the Colorado–New Mexico state line on the south, and the La Garita range on the north. Six counties lie within the San Luis Valley and include Alamosa, Conejos, Costilla, Mineral, Rio Grande and Saguache.

The economy in the San Luis Valley is firmly connected to agriculture with a significant share of its gross domestic product coming from agricultural sales and associated income. Important agricultural goods include the San Luis Valley's premier potato production and its high quality alfalfa, barley and cattle. Agriculture is tightly woven with other industry sectors because of the local purchase of inputs and the local spending of wages. Irrigation is the lifeblood of the agricultural engine, as seldom is more than eight inches of precipitation received each year.

Snowmelt is the primary source of water for surface irrigation in the San Luis Valley, and centuries of snowmelt and the ensuing runoff have filled the aquifer that lies beneath the surface of farmland acres. Irrigation wells have tapped this rich water resource. However, persistent drought conditions in the last decade have reduced the recharge of aquifer that occurs from natural runoff. Recharge also suffers when drought limits diversions from the Rio Grande, causing underground aquifers to be depleted at an unsustainable rate.

Research Statement

The communities, governments and citizens of the San Luis Valley are mobilizing positive approaches for maintaining the sustainability of underground water supplies into the future while also safeguarding the economic base of local communities. One approach to sustainability is reducing irrigated agriculture's aquifer depletions through a mix of conservation strategies, alternative crop rotations and the fallowing of agricultural lands. However, altering irrigated agriculture in the San Luis Valley may have widespread impacts to the local economy where few alternatives currently exist.

An important set of questions centers on the overall economic ripple effects that occur when irrigated cropping changes in the San Luis Valley. These questions include:

- What is the benchmark level of irrigated agriculture in the San Luis Valley?
- How are final product sales, input purchases and wages for irrigated agriculture connected to allied industries and employment in local communities?
- In what way does irrigated agriculture and allied industries contribute to government revenues that are then spent on local infrastructure and services?
- How will the economic adaptations from reduced groundwater depletions be distributed among stakeholders (e.g., businesses, households and government) in the local economy?

Objectives of the Study

The San Luis Valley Council of Governments, Colorado Water Institute and CSU Extension are partnered to provide insights into these key questions, and a local engagement process provided important advice. An advisory committee of local stakeholders helped to guide the research and engagement activities. Beginning in May 2015, the advisory committee met to define objectives for the research activities and to provide needed feedback on the project's progress, evaluate preliminary results and to suggest alternative approaches. The advisory committee and research team developed the following objectives:

1. Identify sectors of the region's economy most closely aligned with the economic activity generated by irrigated crop production.

2. Create a tool that uses economic activity matrices for assessing future changes to economic activity in the region.

3. Characterize the economic ripple effects of proposed strategies for reducing groundwater depletions such as changing the crop mix and conservation fallowing cropland.

In particular, this research project describes the economic activity in the San Luis Valley and considers the likely distribution of economic changes that come from scenarios that include:

- *Scenario 1*: Reducing cropping acres for the four primary irrigated crops of the San Luis Valley—alfalfa hay, potatoes, barley and wheat.
- *Scenario 2*: Reducing irrigated production of alfalfa and grass hay.
- *Scenario 3*: Substituting a less water-using crop, wheat, in favor of alfalfa
- *Scenario 4*: Enrolling irrigated cropland in a Conservation Reserve Enhancement Program (CREP).

An economic activity matrix was created for the San Luis Valley and is being created for each of the six individual counties in the San Luis Valley. These matrices will be used to create tools for the region as a whole and each of the six counties in the region. The activity matrix proxies the economic linkages among sectors of the economy based on the purchases and sales of goods as measured in 2013, which is the most recent year of available data. The matrix is placed in a spreadsheet and modified so community members can use it as a planning and discussion tool. The tool provides a snapshot of how economic activity is altered when the value of goods produced by economic sectors, such as irrigated cropping, is altered. The following sections of this report will describe the research and results from this study related to each of the five objectives outlined above.

Objective 1. Identify Sectors of the Region’s Economy Most Closely Aligned with the Economic Activity Generated by Irrigated Crop Production.

Geography and Natural Resources of the San Luis Valley Especially Water

The geography and natural resources of the San Luis Valley are key ingredients to its economic base. The purpose of this section is to provide a basic description of available natural resource with particular emphasis on water resources. The San Luis Valley is a geographically defined region in south-central Colorado located about midway between Denver and Albuquerque, and contains the following six counties which can be seen in Figure 1 below: Alamosa, Conejos, Costilla, Mineral, Rio Grande and Saguache.

Figure 1. Counties in the San Luis Valley (DOLA, 2014).

The Valley floor sits at an altitude of 7,500 feet, to the east are the Sangre de Cristo Mountains and to the west are the peaks of the San Juans. The valley is about 122 miles long from the north to the south and 74 miles across, covering an area of 8,193 square miles (CEDS, 2013). Snowmelt is the primary source of water for surface irrigation in the San Luis Valley, and centuries of snow and the ensuing runoff have filled the aquifer that lies beneath the surface of farmland acres. The Rio Grande River main-stem rises in the San Juan mountains, flows south-easterly through the San Luis Valley to Alamosa, and then runs south through a break in the San Luis hills, which border the valley on the south, into the state of New Mexico, then along the border between Texas and Mexico, emptying into the Gulf of Mexico, The Conejos River rises in the Conejos Mountains to the southwest and flows north-easterly along the southern edge of the valley, joining the Rio Grande main stem at Los Sauces. Despite its high altitude, short growing season, and average annual precipitation of only about 7.5 inches, the valley sustains a productive agricultural economy dependent upon irrigation water (ScSEED, 2001) from the underlying aquifer. However, persistent drought conditions in the last decade reduced the recharge that occurs from natural runoff. Recharge also suffers as drought limits diversions from the Rio Grande River. Combined these factors have caused underground aquifers in the region to be depleted at an unsustainable rate.

Water is important for various competing uses in the San Luis Valley, including domestic, recreation, wildlife, agriculture and mining, although most mining operations closed by the end of the 20th Century. Domestic use includes drinking water, small businesses and lawn/garden watering for individuals and communities. Over 95% of the San Luis Valley's domestic use depends on groundwater supplies. In addition, the San Luis Valley is endowed with over 230,000 acres of wetlands, the most extensive system in the Southern Rocky Mountains. Numerous species of water birds breed, raise their young, and migrate through the Valley. Artesian and surface flows combined with high alkaline soils in some parts of the Valley result in many unique wetlands. The Rocky Mountain population of Greater Sandhill Cranes depends on this critical spring and fall migration habitat. Approximately 22,200 acres of publicly owned wetlands exist, which are actively managed, primarily for the water birds. Wetland habitat on refuges and other managed areas depend upon irrigation and intensive management of water (ScSEED, 2001).

Population Demographics

Irrigated agriculture in the San Luis Valley is an important source of jobs whether it be directly attributable to agricultural production, or indirectly tied to support industries. The purpose of this section is to review population and business demographics in the region. The San Luis Valley has a population of just over 45,000 individuals, which can be seen in Figure 2. In terms of self-reported ethnicity, the population is almost evenly split between white and Hispanic, with only a small proportion of the population being any other race.

The population of the area is relatively stable with anticipated annual growth of 0.9% anticipated in the coming years, Figure 3 shows population changes over time for each of the six counties in the region. As can be seen in Figure 3 the largest concentration of regional population is in Alamosa County. Alamosa County's population increased from 2000-2012, Conejos County's population declined slightly.

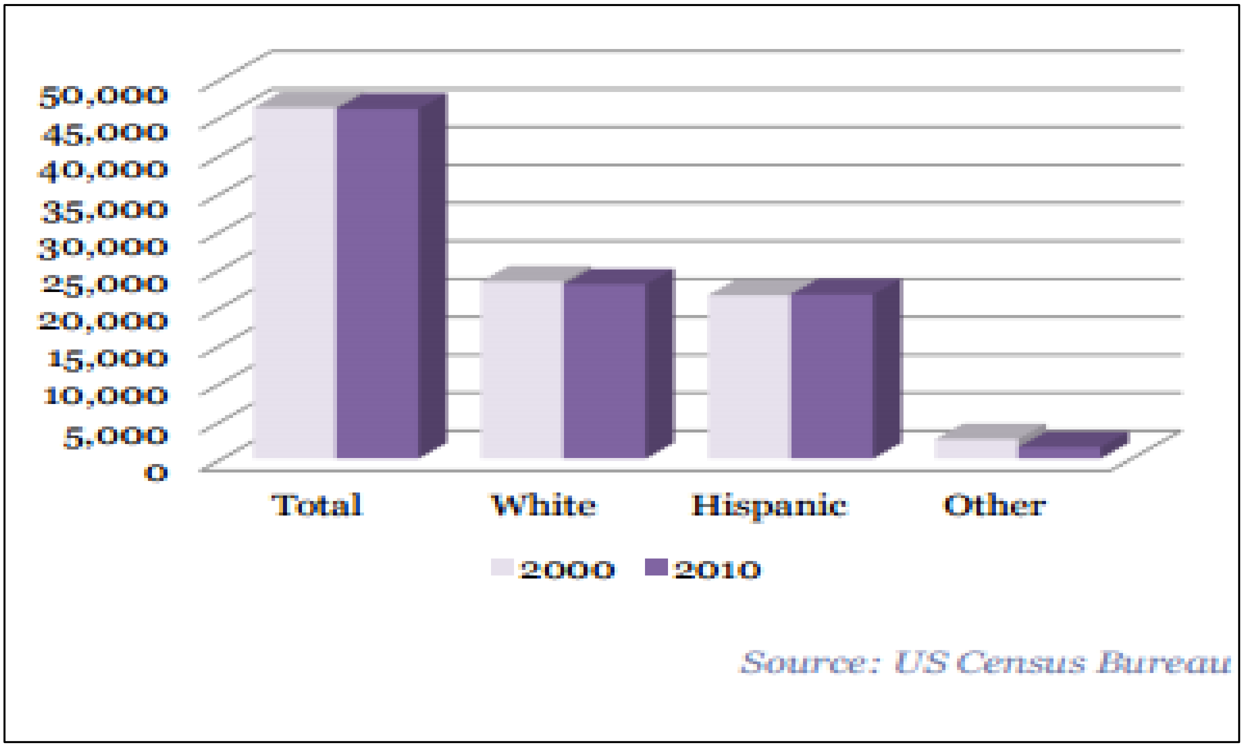

Figure 2. Population change (2000 to 2010) by Ethnicity in the SLV (DOLA, 2014).

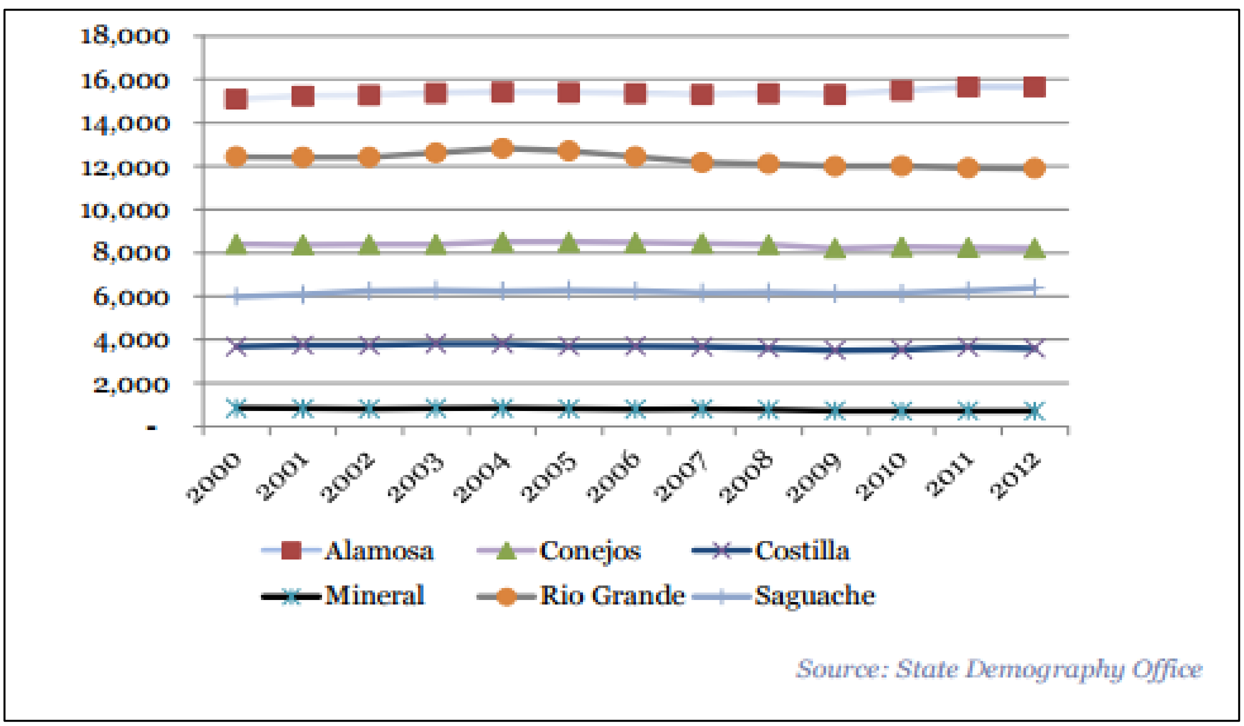

Figure 3. Population estimates from 2000 to 2012 by County (DOLA, 2014).

