IRRIGATION DEVELOPMENT AS AN INSTRUMENT FOR ECONOMIC GROWTH IN SASKATCHEWAN: AN ECONOMIC IMPACT ANALYSIS

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ABSTRACT

Allocation decisions in Saskatchewan of water are needed because of the limited nature of the resource in the province. Timely allocation of water can impact crop production, and through that economic development in the province, which may result through the value of the improved crop production as well as the economic linkages within the economy. Irrigation can be seen as a tool for economic growth as it decreases the reliance on natural factors which are critical for crop production in the province. The provincial government has committed, among its various agricultural initiatives, to develop tools to reach economic development goals. A study of the economic importance of irrigation in Saskatchewan is important to understand its contribution provincially and regionally as a possible tool for this economic development. The economic impacts of irrigation extend beyond farm-level impacts and understanding how it contributes to the entire economy at a provincial and regional level is information needed by decision makers. The purpose of this study is to provide the contributions of the irrigation sector on the provincial and regional economy.

The Saskatchewan Irrigation Impact Analyzer (SIIA) model was built as a part of this study. The SIIA was based on a regionalized rectangular input-output model of the irrigation sector. Base data for the model were obtained from Statistics Canada Transaction Tables for 2011. The model was regionalized into: The Lake Diefenbaker Development Area (LDDA) and the other regions of Saskatchewan. The original data for agriculture production were disaggregated into irrigated and dryland production, each further disaggregated to crop and livestock production sectors. The model was further augmented with an employment model. Two scenarios of irrigation development were tested in the study: First, irrigation development that occurred during 2011-2016; Second, new irrigation development through infill expansion. In addition, the marginal contribution of the irrigation activity on the lake Diefenbaker Development Area region was also undertaken, which required a survey of producers.

The study found that the total economic impacts of irrigation development during 2011-2016, enabling an additional 8,472 acres of irrigated production, amounted to $200.83 million in output (sales) generating $86.60 million in GDP contributions at market prices. This resulted in 1,179

full-time equivalent (FTE) employment years and $62.48 million in household income contributions. These estimates are based on a simulation of irrigation over a twenty-year period. With respect to potential irrigation expansion, the study found that if the 32,250-remaining infill-acres (that have been identified as offering irrigation potential) were to be developed and under production for a twenty-year period, the total economic impacts to the province of Saskatchewan would be $603.70 million in output (sales) responsible for 2,908 FTE employment years. This would amount to $181.12 million in household income contributions and $240.89 million in gross domestic product (GDP) contributions at market prices, at 2011 dollars.

The study also found that regionally, irrigation provides an impetus for economic development. During the 2011 year, the marginal contribution of irrigation production, over and above the alternative of dryland production, was created through purchases of higher amounts of farm inputs, as well as spending of additional household income. These two avenues resulted in total economic impacts of $116.53 million in output (sales) which generated $78.47 million in GDP contributions at market prices. In the region, $58.72 million in household income gains also were incurred as a result of the 1,323 FTE employment years generated. The study found the economic impacts of irrigation, currently and potentially, to be extensive in each scenario and offering considerable regional impacts over and above the dryland production alternatives.

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CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

In Saskatchewan, like other semi-arid regions, water resources are limited and allocation decisions need to be made. Such allocation decisions affect crop and livestock production choices, and through that, economic development of the province. Furthermore, parts of Saskatchewan experience periodic flooding and droughts, which creates higher variability in agricultural production, increasing risks for producers. Irrigation is a tool that can be used to help manage factors related to water shortages resulting in variability in soil moisture.

Irrigation can contribute to improved economic growth not only for irrigators but also to other members of the Saskatchewan society. The presence of irrigation enables the production of high value crops, which through economic linkages, could add further value to the Saskatchewan economy.

In October of 2012, the Government of Saskatchewan introduced the Saskatchewan Plan for Growth (Government of Saskatchewan, 2012). With the intent of maintaining strong growth, the plan highlighted core activities of focus for the provincial government. Two of these activities applicable to irrigation were: investment in infrastructure as it applies to growth and maintaining competitiveness with respect to the Saskatchewan economy. Targets in the report include doubling the value of Saskatchewan's exports, increasing crop production by 10 million tonnes, increasing exports of agriculture and food production by $5 billion, additional employment of 60,000 people and increasing Saskatchewan's competitiveness in the world markets.

The above report also commits the provincial government to advance Saskatchewan's natural resource and agriculture advantage while recognizing the value in irrigation as a strategy to help achieve these key goals and actions. Specific to its component of irrigation strategy (Government of Saskatchewan, 2012), the Saskatchewan Plan for Growth included goals of enhancing returns from existing irrigation, irrigation expansion, and infrastructure sustainability.

1.2 Problem Statement

The Saskatchewan Government administers provincial irrigation activities by dividing the province into four Irrigation Development Areas, where not only administration of project is different, but also the nature of irrigation activity. These areas are the Lake Diefenbaker Development Area (LDDA), the Northern Development Area (NDA), the Southeast Development Area (SEDA) and the Southwest Development Area (SWDA). A large portion of provincial irrigation takes place in the LDDA and in the SWDA.

Irrigation provides a stable water source when needed during the growing season. A reliable water source may expand the types of crops that can be grown in a region, providing avenues for diversification. Having different (specialty) cropping choices allows irrigating producers more options which are possibly not available to dryland producers due to weather considerations. In addition to risk management, irrigation can also improve yields. Higher yields increase the need for crop storage and transportation as well as the need for farm machinery and labor to manage the increased production.

Irrigators, through their production and living expenditures, support local communities. These communities then develop and are more economically stable over time. Knowledge of such economic impacts are somewhat unknown. Their understanding could contribute to the process of such economic development in these regions and a better quality of life to residents. Different factors influence the magnitude of the impact of irrigation on local development. An understanding of the impacts of existing and future irrigation development as well as community level linkages can provide information to public policy makers and private decision makers with respect to the most appropriate allocation of limited water resources.

1.3 Need for the Study

As noted above, Saskatchewan's *Plan for Growth* is a directive by the provincial government which highlights the level of commitment to develop and maintain agricultural initiatives, such as irrigation, to meet its development goals (Saskatchewan Government, 2012). Economic

impacts of irrigation lead to provincial (and regional) economic growth. A thorough study of the economic importance of irrigation in Saskatchewan has not been reported. Such a study could help to fill this gap in the literature, particularly with respect to community level linkages. Regional development can be measured through indicators, such as population growth and earnings (Shaffer, 1989). Changing conditions, both environmentally and economically, may influence a community's economic development. The magnitude and nature of impacts at a regional level are also needed to give public-assistance providers a greater level of detail in their decision making.

Various aspects of irrigation have been previously studied for Canada and Saskatchewan. These include studies in areas such as those related to irrigation economics (Kulshreshtha, 1989), regional and national irrigation derived water demand (Kulshreshtha and Tewari, 1991), the relationship of climate change to irrigation (Kulshreshtha and Junkins, 2001), producer adoption of irrigation technology in Saskatchewan agriculture (Kulshreshtha and Brown, 1993), the value of irrigation water for crop production (Samarawickrema and Kulshreshtha, 2008a) and drought proofing (Samarawickrema and Kulshreshtha, 2008b). Additional work has been done to capture the primary and secondary benefits of irrigation development in Alberta (Kulshreshtha et al., 1985) as well as industry effects in the southern Alberta region (Kulshreshtha and Russell, 1988).

