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Regional Economic Effects of Irrigation Along the McClusky Canal in North Dakota

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Table of Contents

Page

List of Tables

List of Figures

Executive Summary

The Dakota Water Resources Act passed in 2000 by the 106th Congress mandated the maintenance of the McClusky Canal and authorized development of irrigation along the canal. Garrison Diversion Conservancy District is evaluating the economic implications of expanding irrigation along the 60-mile length of the Canal in McLean and Sheridan Counties in central North Dakota. Full development would result in about 404 center pivots based on approximately 51,700 authorized acres.

The study uses the IMPLAN modeling system to estimate the state-level economic effects of expanding irrigation along the McClusky Canal in McLean and Sheridan Counties.

Acquisition and installation of irrigation equipment would create a one-time set of economic impacts. Average total private and public investment for infrastructure and development was estimated at $246,300 per center pivot, although adjustments for out-of-state expenditures and out-of-state sourcing of irrigation equipment reduced the direct impacts to $132,100 per center pivot system. The total economic impact (i.e., sum of direct, indirect, and induced effects) on the state economy of developing all 404 center pivots would be $82 million, economy-wide personal income would be $31 million, and value-added to the state economy would be nearly $45 million. If total development occurred over a one-year period, statewide change in employment would be 598 jobs. Total state and local government one-time revenues from full development/construction were estimated at $5.6 million.

Irrigated crop rotation of primarily corn and dryland crop rotation of spring wheat-soybean-canola were selected for modeling the annual economic effects of irrigated crop production. Irrigation would average about $355 per acre more in crop sales per year, based on yield estimates from North Dakota State University Extension crop budgets and expected 2014 crop prices. Full development of all authorized acres was estimated to increase crop sales by $18.4 million annually and would increase gross business volume in the state by $30 million annually. Further, full development would increase employment in the state by 242 jobs and result in an increase of about $1.1 million annually in state and local government revenues.

Irrigated crop production can influence the creation of processing activities related to an increase in crop production, supply of a previously unavailable crop, or production-related factors affecting quality or crop attributes. However, it was not expected that expanded irrigation along the McClusky Canal would directly lead to new or expanded crop processing. Expansion of irrigation in the region also was not likely at this time to alter or change existing trends in livestock production in the state.

From an economy-wide perspective, the strongest likelihood of on-going changes in economic activity associated with irrigation development along the McClusky Canal would be associated with crop production. Expanding irrigated crop production would result in an increase of $575 in gross business volume per acre, and would produce positive employment and tax collections at the state and regional level.

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Introduction

The Dakota Water Resources Act passed in 2000 by the 106th Congress mandated the maintenance of the McClusky Canal and authorized development of irrigation in the Turtle Lake service area (13,700 acres), McClusky Canal service area (10,000 acres), and other undesignated areas (up to 28,000 acres).

Economic evaluations of the profitability and economic impacts of irrigation development in North Dakota have been periodically conducted since the 1950s. The most recent studies to examine farm-level economics and economic impacts were conducted in the 1990s (Givers et al. 1994; Leitch et al. 1991). While the general economic methods used remain relevant, changes in prices, crop rotations and yields, production practices, government programs, and the natural climate have almost certainly altered the results. In addition, developments in the ability to measure risk on investment decisions can be leveraged to understand potential returns to individual producers and the public.

While acknowledged in some previous economic assessments that irrigation may reduce risk to a producer by reducing yield variability, risk has not been specifically addressed. Stochastic modeling can now quantitatively address yield variability for irrigated crop production, or more specifically, the difference in variability between dry land and irrigated production. Also, crop prices, yields, crop mixes, input costs, federal farm programs, and federal crop insurance instruments have all changed since the 1990s. These changes suggest the potential for state-level economic impacts of converting crop land from dryland to irrigated production also may have changed from previous assessments. These factors warrant an updated analysis to examine the potential economic outcomes of converting from dryland to irrigated crop production.

Project Scope

Expansion of irrigation often results in evaluations of producer-level returns and regional economic assessments. However, other important questions also are often part of any plan to expand irrigation, and those fundamental questions become centered on producers' willingness and ability to invest in irrigation equipment and public support to fund or enable additional development of irrigation in the state. This project will not directly answer those questions, but it will illustrate how irrigation may potentially affect producer returns and producer risk, address questions on return on investment, and estimate the economy-wide implications of expanded irrigation.

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Research questions pertaining to farm-level returns and production risk issues in converting dryland to irrigated crop production are addressed in another report (Ripplinger et al. 2014). This report addresses the likely economic impacts to the state economy from expanded irrigation development along the McClusky Canal in central North Dakota.

Background on Garrison Diversion

Congress authorized the construction of Garrison Dam on the Missouri River in North Dakota in the 1940s; the dam was constructed in the 1950s. The intended benefits of the dam included irrigating agricultural land in north central North Dakota. Based on technology at that time, water would be moved via canals and applied by flood-type irrigation. Some of the primary features of the overall project would be the Snake Creek Pumping Station to lift water from Lake Sakakawea to maintain water levels in Lake Audubon. The McClusky Canal would then convey water from the eastern edge of Lake Audubon into central North Dakota.

Construction of the pumping station and two canals was commenced in the 1960s but the overall project was not completed due to a variety of concerns, including the environmental impact of moving Missouri River water into the watershed of the Red River of the North. Accordingly, the McClusky Canal -- although constructed -- is blocked near the continental divide between the Missouri River and Red River basins. This point is located several miles north of the community of McClusky, North Dakota in Sheridan County. The length of the McClusky Canal from its source at Lake Audubon to its point of blockage is approximately 60 miles.

Despite the inability to complete the original Garrison Diversion project, there is continued interest in pursuing projects to supply water from the Missouri River to meet a variety of needs in central and eastern North Dakota. One such project is the "Milepost 7.5" irrigation project along the McClusky Canal. The features of this irrigation project include a pump site on the McClusky Canal 7.5 miles from its origin on Lake Audubon. Five electric-powered pumps move water through buried pipelines to irrigate approximately 3,500 acres (i.e., 30 center-pivot irrigation systems) along the north side of the McClusky Canal. The vision is to construct additional irrigation "units" along the 60-mile length of the Canal. This section of the Canal is located in McLean and Sheridan Counties in central North Dakota.

Not all land along the McClusky Canal is irrigable for a variety of reasons. Nor can water be moved an unlimited distance from the Canal. Accordingly, one possibility is to irrigate up to 51,700 authorized acres in a 20-mile wide corridor (i.e., 10 miles on each side of the Canal) along the length of the Canal where the land is irrigable. Each "unit" would consist of a pumping station at the Canal and a network of buried pipelines to distribute water to land that will be sprinkler-irrigated.

But are such irrigation projects economical? Although a series of economic analyses of diverting water from the Missouri River into central and eastern North Dakota have been completed since the 1960s, an updated analysis is needed again. Changes in the technology of conveying and applying irrigation water (i.e., buried pipes and center pivot sprinkler irrigation systems), crops being produced, and crop production technologies are only a few of the reasons for needing an updated analysis. The commitment by the State of North Dakota to expand irrigation by funding a share of the cost of constructing the irrigation infrastructure in central North Dakota also impacts the economics of this effort.

Modeling Economic Impacts

Economic impact assessments measure the economic activity from a project, program, policy, or activity. Economic activity is categorized into direct and secondary impacts. Direct impacts are those changes in output, employment, or income that represent the initial or first-round effects of a project, program, or event. Secondary impacts result from subsequent rounds of spending and re-spending within an economy.