The median age in the San Luis Valley in 2010 was 38.8 which is greater than the median age for the state of 36.1. Figure 4 shows the number of residents by age for each of the six counties in the San Luis Valley region. The reason for the greater median age in the region relative to Colorado stems from a larger proportion of the population over 45 as compared to state proportions. According to the Colorado Department of Local Affairs (DOLA) the median age of the region is expected to decline to 37.6 with additions of new worker-related families in the future. In addition DOLA predicts that "from 2010 to 2020, the population over the age of 65 will grow an average of 3.6 percent annually (in the San Luis Valley Region) slower than the state average of 4.9 percent." Expected Population changes by age can be seen in Figure 5. Notice that the population in each of the age groups is expected to increase except for the 45-64 year old age group.

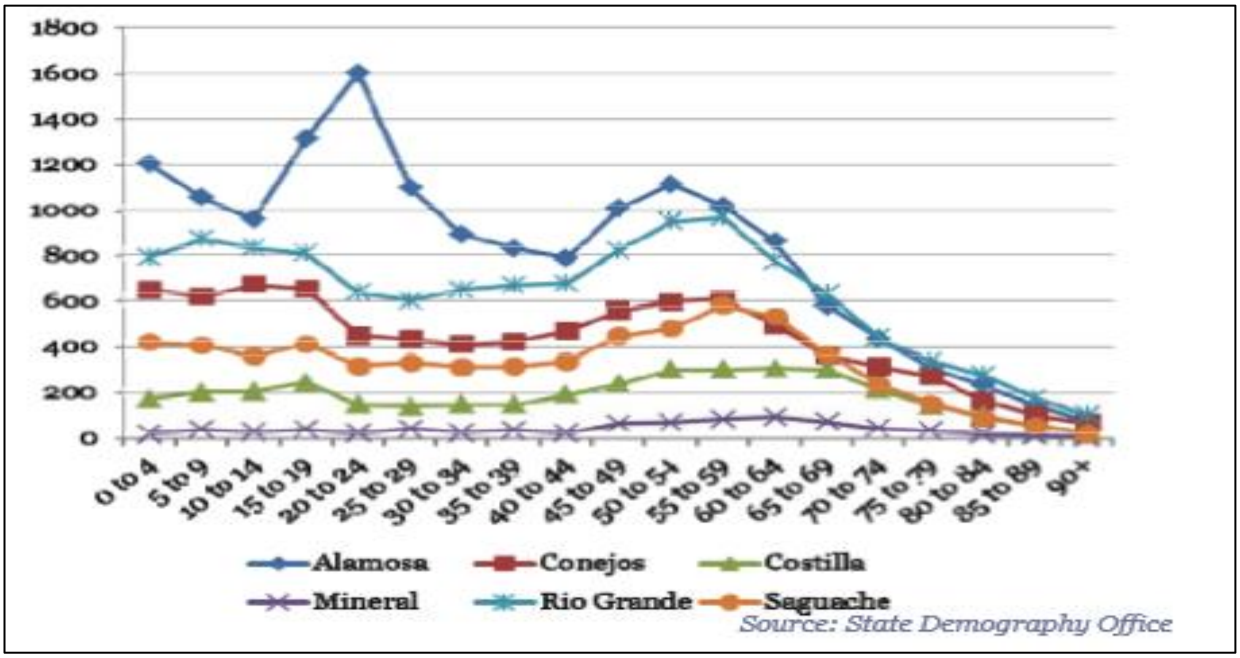

Figure 4. Residents by age 2010, by County (DOLA, 2014).

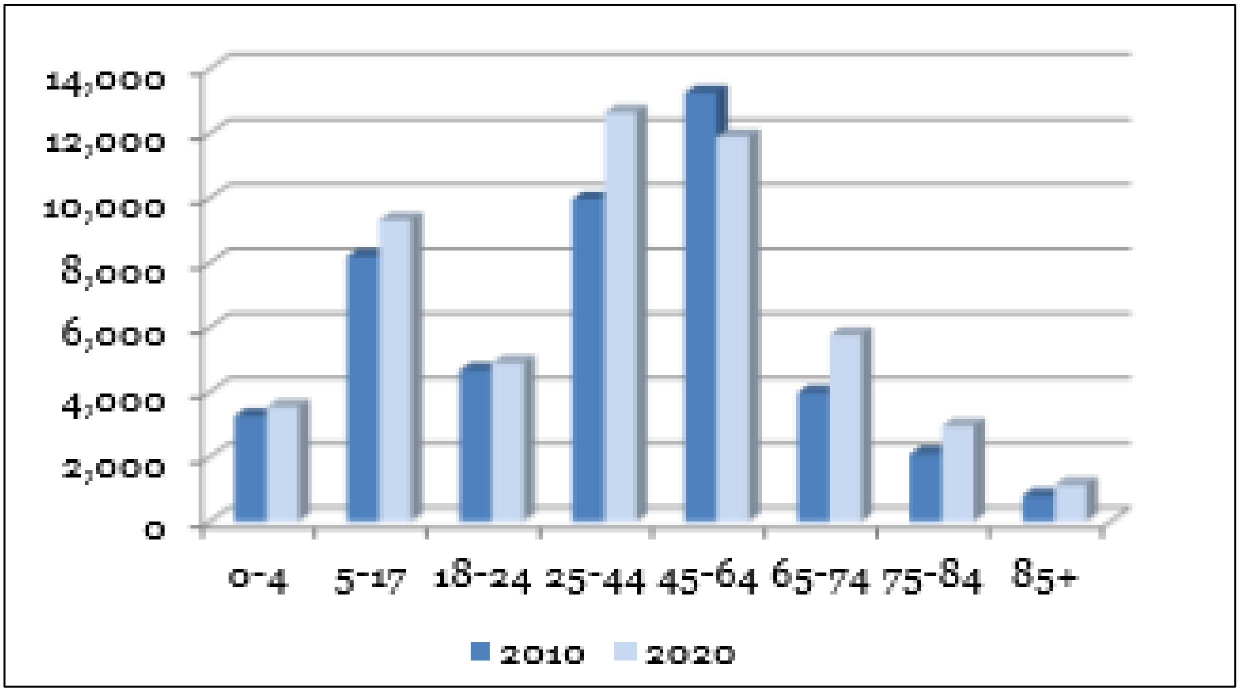

Figure 5. San Luis Valley Population Change by Age Group (DOLA, 2014).

The San Luis Valley has a population density of 5.6 persons per square mile, with Alamosa having the highest density at 21.4 persons per square mile and Mineral having the lowest population density per mile at 0.81 persons. The population density of the San Luis Valley is well below the state average, which is 48.5 persons per square mile. Table 8 displays the land area and population densities of each county, the region and the state (US Census Bureau, 2000 & 2010).

Table 8: Land area and population densities (US Census Bureau, 2000 & 2010).

Land Use and Population Densities	Alamosa	Conejos	Costilla	Mineral	Rio Grande	Saguache	San Luis Valley	Colorado
Total Square Miles	723	1,287	1,227	875.7	912	3,169	8,193	103,642
Person per Sq/Mi (2010)	21.4	6.4	2.9	0.8	13.1	1.9	5.6	48.5
Person per Sq/Mi (2000)	20.7	6.5	23	0.9	13.6	1.9	5.6	41.5

Business Demographics and Employment including Primary Sectors

In the San Luis Valley, business activity is centered on more than 825 establishments[1]. The current unemployment rate is slightly more than 6%. The San Luis Valley economy is firmly intertwined with agriculture as a significant share of its gross domestic product coming from agricultural sales and associated income. Important agricultural goods include the San Luis Valley's premier potato production and its high quality alfalfa, barley and cattle. Agriculture is tightly woven with other industry sectors because of the local purchase of inputs and the local spending of wages. Irrigation is the lifeblood of the agricultural engine in the region, as seldom is more than eight inches of precipitation received each year, and this is insufficient for the production of high value potatoes, alfalfa and barley.

Economic statistics from the US Census and the Bureau of Labor Statistics in 2013 underscore the importance of agriculture to the San Luis Valley. In 2013, the gross domestic product of the counties in the San Luis Valley totaled more than $3.3 billion, and the equivalent of slightly more than 28,000 full time employees earn wages. Potato production generates the greatest economic activity measuring nearly $180 million in sales in 2013, and employs the equivalent of more than 1,100 individuals in the San Luis Valley.

Table 9. Top 10 Sectors of San Luis Valley Economy for 2013 (IMPLAN).

Rank	Sector	Employment	Output (Mill. $)	Output Multiplier
1	Potato Farming	1,141	$179.2	1.47
2	Wholesale Trade	717	$161.1	1.46
3	Electric Power	121	$151.6	1.22
4	Alfalfa Farming	886	$117.3	1.52
5	Agriculture Production Support Industry	2,694	$100.2	1.44
6	Hospitals	772	$96.2	1.50
7	Beef Cattle	411	$93.9	1.60
8	Local Gov./ Educ.	1,321	$67.8	1.43
9	Trucking	402	$57.1	1.58
10	Real Estate	394	$56.6	1.20

Table 9 displays the top ten largest sectors – ranked by output –which includes direct agricultural activity (potatoes, alfalfa and cattle) as well as indirect activities in support of agriculture (wholesale trade, trucking, and agriculture production support industry). Table 9 also contains the estimated output multiplier for each of the top ten industries in the region. The output multiplier indicates that for

[1] According to the Bureau of Economic Analysis (BEA) and establishment is an economic unit – business or industrial – at a single physical location where business is conducted or where services or industrial operations are performed. Examples include a factory, store, hotel, mine, farm, bank, railroad depot, sales office, warehouse, and central administrative office. A single establishment may be comprised of subunits, departments, or divisions, and one or more establishments make up an enterprise or company.

every dollar of direct sales there is an additional amount of local economic activity generated. For example, a dollar of potato sales generates 47 additional cents of local economic (The output multiplier for potatoes is 1.47). The multiplier calculates the local economic activity that includes the direct sale of potatoes, the purchase of inputs needed in potato production and the activity generated by wages that are spent locally. The size of the multiplier will depend on the basic demographics of the region, the diversity of the regional economy, the relative importance of irrigated agriculture in the regional economy, and the strength of the backward and forward linkages between irrigated agriculture and supplying and processing sectors. In a later section we provide a more in depth discussion of multipliers and their interpretation.

Tourism is also an important industry in the San Luis Valley Economy. Because tourism involves so many different sectors within the economy it can be difficult to quantify the total impact to the local economy. Headwaters Economics reports that tourism and travel contributes more than 15% of the total private employment in the San Luis Valley. Figure 6 displays jobs in the San Luis Valley that are in industries that include travel and tourism from 1998 to 2013 (Headwaters, 2016).

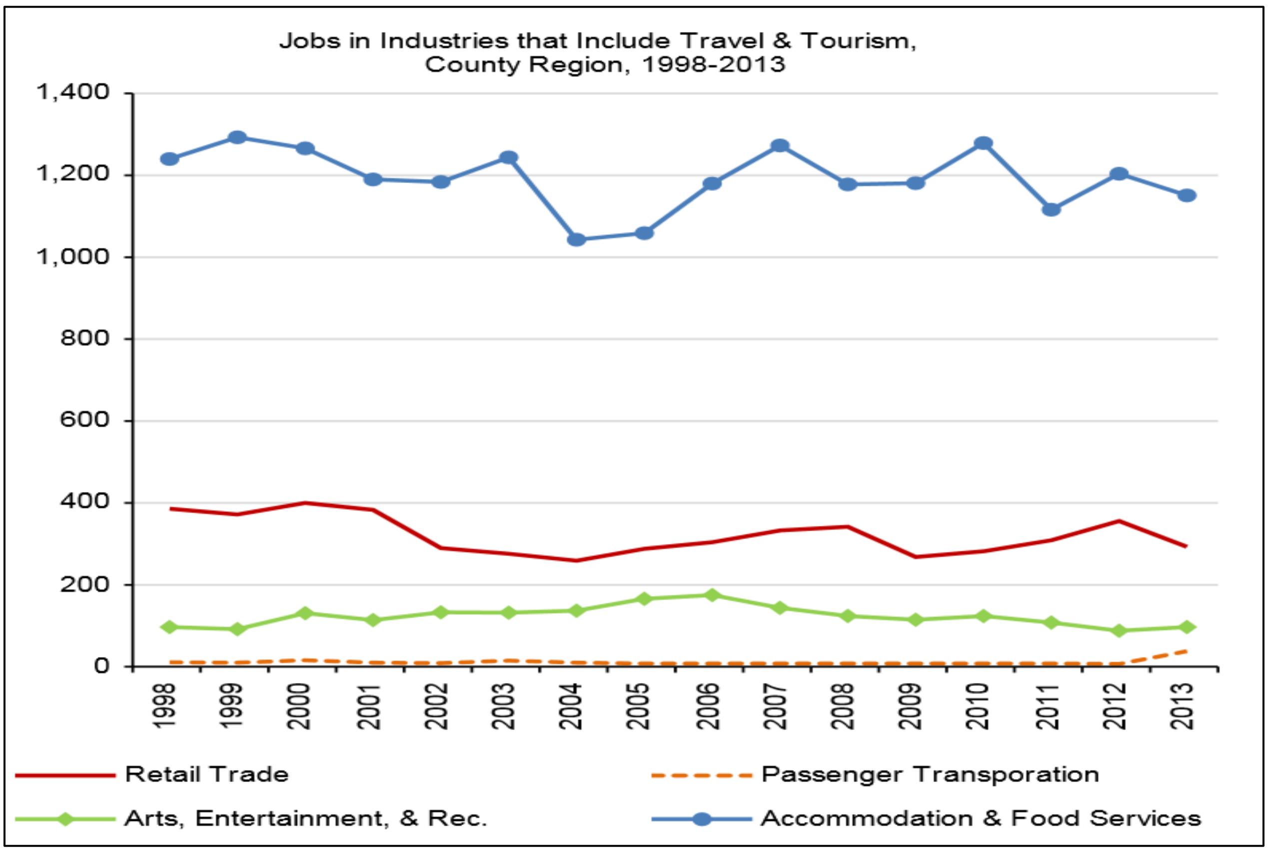

Figure 6. San Luis Valley jobs that include travel and Tourism, 1998 – 2013 (Headwaters, 2016).