In Saskatchewan, some work has been done to estimate the economic impact of irrigation programs in the province (Klein and Kulshreshtha, 1991), a study which is somewhat dated and does not reflect the economic impacts of current levels of economic activities, and the Lake Diefenbaker region (Clifton and Associates, 2008a and 2008b). However, the current provincial level impacts created by irrigation in Saskatchewan have not been documented and community level impacts of irrigation have received little attention in the existing literature. Knowledge of the impacts of Saskatchewan irrigation investment both provincially and regionally is needed to appreciate the role that irrigation can play in provincial economic growth.

Answering fundamental questions with respect to provincial and regional components of irrigation in Saskatchewan is desirable. These questions include:

- What is the economic impact of irrigation in Saskatchewan and how are these impacts diffused on a regional basis?

- How will future irrigation development impact the province and local region? and,

- What is the level of economic impact of irrigation on the local region?

This study proposes to answer these questions and address issues related to them.

1.4 Objective of The Study

As will be reported in Chapter 2, much of the provincial irrigation activities in Saskatchewan are located in the Lake Diefenbaker Development Area (LDDA). This study designates this as the local region. The objectives of the study include:

- To estimate the economic impacts of existing levels of irrigation in Saskatchewan and the local region;

- To estimate the economic impacts of expanded levels of irrigation in Saskatchewan and the local region; and,

- To estimate net regional (community level) impacts of a conversion from dryland farming to irrigation at the regional level (for the LDDA).

1.5 Scope of the Study

This study undertook economic impact analysis of two levels: First, irrigation administrative region of the Lake Diefenbaker Development Area (LDDA), and second, the rest of the

Saskatchewan economy. In addition, impacts were also estimated for the province as a whole. Feedback interactions between the region and the province were accounted for in the provincial model. Both on and off-farm level activities related to irrigation were included in the analysis.

1.6 Organization of the Study

This chapter outlined the general purpose of the study and its basic construction and functionality. The subsequent Chapter 2 reports a history of irrigation investment in Saskatchewan. The review of the history is followed by a literature review in Chapter 3, conceptual model in Chapter 4 and methodology in Chapter 5. The remaining chapters present the results and their implications. Chapter 6 presents the results of the economic impact analysis for 2011-16 period irrigation activities. Chapter 7 presents the economic impact analysis results for irrigation expansion in the future. Chapter 8 presents the marginal gains to the LDDA economy that have occurred as a result of conversion of dryland production to irrigation. The final Chapter (Chapter 9) summarizes the study and presents conclusions and implications.

CHAPTER 2 IRRIGATION DEVELOPMENT IN SASKATCHEWAN

This chapter provides a review of the history of irrigation development and its existing level in the province of Saskatchewan. It is divided into six Sections. Section 2.1 outlines the early history of irrigation in Saskatchewan and highlights geographical and climatic conditions that influenced the use of irrigation in the province. Based on Topham (1982), a collection of contributing factors to the development of irrigation in Saskatchewan are presented here. Section 2.2 includes a discussion of the recent growth of irrigation in Saskatchewan. Section 2.3 discusses the planned irrigation development projects as of 2010, and is followed by Section 2.4, which provides a discussion on irrigation based organizations in Saskatchewan. Section 2.5 highlights the role of irrigation in community/regional level development, particularly with respect of the LDDA region. A concluding summary follows in Section 2.6.

2.1 History of Irrigation in Saskatchewan

The topographic characteristics of the Prairies of Canada were determined over 15,000 years ago by glacial activity. Ice sheet melt after the Wisconsinan glacial period led to the formation of several of the large lakes in the lowlands of the region. Sedimentary activity in these lakes led to the present-day layers of lacustrine soil that are thick in the Prairie region (Topham, 1982).

In the extreme southwest of the province, channels for water movement were created throughout the region as melting glacial waters travelled toward the Mississippi River Basin. These channels ultimately contributed to formation of irrigation reservoirs within the southwest region of the province (Topham, 1982).

The Saskatchewan River drains the western half of the prairies. The North and South Saskatchewan Rivers make up the Saskatchewan River System (Figure 2.1). Glaciers of the Alberta Rockies originally formed the river system. This system receives 90% of its water sourcing from the Rocky Mountains of Alberta (Topham, 1982).

Source: University of Guelph, n.d.

Figure 2.1: Map of the Saskatchewan River System

Without the moisture, which is common in the spring and fall in the prairies, the semi-arid region would be a barren desert (Topham, 1982). With its inherent high rates of evaporation and low annual precipitation, the prairie region often experiences critical conditions of low moisture. Approximately 25% of annual precipitation in the region falls as snow while more than 75% of annual runoff occurs in the spring (Topham, 1982). Frost in the spring prevents soil absorption, encouraging further runoff, as a result of which there is a high median average run off.

Additionally, Chinook winds flowing through the region may decrease snow cover during the winter period. The fluctuation of the impact of each of these processes in any given year results in a high degree of variability around the median. These environmental characteristics, from an agricultural perspective, often lead to limiting crop and cattle feed restrictions as well as growing season instabilities (Wiedmann et al., 2007).

In 1857, Captain John Palliser assessed the drought conditions in parts of Southwestern Saskatchewan and Southeastern Alberta, what has since come to be known as the Palliser Triangle. The purpose of his expedition was to examine the habitability of the region. His

assessment was that these areas were too dry to sustain agriculture. Despite this assessment, predominately dryland farmers and cattle operations settled in the area over the last part of the 19th century. Irrigation was not encouraged during the time as the federal government was wary to indicate the full extent of the dryness to possible immigrants (Briere, 2009). However, periods of drought in the 1890s led to the development of the Northwest Irrigation Act of 1894, which suggested a major shift in thinking in favor of irrigation.

The Northwest Irrigation Act of 1894 vested water rights in the Crown. The Act charged the federal government with the responsibility to encourage irrigation and applied the same safeguards as used to govern water use as private property. Private companies, such as railways, that had the means to invest the required capital were originally hesitant to undertake an investment in the Palliser Triangle region. This legislation empowered private entrepreneurs and railway entities which led to further irrigation investment.

2.1.1 Early Irrigation in Saskatchewan

Before 1905, when the province was established, irrigation in Saskatchewan was largely dedicated to hay production in the Southwest region of the province. Water was sourced from the Cypress Hills. At the time of provincial establishment, there were 110 irrigators operating 304 km of canals. The irrigators at that time were ranchers who benefited from increased hay and pasture yields for feeding their livestock (Clifton and Associates, 2008a).

Irrigation development continued to increase over the next fifteen years before the First World War. By 1920 there were 10,920 acres of irrigation in the province (Clifton and Associates, 2008b). To facilitate this development, the province issued annual irrigation licenses after the spring run-off. However, between 1914-1935 irrigation development in Saskatchewan stalled due to limited government support. This continued until the 1930s when water management responsibility was transferred from the federal government to each province.

In 1935, the federal government established the Prairie Farm Rehabilitation Administration (PFRA). The administrative agency was charged with the mandate to rehabilitate areas of

drought and drifting soil across the provinces of Manitoba, Saskatchewan and Alberta. This was to be achieved through education and institutional investment and management practices, along with further development and rehabilitation of irrigation projects.