Direct economic impacts are usually measured as injections of money into a specified economy. In the case of expanded irrigation, the direct impacts include one-time infrastructure acquisition and annual impacts of a change in production input purchases and net returns to producers and landowners. The direct impacts (i.e., the regional estimates of the net gain in crop sales) represent input into the IMPLAN modeling system. IMPLAN is an input-output model that traces linkages among sectors of an economy and calculates various forms of business activity resulting from a direct impact in an economic sector (IMPLAN Group, LLC 2013). The secondary changes in business activity can be further separated into indirect and induced effects; both types of secondary economic activity will be included in the economic impacts.

Types of Economic Assessments

Input-Output analysis provides a tool for economists to perform economic *impact* and economic *contribution* analyses. These analyses can be applied to programs, projects, developments, industries, and other economic activities. Key macro-economic indicators such as retail trade activity, economy-wide personal income, total business activity, secondary economic business activity (indirect and induced), selected state tax collections, and secondary (indirect and induced) employment can be estimated using input-output analysis.

Economic impact analysis estimates the **change** in key economic indicators resulting from the 'new' dollars a specific project or development would generate in the state (or local economy). An economic *impact* analysis measures the net effect of two possible situations – often these situations would be the presence or absence of some type of economic activity, development, or program. Measures of the business activity generated in secondary industries are included in economic impact figures.

Economic contribution analysis differs in that it includes **all** relevant expenditures and other revenue streams (e.g., severance taxes) in the generation of the amount of economic activity created in an economic unit. Typically an economic *contribution* analysis will produce more economic activity than an economic *impact* study for the same industry or activity. Economic *contribution* analyses attempt to capture all economic activity without regard to the net change or value of alternative economic activities; therefore, *economic contribution* assessments provide measures of the gross effects. Measures of the business activity generated in secondary industries are included in economic impact figures

When comparing economic analyses, it is important to know what type of study was conducted so valid comparisons can be made. For a detailed discussion of these types of analyses, see Leistritz (1994) and Leistritz (1998). This study conducts an *economic impact* analysis.

Direct Economic Effects

The direct impacts from a conversion of dryland crop production to irrigated crop production are estimated by comparing a dryland baseline crop mixture comprising the most common crops raised in the study region to several potential scenarios reflecting various irrigated crop rotations. The dryland baseline condition is described using a composite-acre approach that combines costs and revenues in proportion to the acreage of the crops raised in the region. The irrigation scenarios also use a composite-acre approach to represent potential crop rotations under irrigation.

Since both production input costs and producer revenues in the dryland baseline and irrigation scenarios are estimated using a composite-acre basis, the difference in those cropping systems can be estimated on a per-acre basis. The net change between composite acres represents the ongoing direct impacts of irrigation. The direct impacts can then be scaled based on assumptions for how much acreage is converted to irrigation.

Direct economic impacts of expanded irrigation represent the change in gross crop sales, production costs and net returns to producers. The net increase in production expenses and producer returns are then allocated to various economic sectors (as defined by the IMPLAN input-output model) since they represent an increase in the purchase of goods and services from those economic sectors. For example, purchases of seed affect the Farm Input sector of the economy, and interest charges on borrowed capital affect the Finance/Banking sector. This expenditures-based approach, when using IMPLAN, is sometimes referred to as 'Analysis-by-Parts.' In the case of an expenditures-based approach, allocation of purchases of inputs and services by the producer represent sales to various economic sectors. IMPLAN then estimates the business activity from a change in sales in those sectors.

Another approach to estimating a change in economic activity from production agriculture is to measure the change in crop sales, and allocate the change in crop sales to appropriate agricultural production sectors of IMPLAN. In a crop-sales approach, IMPLAN estimates the changes in economic effects using typical input requirements for crop production, and traces the impacts of those changes in crop inputs. For example, IMPLAN translates the change in sales into subsequent purchases of inputs and services and estimates the change in business activity.

This study used *crop sales* as input into IMPLAN since those effects were the most consistent data comparing changes between irrigation and dry land crop production (Ripplinger et al. 2014).

Indirect and Induced Economic Effects

Secondary economic impacts arise from subsequent rounds of spending and purchases within an economy that result from the direct effects. Input-output (I-O) analysis traces linkages (i.e., the amount of goods and services) among sectors of an economy. An economic sector is a group of similar economic units (e.g., communications and public utilities, retail trade, construction). The change in demand for goods and services produced by one sector translates into a change in demand for goods and services in other sectors.

IMPLAN estimates the indirect and induced economic effects associated with an increase in the goods and services demanded by an economic sector. The indirect economic effects arise from the additional consumption of goods and services triggered by businesses that supply inputs to firms in the affected sector as they need to acquire additional goods and services to meet the change in demand. As an example, a firm selling and installing irrigation equipment will purchase business inputs (labor, utilities, inventory, services, and so on) from other businesses, which in turn also purchase additional inputs to meet the change in demand for their products. That cycle of business purchases continues until purchases are made for inputs that result in those dollars leaving a specified economy.

The induced economic effects arise from the additional spending by households due to changes in personal income associated with the direct effects and indirect effects. Changes in personal income can come from payrolls of businesses that are directly impacted, changes in payroll from businesses that supply goods and services to the impacted sector, and proprietor income resulting from a change in business volume. The induced effect measures the additional business activity that is triggered as changes in personal income are translated into the purchase of goods and services for personal consumption.

Economic Impact Indicators

Direct, indirect and induced economic effects or impacts can be measured by different indicators depending on the outcome being considered. For example, the decision maker may be interested in a project’s impact on employment; e.g., how many jobs is the proposed project expected to create. This question is relevant especially if employment opportunities are a goal for the decision maker. Employment effects in IMPLAN are based on job-months, and do not necessarily represent full-time equivalent positions. Job values reported by IMPLAN represent full-time, part-time, and temporary positions. Employment change is measured for direct, indirect, and induced economic effects.

An alternative measure is economy-wide personal income. IMPLAN estimates a change in personal income by measuring changes in employment income (wages/salaries and benefits) and proprietor income. The expectation is that these employees and business owners will spend some of their earnings on consumer items in the local economy. The decision maker may want to know how much wage and profit is expected to be generated and circulated through the local economy as a result of the project.

A third indicator is value-added economic effects. Value-added measures payment for labor and capital, and includes labor income, indirect business taxes, and business/proprietor income. This economic effect is sometimes described as the value that regional businesses or industry add to purchased inputs. Restated, value-added determines the amount of the proposed project's impact that is attributable to local efforts, such as local manufacturing, workers, business owners assuming the risk of business ownership, and investors committing their capital to the project. These local efforts are "adding value" to manufactured items and resources from outside the region. Value-added measures the extent to which this project's economic impact is due to the efforts of local business, workers, and other resources.

A fourth indicator is business volume; also, sometimes called gross business volume. This measure determines the total amount of dollars that will circulate through the local economy as a result of this project. Gross business volume often is used in describing economic impact of a project, such as the irrigation project analyzed in this study.

All four indicators are used by decision makers and analysts, so all four indictors are calculated in this report. The focus of this report, however, is on gross business volume and employment.

Government Revenue

Changes in public revenues to state and local governments are another important measure in describing the economic effects of a project, program, or activity. As part of the evaluation of a change in economic activity, IMPLAN estimates the change in state and local government revenues stemming from a change in economic activity. The categories of government revenues include payroll taxes, personal income, sales and use, and corporate income taxes, property taxes, and a variety of miscellaneous revenues such as permits, fees, licenses, and dividends.

Timeline for Economic Effects

Not all targeted acreage will come under irrigation at one time. Development will be phased-in over a multiple-year period. As a result, it is anticipated there will be overlap in the economic effects from irrigation development and irrigated crop production during some years.