The distribution of tourism employment is not spread evenly across the San Luis Valley counties. Indeed Figure 7 illustrates that Mineral County contains the greatest proportion of private employment related to travel and tourism (40%) and Saguache has the smallest proportion (10%). It is important to note that this employment information only looks at private employment (and not the significant government employment of the region) and is thus not directly comparable to the information contained in earlier tables which include government employment (Headwaters, 2016).

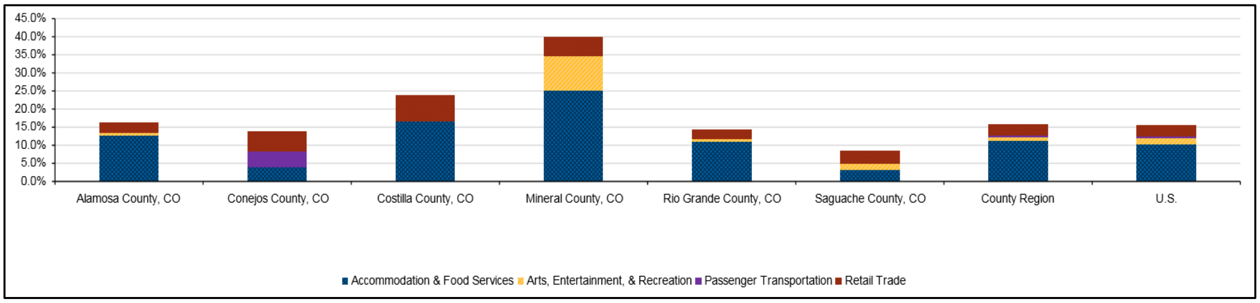

Figure 7. Percent of total private employment by county and region that include travel and tourism.

The Colorado Tourism Office also evaluates the economic impact of travel by county. In a Colorado Tourism Office report entitled *Colorado Travel Impacts*, the Tourism Office indicates that $87.1 million is spent on overnight travel in the San Luis Valley driving 1,478 jobs (Runyan, 2015). At an output value of $87.1 million places travel and tourism as one of the top ten sectors in the San Luis Valley.

Education

Human capital plays a central role in regional economic development. The size of the population as well as its workforce and education levels are key components of human capital. The following section considers the educational attainment of the San Luis Valley. The six county region is home to 14 school districts with a public school enrollment of 7,543 students in fall of 2012. Public school enrollment rates vary by county (Table 10) with Alamosa County having the highest enrollment and Mineral County having the lowest enrollment. Generally speaking, school enrollment is declining indicating an aging population in spite of population growth (SLVDRG, 2012).

Table 10: Public School Enrollment by County and Year (SLVDG, 2012).

County	Fall 2008	Fall 2009	Fall 2010
Alamosa	2,436	2,369	2,393
Conejos	1,698	1,671	1,613
Costilla	457	472	508
Mineral	115	101	92
Rio Grande	2,197	2,262	2,217
Saguache	913	956	906
San Luis Valley	7,816	7,831	7,729

Students graduate from San Luis Valley high schools at a rate of 85% of the student population. All counties in the region except for Saguache have seen an improvement in graduation rates from 2010 to 2014 (Figure 8).

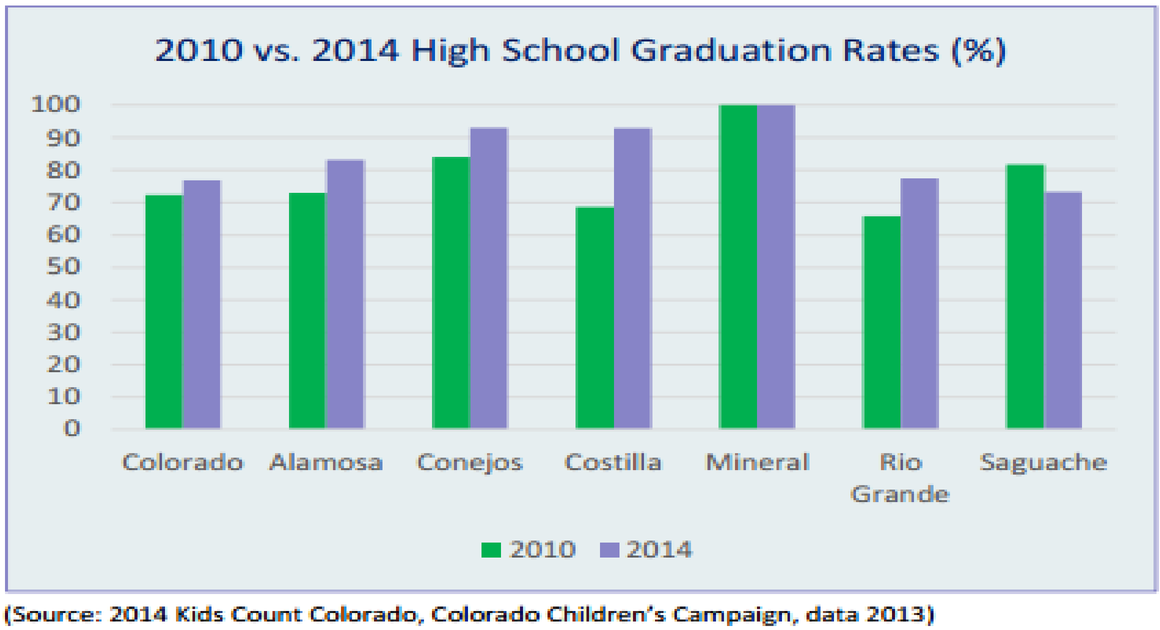

Figure 8. 2010 vs. 2014 High School Graduation Rates (Community Assessment, 2014).

The region also has two institutions of higher education Adams State University, which had an enrollment of 2,971 in 2015 and Trinidad State Junior College which had an enrollment of 829 in 2015 (SLVDRG, 2015). Adams State University offers B.S., B.A., M.A., and associate degrees and is particularly noted for excellence in business and teaching professions. About 40% of Adams State students originate from the San Luis Valley, 45% from other parts of Colorado, and 15% from out-of-state (CEDS, 2013). Trinidad State Junior College offers two year associate degrees in applied science; certified occupational training; pre-collegiate and specialized educational programs; adult basic and remedial education as well as a diversity of educational niches for practical skill training (CEDS, 2013).

The percentage of the population with bachelor's degrees varies by county from almost 40% of the population (Mineral County) to around 15% of the population (Costilla County) (Figure 9). While the region tends to have a higher high school graduation rates than Colorado average, the percent of the population with a high school degree is lower than the Colorado average in all counties except Mineral County.

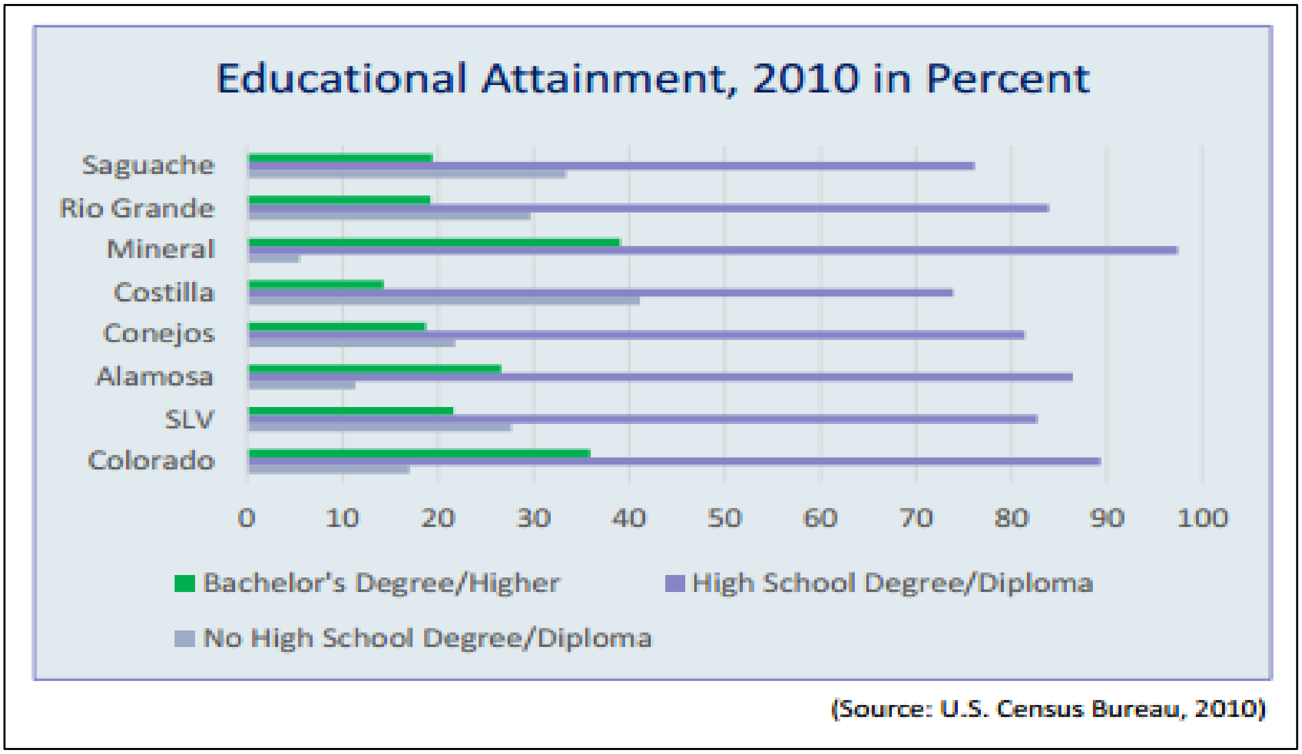

Figure 9. Percentage of population with a bachelor's degree, high school degree and no high school degree by county (DOLA, 2014).

San Luis Valley Agricultural Demographics

Agricultural Labor, Cash Receipts, and Land

Agriculture is an important industry in the San Luis Valley generating substantial proportions of the area's output and employment. Indeed, the subsector of farm employment is 9.7% of the total employment in the region, which is considerably greater than the proportion defined for the United States or for the proportion defined in Colorado (Headwaters Economics, 2016). Farm employment is one part of overall agricultural employment which includes a number of other sectors such as trucking, wholesale trade and production agriculture support industries.

Agriculture is a primary economic driver for the region. Headwaters Economics has calculated the cash receipts for San Luis Valley livestock and crops from 1970 -2014, and the results are reported in Figure 10. As you see fin Figure 10 cash receipts from crops are about three times cash receipts from livestock (Headwaters Economics, 2016).

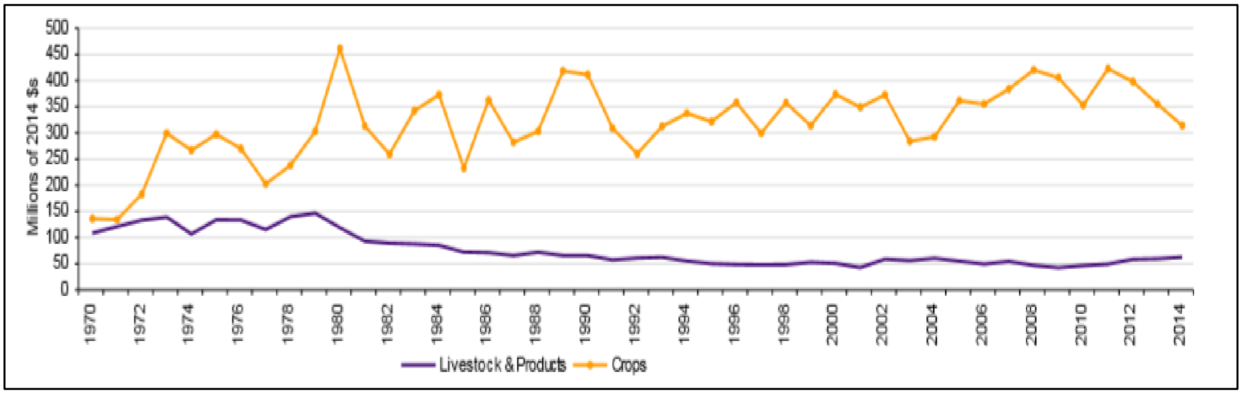

Figure 10. Cash receipts from Livestock and Crops in the San Luis Valley (Headwaters Economics, 2016).