Since its inception, the PRFA has developed 26 water storage reservoirs and six irrigation projects in the Southwestern Saskatchewan. The Saskatchewan government has continued to develop additional irrigation projects relying on these PFRA water reservoirs. In addition to their use as a water source for irrigation, these reservoirs have provided focal points for parks and cottages, generating recreational and wildlife benefits as well as being a source of domestic and urban water use development. These 26 reservoirs were developed at a cost $4.7 million investment, producing 23,006 acres of irrigated land devoted entirely to hay and fodder (Topham, 1982).

Surface or flood irrigation, done by controlling water levels from a source, through dikes and ditches and flooding the targeted land when necessary, is a common form of irrigation used in Saskatchewan. Sprinkler irrigation occurs when water is piped in from a source and distributed through a pressurized system on the land. This system is very common in other parts of Saskatchewan. However, in southwest Saskatchewan during the 1930s and 40s, flood irrigation was the most common form of irrigation used, although some sprinkler irrigation did exist. An example of an irrigating sprinkler system during the period is shown in Figures 2.2 and 2.3. Figure 2.2 shows an irrigating producer maintain an early irrigation sprinkler while Figure 2.3 shows a man manually diverting water from an irrigation ditch. Comparatively Figure 2.4 shows a modern day self-propelled irrigation sprinkler and Figure 2.5 shows a producer diverting water for irrigation from a source using a mechanized pumping device.

Culminating in 1943 the PFRA began to move toward the idea of building a dam on the South Saskatchewan River (Clifton and Associates, 2008b). The dam was envisioned to fulfil hydro-electric and water supply needs of the province in addition to expanded irrigation.

Source: Briere (2009)
Figure 2.2: Early Sprinkler Irrigation Practices circa 1940s, Saskatchewan

Source: Briere (2009)
Figure 2.3: Early Flood Irrigation Practices circa 1930s, Saskatchewan

2.1.2 The Gardiner Dam and Lake Diefenbaker

In 1946 the Saskatchewan River's Development Association (SRDA) was founded to lobby for the creation of the Gardiner Dam. The dam project was identified as the South Saskatchewan River Basin Project eventually encompassing the Gardiner Dam, Lake Diefenbaker and the Qu'Appelle Dam. The project began in 1959 and was completed in 1967.

Source: Glen (2014)
Figure 2.4: Modern Day Sprinkler Irrigation Practices circa 2007, Saskatchewan

Source: Warren (2015)

Figure 2.5: Mechanized Pumping for Irrigation from a Water Source circa 2001, Saskatchewan

By 1947 the SRDA counted eighteen rural municipalities and several different farm organizations as coordinating partners (SWA, 2012). Communication between the provincial and federal governments increased in the 1950s as a federal Liberal government was replaced by a Conservative one.

The Hogg Commission was established in 1957 charged with determining economic and social returns and validity of the project. The commission's appointed commissioners were Dr.T.H. Hogg, G.A. Gahery and Dr. John A. Widtsoe. The Commission reported that the proposed Gardiner Dam did not provide the greatest option for profitability during the time period and that there was little likelihood that dryland farmers would choose to irrigate (Makahonuk, n.d.). In spite of these observations, in 1958 the project was approved with support from both federal and provincial governments. Construction began in 1959 and was completed in 1967. The Gardiner, and Qu'Appelle Dams and Lake Diefenbaker, a 200-km long body of water, are shown in Figure 2.6.

These developments provided the capability of facilitating 500,000 acres of irrigation in Saskatchewan (Clifton and Associates, 2008b). The Gardiner Dam is still the largest earth filled dam in Canada (Tourism Saskatchewan, 2016). The dam is credited with supplying upwards of 10% of Saskatchewan's power and is also a key component of flood control in the region (Miller, 2009). Additionally, the development provides drinking water for up to 45% of Saskatchewan's population, reservoir storage which allows for year-round sustainability, as well as a recreational, industrial and agricultural water source within the region (Miller, 2009).

Source: Casey (2010)

Figure 2.6: Map of the South Saskatchewan River's Path through Lake Diefenbaker, Saskatchewan

The original South Saskatchewan River Basin Project established an era of foundation for infrastructure development, now known as the South Saskatchewan River Irrigation District #1. Subsequently, many irrigation districts in the area of Lake Diefenbaker were also established.

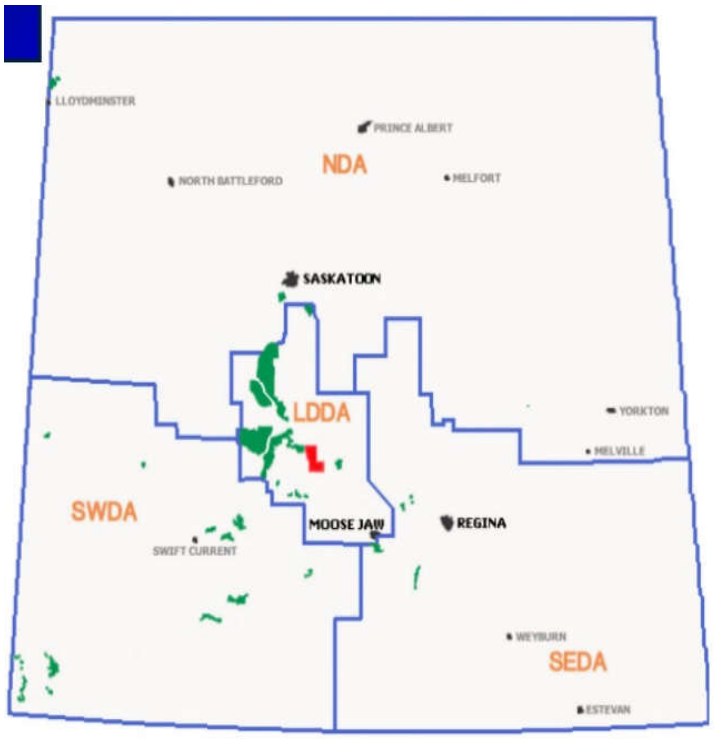
2.2 Existing Irrigation

The South Saskatchewan River Irrigation District #1, located in the Outlook area was established in 1966 as a project to facilitate crop and livestock production and diversity, assist irrigators in the Outlook area, and facilitate greater development in other areas of Saskatchewan (SWA, 2012).

Under the Irrigation Act of 1996, irrigation districts were legitimized and became responsible for administration of a portion of Saskatchewan's irrigated acres. The irrigation districts reside in

various irrigation development areas of the province. There are thirteen irrigation districts in Saskatchewan across the four development areas, which are shown in Figure 2.7. Within these areas, a portion of irrigated land is managed privately and a portion is managed under the district irrigation authority, as licensing is required for all irrigation activity.

Irrigation undertaken privately is organized by individual land owners while district irrigation is managed as a group. Irrigation districts develop an area of land accessible by members through pipelines or canals for irrigation. The irrigation districts are responsible for their own operations. This operation includes 100 percent of their costs which include replacement, operation, maintenance and administration.