Impacts can be presented based on a timeline for anticipated development of additional irrigation in the region (i.e., an annual value), or the impacts can be estimated based on a physical metric (e.g., center pivots or acres). Since the timeline for development is unknown, projecting impacts on a prescribed annual basis is difficult. By relating the impacts to a physical unit, a future timeline of impacts can be compiled when the development schedule becomes better understood.

Expanding irrigation in the region will require the installation and development of additional infrastructure. It is unlikely that all infrastructure and development will occur in one year. Also, expanding irrigation in the region will occur in steps, and those steps are likely targeted to various acreages or land tracts. Those targeted acreages likely would have pumps, pipelines, and pivot systems installed as a unit that serves a targeted acreage. It is not expected that pumps will be installed in year 1, followed by pipelines in year 2, pivot systems in year 3, and so on such that all acreage can then be irrigated simultaneously in year 4. An implied assumption used for modeling the economic impacts is that all of the infrastructure required for one center pivot system will be installed in a single year.

Expanding irrigation in the region will be phased in over a period of years; how many years are unknown. Therefore during the period when development and expansion of infrastructure is occurring, it is likely that the regional economy could have one-time impacts associated with development along with on-going impacts from irrigated crop production.

Impacts of Expanding Irrigation

The direct economic impacts from a conversion of dryland crop production to irrigated crop production include the expenditures necessary to develop and install infrastructure for irrigation, the net change in inputs and producer net returns between dryland and irrigated crop enterprises, and potential downstream effects from new or incremental increases in processing activities. Expenditures associated with development of irrigation represent one-time impacts, even if development occurs over a multiple-year period. Impacts from changes in inputs and net returns from irrigated crop production represent ongoing impacts and those impacts continue after development of irrigation infrastructure is completed. Downstream impacts are usually described as ongoing impacts and would involve processing or other economic activities that can be directly linked to an expansion of irrigation.

The first step in estimating the economic effects is to estimate the direct impacts. Direct impacts would then be allocated to various economic sectors of IMPLAN. Indirect impacts are estimated as the additional business activity created as affected businesses have to change their purchases of inputs and services to expand their output. In the case of irrigation, the expansion of business activity is driven by a need for more production inputs (e.g., fuel, seed, fertilizer). This initial change triggers subsequent rounds of purchases of goods and services by businesses that supply inputs to the businesses that supply the farm inputs. Induced impacts are generated as a change in personal income (i.e., producer net returns, wages/salaries of affected employees) is translated into a change in personal consumption. IMPLAN estimates how an increase in personal consumption relating to a change in person income affects purchases of goods and services in the economy.

Irrigation Infrastructure

Purchase and installation of irrigation equipment would create a **one-time set of economic impacts**. Average total investment for infrastructure and development was estimated at $246,300 per center pivot (Table 1) (Garrison Diversion Conservancy District 2014). Infrastructure expenditures include water intake, pumps, distribution pipes, electrical infrastructure, and center pivot sprinklers. Additional development costs include construction labor and professional services.

Table 1. Infrastructure Expenditures for Development of Center Pivot Irrigation along McClusky Canal, McLean and Sheridan Counties, North Dakota, 2014

Expenditure	Per Center Pivot System[a]
	--- $ 000s ---
On-farm Costs	
Center Pivot	70.0
Freight, Installation, Pad, Fittings	9.0
Pipe and Power	34.9
Off-farm Costs	
Construction (irrigation contractors)	111.5
Intake	10.0
Pumps	6.2
Services (legal, engineering, other)	4.7
Total Development Cost	246.3

[a] Based on 128-acre system. Does not include sunk costs associated with development of McClusky Canal.

Source: Garrison Diversion Conservancy District (2014).

Some of the expenses for infrastructure (e.g., pipe, pumps) are likely to be cost-shared with public funds. While cost-sharing directly influences on-farm economics of irrigation, the economic impact analysis was not adjusted to reflect private versus public funding of irrigation development.

Data on development costs from Garrison Diversion Conservancy District (2014) contained expenses relating to specific irrigation contractors. Two of the contractors represented out-of-state firms. An assumption was made that 25 percent of the payment to those firms for irrigation development would represent a direct economic leakage of the development expenditures. For example, employees of out-of-state firms installing irrigation equipment are likely residents of another state, and would spend much of their wages/salaries earned on the project in their home state. Therefore, labor income from that portion of the project would not produce the same economic effects in North Dakota as labor income generated for a construction worker living in the state. Also, economic leakage occurs when contractors directly acquire inputs from their home state and when they keep some retained earnings from the project in their home state. IMPLAN accounts for natural leakages associated with the construction sector, but those leakages are developed by spending patterns relating to firms who have in-state offices or operations in the state. The economic leakage accounted in this analysis is to cover the likely portion of contractor payments made by Garrison Diversion Conservancy District to out-of-state firms that do not get circulated through the North Dakota economy.

Other adjustments in the analysis included assumptions on which irrigation equipment needed for the McClusky Canal development was manufactured in North Dakota. Expenditures for irrigation equipment were assigned to the Irrigation Equipment Merchant Wholesalers sector (sector no. 319) of IMPLAN. IMPLAN has two options for the treatment of wholesale trade expenditures, and the adjustments are related to in-state or out-of-state manufacture of the equipment purchases allocated to that sector. If the inputs represented by project expenditures are not manufactured in North Dakota or if it is known that sales in that sector represent equipment that will be acquired from outside the state, those direct impacts should be specified as gross retail *sales*. If the irrigation equipment used in the McClusky Canal development is manufactured in North Dakota, and the equipment will be acquired from those manufacturers, the expenditure sales in sector 319 are specified as gross retail *margin*.

While an exhaustive investigation was not performed, this study treated the manufacture of center pivots as occurring outside of North Dakota. Some pumps and miscellaneous equipment are manufactured by two firms in the state. Therefore, the analysis treated the expenditures for center pivots as being manufactured outside North Dakota, and some expenditures for pumps as being manufactured in the state.

<u>Direct Economic Impacts</u>

Of the $246,300 of total development costs per center pivot irrigation, a total of $227,300 was considered direct impacts to the North Dakota economy (Table 2). Equipment purchases were allocated to the Irrigation Equipment Merchant Wholesalers sector based on assumptions for in-state manufacturing. Expenditures for irrigation contractors were allocated to the Construction sector. Expenditures for engineering and legal services were allocated to Law Services and Engineering Services sectors of IMPLAN (Table 2).

<u>Total Economic Impacts</u>

The direct impacts of irrigation development were estimated at $227,200 per center pivot system; however, IMPLAN reduces the direct impacts in the Irrigation Equipment Merchant Wholesalers sector using a margin adjustment to account for out-of-state manufacturing of equipment. Therefore after those internal adjustments, total direct impacts on gross business volume are estimated at $132,100 per center pivot system (Table 3).

Each center pivot was estimated to create $202,900 in gross business activity (volume) in the state economy (Table 3). Of the total business activity, approximately $30,100 was associated with indirect effects and $40,700 was associated with induced effects. Labor

Table 2. Direct Impacts for Development of Center Pivot Irrigation along McClusky Canal, by Economic Sector, McLean and Sheridan Counties, North Dakota, 2014

Economic Sector	IMPLAN Sector No.	Per Center Pivot System
		--- $ 000s ---
Irrigation Equipment Merchant Wholesalers	319	
In-state manufacture		6.2
Out-of-state manufacture		114.9
Construction	36	101.4
Legal Services	367	0.1
Engineering Services	369	4.6
Total Direct Impacts		227.2

Table 3. Statewide Economic Effects of Development of Center Pivot Irrigation Systems along McClusky Canal, McLean and Sheridan Counties, North Dakota, 2014

Impact Type	Employment[b]	Personal Income	Value-Added	Gross Business Volume
	-- No. of Jobs --	--- $ 000s ---		
		Economic Effects per Center Pivot[a]		
Direct Impact	0.9	51.8	68.3	132.1
Indirect Impact	0.2	12.1	17.4	30.1
Induced Impact	0.4	13.9	24.9	40.7
Total Impacts	1.5	77.7	110.5	202.9
		Economic Effects of Total Development of Authorized Land[c]		
Direct Impact	348.8	20,927	27,593	53,368
Indirect Impact	94.8	4,888	7,030	12,160
Induced Impact	154.8	5,616	10,060	16,443
Total Impacts	598.4	31,391	44,642	81,972

[a] Development of center pivot irrigation would represent a one-time economic effect. The effects accrue to the state economy during the construction and development of the irrigation systems, but those effects are not present after construction is completed.