Table 11 shows the number of farms, the land in farms and the average farm size for each county in the San Luis Valley in 2012 (Census of Agriculture, 2012). From the table you can see that Costilla County has the largest land area in farms at 376,154 acres but not the most farms. In Costilla County two large private land holdings account for a proportion of the land area in farms, Trinchera Ranch and Taylor Ranch respectively. Mineral has the smallest land area devoted to farming at 6,628 acres and only 14 farms in 2012. In some counties, the land area in farms increased in the 2007 – 2012 time period, while in other counties the land area decreased during the time period (Table 12). Most notably are Mineral County which saw a 25% decrease and Conejos County which saw a 13% increase in land area in farms (Census of Agriculture, 2012).

Table 11: Number of farms, land in farms and average farm size by County.

County	Number of Farms	Land in Farms (acres)	Average Size of Farm (acres)
Alamosa	322	182,402	567
Conejos	605	257,691	426
Costilla	251	376,154	1,499
Mineral	14	6,628	473
Rio Grande	377	185,489	492
Saguache	277	311,373	1,124

Table 12: Change in land in farms by county, 2007 – 2012.

County	Change (2007 - 2012)
Alamosa	3%
Conejos	13%
Costilla	- 6%
Mineral	-25%
Rio Grande	4%
Saguache	8%

Crop Revenues by Type and Historical Context

The San Luis Valley's most important crops as measured by land area and annual output are barley, alfalfa, wheat and potatoes. (USDA/NASS Quick Stats). The data in Table 13 indicates alfalfa is the largest crop by area at 137,000 acres, followed by potatoes and barley. In 2013, 5,900 acres of wheat were harvested in the San Luis Valley. Notable in Table 13, the vast majority of irrigated cropping is directed to alfalfa production followed by nearly equal amounts of barley and potato farming. If irrigated cropping is reduced in the San Luis Valley, it may be that hay acres will be impacted the most and associated ripple effects will be transmitted throughout the economy. Historically, alfalfa production has increased in the period 2010-14 with some easing recently. Potato production has decreased by 10% over the 2010-14 period while barley acres has increased slightly.

Interestingly, alfalfa is grown on the largest land mass, but does not generate the greatest farm gate sales in 2013. As indicated in Table 13, potatoes generated nearly $180 million in sales over 46,600 acres. Clearly, potatoes are a significant crop for the San Luis Valley and depending on the associated prices and yields, potatoes can be the largest generator of revenues to the area. The value of annual output can be interpreted as crop revenues and this depends significantly on market prices and yields.

Table 13: Acres and output (value) by crop San Luis Valley (2013) (USDA and IMPLAN)

Crop	Acres	Annual Output (Million $)
Barley	46,000	$38.80
Alfalfa and Grass Hay	137,000	$117.30
Potatoes	46,600	$179.20
Wheat	5,900	$6.10
San Luis Valley Total	***235,500***	***$341.4***

Data on historical acreage and output is collected demonstrating trends over time and year-to-year variability. Figures 11 – 14 illustrate the acres harvested and the value of each of the four crops from 2002 to 2013 based on data reported in the USDA/NASS Quick Stats. As indicated in Figure 11, barley acres oscillate between a low of 25,400 acres in 2006 and a high of 55,800 acres in 2009. All of the other crops saw a reduction in acreage in the 2002 – 2013 timeframe. Alfalfa acres are considerably lower in 2013 than they were in 2002 -- 137,000 acres and 206,000 acres respectively. Alfalfa acreage in the San Luis Valley reached a high in 2006 and 2007 with 266,000 acres and has decreased each year since (Figure 12). Potato acreage decreased between 2002 and 2013 from 71,500 to 49,600 acres. Lastly, wheat acreage decreased from 17,000 acres in 2002 to 5,900 acres in 2013.

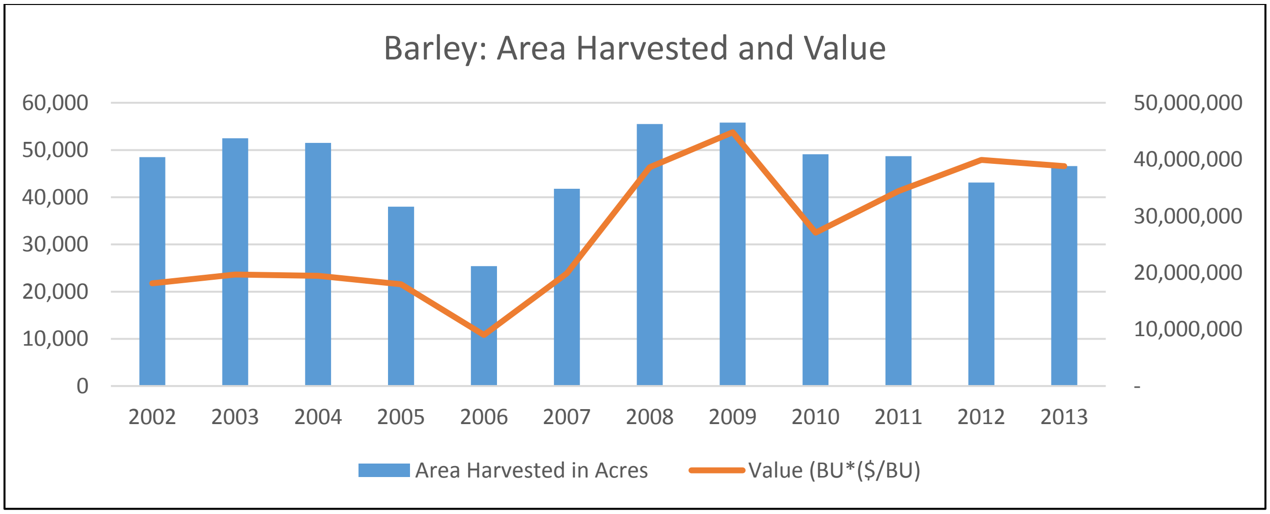

Figure 11. San Luis Valley Area Harvested and Value – Barley (USDA/NASS Quick Stats).

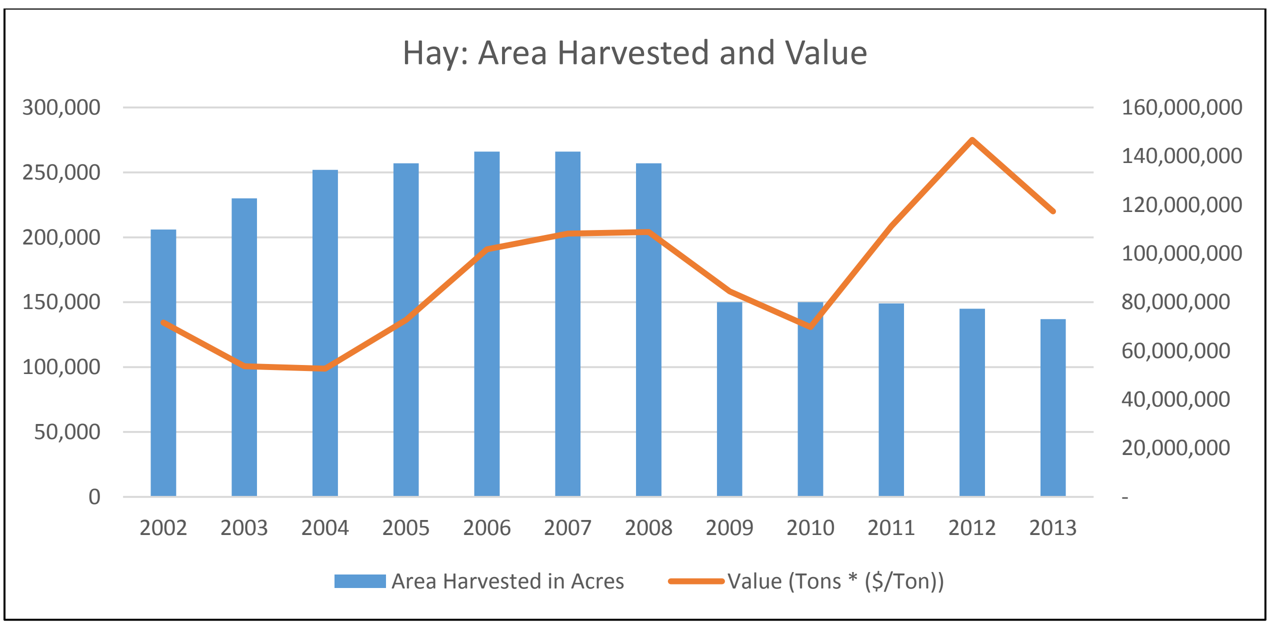

Figure 12. San Luis Valley Area Harvested and Value – Alfalfa (USDA/NASS Quick Stats).

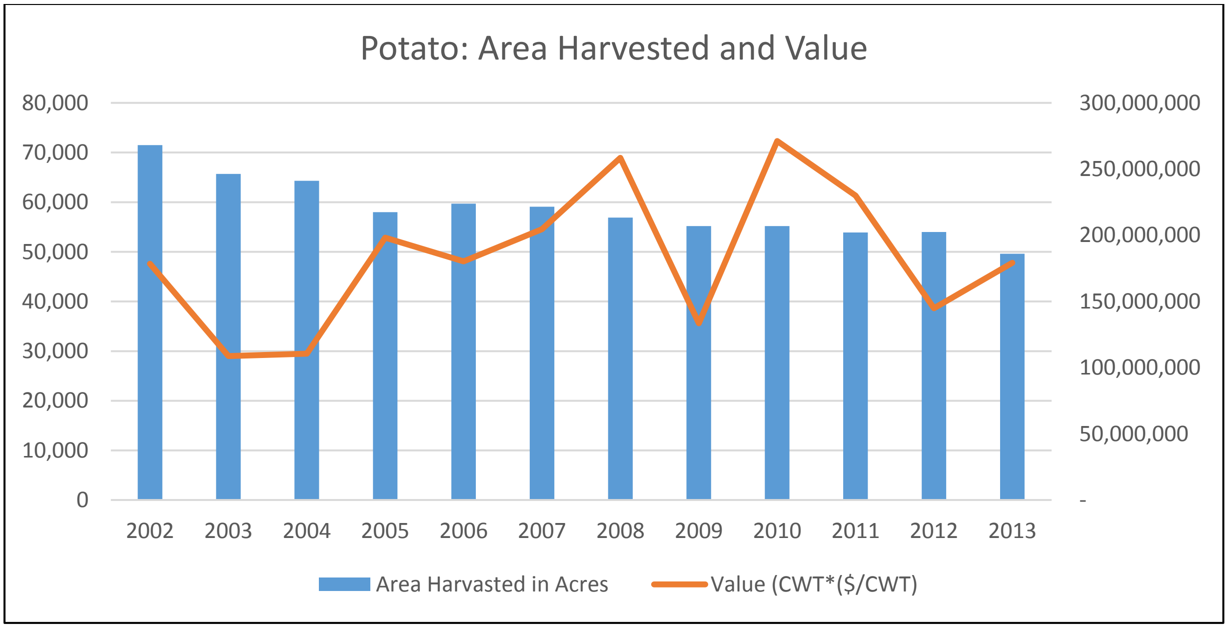

Figure 13. San Luis Valley Area Harvested and Value – Potato.