Source: Clifton and Associates (2008a)

Figure 2.7: Map of Irrigation Administrative Areas of Saskatchewan

2.2.1 Characteristics of Irrigation Development Areas

In the SWDA, the crop mix is comprised of forage, hard wheat and durum, barley, canola and lentils. Irrigated forage production makes up the majority of irrigated acres (83%) in the SWDA

(Clifton and Associates, 2008b). In addition, near the city of Swift Current, there is one of the largest areas served through effluent irrigation in the province. This irrigation takes place in the rural regions of the irrigation district of North Waldeck. The majority of irrigated acres within the region are comprised of surface (flood) irrigation while a portion is irrigated with a sprinkler system (Clifton and Associates, 2008a). The crop mix for the region is presented in Table 2.1 based on Clifton and Associates (2008a).

The SEDA and NDA are regions with predominately private irrigation. Effluent irrigation projects also exist in these areas. Moose Jaw and Lloydminster (Northminster irrigation district) are the next two largest centers of effluent irrigation in this region. Specialty crops, such as potatoes, turf grass, market gardens and tree nurseries, are also grown in these regions, particularly in the irrigation districts of Moon Lake, Northminster, Baildon and Rockey Lake. While a small portion of the regions is served by surface irrigation, sprinkler irrigation has become more and more common.

Table 2.1: SWDA Crop Mix. 2006.	
Wheat, Except Durum	3%
Durum	4%
Barley	3%
Oats	3%
Canola	2%
Lentils	2%
Alfalfa and Mixed hay	83%

Source: Clifton and Associates (2008a)

The LDDA is the development area of greatest interest in this study. Irrigation in the area developed only as a result of the construction of the Gardiner Dam and Lake Diefenbaker. Similarly, to the SEDA and NDA, the area uses primarily surface irrigation with an increasing trend toward greater amounts of sprinkler irrigation.

The crop mix for the LDDA, SEDA and the NDA could be considered equivalent (Ewen, 2014). Additionally, the management structure of the irrigated land could also be considered the same

among these areas. The crop mix for these districts is shown in Table 2.2. Within these areas, a portion of irrigated land is managed privately and a portion is managed under the district irrigation areas, as licensing is required for all irrigation activity. Because of lack of data, it was assumed that district as well as private irrigation has the same crop mix.

Table 2.2: LDDA, SEDA, NDA Crop Mix. 2014.	
Wheat, Except Durum	21.80%
Durum	5.80%
Barley	6.00%
Oats	0.50%
Canola	24.80%
Flax	7.00%
Field Peas	3.90%
Lentils	0.50%
Alfalfa and Mixed hay	9.20%
Potato	6.90%
Specialty and Other	13.60%

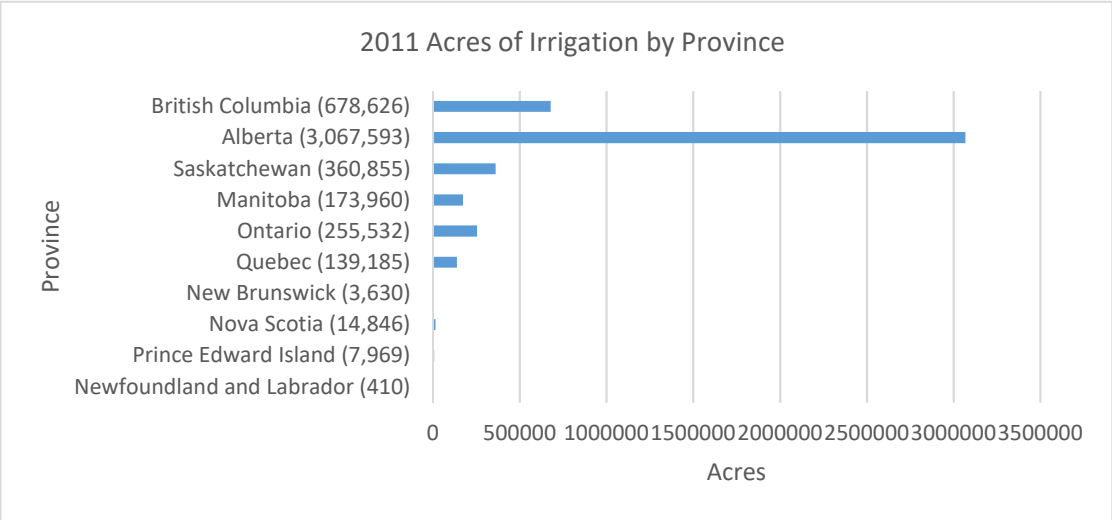
Source: Ewen (2014)

2.2.2 Existing Irrigation Dispersion

In 2011, combined irrigated area in Saskatchewan district irrigation (served through irrigation districts) and private irrigation were estimated to be 360,855 acres (Ewen, 2014) which makes Saskatchewan the third largest irrigating province irrigated production. (Figure 2.8). No information exists to differentiate what portion total acres is under private and / or district structuring and a proxy was used in this thesis[1]. Of the total 360,855 acres of irrigated crop production in Saskatchewan 104,160 acres were designated to fall under irrigation district

[1] Clifton and Associates (2008a), through survey analysis, has identified a proportion within each district that was privately irrigated during the 2001 year. This ratio was applied to estimate this area for various irrigation regions using a total irrigated area of 360,855 acres, as estimated by Statistics Canada. The remaining area was allocated to district irrigation in the region.

management while the remaining 256,695 acres were assumed to be privately managed[2] (Table 2.3).



Source: Statistics Canada (2011f)

Figure 2.8: Distribution of Irrigation Acres in Canada, by Province, 2011

Table 2.3: Estimated District and Private Irrigation by Administrative Area. 2011.

Administrative Area	Management Structure		Total Regional Irrigated Acres
	District	Private	
LDDA	75,414	41,071	116,485
NDA	3,431	46,205	49,636
SEDA	7,282	35,937	43,219
SWDA	18,033	133,482	151,515
Total	104,160	256,695	360,855

Source: Author calculation based on survey shares identified by Clifton and Associates (2008a).

Using the information presented in Table 2.3, accompanied with crop mix by administrative area previously reported, Table 2.4 outlines distribution of irrigated acres in various administrative districts by crops.

[2] This is based on 16% of privately managed irrigation acres exist within the LDDA, 18% within the NDA and 14% and 52% to the SEDA and SWDA, respectively. The remaining areas of 84%, 82%, 86% and 48% of the LDDA, NDA, SEDA and SWDA, respectively, are publicly managed.

Table 2.4: Irrigated Acres by Administrative District, Management Structure and Crop Mix. 2011.							
Crop	Administrative Area				Total Area in Acres		
	SWDA		LDDA, NDA, SEDA				
	Share	Acres of Crop	Share	Acres of Crop	District	Private	Total
Wheat, Except Durum	3%	4,545	21.80%	45,637	19,317	30,865	50,182
Durum	4%	6,061	5.80%	12,142	5,717	12,486	18,203
Barley	3%	4,545	6.00%	12,561	5,709	11,397	17,106
Oats	3%	4,546	0.50%	1,047	972	4,621	5,593
Canola	2%	3,030	24.80%	51,916	21,720	33,226	54,946
Lentils	2%	3,030	0.50%	1,047	791	3,286	4,077
Flax	0%	0	7.00%	14,654	6,029	8,625	14,654
Field Peas	0%	0	3.90%	8,164	3,359	4,805	8,164
Alfalfa and Mixed Hay	83%	125,758	9.20%	19,259	22,891	122,126	145,017
Potato	0%	0	6.90%	14,445	5,943	8,502	14,445
Specialty and Other	0%	0	13.60%	28,470	11,713	16,757	28,470
Total Acres		151,515		209,340	104,160	256,695	360,855

Source: Author calculations based on survey shares identified by Clifton and Associates (2008a).