[b] Employment values represent jobs, and are estimated assuming one-year development period.

[b] Based on 404 center pivots developed for 51,700 acres of authorized land along McClusky Canal in McLean and Sheridan Counties.

(personal) income was estimated at $77,700 and value-added effects were estimated at $110,500. A total of 1.5 jobs[1] would be supported by the development of each center pivot system, assuming the full development process occurred over the course of one year. Annualized employment effects would be different if development of a center pivot system extends over more than one year.

Full development of all irrigable acreage considered in this study would result in about 404 center pivots based on approximately 51,700 authorized acres. The total economic impact (i.e., sum of direct, indirect, and induced effects on gross business volume) on the state economy of developing all 404 center pivots would be $82 million (Table 3). Economy-wide personal income would be $31 million associated with full development of authorized land, and value-added to the state economy would be nearly $45 million. If total development occurred over a one-year period, statewide change in employment would be 598 jobs. That level of employment would be sustained for one year; however when development was completed, those jobs would no longer be sustained in the state economy. Statewide employment will likely be lower than estimated in Table 3 since full development will take more than one year. The overall employment effect is likely to be fewer jobs created during the development phase than indicated in Table 3, but those jobs are likely to last for several years.

Government Revenues

Changes in public revenues to state and local governments are another important measure in describing the economic effects of a project, program, or activity. As part of the evaluation of a change in economic activity, IMPLAN estimates the change in state and local government revenues stemming from a change in economic activity.

The development of each center pivot system was estimated to generate $14,000 in state and local government revenues (Table 4). The largest category of government revenues were associated excise (sales and use) taxes. Total development of all authorized acres along the McClusky Canal was estimated to produce about $5.6 million in state and local government revenues (Table 4).

Crop Production

The direct impacts from a conversion of dryland crop production to irrigated crop production are estimated by comparing a baseline crop mixture comprising the most common crops raised in the study region to several potential scenarios reflecting various crop rotations under irrigation. The baseline condition is reflected using a composite-acre approach that combines costs and revenues in proportion to the acreage of the crops grown in the region. The region raises a number of crops, but spring wheat has historically been the dominant crop in Sheridan and McLean Counties (Figure 1).

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[1] Jobs represent the sum of full-time, part-time, and temporary positions over a one-year period. The time period for analysis of development impacts was assumed to be one year. Therefore, if development occurs over more than one year, estimates of jobs from multiple analyses (years) are not additive. Employment from year 1 and employment from another period (e.g., year 2) cannot be combined when describing total employment effects.

Table 4. State and Local Tax Collections, Development of Center Pivot Irrigation Systems along McClusky Canal, McLean and Sheridan Counties, North Dakota, 2014

	Total State and Local Revenue Collections[a]	
Type of Revenue	Per Center Pivot	Total Development[b]
	------------------- $ 000s ----------------	
Payroll Taxes	1.2	484.8
Excise Taxes	6.0	2,427.2
Property Tax	1.0	391.1
Personal Income Tax	0.7	298.6
Corporate Income Tax	1.1	437.1
Permits, Fees, Fines, Licenses	2.0	799.9
Miscellaneous	2.0	809.6
Total	14.0	5,648.3

[a] Represents total tax revenues associated with development of the irrigation infrastructure. Tax collections from development represent a one-time set of revenues even if development occurs over multiple years.
[b] Based on 404 center pivots developed for 51,700 acres of authorized land along McClusky Canal in McLean and Sheridan Counties.

From 2003 through 2012, a total of eight crops represented 3 percent or more of annual planted acreage in the two-county region. Over that same period, wheat was the dominant crop and comprised approximately 50 percent of planted acreage. The other seven crops ranged from around 3 to 10 percent of annual planted acreage.

Despite the historical dominance of wheat among a large number of crops raised in the region, acreage for soybean and corn has been rapidly increasing in recent years. In 2003, corn represented less than 2 percent of planted acreage, but by 2012 that percentage had grown to nearly 9 percent. Soybeans have exhibited a similar trend and represented less than 2 percent of planted acreage in 2003 but have grown to represent about 8 percent of planted acreage in 2012.

Corn and soybean acreage has generally followed a migration of expanded acreage westward and northward in the state over the past decade (Bangsund et al. 2011). In an attempt to gather more insight on the trends in corn and soybean production, two multiple-county areas-one to the east and one to the south of the study region–were examined for changes in crop acreages.

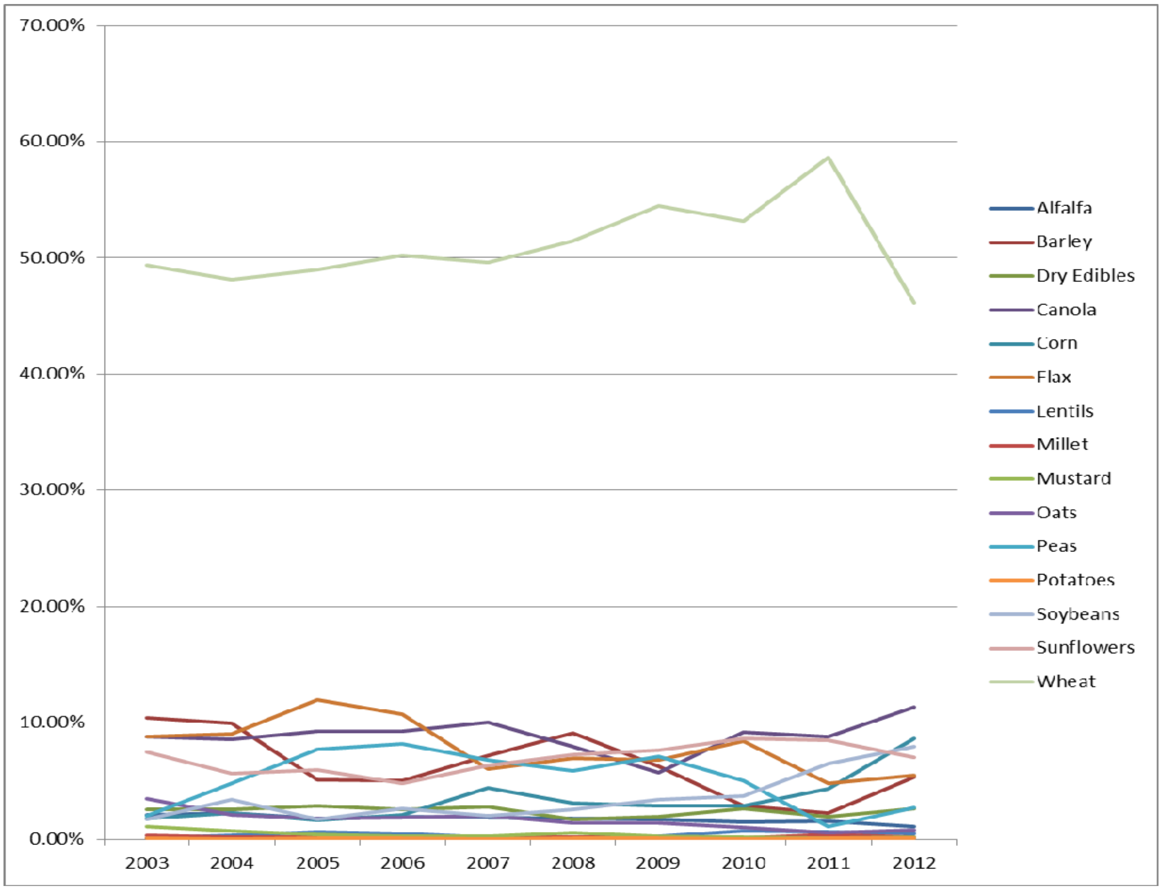

Figure 1. Historical Share of Crop Production, Sheridan and McLean Counties, 2003 through 2012
Source: Farm Service Agency (2013).