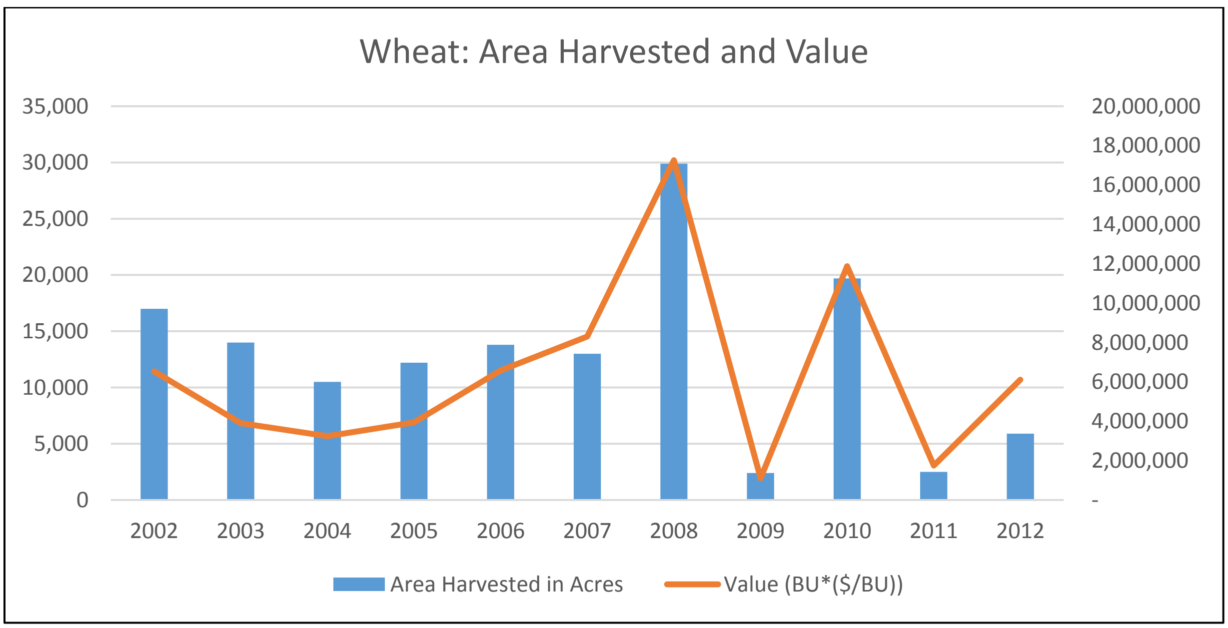

Figure 14. San Luis Valley Area Harvested and Value – Wheat (USDA/NASS Quick Stats).

Crop Enterprise Budgets and Major Sources of Inputs

Crop production in the San Luis Valley requires a number of key inputs such as seed, fertilizer, crop insurance, financial capital, and energy. In order to identify sectors of the region's economy that are most closely aligned with irrigated cropping, an understanding of the relationships between agriculture outputs and its specific inputs is important. The production relationships for agricultural foods are embedded in crop enterprise budgets, and Colorado State University created enterprise budgets for the region (CSU Extension). In addition, the 2015 cost of potato production study created by the United Potato Growers of America was used to supplement the CSU Extension potato enterprise budget (Patterson, 2015).

Importantly, detailed agricultural employment data by crop is not readily available, and it was necessary to back out individual crop sector employment from reported total agricultural employment in the San Luis Valley. To do this we used the Center for Farm Financial Management labor hour estimates (FINPACK, 2010) coupled with the acres of each crop in the San Luis Valley to find the proportion of total agricultural employment for each sector. Table 14 displays the FINPACK labor hour estimates as well as the calculated employment by each crop sector.

Table 14. Labor Hour Estimates (FINPACK) and Employment by Sector.

Crop	Labor (hrs/ac)	Employment
Barley	1.2	97
Alfalfa	3.7	886
Potatoes	14.0	1,141
Wheat	1.3	13
San Luis Valley Total	**XXX**	**2,137**

Potatoes tend to be the most labor intensive crop with 14 labor hours expended per acre of production, which leads to a greater impact on local wage income when additional acres of potatoes are grown relative to other crops. It also translates to over 50% of the agricultural employment in the San Luis Valley being involved in potato production.

Discussion of Multipliers and How Industries are Related

Economic impact assessment is commonly used to determine the effects of an activity like irrigated cropping on a broader economy such as the San Luis Valley. Typically, an industry's economic impact on a local economy originates from industry sales within the region, and the metrics of measuring impacts include 'output' (total sales), employment, and 'value added.' Value-added is the industry's net revenues, the difference between what someone sells a good for and what one pays for all of the components used in producing the good.

The economic impact of irrigated agriculture in the region is not limited to just agriculture, which are the direct expenditures, it also includes indirect and induced economic impacts. Direct expenditures drive purchases in related sectors of the economy, such as input suppliers (equipment suppliers and accountants for example) and employee spending in other industries, such as spending their wages at a local grocery store for example. To account for the full economic impact of irrigated agriculture sectors we must analyze indirect and induced effects in addition to the direct effects. More specifically these effects can be defined as follows:

- ***Direct effects***: These effects are a result of actual sales from the industry. For an example of a direct effect think of a producer selling $2,000 worth of product, that $2,000 is a direct effect.

- ***Indirect effects***: These effects arise due to linkages in the supply chain, such as local industries buying goods and services from other local industries. The cycle of spending works its way backward through the supply chain. For example, the store from which a producer buys their fertilizer will use part of the money from the sale elsewhere in the economy, such as for buying more inventory, paying rent or hiring an accountant.

- ***Induced effects***: These effects are a result of employee household spending. For example, when a producer sells $2,000 of product, some portion of those proceeds goes toward paying the wages of an employee, who then re-circulates those wages in the form of household purchases of things such as clothing or groceries.

Because of the spin-off effects (indirect and induced effects), we see that an initial dollar of sales from an irrigated agricultural industry can generate more than a dollar of total activity in the regional economy as it ripples through the other businesses and households buying goods and services. The multiplier process continues with each additional round of income/spending, but typically becomes smaller as money "leaks" out of the region to purchase goods and services from outside the region. Figure 15 illustrates the multiplier concept and demonstrates how spending gets smaller as it leaks out of the region.

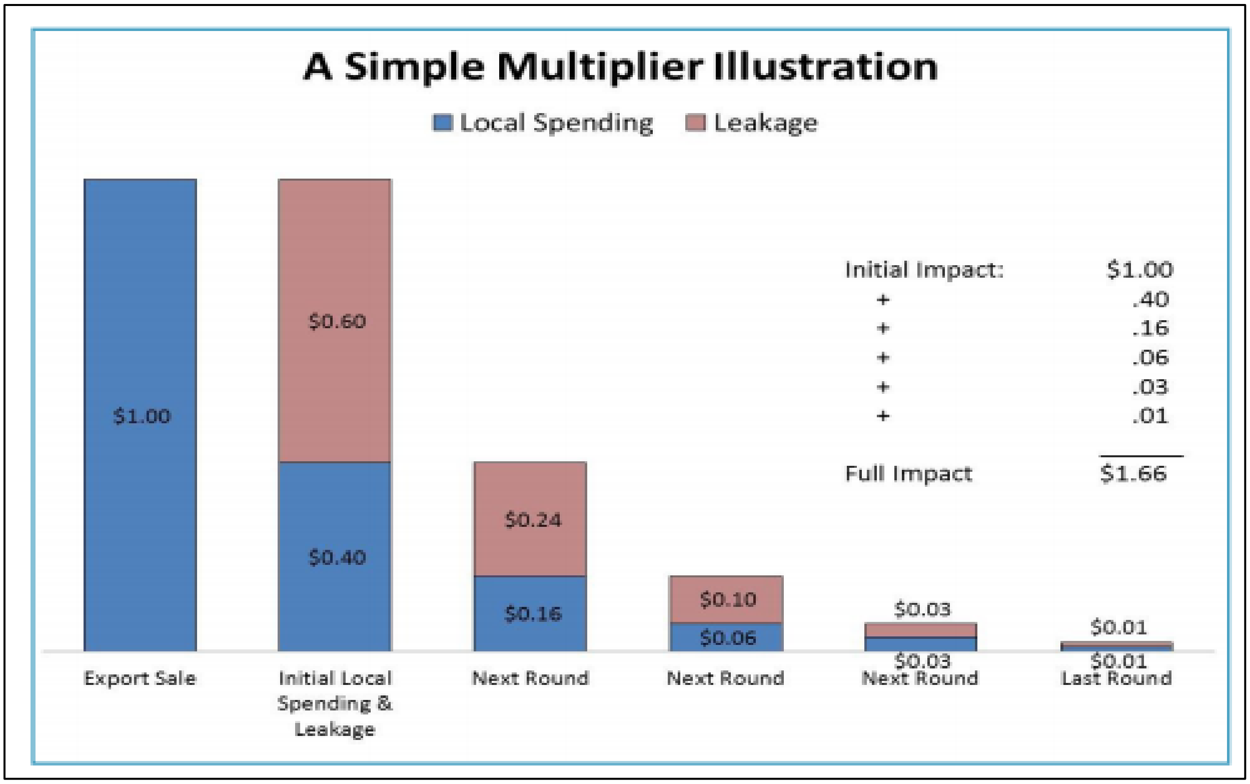

Figure 15. A Simple Multiplier Illustration (Thilmany et al., 2016).

The most common approach to estimating the economic impacts of industry activities is the use of the software IMPLAN (www.implan.com). Originally developed by the U.S. Forest Service, IMPLAN establishes the characteristics of economic activity in terms of 528 economic sectors and draws on data collected by federal and state government agencies. IMPLAN also uses regional industry purchasing patterns to examine how changes in one industry will affect others. The IMPLAN model has been used as the basis for thousands of economic analyses throughout the United States. For more details on the IMPLAN model and the analysis please reference **Appendix C**.

San Luis Valley Multipliers

The San Luis Valley is the regional economy of interest in this study, so a San Luis Valley IMPLAN model was created using the information outlined in the previous sections including the benchmark levels of irrigated agriculture, sales, and employment and input relationships in the region. The IMPLAN model then uses this information to generate industry specific economic multipliers.

Irrigated agriculture influences the local economy through several different channels: the most obvious are sales of irrigated crops that directly influence the economy as they are purchased by consumers or processors, but these crops in turn generate demand for intermediate goods and services from other, related sectors of the economy. In addition, the direct and indirect purchases increase employment and income, enhancing the overall economy's purchasing power, thereby inducing further spending on goods and services. This cycle continues until the spending eventually leaks out of the local economy as a result of taxes, savings, or purchases of non-locally produced goods and services.

Table 15 reflects the interrelationship between the primary irrigated crops in the San Luis Valley and the remainder of the economy. Output multipliers for each crop are listed in the second column of Table 15, and these multipliers reflect the overall economic impact of a dollar received for a crop. As an example, an additional dollar of sales of barley generates a total impact of $1.43 to the economy because of the direct sale of the barley, the indirect purchases of inputs for growing barley and the induced spending of barley based wages in the economy.

Table 15. Multipliers and economic activity per acre for four irrigated crops in the SLV using 2013 Information (USDA, IMPLAN).

Crop	Output Multiplier	Economic Activity ($/ac)	Employment Multiplier
Barley	1.43	$844	6.1
Alfalfa	1.52	$856	12.1
Potatoes	1.47	$3,846	10.4
Wheat	1.43	$1,035	5.7

The third column of Table 15 measures the economic activity generated by an irrigated acre of the crop. The greatest economic activity is generated by potatoes at $3,846 per acre. This value is not a measure of profit, rather it is the summed value of potato revenues, the costs of the inputs purchased to grow potatoes and the amount of wages paid. The combination of these economic activities generates the highest level of overall economic activity – but not necessarily the greatest profits to the producer. Indeed, high cost crops may generate large economic activity via input purchases, but yield meager producer profits.

The last column of the table indicates the additional full time equivalent jobs generated by an additional million dollars of sales of the crop. Put another way, for every million-dollar change in final demand (direct output) in a sector, the multiplier represents the change in the number of jobs present in the economy. In the case of wheat, a less labor-intensive crop, selling $1 million more wheat would generate almost 6 labor positions in the local economy.

Care should be taken when interpreting the values listed in Table 15. First, these values represent a snapshot of the local economy, rather than a forecast of what will happen if irrigated cropping acres are altered. More specifically, these values fail to reflect the adaptations of farmers and agribusinesses who observe the change in irrigated acres and develop business strategies to compensate for lost opportunities. Adaption is likely to mitigate some of the lost economic activity. In addition, the estimates are specific to the year 2013, so local commodity prices and local yields influence the value of crops produced. Lastly, the values do not capture the notion of a “tipping point,” in which lost irrigated acres might cross a critical threshold so that the business supporting agriculture are no longer viable. For this reason, these estimates are better approximations of smaller changes in irrigated acres rather than large wholesale changes.

The previous discussion indicates the importance of irrigated cropping to the local economy – farm gate sales account for a significant portion of the San Luis Valley's regional economic activity and employment. This activity is almost entirely sourced from four irrigated crops – potatoes, alfalfa, barley and wheat – which have varying contributions to regional economic output due to the value of their sales, the costs of locally sold inputs and the payment of wages to local labor. The synergies between sectors of the economy can be captured through the use of economic output and employment multipliers as are represented in Table 15. In fact, every sector of the San Luis Valley economy can be interrelated with the others via multipliers, and these can be combined to create an economic activity matrix that reveals the likely economy-wide impacts of changing irrigated cropping and/or associated re-investment meant to mitigate these changes. The matrix may then be adapted to a form that allows decision makers and stakeholders to alter sector outputs and trace how the impacts are transmitted through the economy.

Objective 2. Create a Tool that Uses Economic Activity Matrices for Assessing Future Changes to Economic Activity in the Region.