2.3 Planned Irrigation Expansion

The irrigated area within Saskatchewan has the potential to increase and several irrigation projects have been identified as possible contributors. The administrative area of the LDDA offers extensive potential for irrigation expansion. In fact, the current irrigated area in Saskatchewan (approximately 361,000 acres) could increase to nearly 995,000 acres though various expansions using water from the Lake Diefenbaker (Miller, 2009). Several reasons, such as extensive water supply and adequate soil for irrigation purposes, have been suggested for this magnitude of expansion of the LDDA (Clifton and Associates, 2008b).

As of 2009, infill and expansion adjacent to three existing irrigation projects (Luck Lake Irrigation District, Riverhurst Irrigation District No. 1 and the Saskatchewan River Irrigation District No.1) in Saskatchewan along with two new irrigation projects (Westside Irrigation Project and the Qu'Appelle South Irrigation Project) were identified as offering provincial irrigation development potential of approximately, 630,000 acres (Miller, 2009). These projects

and their contributing area are shown in Table 2.5. Despite the expansion potential being very large, it is not expected to substantially tax the natural water flow in the region. Even if all these identified areas for expansion were developed, this would only impact 20% of the average annual inflow of water into Lake Diefenbaker (Miller, 2009).

Table 2.5: Proposed Irrigation Development in Saskatchewan.

Proposed New Project	Location	Added Irrigated Acreage Capability (Acres)
Qu'Appelle River Basin	Qu'Appelle South	108,000-120,000
	Qu'Appelle North	100,000
South Saskatchewan River Basin	SSRID Expansion	28,254
	Lucky Lake ID* Infill	9,397
	Riverhurst ID* Infill	11,000
	Westside Irrigation District	356,800
North Saskatchewan River Basin (NSRB)	Westside Irrigation District in NSRB	17,670
	Total Irrigated Acreage Capacity	631,121-643,121

* ID = Irrigation District

Source: Clifton and Associates (2008b).

The capacity of a region for further irrigation development is not the only determinant of the development level. Factors such as adoption rates of irrigated production, market accessibility for irrigated crops and capital investments also contribute to development levels. Several institutions exist in Saskatchewan focused on addressing obstacles such as these.

2.4 Organizations Assisting Irrigation

The PFRA identified five components as the most commonly addressed obstacles by agencies assisting irrigation in Saskatchewan (Hill and Tollefson, 1996). These components are:

1) Unreliable and inconsistent crop yield;
2) Lack of market demand for certain irrigated cash crops;
3) High cost of specialized farm equipment for specialty irrigated crops;

4) Farmers lack of familiarity with agronomic components of specialty crop production, and
5) Lack of local processing facilities.

The Canada-Saskatchewan Irrigation Diversification Centre (CSIDC), the Outlook Irrigation Branch, the Saskatchewan Irrigation Projects Association Inc. (SIPA), and the Saskatchewan Irrigation Crop Diversification Corporation (ICDC) are institutions that play an important role in attempting to overcome the above-noted constraints in Saskatchewan.

Details in the Government of Saskatchewan's Plan for Growth include an agenda for the research, innovation, productivity and goals of the provincial government's partnership with industry through the CSIDC, Outlook's Irrigation Branch, SIPA, and the ICDC. The mandates and roles of these organizations identify the basis of their role in this partnership.

The CSIDC's mandate is to provide technical and transitional support for Saskatchewan's irrigation producers. Its role was expanded later to "conduct, fund and facilitate irrigated research and demonstration in response to industry needs".[3] Objectives of the framework of agreement between the partners of the organization included:

> "To create a mechanism that supports a coordinated approach between the parties to promote the economic and environmental goals of the partners"; "To establish a management structure and to provide resources to enable a co-operative approach to irrigation research, demonstration, education, and public awareness"; and "To provide for the collaborative use of the CSIDC's land, facilities, and equipment to conduct irrigation research, demonstration, and education activities".[4]

The Outlook Irrigation Branch was established in 1977 to administrate irrigation extension practices for Saskatchewan and oversee provincial irrigation activity within the Outlook area. The Saskatchewan Ministry of Agriculture, through the Irrigation Branch, offers funding to the

[3] Comments expressed in the Memorandum of Understanding between the partners (AAFC, 2010).

[4] Comments expressed in the strategic framework agreement the partnership now operates under known as the Canada-Saskatchewan-Industry Framework Agreement for Irrigation Based Economic Development and Environmental Sustainability (AAFC, 2010).

Branch to encourage academic and private research, adoption, and adaptation and awareness platforms. The office provides regional and provincial extension services thorough specialists involved in farm business management, livestock, forages and specialty crops.

The Saskatchewan Irrigation Projects Association (SIPA) is the umbrella group under which the irrigation districts provide services to producers and allocate water resources. This system is an alternative to private irrigation schemes which are not undertaken on an organized group basis. Key roles of the organization include advocacy through lobbying roles for irrigation projects in Saskatchewan, in addition to administration and formation of irrigation districts. The organization's mandate is to develop irrigation strategy for the province and to facilitate and assist in irrigation policy setting.

The ICDC was established under the Irrigation Act of 1996. The corporation is a private, not-for-profit institution funded by both the Saskatchewan Ministry of Agriculture and by Irrigation Districts through a levy on irrigated acres. These levy dollars are used in conjunction with the partnerships of CSIDC and SIPA, in addition to other public and private groups to provide field demonstration and research on ideas from various industry sources. The research findings are disseminated through field days, annual publication and workshops administrated by the corporation.

2.5 Regional Level Impacts of Irrigation

The outcome of government support and planning of strategies for expansion of irrigation would have repercussions not only on the irrigation producers but also on the economic development of surrounding regions. Of the four development areas identified by the Provincial government, the LDDA is of significant importance to irrigation in Saskatchewan. This is because it has the largest irrigated acreage and the greatest amount of irrigation infrastructure in the province. The LDDA's borders encompass the city of Moose Jaw at its south boundary and run north to just south of Saskatoon. The LDDA's primary irrigation infrastructure consists of Gardiner and Qu'Appelle River Dams, and the Lake Diefenbaker reservoir. The development allows for consistent water supply and flood control for the regions surrounding Qu'Appelle and South

Saskatchewan Rivers, water supply for industry, municipalities, and hydropower, in addition to its primary role in allowing for extensive acres of irrigated crop production.

The town of Outlook is the largest urban center situated within the LDDA. Its economic development is mostly contributed by past irrigation development. This is evidenced though the presence of various business establishments and support centers that are dedicated to supplying and maintaining irrigated production. The town is considered an example of irrigation's development potential at a community level through its linkages to various sectors that go beyond the irrigation producer (Wittrock et al., 2007; Pittman, et al., 2011).