In the counties of Foster, Griggs, and Stutsman, soybean acreage has gone from around 30 percent of planted acreage in 2003 to over 53 percent in 2012. A similar change was observed in Emmons, Logan, and McIntosh Counties, where soybeans represented 9 percent of planted acreage in 2002 but increased to 26 percent of planted acreage in 2012. Over the same period, corn acreage increased in nearly similar magnitudes in each multi-county region. While acreage of some minor crops declined from 2003 through 2012, the biggest reductions in planted acreage in those two regions came from spring wheat.

While changes in cropping practices and crop rotations in neighboring regions are not a binding precursor to future crop rotations in McLean and Sheridan Counties, soybean and corn production have increased to represent substantial portions of planted acreage in those areas. Also, soybean and corn acreage are rapidly increasing in the study counties. The observed change in cropping patterns has implications for selecting the appropriate dryland baseline budget for which to compare to irrigated crop rotations.

Several baseline budgets were developed that represent potential dryland cropping mixes in the study region (Ripplinger et al. 2014). A composite-acre budget representing a crop rotation of soybean, canola, and spring wheat was developed to reflect growing regions where substantial increases in corn and soybean acreage have not occurred and/or may not occur due to agronomic factors. A corn-soybean-wheat rotation and a corn-dry beans-wheat rotation also were developed that may approximate a future dryland crop rotation if current trends in cropping patterns continue. Average net returns per year ranged from $35 to $52 per acre for the dryland composite budgets (Table 5).

Table 5. Baseline Dryland Crop Rotations, McLean and Sheridan Counties, North Dakota, 2014

	Composite-Acre Budgets[a]		
	Soybean/ Canola/Spring Wheat	Corn/ Soybeans/ Spring Wheat	Corn/Dry Bean/Spring Wheat
	------------------------------- $/acre --------------------------------		
Revenue[b]	284.92	315.17	358.05
Direct Costs	160.81	187.10	207.10
Indirect Costs	88.67	94.31	98.36
Total Cost	249.48	281.41	305.46
Net Returns[c]	35.44	33.72	52.53

[a] Crops assumed to be raised in equal proportions, except soybean-canola-spring wheat rotation was based on 50 percent spring wheat.
[b] Based on expected dryland crop yields and expected 2014 prices.
[c] Represent returns to unpaid labor and management.
Source: Ripplinger et al. (2014).

Four potential crop rotations were developed for irrigation (Ripplinger et al. 2014). A crop rotation of mostly corn (i.e., called primarily corn) would represent an option for producers desiring to use irrigation to expand corn production (Table 6). A crop rotation of corn, corn, dry beans, and spring wheat would represent a rotation dominated by corn production, but account for some rotation of other crops. A crop rotation of corn, dry beans, barley, and sugarbeets was developed to approximate crops that may be raised in combination with sugarbeets. A fourth crop rotation of corn, dry beans, barley, and potatoes was developed that might reflect crops associated with potato production. Both the sugarbeet and potato rotations would require more than an expansion of irrigation providing there was a net gain in acreage of those crops in the state. If potato production was brought into the study region due to an expansion of irrigation, in the absence of expanded processing capacity, that expansion of acres would represent a shift from one production region to another. While it is possible that potato production could enter into the crop rotation in the study region, from an economic impact perspective, those possibilities were not considered in the economic impact analysis. The issue of expanded crop processing is discussed again in the **New or Expanded Crop Processing** section.

Table 6. Baseline Irrigated Crop Rotations, McLean and Sheridan Counties, North Dakota, 2014

	Composite-Acre Budgets[a]			
	Primarily Corn	Corn/Corn/ Dry Bean/ Spring Wheat	Corn/Dry Bean/Barley/ Sugarbeets	Corn/Dry Bean/Barley/ Potatoes
	------------------------------------ $/acre ------------------------------------			
Revenue[b]	640.00	608.45	715.25	1,449.25
Direct Costs	331.12	283.27	342.74	608.57
Indirect Costs	216.73	209.90	236.53	229.82
Total Costs	547.85	493.17	579.27	838.39
Net Returns[c]	92.15	115.28	135.98	610.86

[a] Crops assumed to be raised in equal proportions.
[b] Based on expected irrigated crop yields and expected 2014 prices.
[c] Represent returns to unpaid labor and management.
Source: Ripplinger et al. (2014).

Since both production input costs and producer revenues in baseline and irrigation scenarios are estimated using a composite-acre basis, the difference in those cropping systems also can be estimated on a per-acre basis. The net change between the existing and potential irrigated composite-acres represents the ongoing direct impacts of continuous irrigation, and the direct impacts can then be scaled based on different assumptions for how much acreage is converted to irrigation.

Comparisons among the dryland and irrigated crop rotations showed substantial increases in gross revenue and total costs as crop production moved from dryland to irrigation. Those changes are reflective of a change in expected yields, change in the amount of inputs as crops go from dryland to irrigated, and a change in quantity and type of inputs associated with different crops (e.g., wheat versus sugarbeets). Gross revenues, total costs, and producer net returns all increased from dryland to irrigated crop production (Table 7). The change in gross crop sales (i.e., total revenue) varied from around $355 to over $1,100 per composite acre. The greatest changes in gross crop sales between dryland production and irrigation came from crop rotations involving potatoes. In each of the four scenarios evaluated, a crop rotation containing 25 percent of total planted acreage devoted to potatoes produced gross revenues in excess of $1,000 per irrigated acre over the dryland crop rotations.

Table 7. Difference between Baseline Dryland and Irrigated Crop Rotations, McLean and Sheridan Counties, North Dakota, 2014

Dryland Rotations[a]	Irrigated Crop Rotations[a]: Primarily Corn	Corn/Corn/ Dry Bean/ Spring Wheat	Corn/Dry Bean/ Barley/ Sugarbeets	Corn/Dry Bean/ Barley/ Potatoes
	Change in Gross Revenue per Acre[b]			
Soybean, Canola, Spring Wheat	355.08	323.53	430.33	1,164.33
Corn, Soybeans, Spring Wheat	324.83	293.28	400.13	1,134.08
Corn, Dry Beans, Spring Wheat	281.95	250.40	357.29	1,091.20
	Change in Total Costs per Acre			
Soybean, Canola, Spring Wheat	298.37	243.69	299.79	558.91
Corn, Soybeans, Spring Wheat	266.44	211.76	267.86	556.98
Corn, Dry Beans, Spring Wheat	242.39	187.71	243.81	532.93
	Change in Net Returns per Acre[c]			
Soybean, Canola, Spring Wheat	56.71	79.84	130.54	575.42
Corn, Soybeans, Spring Wheat	58.43	81.56	132.26	577.14
Corn, Dry Beans, Spring Wheat	39.62	62.75	113.45	558.33

[a] Crops assumed to be raised in equal proportions, except rotation of soybean-canola-spring wheat had 50 percent spring wheat.