Input-Output Models

The multipliers described in Table 15 (in the previous section) represent economic activity and have been created using a tool that economists have labelled as input-output (I-O) models. I-O models provide an empirical representation of the economy and its inter-sectoral relationships keeping track of the purchases and sales of every sector. This enables the user to determine the economy-wide effect that results from a change in the production of one sector of that economy, such as changes to irrigated cropping in the San Luis Valley. An I-O model has an economic activity matrix at its core, and it is this economic activity matrix that describes how transactions in one economic sector influence the sales and purchases of another sector. For example, the economic activity matrix for the San Luis Valley can suggest how an additional dollar of potato sales will influence the amount of fertilizer that is purchased and sold in the local economy.

I-O analysis is comprised of two phases: descriptive modeling and predictive modeling. The descriptive model includes information about local economic interactions known as regional economic accounts. The regional account tables describe a local economy in terms of the flow of dollars from purchasers to producers within the region. In the predictive phase, these regional economic accounts are used to construct local-level multipliers, which express the response of the economy to an impact such as a change in demand or production.

In agriculture, crop enterprise budgets describe how farmers spend revenues on particular inputs. These enterprise budgets serve two purposes in this study. First, they were used to adjust the basic I-O model, which is derived from a national model, to make it specific to the San Luis Valley and its crops. The national model represents the "average" condition for a particular industry. Without adjustments for regional differences, the national statistics do not necessarily represent industries comprising the San Luis Valley. Second, these enterprise budgets are used to create a new sector for each irrigated crop in that region. Having a separate sector for each irrigated crop creates a more accurate calculation of the output multiplier, and thus a more accurate portrayal of the size and distribution of the impact of changing irrigated cropping acres.

For this study, crop prices and enterprise budgets are provided by Colorado State University Extension with validation from local producers and agribusinesses. The enterprise budgets reflect the 2013 costs of production, although prices and yields can be changed within the model to reflect various economic impacts. The economic activity that is generated by an industry does not end simply at its sale in the marketplace. In order to more fully describe the economic contributions of specific industries in a regional economy, the indirect and induced effects must also be explored.

IMPLAN and its Assumptions

The economic activity that is generated by an industry does not end simply at its sale in the marketplace. In order to more fully describe the economic contributions of specific industries in a regional economy, the indirect and induced effects must also be explored. For example, if an analyst studies the economy of a rural farming region and adds together only the direct impacts of each sector in the economy, the omission of indirect and induced activity may skew the results. Farming in the region is not only responsible for generating direct revenues, it also is responsible for demanding fertilizer and seed from the local farm supply store, and tractors from the local dealer, all of which are indirect effects. The farmers also spend their income at the local diner and provide tax revenues to county services, which are induced effects. Therefore, a one-dollar decline in agriculture revenue would have a greater than one-dollar effect on the regional economy because of these linkages. This is the fundamental rationale behind looking at indirect and induced effects in addition to direct effects when conducting regional economic impact analysis. The total effect of a change in the economy is the sum of the direct, indirect, and induced effects, and the multiplier is calculated by dividing the total effect by the direct effect.

I-O modeling is based on several economic assumptions about technical relationships and business behavior:

- <u>Constant returns to scale</u>: This implies that the production of goods and services are scalable and linear in the scaling --if additional output is required, all of the necessary inputs increase proportionately. This assumption generally holds in economic analysis for short run periods and for incremental changes.

- <u>No supply constraints</u>: With thus assumption, an industry has limitless access raw materials at a fixed price, and industry output is limited only by the demand for its products. This assumption is generally reasonable for agriculture, with the exception of water, which can certainly be a limiting factor in production. Because this study looks at industry contraction, rather than expansion, limiting inputs is of less concern.

- Fixed commodity input structure: This implies that price changes do not cause a firm to buy substitute goods--changes in the economy will affect the industry's output but not the mix of commodities and services it requires to make its product. This is the most troubling assumption and is the reason that the model is static and should not be used to forecast much beyond one year.

- Homogenous sector output: This implies that the proportions of all the commodities produced by that industry remain the same, regardless of total output--an industry won't increase the output of one product without proportionately increasing the output of all its other products. This is a reasonable assumption for the agricultural sector.

- Homogenous industry technology: This implies that an industry uses the same technology to produce all of its products. This is a reasonable assumption for the agricultural sector.

IMPLAN is the I-O modeling system used in this study. IMPLAN (IMpact Analysis for PLANning) was originally developed by the USDA Forest Service in cooperation with the Federal Emergency Management Agency and the Bureau of Land Management to assist the Forest Service in land and resource management planning. It is now widely used by many state /federal agencies, universities and private consulting firms, and is the modeling system employed for this study. The following section describes how the IMPLAN software is used to create individualized I-O models and how impact analysis is then performed on those models.

'What-if' Scenario Tool and Example Scenario

An objective of this study is to create a user-friendly tool with which stakeholders can perform "what-if" analysis when examining changes to the local economy, such as when the crop mix shifts from more water intensive crops to less water intensive crops. In order to do this, the economic activity matrix is embedded in an Excel® spreadsheet. The economic activity matrix is the heart of a spreadsheet tool that permits stakeholders to approximate the impact of changing irrigated cropping scenarios, or to examine other mitigating investments in the economy.

To create a regional I-O model and the economic activity matrix, the regional data is combined with the national structural matrices to form regional multipliers. In the first step, the IMPLAN software creates the regional study area file by combining the counties selected by the user (in our case the region which contains the six counties of the San Luis Valley). From the initial study area data, the software regionalizes the national structural matrices by eliminating industries that do not exist in the region. Imports are then estimated via the regional purchase coefficients (RPC's). An RPC represents the proportion of total supply of a good or service required to meet a particular industry's demands that are produced locally. For example, an RPC value of 0.8 for the commodity "potatoes" means that 80 percent of the demand for potatoes is provided by local farmers. The RPC's for this study are revised when appropriate to reflect conditions in the San Luis Valley. Once RPC's are derived, imports are calculated using the minimum of the RPC or supply/demand pool ratio. Local demands are multiplied by the RPC's to create set of net local demands (total demand minus imports). This creates a set of matrices and final demands that are free of imports. Domestic exports are the residual of regional production not locally consumed. The result is a balanced set of regional economic accounts.

The regional use matrix and final demands are converted from commodity to an industry basis. The subsequent inversion of the I-O accounts provides an import-free matrix of multipliers, which are used to calculate the indirect and induced impacts that result from the direct impact. This matrix is an economic activity matrix that can be used to proxy changes to the San Luis Valley economy of different irrigated cropping patterns.

Once the background structural matrices have been characterized the next step was to create an input sheet that lists important economic sectors, and the dollar level of sales for any of the region's economic sectors can be adjusted depending on the scenario of interest. As an example, alfalfa sales can be decreased and barley acres increased to proxy a shifting crop mix. The input levels are multiplied by the appropriate economic activity multipliers to indicate changes in regional economic output, which then can be shown in the spreadsheet.

The input sheet is displayed in Figure 16. This sheet contains the "shocks," or changes in output by sector, that are changed initially and then the impacts traced. First, the user needs to develop the dollar amount of the initial shock, and then decide which sector will be shocked. In this tool, any of 184 sectors might be shocked. A description of each sector can be found on IMPLAN's website; www.implan.com. Note that Figure 16 only contains multiplier value, as it shows the basic tool structure before shocks have been entered, once shocks have been entered the tool will automatically update with the economic impact values associated with the inputted shock.

To use the tool, the change in direct output (a $100,000 reduction in alfalfa sales for example) is entered into the green cell to the left of the "shocked" sector (such as alfalfa). The "User Inputted Shocks" column has 184 green cells, each cell is associated with an industry within the regional economy (see Appendix A for a full list of the 184 industries). **A positive number indicates an expansion, and a negative number indicates a contraction.** Multiple sectors can be shocked simultaneously. For example, if a scenario involves a contraction to both alfalfa and wheat, both the wheat and alfalfa sales will contain a negative change in sales, and one can observe the combined effect of the change.

SUMMARY RESULTS: Outcome values from specificed changes in economic activity

	Direct	Indirect	Induced	Total
Total Output	$ -	$ -	$ -	$ -
Employment	0.0	0.0	0.0	0.0
Value Added	$ -	$ -	$ -	$ -
Non-Property Tax	$ -	$ -	$ -	$ -

User scenarios - Shocks to Economic Activity

Industry Name	User Inputted Shocks	Industry Output Results	Industry Employment Results	Total Output Multiplier
Barley		$ -	0.0	1.43
Potato		$ -	0.0	1.47
Wheat		$ -	0.0	1.43
Alfalfa		$ -	0.0	1.52
Oilseed farming		$ -	0.0	1.30
Greenhouse, nursery, and floriculture production		$ -	0.0	1.32
Beef cattle ranching		$ -	0.0	1.60
Dairy cattle and milk production		$ -	0.0	1.37
Poultry and egg production		$ -	0.0	1.48
Animal production, except cattle and poultry and eggs		$ -	0.0	1.24
Commercial logging		$ -	0.0	1.72
Commercial hunting and trapping		$ -	0.0	1.39
Support activities for agriculture and forestry		$ -	0.0	1.44
Extraction of natural gas and crude petroleum		$ -	0.0	1.40
Gold ore mining		$ -	0.0	1.35
Silver ore mining		$ -	0.0	1.29
Stone mining and quarrying		$ -	0.0	1.30
Sand and gravel mining		$ -	0.0	1.38
Other nonmetallic minerals		$ -	0.0	1.28
Drilling oil and gas wells		$ -	0.0	1.43
Support activities for oil and gas operations		$ -	0.0	1.38

Figure 16. Screenshot of Input Spreadsheet in the "What-If" tool.

Once shocks are entered, the tool then displays the economic impacts to each sector in the orange cells. The table located at the top of the worksheet shows aggregate shocks to the San Luis Valley economy in terms direct and indirect impacts to output, employment, value added and non-property taxes.

The 'what-if' tool also summarizes the ten sectors with the largest positive and negative output impacts. In any given scenario, it is possible that certain scenarios simultaneously impact some sectors at the same time that others are negatively impacted. Additional discussion is provided later sections. A screenshot of the top sectors affected tables is show in Figure 17, note that the screen shot is void of values as the tables self-populate once a shock has been entered into the green column in Figure 16.

Top 10 Industries Affected

Positive Economic Impact to Industry

Industry Name	Industry Output Results	Industry Employment Results
--	$ -	--
--	$ -	--
--	$ -	--
--	$ -	--
--	$ -	--
--	$ -	--
--	$ -	--
--	$ -	--
--	$ -	--
--	$ -	--

Negative Economic Impact to Industry

Industry Name	Industry Output Results	Industry Employment Results
--	$ -	--
--	$ -	--
--	$ -	--
--	$ -	--
--	$ -	--
--	$ -	--
--	$ -	--
--	$ -	--
--	$ -	--
--	$ -	--

Figure 17. Screenshot of Top 10 Industries Affected Table.

Objective 3. Characterize the Economic Ripple Effects of Proposed Strategies for Reducing Groundwater Depletions such as Changing the Crop Mix and Conservation Fallowing Cropland.

Policy makers often use economic analysis to explore the economic tradeoffs that surround a policy decision. The findings from an economic impact analysis may identify, for example, that an expansion or contraction of one industry causes job creation or job loss in other industries. Economic impact analysis may also be used to determine output, value added or non-property tax impacts of an expansion or contraction. Economic impact analysis is also used to compare the effects on the economy of different approaches for reaching an outcome.

The tool described previously provides an approximation of these types of tradeoffs. A key ingredient of successfully using the tool is first defining a research question, and then developing accurate and thoughtful scenarios that help to answer the research question. The three basic steps for using the "what-if" SLV Economic Impact Calculator are contained within the Excel spreadsheet in the "how to use the tool tab" (Figure 18). Notice that in addition to the 'what-if' tool there is also an "Acreage Converter Tool" which will allow for the conversion of acre reduction values to output reduction values.

A
Welcome to the SLV Economic Impact Calculator
Step 1: Before using the calculator you must come prepared with some information as well as an idea of what questions about the economy you want to answer:
• Start by framing a scenario, your "what-if" question
• Such as what if we reduced Potato production by 500 acres
• Or what if output in Potato production was reduced by $1,000,000
• See the supporting document for more information on how to frame a scenario
Step 2: Once you have framed your "what-if" scenarios, go to the Tool tab and directly enter the dollar values into the green cell next to the industry in which the change will occur.
• Does your scenario involve acres reduced instead of dollar values?
o Download the "Acreage Converter" Tool, to convert acres to dollar values that can be used in this tool
Step 3: RESULTS - the economic impacts of your scenario changes will appear in the orange cells
• For more information on how to interpret economic impact results see the supporting document
Questions? Contact James Pritchett at james.pritchett@colostate.edu, 970-491-5496

Figure 18. Screenshot of "How to Use the Tool" Tab.