The town of Outlook is also the largest community in the South Saskatchewan River Irrigation District #1 (SSRID#1), located within the LDDA. The SSRID#1 represents an estimated 52% of the total irrigated acres in the LDDA. Of the district managed irrigated acres in the province 37% are in the district and 11% of the privately managed acres are within its boundaries. (Clifton and Associates, 2008b). Outlook has benefited from agro-climatic and topographical advantages that make irrigation viable in the region. These include above average heat units and proximity to the South Saskatchewan River (Ewan, 2014).

2.5.1 The Development of the Town of Outlook

The landscape of rural Saskatchewan has long been affected by a trend toward urbanization due to mechanization and technological advancement on farms and an increase in the outmigration of the rural population. In general, rural population has been declining. An exception to this trend is the increased population of Outlook. The population of Outlook has increased by 226% during 1951-2011. This can be compared to the provincial population increase of 24% during the same time periods (Table 2.6).

As shown in Table 2.6, the town of Outlook's sustained increase in population in the last sixty years is at a greater rate than the provincial rate. One hypothesis may be that irrigation helped the community to grow faster over this period.

Table 2.6 Population Changes of the Town of Outlook and the Province of Saskatchewan. 1951-2011.				
Year	Outlook Pop.	% Change Over Previous Values	Sask. Pop.	% Change Over Previous Values
1951	676	-	831,728	-
1961	1,340	98.2%	925,181	11.2%
1971	1,767	31.9%	926,242	0.1%
1981	1,976	11.8%	968,313	4.5%
1991	2,091	5.8%	988,928	2.1%
2001	2,129	1.8%	978,933	-1.0%
2011	2,204	3.5%	1,033,381	5.6%
Total Change During 1951-2011	Increase of 1,528 Since 1951	226% increase over the 1951 population	Increase of 201,653 Since 1951	24% increase over the 1951 population

Source: Statistics Canada (2012)

2.5.2 Employment, Extension Services and Linkages Related to Irrigation in the Town of Outlook

The agriculture industry is more prominent (in terms of employment) in Outlook than for the province as a whole. Table 2.7 outlines statistics drawn from the National Household Survey (NHS) of Canada highlighting proportions of employment belonging to agriculture, forestry, fishing and hunting combined together (Statistics Canada, 2011i). The industries employed 14.9% of total workers in the community while in Saskatchewan this proportion was only 9.1%.

Table 2.7: Share of Employment by Industry and Region. 2011.		
Particulars	Outlook	Saskatchewan
Total Labor Force	1,040	562,310
Proportion of total employment in Agriculture, forestry, fishing and hunting[5]	14.9%	9.1%

Source: Statistics Canada (2011i.)

Irrigation could be regarded as a major contributor to the region's economic growth, as evidenced by the presence of industries that are directly linked to it. These linkages include both backward linkages (inputs provided for production) and forward linkages (sales of products for further processing) (Miller, 2009). Example of businesses that provide irrigation equipment sales and repairs include: Valley West Irrigation, Rain Maker Irrigation Development Ltd., New Way Irrigation, and Western Irrigation Inc. (Ewen, 2014). Organizations such as CSIDC, the Outlook Irrigation Branch, SIPA, and the ICDC are located in Outlook only due the presence of

[5] Category includes several sectors due to the Statistics Canada's aggregation method.

irrigation, providing further impetus to irrigation development through their irrigation-based extension services (Ewen, 2014).

2.6 SUMMARY

This Chapter discussed the history of irrigation in Saskatchewan and conditions that influenced its development were presented. Conditions of drought necessitated irrigation development initially which coincided with government intervention for expansion of the original irrigation efforts of farmers and ranchers. This intervention included the establishment of the PFRA, which was heavily involved in the development of various reservoir and irrigation project developments. Surface and sprinkler irrigation systems continue to evolve and both continue to be used today, although sprinkler irrigation systems are more dominant.

The creation of Gardiner Dam and Lake Diefenbaker followed under the PFRA leadership and have added to the capacity to irrigate in the province. While the potential of provincial infrastructure was estimated to be service more than 600,000 irrigated acres, such a target has yet to be reached, as at present only 360,855 acres of irrigation exist in the province. Of the existing acres 104,160 are under administrative management of Irrigation Districts. The provincial government administers irrigation through creation of four areas. These are the administrative areas of the SEDA, LDDA, SWDA and the NDA. Future irrigation development opportunities, primarily in the development area of the LDDA, were discussed in the Chapter that could provide an avenue to reach the target of 600,000 acres of irrigation.

Organizations, such as the CSIDC, the Outlook Irrigation Branch of the Ministry of Agriculture, SIPA, and the ICDC provide producers with extension services and government direction with respect to irrigation to overcome obstacles to expansion of the original infrastructure development. Finally, the LDDA region and the town of Outlook were presented as a demonstration of the importance of irrigation in economic development at the regional level.

CHAPTER 3 LITERATURE REVIEW

This chapter presents a review of the literature related to assessment of economic impacts of irrigation. Section 3.1 provides a review of various economic impact analysis methodologies that have been used, including the merits of using the input-output (I-O) modelling. Section 3.2 details a review of various studies that have undertaken using the I-O based economic impact analyses. Both international and North American studies are included here. Section 3.3 presents a review of Canadian studies that have used I-O analysis. The chapter concludes in Section 3.4 with a summary of the chapter.

SECTION 3.1 APPROACHES TO ECONOMIC IMPACT ANALYSIS

According to Davis (1993) economic impact analysis centers on conditional predictive models. Such models are developed to improve our understanding of the effects of economic stimulus – referred to as events. Such knowledge may help investors better understand what will happen if an event, such as a change in production levels, is introduced into an economy. Economic impact assessment estimates the economic impacts of a project or a new industry in an economy. Estimates of the changes that are associated with the event are generally estimated by economic indicators, such as: (i) spending (output or sales); (ii) income and; (iii) employment. These quantitative estimates can be developed using one of the three principle techniques: economic base analysis, income-expenditure analysis, and input-output (I-O) analysis.

In the economic base analysis, exportation activity is viewed as the determining factor on regional production. The total economy is divided into two types of sectors: exporting sector (basic sector) or non-exporting sector (the service sector). The exporting sector drives the non-exporting sector. A multiplier can be estimated as a ratio of service to the base sector production.

Economic base analysis, according to Shaffer (1989), is applied most effectively to a primarily exporting economy. Major limitations of the method include: assumptions of a constant base sector to service sector production ratio, homogeneity of the export sector, and primary dependence of the region on exports as the only source of regional economic growth. These

assumptions, in addition to the exclusion of reactionary feedback, make the model unsuitable for an analysis of a complex and mature economy.

The second type of model that may be suitable for economic impact analysis is the income-expenditure analysis model. In this model, regional income is a summation of consumption, investment, government spending and net imports. Consumers pay taxes and save some, and the remaining disposable income is spent on consumption by households. The level of consumption is determined solely by the personal disposable income in the region. Imports are also allowed and are primarily in response to local consumption patterns. The model does not generate employment or any type of social assistance, including unemployment benefits. The reactions of each of the producing sectors to the stimuli are affected equally. This assumption does not account for the specific production strategies of sectors dependent on stimuli and their relation to the investment (Shaffer, 1989). Furthermore, each type of stimulus has an identical impact on the economy.

Assumptions of the model include: constant multiplier coefficients for consumptive spending, import and export levels, tax rate, homogeneity of the production sector; limitless production capacity and limited interregional feedback effects (Shaffer, 1989). Like economic base analysis, these assumptions reflect the limitations of the model. The model is more suitable to a small economy, and thus not for estimation of economic impacts of a stimulus in a large and mature economy.