[b] Based on expected irrigated crop yields and expected 2014 prices.

[c] Represent returns to unpaid labor and management.

Source: Ripplinger et al. (2014).

Out of the twelve (12) possible comparisons between irrigated crop rotations and dryland crop rotations, rotations of primarily corn for the irrigated composite-acre budget and soybean-canola-spring wheat for the dryland composite-acre budget were selected for modeling economic impacts. An irrigated rotation of primarily corn was expected to generate about $355 per acre more in crop sales per year than the dryland rotation of soybean-canola-spring wheat. Production expenses were expected to average approximately $298 more per acre for irrigated corn than the baseline dryland composite budget, and also expected to result in an increase in producer net returns of about $57 per acre over the dryland crop rotation (Table 7).

Direct Economic Impacts

The change in crop sales of $355 per acre was inputted into the IMPLAN model as the direct economic impacts of a change in dryland crop production to irrigated crop production. The economic impacts were modeled for a single center pivot system and for full development of 51,700 authorized acres (Table 8). The direct impacts on gross business volume for a center pivot system were based on 128 acres under irrigation, and represented a change of $45,450 in gross revenues on those acres over what would have been generated under dryland production.

The expected change in crop sales (i.e., direct impact on gross business volume) for 404 center pivot systems were estimated at $18.4 million (Table 8). Economic effects associated with conversion of dryland to irrigation were expected to be annual impacts, as opposed to one-time impacts of irrigation development.

Table 8. Statewide Annual Economic Effects of the Change in Dryland Crop Production to Irrigated Crop Production along McClusky Canal, McLean and Sheridan Counties, North Dakota, 2014

Impact Type	Employment[a]	Personal Income	Value Added	Gross Business Volume
	-- No. of Jobs --	---------------------------- $ 000s ----------------------------		
		Economic Effects per Single Center Pivot[b]		
Direct Impact	0.4	12.2	12.4	45.5
Indirect Impact	0.1	5.0	9.8	17.1
Induced Impact	0.1	3.8	6.9	11.2
Total Impacts	0.6	21.1	29.0	73.8
		Economic Effects of Total Development of Authorized Acres[c]		
Direct Impact	146.5	4,929	5,010	18,382
Indirect Impact	52.2	2,020	3,959	6,908
Induced Impact	42.8	1,535	2,788	4,525
Total Impacts	241.5	8,534	11,716	29,815

[a] Employment values represent jobs, and those jobs would be sustained for each year the center pivot system is operated. However, jobs are not additive across years.
[b] Annual economic effects (i.e., recurring) that occur each year the center pivots are operated.
[c] Based on 404 center pivots developed for 51,700 authorized acres along McClusky Canal in McLean and Sheridan Counties.

Total Economic Impacts

Each center pivot system was estimated to create about $73,800 in total additional gross business activity (volume) in the state economy (Table 8). Of the total business activity, around $17,100 was associated with indirect effects and $11,200 was associated with induced effects. Labor (personal) income was estimated at $21,100 and value-added effects were estimated at $29,000.

The total economic impact (i.e., sum of direct, indirect, and induced effects on gross business volume) on the state economy of developing all 404 center pivots would be about $30 million annually (Table 8). Economy-wide personal income would be $8.5 million associated with full development of authorized land, and value-added to the state economy would be approximately $11.7 million.

Each center pivot irrigation system was estimated to increase employment in the state by 0.6 of a job. If all authorized acreage was developed, statewide employment would be expected to increase by nearly 242 jobs.

Government Revenues

Overall change in state and local tax revenues were estimated at $2,800 per year for each center pivot system (Table 9). Total development of all authorized acreage would result in an increase of about $1.1 million annually in state and local government revenues.

Table 9. State and Local Government Revenue Collections, Change in Dryland Crop Production to Irrigated Crop Production along McClusky Canal, McLean and Sheridan Counties, North Dakota, 2014

	State and Local Revenue Collections[a]	
Type of Revenue	Per Center Pivot	Total Development[b]
	------------------- $ 000s	----------------
Payroll Taxes	0.2	61.4
Excise Taxes	0.9	383.0
Property Tax	0.2	63.4
Personal Income Tax	0.2	87.3
Corporate Income Tax	0.3	120.0
Permits, Fees, Fines, Licenses	0.6	226.6
Miscellaneous	0.4	147.9
Total	2.8	1,089.6

[a] Annual government revenues (i.e., recurring) that occur each year the center pivots are operated

[b] Based on 404 center pivots developed for 51,700 acres of authorized land along McClusky Canal in McLean and Sheridan Counties.

New or Expanded Crop Processing

Irrigated crop production can influence the creation of processing activities related to an increase in crop production, supply of a previously unavailable crop, or production-related factors affecting quality or crop attributes.

Changing the supply of crops already produced in the region is usually insufficient by itself to create new processing activities. It is anticipated that irrigation in the study region will lead to increases in some row crops, particularly corn. However, increased supply of corn from expanded irrigation is not likely to lead to additional processing of corn in the region.

While the supply of a previously unavailable crop could influence the likelihood of creating additional crop processing activities, the biggest determinant will be the economics of the plant or processing activity. Supply of the crop being processed may factor into the economic feasibility, but is unlikely to be the only major driver of economic viability. As an example, the study region has the agronomic and economic potential to produce sugarbeets on the irrigated acreage. Irrigation therefore can enable the supply of a crop that would not likely be raised in the absence of irrigation. However, the decision to build and operate a sugarbeet processing plant in the study region would have to first be determined on whether the costs and returns from that plant made economic sense. Some costs to the plant might be influenced based on the presence of irrigation in the region (e.g., feedstock costs, transportation expenses), but it would not be expected that those influences be sufficient to make a plant economically feasible. Irrigated production would likely represent a necessary condition, but not a sufficient condition. The sufficient condition in this example would be the profitability (cost and returns) from operating the plant.

Maung and Gustafson (2010) evaluated the economic feasibility of sugarbeet biofuel production in central North Dakota. A plant with an annual output of 20 million gallons of ethanol was economical at beet prices of $42/ton or less and ethanol prices of $1.84 per gallon or higher. A smaller plant, 10 million gallons per year, was generally less economical, and returns on investment were more vulnerable to variations in beet and ethanol prices. The study concluded that ethanol price was the single most important factor affecting profitability of a sugarbeet plant producing bio-fuels. As of May 2014, ethanol prices in the region were generally above $2 per gallon (Agricultural Marketing Resource Center 2014).

Based on data provided by Maung and Gustafson (2010), a 20-million gallon per year (mgy) ethanol plant would require about 755,000 tons of sugarbeets. Currently, about 51,700 acres of potential irrigable land along the McClusky Canal has been authorized for development. If a crop rotation limiting sugarbeets to 25 percent of irrigated land was adopted, assuming full development of all authorized land, the region could provide about 12,900 acres of sugarbeets. With a yield of 32 tons per irrigated acre, a full 25 percent of the total irrigated acreage could produce around 413,600 tons of sugarbeets. The remaining tonnage (341,400) would require nearly 18,000 additional acres of dryland beet production at an average yield of 19 tons/acre. From the above information, expanded irrigation in the two-county region is not likely to provide all the sugarbeets necessary to supply a 20 mgy sugarbeet-to-ethanol processing plant. Given the yield differential between dryland and irrigated sugarbeet production, irrigation would substantially reduce the total acreage needed to supply a bio-fuels plant in the region.