A Hypothetical Example: Reducing 24,500 AF of Irrigated Cropping Depletions

This section will walk through a series of 'what-if' scenarios that are examined using the tool. Importantly, the scenarios are treated as **hypothetical** changes for demonstrating the tool rather than actual policies or predictions of changes to the San Luis Valley economy. The example scenarios illustrate the use of the 'what-if' spreadsheet tool in describing the one-time changes to the San Luis Valley economy when an economic disruption, such as a changing crop mix, occurs. In the following **hypothetical** examples, the economic disruption involves four different approaches for reducing the consumptive use of groundwater irrigation by 24,500 acre feet. The four potential strategies are:

Scenario One: Equal water savings distributed among the four crops to meet the 24,500 AF hypothetical reduction goal

Scenario Two: Reduction of irrigation only in alfalfa cropping to meet the 24,500 AF hypothetical reduction goal

Scenario Three: Shifting acres from alfalfa to the less water intensive crop wheat to meet the 24,500 AF hypothetical reduction goal

Scenario Four: Reduction of irrigation in alfalfa combined with participation in a Conservation Reservation Enhancement Program (CREP) to meet the 24,500 AF hypothetical reduction goal

Scenario One

This scenario reduces the overall production of four crops so that each crop saves an equal amount of irrigated cropping depletions. The total savings goal is 24,500 acre feet (AF) which is distributed equally as 6,125AF for each of the SLV's principal crops. In this scenario, we assume that acres are fallowed for each crop rather than pursuing a limited irrigation strategy. The fallowed acreage varies by crop as individual consumptive use requirements differ by crop. The acreage change and the percentage of total output reduction represents is shown in Table 16. Wheat output reduction is larger than alfalfa because wheat is a less intensive water-using crop than alfalfa.

Table 16. Equal Water Savings Scenario and Associated Crop Acreage and Revenue Reductions.

Crop	Acreage Change	Total Economic Output Change	Percent Change in Economic Output
Barley	-4,224	$ (3,565,926)	-9%
Alfalfa	-2,500	$ (2,140,000)	-2%
Potatoes	-5,104	$ (19,631,282)	-11%
Wheat	-4,224	$ (4,372,341)	-72%
San Luis Valley Total	**-16,052**	**$ (29,709,549)**	**-9%**

Fallowing necessarily reduces crop sales because fewer acres are grown and sold. If fewer acres are grown, then fewer inputs and labor are needed, so an economic ripple effect is transmitted through the economy. The economic impact calculation begins when the reduced sales associated with the acreage reductions are entered into the input page of the what-if spreadsheet tool. The reduction in sales can be seen in the middle "Total Economic Output Change" column in Table 16. The reduced sales are then multiplied by the economic activity matrix to develop measures of economic output changes. In the current scenario, the crop is assumed to generate revenues per acre that are equivalent to the revenues generated in 2013. As might be expected, the acreage reductions vary by crop because some crops are more water intensive when compared to others. The total reduction in crop acres is 16,052 acres of which wheat has the greatest percentage share (only 5,900 acres of wheat are grown so the reduction of 4,224 acres is quite large) and alfalfa hay has the lowest proportion. The total reduction in economic output is more than $29 million of which potatoes comprises $19 million. Each acre of potatoes generates significant economic activity, hence the large decrease in economic output.

Figure 19 shows the results of these impacts as calculated by the 'what-if' tool. From the analysis we can see that the direct output reduction of $29,709,549 from scenario one trickles through the economy creating both indirect and induced effects for a total economic impact to the San Luis Valley economy of $43,516,403. We also see a reduction in employment of 294 jobs, a reduction in value added of $22,233,483, and a reduction in non-property tax to the region of $674,822.

SUMMARY RESULTS: Outcome values from specificed changes in economic activity				
	Direct	Indirect	Induced	Total
Total Output	$ (29,709,549)	$ (7,498,450)	$ (6,308,404)	$ (43,516,403)
Employment	-133.9	-103.9	-56.3	-294.1
Value Added	$ (14,407,001)	$ (4,369,536)	$ (3,456,946)	$ (22,233,483)
Non-Property Tax	$ (17,605)	$ (257,402)	$ (399,816)	$ (674,822)

Figure 19. Scenario One Results from the 'What-If' Tool.

The 'what if' tool also allows for analysis of the economic impact to individual industries within the economy. The tool show the economic impact in both output and employment for each industry as well as listing the top ten industries that are negatively impacted and the top ten industries that are positively impacted, sorted by output impacts. The top ten industries affected are shown in Figure 20. The output changes stemming from this scenario do not positively impact any industries in the region, and thus we only report the negative economic impacts of the scenario. As would be expected the industry with largest negative impact is potato, followed by wheat and barley. It is not only the industries that were directly shocked that are impacted it is also industries that support agriculture or are linked through indirect and induced impacts to agricultural spending such as wholesale trade and hospitals.

Negative Economic Impact to Industry

Industry Name	Industry Output Results	Industry Employment Results
Potato	$ (19,885,983)	-99.2
Wheat	$ (4,374,385)	-7.9
Barley	$ (3,709,481)	-7.3
Support activities for agriculture and forestry	$ (2,784,953)	-74.9
Alfalfa	$ (2,247,348)	-22.2
Wholesale trade	$ (1,530,791)	-6.8
Owner-occupied dwellings	$ (1,074,411)	0.0
Real estate	$ (531,026)	-3.7
Maintenance/repair of nonresidential structures	$ (473,072)	-3.3
Hospitals	$ (466,753)	-3.7

Figure 20. Scenario One Top Ten Affected Industries.

Scenario Two

An alternative water savings approach might be to seek reductions in alfalfa hay alone, which is grown widely throughout the San Luis Valley and is a more intensive water using crop. The reductions in economic activity for this approach are found in Table 17. Note that given the consumptive use of Alfalfa reaching the 24,500 AF reduction would require an acreage reduction of 10,000 acres of alfalfa.

Table 17. Achieving Water Savings by Reducing Alfalfa Production

Crop	Acreage Reduction	Total Economic Output Change	Percent Change in Economic Output
Barley	0	0	0
Alfalfa	-10,000	$ (8,560,000)	-7%
Potatoes	0	0	0
Wheat	0	0	0
San Luis Valley Total	**-10,000**	**$ (8,560,000)**	**-3%**

As indicated in Table 17, fewer acres are fallowed when hay is the only crop that is part of the water savings approach, and the total economic output change is $8.5 million rather than the $29 million that is reported in the previous table. It would seem that focusing fallowing approaches on water intensive crops that generate less economic activity per acre is beneficial to the regional economy relative to other approaches, although this may not be the best strategy for individual farmers or particular sub-districts.

Figure 21 shows the results of these impacts as calculated by the 'what-if' tool. From the analysis we can see that the direct output reduction of $8,560,000 from scenario two trickles through the economy creating both indirect and induced effects for a total economic impact to the San Luis Valley economy of $13,007,611. We also see a reduction in employment of 139 jobs, a reduction in value added of $5,575,875, and a reduction in non-property tax to the region of $265,864. Figure 22 shows the top industries affected from this scenario, just as with scenario one no industries are positively affected. Alfalfa is the top industry negatively affected followed by agricultural support industries.

SUMMARY RESULTS: Outcome values from specificed changes in economic activity

	Direct	Indirect	Induced	Total
Total Output	$ (8,560,000)	$ (2,691,375)	$ (1,756,236)	$ (13,007,611)
Employment	-84.4	-39.2	-15.7	-139.3
Value Added	$ (3,054,287)	$ (1,559,193)	$ (962,395)	$ (5,575,875)
Non-Property Tax	$ (70,418)	$ (86,178)	$ (109,268)	$ (265,864)

Figure 21. Scenario Two Results from the 'What-If' Tool.

Negative Economic Impact to Industry		
Industry Name	**Industry Output Results**	**Industry Employment Results**
Alfalfa	$ (8,657,349)	-85.4
Support activities for agriculture and forestry	$ (1,085,519)	-29.2
Wholesale trade	$ (428,795)	-1.9
Owner-occupied dwellings	$ (298,731)	0.0
Real estate	$ (155,925)	-1.1
Monetary authorities and depository credit intermed	$ (147,387)	-1.2
Electric power transmission and distribution	$ (143,432)	-0.1
Hospitals	$ (130,191)	-1.0
Insurance carriers	$ (121,485)	-0.4
Truck transportation	$ (107,253)	-0.8

Figure 22. Scenario Two Top Ten Affected Industries.

Scenario Three

The third scenario involves shifting the production of alfalfa hay acres into a wheat crop. In this scenario, reducing alfalfa by one acre in lieu of wheat production saves one acre-foot of water for each acre and a total of 24,500 AF needs to be saved. For every acre of alfalfa lost, an additional acre of wheat is grown. This scenario makes the rather large assumption that increasing wheat production by 24,500 acres (a 315% increase) is feasible within the San Luis Valley. While this may not be realistic the inclusion of a scenario that illustrates the economic impacts of a shifting of the crop mix rather than a fallowing program is important to the discussion. The reductions in economic activity for this approach are found in Table 18.

Table 18. Shifting Crop Acres from Alfalfa Hay Production to Wheat Production.

Crop	Acreage Reduction	Total Economic Output Change	Percent Change in Economic Output
Barley	0	0	0
Alfalfa	-24,500	$ (20,972,000)	-17%
Potatoes	0	0	0
Wheat	24,500	$ 25,359,576	315%
Total	**0**	**$ 4,387,576**	**2%**

In this case, the output gains from increasing wheat acres more than offset the output loss from the reduction in alfalfa acres, so economic output increases by $4.3 million. Of course, this result is heavily dependent on how realistic a 315% increase in wheat production is.

Figure 23 shows the results of these impacts as calculated by the 'what-if' tool. From the analysis we can see that the combination of the reduction of output in alfalfa with the increase in acres of wheat caused economic output to increase by 4.3 million in the region. This increase in output from scenario three trickles through the economy creating both indirect and induced effects for a total economic impact to the San Luis Valley economy of $4,286,680. Notice here that our total impact is lesser than the direct impacts from this scenario. This is because of the indirect impacts that alfalfa brings to the region, while the direct impacts from this crop mix shift is positive the indirect impact is negative. We also see a reduction in employment in the region of 174 jobs. Value added to the region increases by $3,374,636 but there is a reduction in non-property tax to the region $86,507. This scenario shows how it is important to look at more than just direct changes in sales when evaluating the impacts of changes to the economy.

SUMMARY RESULTS: Outcome values from specificed changes in economic activity				
	Direct	Indirect	Induced	Total
Total Output	$ 4,387,576	$ (137,504)	$ 36,608	$ 4,286,680
Employment	-161.2	-13.1	0.4	-173.9
Value Added	$ 3,479,360	$ (124,821)	$ 20,097	$ 3,374,636
Non-Property Tax	$ (172,525)	$ 40,079	$ 45,939	$ (86,507)

Figure 23. Scenario Three Results from the 'What-If' Tool.

Figure 24 shows the top ten industries that this scenario affects. Here we do have some industries that are positively affected while others are negatively affected. Alfalfa is the top negatively affected industry and wheat is the top positively affected industry. But the two crops have different economic interrelationships which cause some industries to be winners in this scenario while other industries are losers.

Top 10 Industries Affected		
Positive Economic Impact to Industry		
Industry Name	**Industry Output Results**	**Industry Employment Results**
Wheat	$ 25,359,189	45.7
Barley	$ 231,891	0.5
Wholesale trade	$ 212,028	0.9
Real estate	$ 198,866	1.4
Maintenance/repair of nonresidential structures	$ 133,396	0.9
Rail transportation	$ 49,108	0.1
Beef cattle ranching	$ 43,826	0.2
Stone mining and quarrying	$ 18,911	0.1
Fertilizer mixing	$ 11,845	0.0
Animal production, except cattle and poultry and egg	$ 8,866	0.0
Negative Economic Impact to Industry		
Industry Name	**Industry Output Results**	**Industry Employment Results**
Alfalfa	$ (20,989,665)	-207.0
Support activities for agriculture and forestry	$ (566,401)	-15.2
Electric power transmission and distribution	$ (157,653)	-0.1
Insurance agencies, brokerages, and related activities	$ (91,690)	-0.6
Insurance carriers	$ (84,421)	-0.3
Other local government enterprises	$ (42,116)	-0.2
Water, sewage and other systems	$ (30,076)	-0.1
Monetary authorities and depository credit intermed	$ (19,656)	-0.2
Accounting, tax preparation, bookkeeping, and payro	$ (17,498)	-0.2
Electric power generation - Solar	$ (9,062)	0.0

Figure 24. Scenario three top ten industries affected.

Scenario Four

The fourth and final scenario is similar to scenario two in that all of the reduction comes from alfalfa, but adds in a Conservation Reserve Enhancement Program (CREP) payment to each acre that is fallowed. The CREP payment policy was chosen for our scenario analysis as it has been utilized in sub-district one already and is a potential option that could be used to mitigate some of the negative economic impacts that are associated with reductions in irrigated agriculture. The CREP program provides an incentive for farmers who conserve irrigation water and groundwater withdrawals while also enhancing water quality, reducing erosion, improving wildlife habitat and conserving energy within the watershed. CREP payments are payments from the USDA directly to the farmer. Since these payments are federal they are essentially money coming from outside the San Luis Valley into the region and can thus be counted as a direct increase in output in the region. If these payments came from within the region they would not be considered as direct impacts as they would just involve shifting of money within the region. The Rio Grande CREP has USDA irrigated rental payments in the region of $175 per acre taken out of production per year through the term of the contract (RGWCD, 2015), so we use a CREP payment of $175 per acre in this scenario. This assumption of a $175 payment is an oversimplification of the complexities involved in the CREP program but is used here as an illustration of how the 'what-if' tool can be used to evaluate the impacts of a program such as CREP.