Both Davies (1993) and Shaffer (1989) recognize that the most suitable method of impact analysis for a complex (multi-sector, multi-product) region is I-O analysis since in these situations the impacts are determined by inter-sectoral relationships for the region / community. Because the focus of the I-O model is on the inter-sector relationships within the economy, it is recognized as a preferred choice in the study of economic impacts. By accounting for the inter-sector microeconomic effects of stimuli, an I-O model can present the macroeconomic influences on the economy.

The I-O based economic analysis has a rich history. The original I-O model was a square input-output model. The structure of the square I-O model is based on the accounting framework of equal number of goods and services producing and selling sectors, thus leading to a square form of the economic system. In this framework, each of the sectors is allowed to trade with other sectors as well as with other economic agents, called final demand agents. This representation of the economy is called a transactions table, which is the starting point of the I-O model based economic analysis. The transactions table includes inter-sectoral sales during a given time period (usually a year) in value terms (evaluated in producers' dollars and those supplied locally) (Statistics Canada, 1979). The selling sectors are listed as rows while in the column enlists purchasing sectors. The sectoral transactions are appended with two other sets of internal trade that takes place: value-added agents, and final demand agents. The former includes wages, salaries, rents, interest, dividends, while the latter includes households, government (operations and investment), business investment, and exports less imports. A final important characteristic of the transactions table is that total value of sales from all sectors must equal total value of production.

Using the values in the transactions table, one can construct matrix of direct requirements of a sector (expressed as purchases of various goods and services per dollar of its total output). Each cell for a given sector expresses the percent of total demand (equal to its output) of the i^{th} sector purchased from another sector (sector *j*). The same value also indicates the sales of sector *j* to sector *i.*

3.1.1 Square and Rectangular I-O Modelling

The square I-O model assumes that each industry produces one single commodity. Thus, the number of good producing and good purchasing sectors are equal, resulting in a square transactions table, as shown in Figure 3.1. It shows a descriptive construction of the original Leontief's square I-O model in which the trade flows between input sectors and output producing sectors are presented. In addition, trade flows to final demand sectors (such as exports, consumers, government, and business investment) are also included in this table.

Selling Sector	Sectors		
	Purchasing Sector (Intermediate Demand)	Final Demand	Total Output
	1…*n*		
1 . *n*	Interindustry Transactions		
Imports			
Value Added			
Total Input			

Source: Miller and Blair (1985)

Figure 3.1: Descriptive Construction of a Square I-O Model

Realistically the assumption of the number of goods producing and purchasing sectors being equal was considered too restrictive since many sectors produce more than one good and service and the rectangular version, in which each sector can produce more than one commodity, is a more representative model of the industry capabilities of advanced economies.

Anderson and Manning (1993) present their analysis as an example of the inherent limiting structure of the square input-output model. In the above study, an I-O model of the South Saskatchewan River basin region of Alberta (SSRB) was developed using a square I-O transactions table. They found that when a square input-output model was employed several industries were misrepresented due to aggregation. Transferring secondary products within a category to industries in which they are primary products was discarded because it would have increased the size of the model. Furthermore, the determination of each of the commodity input structures empirically on a large regional or national level was difficult to undertake in practice as the inter-industry transaction matrix did not allow for the demand for commodities to be traced through it. The work suggested that the use of a rectangular input-output framework, in conjunction with survey or engineering data to describe individual commodity production functions, provided a better result than the square I-O framework.

3.1.2 Regional Modelling

In I-O modelling, inter-regional modelling and multi-regional modelling are two types of regional models that are commonly estimated (Sohn, 1986; Miller and Blair, 1985). Inter-regional modelling is a version of the I-O model that includes the estimation of each region that engages in trade with other regions. This is a complex model where inter-regional impacts amongst all of the transactions and their components of feed-backs are included. Alternatively, multi-regional modelling, although recognizes the existence of such inter-regional trade transactions, does not model them explicitly. Thus, in this system of modelling, feedback effect of one region on the other are lost, but can be estimated in aggregate.

Examples of regional modelling in a Canadian context for the agriculture industry are provided by Kulshreshtha (1993) and Kulshreshtha and Grant (2003). Kulshreshtha (1993) presented a multi-regional model of the Canadian Prairie provinces. Individual Prairie Provinces (Manitoba, Saskatchewan and Alberta) were further sub-divided into six sub-regional economies. Each of the sub-regions had its own I-O model. As noted above, in this methodology, the feedback effects were not explicitly included. The model was able to estimate total lost feedback effects for the three provinces, using Equation (3.1):

$$\text{LOST FEEDBACK EFFECT} = \text{PROV IMPACT} - \sum_{r=1}^{6} \text{Regional Impact}_{(r)} \qquad (3.1)$$

Equation 3.1 suggests that for a larger region (such as a province) consisting of 6 sub-regions in this particular case, although the feedback effect among individual pairs of regions cannot be estimated precisely, total feedback effect can be approximated. The same methodology can be employed for out-of-region trade transactions, but these require multipliers for the outside regions (Kulshreshtha and Grant, 2003).

Kulshreshtha and Grant (2003) presented economic impacts of irrigation development for five jurisdictions in North America, including: local irrigators, regional economy (considered the irrigating region), the rest of the provincial economy, the rest of the Canadian economy and the United States economy. Although the empirical model was estimated on an aggregate level for

the province, economic impacts on the other regions were estimated using region specific multipliers.

3.1.3 Commodity and Sector Disaggregation

Commodity and sector disaggregation play an important role in describing the economic structure of a region in the context of Canadian agriculture. A detailed disaggregation generates a greater level of complexity, difficulty, and risk of error that is traded-off with the potential for accuracy and applicability of the research.

In past studies, different levels of disaggregation have been undertaken. The level of disaggregation of the agriculture sectors or commodities (and associated with that for the rest of the economy) is different depending on study objectives and scope. For example, Kulshreshtha and Sobool (2006) found relevance in differentiating grains into wheat and other grains while other agricultural products were differentiated into cattle and calves, hogs, poultry and eggs, fluid milk, oil seed, fresh fruit, vegetables, hay and other. Kulshreshtha and Grant (2003) provided commodity disaggregation with a greater focus on the potato industry and its linkages with storage, machinery and plant construction activities.

Johnson and Kulshreshtha (1982) used 12 farm subsectors for analysis of aggregate provincial level impacts for various farm types. All impacts were estimated using an I-O Table for the province of Saskatchewan. Gould and Kulshreshtha (1985) used the concept of sector disaggregation to highlight the impacts of increased export demand for Saskatchewan. Products were disaggregated in the provincial economy into five individual sectors within the Saskatchewan agricultural industry.

Another example of sector disaggregation in the Manitoba agricultural context is provided by Kulshreshtha and Grant (2003). The work disaggregated agriculture into several types of farming enterprises, including dryland grain production, irrigated potato production, dryland potato production, fruit and vegetable production, other irrigated crop production, hog production, beef cattle production, dairy production, poultry production and other production.