Bangsund et al. (2012) evaluated the economic contribution of the Sidney Sugars, Sidney, Montana sugarbeet processing facility. The facility processed over 798,000 tons of sugarbeets in fiscal year 2011. The combined direct economic effects of production and processing expenditures and returns were estimated at nearly $74 million. The overall gross business volume was estimated at $212 million in fiscal year 2011. The analysis represented an economic contribution approach, which measures gross values in crop production and all in-state expenditures associated with production. An economic impact approach, as opposed to economic contribution, would result in smaller economic measures as net values of crop production would be counted in an economic impact study (i.e., sugarbeet expenditures less alternative crops raised in the absence of sugarbeets). Regardless of economic methodology, the study provides an indication of the economic importance of a sugarbeet processing facility with a dedicated acreage of around 31,100 acres and 798,000 tons of beets. Both acreage and beet tonnage from the Sidney Sugars plant would be similar in magnitude to the bio-fuel plant discussed by Maung and Gustafson (2010).

Irrigation is used frequently in North Dakota to produce potatoes for processing. Irrigation is viewed as a means to increase control over the amount and timing of moisture, thereby increasing the likelihood that potato feedstocks will match desired qualities for processing (Berwick et al. 2001). Perhaps the greatest likelihood of changes in regional crop processing may occur from raising a crop (e.g., potatoes) that can be marketed through existing processing plants. However, existing plants are not necessarily inclined to expand output just because the potential exists for a greater supply of feedstocks. Rather, expanded processing output through existing plants would be subject to profitability and marketing requirements.

Coon and Leistritz (2001) evaluated the economic impact of expanded irrigation and potato production in south central North Dakota. Direct impacts associated with irrigation development (equipment and installation), purchases of potato growing machinery, construction of potato storage facilities, and construction of the Aviko potato processing plant in Jamestown, North Dakota, were estimated at $50 million (one-time expenditures). The total impact of irrigation development was estimated at $115 million. Total acreage of irrigated crop production in the study was 41,250 acres. The net change in dryland crop expenditures and irrigated crop expenditures was estimated at $22 million annually based on a potato-corn-dry bean irrigated crop rotation and dryland wheat production. Net returns from crop production were not included in the study. Annual in-state expenditures for the Aviko potato processing plant were estimated at $33 million, which included payroll and other processing inputs. Total in-state expenditures (direct impacts) for the processing plant and associated irrigated crop production were estimated at $55 million annually. The overall economic impact of the processing plant and the 41,250 acres of irrigated crop land was estimated at nearly $147 million annually.

A potential implication of adding irrigation in the study region may include a shift of potato production from other areas in the state, especially non-irrigated production. Potato production has been shifting from dry land to irrigated production in the state for over a decade (Berwick et al. 2001, Coon and Leistritz 2001). At a state level, a shift in acreage of irrigated potatoes from one region or area to irrigated potato production in another region is not likely to result in much change in economic activity. At the regional level, the results are likely to be mixed, that is, a loss of economic activity in one area versus a gain in economic activity in another area. A more interesting comparison would be to assess the state-level economic effects of a potential shift in dryland potato production in one region to irrigated production in another region. The change to the state economy would require an evaluation of the net change in economic activity (e.g., crop sales, input purchases) on the affected acreages in both regions.

The question of expanded irrigation leading to additional crop processing is traditionally discussed every time new irrigation development is proposed. The current prognosis for expanded irrigation in the study region leading to additional processing activities in the state is small. Markets change constantly, and therefore opportunities for additional processing in the state also change. It is entirely possible that additional crop processing could be added in the region in the future, but those impacts would be speculative at this time.

New or Expanded Livestock Production

Another question often asked is whether expanded irrigation along the McClusky Canal will impact the North Dakota livestock industry. Several factors need to be considered to answer this question. If irrigation is to impact the livestock industry, the impact will arise through the production of livestock feed. Irrigation is likely to impact livestock feed by either 1) producing quality feed such as alfalfa, corn silage, corn for grain or other high quality feed, or 2) producing feed as an aftermath of a crop raised for another purpose, such as corn stover, wheat straw, or co-products from energy beets or potatoes. However, co-products would only become available if processing (which does not exist at this time) is added in the study area.

Quality feeds are usually required for dairy and swine production, and to a lesser extent, in beef finishing. Other feedstocks, usually lower in nutrient quality and price, are typically used in cow-calf operations for winter rations and for backgrounding beef feeders. A review of USDA data reveals some trends in each of those livestock sectors in North Dakota (i.e., dairy, hogs, cow-calf production, backgrounding of beef calves, and finishing of beef feeders).

In the past 20 years, dairy processing plants in North Dakota have declined by more than 90 percent, average annual dairy cow inventory has decreased by 75 percent, and total milk production in the state has declined 63 percent (Table 10). While milk production per cow has gone up, the reduction in dairy cows is not likely due to a lack of feed, which is what irrigation would provide. The general belief is that the state lacks producers who are willing to commit to the dairy industry at an economical scale of operation. Additional irrigation in two counties in central North Dakota is not going to reverse the statewide trend of the dairy industry or even reverse the trends in the communities where the irrigation is expected to be developed.

Like dairy, the number of hogs in North Dakota has declined more than 55 percent over the past 20 years (Table 11). Again, the decline is not likely due to lack of appropriate feed. Corn and soybean meal are major feeds used in hog production and both corn and soybean production has increased substantially in the state over the past decade. Given the decline in hog inventory and increase in livestock feed, it is clear that feed availability is not an issue in the declining trend of hog production in North Dakota. Additional irrigated crop production in the study area is not expected to abate the trend of declining hog production in the state.

Table 10. North Dakota Dairy Industry, Selected Industry Statistics, 1993 through 2013

	Number of Processing Plants	Milk Cow Inventory as of January 1	Annual Milk Production Measured in Pounds
2013	2	18,000	342,000,000
2003	4	37,000	500,000,000
1993	25	75,000	918,000,000

Source: National Agricultural Statistics Service (2014).

Table 11. Hog Inventory, North Dakota, 1993 through 2013

	Hog Inventory as of January 1
2013	135,000
2003	150,000
1993	320,000

Source: National Agricultural Statistics Service (2014).

Beef remains a major livestock sector in North Dakota, but the focus on cow-calf production is not likely to be altered with expanded irrigation. In Kansas, for example, irrigated feed crops led to feeding/finishing, and beef cattle finishing led to an increase in slaughter activity over the past 50 years. However, North Dakota's winter feeding climate and the lack of commercial slaughter capacity greatly diminish the likelihood of expanding beef finishing. The state could experience an increase in beef cattle backgrounding, depending upon favorable market conditions. Backgrounding can utilize aftermath feed, but those feedstock are readily available even without irrigation. Increased aftermath feed due to irrigation is not likely to alter the feasibility of beef backgrounding in the region.

It is less expensive to move feeder cattle to the feed source than to move feed to where the livestock are located. Further, it is less expensive to move meat than to move finishing cattle that are ready for slaughter. Therefore, feeding and processing occur where feed is located if there is enough feed and livestock to support economical slaughter facilities.

As in the past, finishing of North Dakota backgrounded feeders is likely to occur outside of North Dakota, near existing slaughter plants. Furthermore, without interest in livestock, irrigation is not likely to significantly increase backgrounding.

Two research projects that studied the expansion of the North Dakota beef industry are Hodur et al. (2007) and Dahlen et al. (2013). Although not a direct issue in either study, both projects confirm that the major emphasis of the North Dakota beef industry is cow-calf operations.

Both studies recognized the heavy reliance on pasture as a feed source for cow-calf operations and the limited finishing of feeder cattle. Likewise, both studies reported a level of interest among beef producers in backgrounding if it was economical, including an interest in backgrounding if adequate feed is available which implies a reasonable cost for the feed.