In this scenario a total of 10,000 acres of alfalfa are fallowed and enrolled in the CREP program to meet the 24,500 AF savings. In this scenario, it is assumed that the payment is used as household spending in the local economy, rather than to start a new enterprise or to invest in operating inputs that enhance production. Table 19 represents the potential economic effect of the program in which $175 million of CREP payments partially offsets the lost economic activity associated with foregone alfalfa production.

Table 19. Reducing Economic Activity for Alfalfa Hay Production.

Crop	Acreage Reduction	Total Economic Output Change	Percent Change in Economic Output
Barley	0	0	0
Alfalfa	-10,000	$ (8,560,000)	-7%
Potatoes	0	0	0
Wheat	0	0	0
CREP Payment	NA	$ 1,750,000	NA
Total	**-10,000**	**$ (6,810,000)**	**-3%**

The total economic output change associated with scenario four is $6,810,000 ($1,750,000 less than the output change in scenario two due to the CREP payment). Figure 25 shows the results of these impacts as calculated by the 'what-if' tool. The total negative economic impact from scenario four is $10,318,292, which is lower than the $13,007,611 seen in scenario two. Due to the way household money ripples through the economy we see an increase in employment into the economy of 16 employees. Value added to the region decreases by $4,138,364 and there is a reduction in property taxes of $211,136. This scenario shows how a policy that injects outside money into the economy can serve to mitigate some of the negative economic impacts associated with the reduction in irrigated agriculture in the San Luis Valley.

SUMMARY RESULTS: Outcome values from specificed changes in economic activity								
		Direct		Indirect		Induced		Total
Total Output	$	(6,810,000)	$	(2,691,375)	$	(816,917)	$	(10,318,292)
Employment		63.2		-39.2		-7.3		16.7
Value Added	$	(1,304,287)	$	(1,559,193)	$	(447,689)	$	(3,311,169)
Non-Property Tax	$	(70,418)	$	(86,178)	$	(51,066)	$	(207,662)

Figure 25. Scenario Four Results from the 'What-If' Tool.

Final Remarks

Irrigated cropping is an important base industry in the San Luis Valley generating significant direct sales in the regional economy, creating important demands for the suppliers of agricultural inputs and generating significant wage income for workers that can drives household demand for local goods. Indeed, output multipliers indicate that an additional dollar of irrigated crop sales results in an additional 43-52 cents of additional economic activity in the San Luis Valley. These complex interrelationships can be explored, albeit imperfectly, by using economic multipliers and organizing them in an economic activity matrix. The foundation for matrix development is an input-output economic model, and in this study the IMPLAN software is used to create the matrix. An economic matrix for the San Luis Valley is developed using specific cropping information and locally relevant modifications to the standard IMPLAN model.

Regional economic issues often involve many stakeholders, and thoughtful deliberation of these issues often entails measuring the economic ripple effects of different policy scenarios. To this end, a spreadsheet tool was created that houses the San Luis Valley economic activity matrix, and four irrigated cropping scenarios demonstrate how such a matrix might be used. Rules of thumb suggest that including high value crops in acreage reductions may create larger economic impacts vis a vis lower value crops, that prevailing prices and yields play an important role in the determining overall impacts, and that CREP payments may not be sufficient to offset losses to economic activity, as well as the fact that payments may not be distributed to all those impacted by reduced irrigated cropping.

Care should be taken when interpreting the results from the four scenarios due to the assumptions they are built on. In addition to the key assumptions of input-output analysis outlined in this report, the scenarios make the fundamental assumption that the four crops are generating revenue values equivalent to the level in the most recently available data, 2013. The 'what-if' tool can be used to relax this assumption and evaluate scenarios based on circumstances in which high revenue years or low revenue year prevail.

'What-if' tools are also being created at the more granular level for each of the six counties in the San Luis Valley. A separate report will be created to accompany this report to detail how scenario analysis and results are different when evaluating smaller economic regions, such as counties. As time passes the quality of the results from the 'what-if' tool for analysis of current conditions diminishes and it becomes important to update the data and the regional economic interrelations periodically as the region changes with time.

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Appendix A: Glossary of Input-Output Terms

Direct Effect – These effects are a result of the actual activity expenditures.

Economic Activity –Dollars spent within a region that are attributable to a given industry, event, or policy.

Economic Impact – The net changes in new economic activity associated with an industry, event, or policy in an existing regional economy. It represents "new" money injected in the local economy from spending by visitors residing outside of the local economy.

Employment – The total number of wage and salaried employee and self-employed jobs in a region. It includes both full-time and part-time workers. The data sets used to derive Employment totals in the IMPLAN model are the ES-202 data, County Business Patterns, and the Regional Economic Information System (REIS) data.

Indirect Effect – These effects arise due to linkages in the supply chain, such as local industries buying goods and services from other local industries. The cycle of spending works its way backward through the supply chain.

Input –Output Models (Analysis) – A specific methodological framework that characterizes the financial linkages in a regional economy between industries, households, and institutions. Input-Output only measures economic activity and does not include any non-market values.

Induced Effect – These effects are a result of employee household spending.

Labor Income – All forms of employment income, including wages, benefits and proprietor income.

Multiplier – A key component of input-output analysis is the production of multipliers that indicate the extent of linked economic activity within a study region resulting from a change in production in a sector of the economy. An income multiplier of 1.75 means that for every dollar of direct income, a total of $1.75 of income is generated in the local economy.

Output – The sales revenue or value of industry production.

Retail Margin – Sales receipts less the cost of goods sold. It consists of the "mark-up" or retail trade margin plus sales taxes and excise taxes that are collected by the trade establishment.

Value Added - Net revenues - the difference between what someone sells a good for and what one pays for all of the components used in producing a good. This is the same measure as Gross Domestic Product.

Appendix B: Top Industry Definitions

Sector 11 – Beef Cattle and Ranching

Backgrounding, cattle, Beef cattle ranching or farming, Calf (e.g., feeder, stocker, veal) production, Cattle conditioning operations, Cattle farming or ranching, Dairy heifer replacement production, Feeder calf production, Stocker calf production, Veal calf production, Beef cattle feedlots (except stockyards for transportation), Cattle feedlots (except stockyards for transportation), Fattening cattle, Feed yards (except stockyards for transportation), cattle, Feedlots (except stockyards for transportation), cattle

Sector 19: Support activities for agriculture

Fertilizer application, Hoeing, Insect control, Agricultural pest control services, Planting crops, Plowing, Pollinating, Seed bed preparing, Seeding crops, Spraying crops , Thinning of crops, Transplanting services, Weed control services, Cultivation services, Disease control for crops, Entomological service, Chopping and silo filling, Combining, harvesting, Hay mowing/raking/ baling/chopping, Fumigating grain, Grain cleaning, Grain drying, Potato curing, Sorting/grading/cleaning/ packing of fruits and vegetables, Agriculture production or harvesting crews, Farm labor contractors, Farm management services

Sector 49 – Electric Power Transmission

Electric power control, Electric power transmission systems, Transmission of electric power, Distribution of electric power, Electric power brokers, Electric power distribution systems

Sector 395 – Wholesale trade

Tools merchant wholesalers, Cold storage machinery merchant wholesalers, Construction machinery and equipment merchant wholesalers, Excavating machinery and equipment merchant wholesalers, Land preparation machinery wholesalers, Agricultural implements merchant wholesalers, Agricultural machinery and equipment merchant wholesalers, Crop preparation machinery (e.g., cleaning, conditioning, drying) merchant wholesalers, Cultivating machinery and equipment merchant wholesalers, Farm machinery and equipment merchant wholesalers, Feeders/animal wholesalers, Haying machines merchant wholesalers, Irrigation equipment merchant wholesalers, Land preparation machinery wholesalers

Sector 411 - Truck Transportation

General freight trucking, Bulk mail truck transportation, Van lines/ moving and storage services, Agricultural products trucking, Grain hauling, Gravel hauling, Livestock trucking, Milk hauling, Waste hauling

440- Real Estate

Dwelling rental or leasing, Auditorium rental or leasing, Commercial building rental, Medical building rental or leasing, U-lock storage, Agricultural property rental leasing, Airport leasing, Grazing land rental or leasing, Mining property leasing, real estate agencies, property managing

Appendix C: Technical Methodology and definitions

In this analysis, we create a framework to estimate the economic impacts of reductions in irrigated agriculture in San Luis Valley to the regional economy using an economic impact software program known as IMPLAN (Impact Analysis for Planning). Originally developed by the U.S. Forest Service, IMPLAN is an input-output model that is widely-used to quantify how businesses use technology, labor and materials (i.e., inputs) to produce a product (i.e., output). The IMPLAN software and database (www.implan.com) establishes the characteristics of economic activity in terms of 10 broad industrial groups, involving as many as 528 sectors. In practice, the IMPLAN model is used in every state and hundreds of communities across the nation to catalog economic activity and predict the effect of alternative policies and various economic changes. In this analysis we use IMPLAN to generate information on a number of important economic indicators.

In order to use models such as IMPLAN to examine the role of an industry in a local economy, analysts should have information on the final demand (i.e., expenditures) for any related goods and services. To adequately represent the impacts of reduction in irrigated agriculture on the San Luis Valley region, it was necessary to categorize the economic interrelationships for each of the four man crops in the region and create them as unique sectors within the IMPLAN model. In the remainder of this Appendix we define multipliers and other topics related to this analysis. The material is largely drawn from the IMPLAN User's Guide. A detailed description the IMPLAN sectoring scheme is available on the IMPLAN website.

Input-Output Definitions

Multipliers

Input-output models are driven by final consumption (or final demand). Industries respond to meet demands directly or indirectly (by supplying goods and services to industries responding directly). Each industry that produces goods and services generates demand for other goods and services and so on, round by round. These so called *ripple effects* are described by **multipliers**. A multiplier examines how much spin-off economic activity is generated by a marginal change in an industry. For example, multipliers can describe how many total jobs (employment) in the economy are created when an industry adds one new job. In general, input-output modelers describe three types of multiplier effects when examining the role of an industry in a county economy.

1. The **direct effect** is the contribution of the industry itself. It may represent the total revenue (output), employment or employee compensation. The value of the direct effect multiplier is always 1.

2. The **indirect effects** are effects of the industry on its suppliers. This multiplier captures the additional activity in businesses that provide inputs to the industry of interest.

3. The **induced effects** capture the impacts of changes in spending from households as income changes due to the direct effect. This effect captures the impact of spending by a) employees of the industry being studied, and b) employees of the input supplying businesses. These effects usually show up in retail and service industries. In the study here, the *secondary effects* are the sum of the indirect and induced effects.

In this study we use the IMPLAN Type SAM multipliers. The Type SAM multiplier is obtained according to the following formula:

Type SAM multiplier = (direct effect + indirect effect + induced effect) ÷ direct effect

Input-output analysis is a means of examining the relationships within an economy both between businesses and between businesses and final consumers. It captures all monetary transactions for consumption in a given time period. The resulting mathematical formulae allow one to examine the effects of change in one or several economic activities on an entire economy.

Industry output is a single number in dollars for each industry. The dollars represent the value of an industry's total production. In IMPLAN, the output data are derived from a number of sources, including U.S. Bureau of Census economic censuses and the U.S. Bureau of Labor Statistics employment projections. Another way to think about industry output is as the total revenue generated by an industry.

Employment is the total number of wage and salaried employee and self-employed jobs in a region. It includes both full-time and part-time workers. The data sets used to derive employment totals in the IMPLAN model are the ES-202 data, County Business Patterns, and the Regional Economic Information System (REIS) data.

While output captures the total dollar value of economic activity, its use as a measure of economic activity can be over-counted, in that it captures the value of all intermediate stages of the production process as well. For example, the price one pays for a car at the local auto dealership in large part represents economic activity that occurred in the production process. If one were to consider the price one paid for a car as the contribution to the local economy, then one would likely be overstating its impact. This is called double counting. To avoid double counting, economists usually examine economic contributions in terms of **value added**. At the local level, value added is equivalent to the concept of Gross Domestic Product, in that it examines the unique contribution of an industry to the overall economy. In input-output analysis, value added consists of four components.

1. **Employee compensation** is wage and salary payments as well as benefits, including health and life insurance, retirement payments, and any other non-cash compensation. It includes all income to workers paid by employers.

2. **Proprietary income** consists of payments received by self-employed individuals as income. This is income recorded on Federal Tax Form 1040C. Note: labor income is the sum of employee compensation and proprietary income.

3. **Other property type income** consists of payments for interest, rent, royalties, dividends and profits. This includes payments to individuals in the form of rents received on property, royalties from contracts, and dividends paid by corporations. This also includes corporate profits earned by corporations.

4. **Indirect business taxes** consist primarily of excise and sales taxes paid by individual to businesses. These taxes occur during the normal operation of these businesses but do not include taxes on income or profit.