Nearly all North Dakota beef producers (94.5 percent) considered themselves cow-calf operators; more than one-third of the producers also background some calves (37.8 percent of the producers) but only 6.4 percent fed cattle to a finishing weight (Dahlen, et al, p. 60). Producers provided a consistent response by reporting that almost 50 percent of the calf production was sold as calves with another 43 percent sold as backgrounded feeders and less than 8 percent sold as fed animals ready for slaughter. The majority of the beef producers (78 to 85 percent) use annual grasses and perennial feed sources; about half (54.4 percent) graze crop residue and 7.8 percent use other sources of forages. A little over 30 percent of the producers use wet or dry distillers grain as a feed supplement; "other" feed supplements were used by 35 percent of the respondents (Dahlen, et al, p. 60). In summary, the majority of beef production is North Dakota is cow-calf operators with some backgrounding; both rely extensively on grazing and hay, that is, feedstuffs that are not likely to be part of an irrigated crop rotation.

For ranchers who did not background calves, the two most important reasons for not backgrounding were "feed shortage resulting from drought conditions" and "inadequate feed supply" (Hodur, et al., p. 26). These two reasons suggest that feed from irrigated land might lead to more backgrounding. However, increased access to pasture land was cited as the second most important influence to increase backgrounding which suggest these producers did not envision raising feed for backgrounding purposes, but intend to have backgrounding calves graze a portion of the time. This is consistent with the survey results by Dahlen et al. in which respondents indicated that pasture yield, rented pasture availability, and corn and hay prices could negatively impact profitability of the farm or ranch (Dahlen, et al, p. 62). The types of high quality feed that could be produced on irrigated land do not appear to be major considerations for North Dakota beef producers. The surveyed producers, however, were not explicitly asked to comment on feed from irrigation.

Co-products are already available in the state (for example, sugar beet pulp from Red River Valley processing plants, DDGs from ethanol plants throughout the state, and co-products from potato processing in the northern Red River Valley and Jamestown). Additional co-product feeds are not likely to impact the overall beef industry. Similarly, it is not likely that much new processing of irrigated crop will be built in central North Dakota. Consequently, availability of co-products is not likely to change much in that region; instead, it is expected that some irrigated crops needing processing may be transported to existing facilities outside the region.

In summary, irrigation is not likely to have much of an impact on feed for the beef, dairy and hog industries at either the state or regional level. At most, additional feed resulting from expanded irrigation in central North Dakota may increase backgrounding by some cow-calf producers.

Summary and Conclusions

The Dakota Water Resources Act passed in 2000 by the 106th Congress mandated the maintenance of the McClusky Canal and authorized development of irrigation along the canal. The McClusky Canal is currently blocked near the continental divide between the Missouri River and Red River basins. Development of authorized land along the canal could result in irrigation on 13,700 acres in the Turtle Lake service area, 10,000 acres near the McClusky Canal service area, and up to 28,000 acres in other undesignated areas. The vision is to construct additional irrigation "units" along the 60-mile length of the Canal in McLean and Sheridan Counties in central North Dakota. Full development would result in about 404 center pivots based on approximately 51,700 authorized acres.

The purpose of this study was to estimate the state-level economic effects of converting land along the McClusky Canal from dry land crop production to irrigated crop production. Direct effects are the first round of economic change associated with a project, program, policy, or activity and usually represent changes in business output, employment, or personal income. The IMPLAN modeling system was used to estimate the indirect and induced economic effects as the direct effects work through a given economy. Indirect impacts are estimated as the additional business activity created as affected businesses have to change their purchases of inputs and services to expand their output. Induced impacts are generated as an increase in personal income results in a change in personal consumption, and how changes in spending affects purchases of goods and services in the economy.

Acquisition and installation of irrigation equipment would create a one-time set of economic impacts. Average total investment for infrastructure and development was estimated at $246,300 per center pivot, although about $227,300 was considered in-state expenditures. In-state expenditures were further adjusted to reflect the percentage of in-state and out-of-state sourcing for irrigation equipment. After those adjustments, IMPLAN estimated direct impacts of $132,100 per center pivot system.

Each center pivot was estimated to create $202,900 in gross business activity in the state economy. Of the total business activity, around $30,100 was associated with indirect effects and $40,700 was associated with induced effects. Labor income was estimated at $77,700 and value-added effects were estimated at $110,500. A total of 1.5 jobs would be supported by the development of each center pivot system, assuming the full development process occurred over the course of one year.

The total economic impact (i.e., sum of direct, indirect, and induced effects) on the state economy of developing all 404 center pivots would be $82 million, economy-wide personal income would be $31 million, and value-added to the state economy would be nearly $45 million. If total development occurred over a one-year period, statewide change in employment would be 598 jobs. State and local government revenues from the development of each center pivot system were estimated at $14,000 with about $5.6 million in state and local government revenues associated with full development.

Irrigated rotations of primarily corn and dryland rotations of soybean-canola-spring wheat were selected for modeling annual economic effects of irrigation crop production. Irrigated corn was expected to generate about $355 per acre more in crop sales per year than the dryland rotation of soybean-canola-spring wheat, based on yield estimates from North Dakota State University extension crop budgets and expected 2014 crop prices. The change in gross crop sales (i.e., total revenue) among all of the potential crop rotations evaluated in the study varied from around $250 to over $1,100 per composite acre.

The direct impacts for a center pivot system were based on 128 acres under irrigation, and represented a change of $39,870 in gross revenues on those acres over what would have been generated under dryland production. Full development of all authorized land was estimated to increase crop sales in the state by $16,104,000 annually.

Each center pivot system was estimated to create about $73,800 in additional gross business activity, economy-wide personal income of $21,100 and value-added effects were estimated at $29,000. The total economic impact (i.e., sum of direct, indirect, and induced effects) on the state economy of developing all 404 center pivots would be about $30 million annually, with economy-wide personal income of $8.5 million, and value-added impacts of nearly $11.7 million. Each center pivot irrigation system was estimated to increase employment in the state by 0.6 jobs. Under full development of all authorized acres, irrigated production would increase employment in the state by 242 jobs. Overall change in state and local tax revenues were estimated at $2,800 per year for each center pivot system (Table 9). Total development of authorized acreage would result in an increase of about $1.1 million annually in state and local government revenues.

Irrigated crop production can influence the creation of processing activities related to an increase in crop production, supply of a previously unavailable crop, or production-related factors affecting quality or crop attributes. However, changing the supply of crops already produced in the region is usually insufficient by itself to create new processing activities. While the supply of a previously unavailable crop could influence the likelihood of creating additional crop processing activities, the biggest determinant will be the profitability (cost and returns) from operating a processing facility.

A potential implication of adding irrigation in the study region may include a shifting of potato production from other areas in the state, especially non-irrigated production. Potato production has been shifting from dry land to irrigated production in the state for over a decade. At a state level, a shift in acreage of irrigated potatoes from one region or area to irrigated potato production in another region is not likely to result in much change in economic activity.

Irrigation is not likely to have much of an impact on availability or cost of feed for the beef, dairy and hog industries at either the state or regional level. Further, recent trends and insights on producer attitudes reveal that factors outside of feed quality or availability are primarily responsible for livestock trends in the state. Irrigation could potentially influence both feed availability and quality, but the addition of irrigated land in the study region was not perceived at this time to alter or change existing trends in livestock production in the state.

From an economy-wide perspective, the strongest likelihood of changes in economic activity associated with development of irrigated land along the McClusky Canal at this time would associated with crop production. The economic effects of irrigation would result in an increase of $575 in gross business volume per irrigated acre, without adoption of any high-value specialty crops. If processing, and associated production of specialty crops (e.g., industrial sugar beets) were to occur, the economic benefits to the state economy would be considerably larger than estimated in this study. The expansion of irrigation in the region is not likely to produce meaningful changes in economic activity related to livestock production, although some local producers may benefit from co-products associated with irrigation (e.g., crop aftermath grazing).

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