A more detailed presentation of the disaggregated agriculture sector was provided by Kulshreshtha and Thompson (2005). In their work, the economic impacts on the provincial economy of Saskatchewan were disaggregated into agriculture and food clusters to independently review the contributions of each. These clusters were further separated into an agriculture production sub-cluster, a food processing sub-cluster and a farm input manufacturing sub-cluster. Analysis of the economic impacts within the clustered presentation of the industry were reviewed at three levels of aggregation: individual farm production activity level, aggregation of similar commodity production, as well as for the entire agriculture and food cluster.

SECTION 3.2 I-O ANALYSES FOR INTERNATIONAL AGRICULTURE

Several studies have used the I-O technique for analyzing the economic impacts related to the role of water use by sectors. The work of Wang et al. (2009) and Duarte et al. (2002) present examples of the adaptability of the input-output model to incorporate impacts as they apply to water consumption resulting from an economic activity. These studies are highlighted below to provide examples of the methodologies adaptability from various perspectives of impact analysis with respect to productive sectors, as well as components of water use.

Wang et al. (2009) developed a regional input-output model which was applied to Zhangye City, Northwestern China. The focus of the work was water consumption and productive activities in the regional economy. The model used 10 by 10 sectors. Each sector aligned with ten water use categories. The regional model quantified the environmental load of water use through an inter-sector water transaction coefficient. Data were collected through Gansu Water Resource Official Reports. The food production and forestry sectors were found to have the largest impact on water supply (as these are large consumers of water), while industrial and services sectors impacted water supply in a relatively smaller way. However, the food production sector was found to be responsible for supplying large quantities of these intermediate inputs which were supplied regionally. Therefore, these relatively higher consumptive sectors had strongly positive net balances which were linked to other sectors. These inter-sectoral relationships were found not to be accurately accounted for in the regional water allocation policy.

Duarte et al. (2002) utilized an I-O model for the analysis of the direct and indirect consumption of water by productive sectors in the Spanish economy. The model was used to calculate water requirements for production by sector, both direct and indirect, and how these requirements impacted supply. Their work exogenized sectors for analysis using, what the study identified, as a hypothetical extraction method (HEM). The HEM is augmented to allow for: (1) a valuation in terms of water consumption, (2) components of impacts to be collected in economy divisions, detailed as blocks of activity, and (3) key sectors to be identified. The methodology of the study allowed for classification of productive sectors by their linkage characteristics. Satellite water accounts for the country, detailing water use in production by sector, and the 1995 Input-Output Table for Spain were used in analysis. The 24-sectors included in the satellite water accounts were aggregated into eight blocks of sectors which included: (1) agriculture, (2) energy, water and mining, (3) food industry, (4) transformation industries, (5) chemicals, metals and electronics industries, (6) construction, (7) public sanitation, and (8) other services. The study found the block of sectors that were the highest direct consumers of water also generated high consumption through direct consumption and vertically integrated consumption. Therefore, demand intervention to stimulate input sales of other blocks would not impact total consumption of the economy.

SECTION 3.3 I-O ANALYSIS WITH RESPECT TO IMPACTS OF IRRIGATION IN NORTH AMERICA

Several studies have analyzed the total economic impacts of irrigation in North American agriculture using the I-O modelling technique. These include Hamilton and Pongtanakorn (1982), Whited (2010), Kulshreshtha and Klein (1989), among others. Studies relevant to this particular research are detailed below.

Hamilton and Pongtanakorn (1982) present an application of marginal I-O methodology when analysing the total economic impacts of 111,000 acres of irrigation development in Idaho. As the new irrigation is energy intensive, the study incorporated a set of marginal technological coefficients as opposed to the tendency of basing it on the average technology of existing firms. These coefficients were supplied by the Idaho Power Company. An absolute unavailability of additional hydropower allowed for the addition of a row and column in the input-output model to

represent the addition of the thermal electricity component. Details of direct use loss of hydro power (replaced by thermal power) from the development of the new irrigation was drawn from the Bureau of Land Management impact statement of 1979. The work found that the development resulted in $50.5 million in increased crop output impacts and $65.4 million in household income impacts (Bureau of Land Management, 1979).

Whited (2010) looked at how water reallocation amongst sectors and users could increase economic efficiency. The economic impact potential of irrigation water transfer, occurring in the region of Uvalde County, Texas, was analysed. The resulting indirect and induced impacts of crop mix changes to labor and industry due to transfer of water permits as well as the water permit payments were considered. Impacts were initially based on locally-produced crop budgets. These impacts were compared to the aggregate production functions of the model. The study included more than just a change in sector output but also evaluated changes to demand of intermediate inputs as they applied to specific crops, including labor components. Lease payments to farmers were evaluated using two scenarios of a flat price and one for a price that fluctuates depending on crop value. The year 2000 was used as a baseline. Average harvest crop acres were adjusted to reflect planted acres published by the National Agricultural Statistics Services. Mean precipitation was used to account for the retention of necessary precipitation. An I-O model was used and incorporate the weighted average value of inputs by crop. Each acre-foot of irrigation water that was transferred reduced output demand on an average of $292, for a total of $34 million dollars. In addition, backward linkages of agricultural support business amounted to more than $8 million in output losses.

The association between regional growth and stable development and irrigation development in Southwest Saskatchewan was reported by Kulshreshtha (2003). The study was undertaken with the objective to assess the success in regional growth and stability of the Southwest Saskatchewan region through development of water supply projects. The study employed an input-output model with over 12 major economic sectors and appended with an employment model. This methodology allowed estimation of secondary economic benefits to the region as well as gain in employment for the selected projects. Data for the study were obtained through a focus group meeting of producers in the region as well as cost of production budgets and yield

and revenue information. Adaptation strategies for a drought period, such as purchase of feed, sale of cattle and additional higher cost alternatives, were also included in this analysis. The study identified several pathways of economic impacts that were grouped into three categories - direct water use impacts (primarily by irrigators), associated and induced economic impacts, and impacts from non-water use related activities. The direct water use impacts were a result of initial expenditures of $1.31 billion during the study period, which resulted in a $501 million increase in the gross domestic product (GDP) regionally, and 31,830 full-time equivalent[6] (FTE) jobs in total.

Kulshreshtha and Klein (1989) estimated the impacts of a drought using the Agricultural Drought Impact Evaluation Model (ADIEM). In this integrated-systems approach, an I-O model was linked to a beef, forage, and grain simulation model to assess the economic impacts of incorporating a small-scale irrigation strategy during normal and drought years. In this study, representative farms were constructed and simulated. Analysis was developed using census and unpublished data from provincial and federal agricultural departments. The study undertook a scenario analysis that compared a normal year of production with no irrigation (designated as the base case), to three alternative scenarios of: (i) drought conditions occurring on non-irrigated land, (ii) no drought occurring but small-scale irrigation development and (iii) drought and irrigation both occurring together. Results showed that during the first year of the drought, both cereal and forage yields were reduced considerably. Drought in the second year was designed to include a very dry spring and good late summer weather conditions. This construction was anticipated to result in normal cereal crop yields while being a detriment to forage yields. The study estimated an increase of $1.7-2.5 million in GDP as the total impact of having irrigation for a two-year drought scenario.

Clifton and Associates (2008a and 2008b) used an Economic Impact Simulation Model to estimate impact the impact of irrigation development in the LDDA (2008a) and in Saskatchewan (2008b). A rectangular accounting-framework was used, and consisted of 73 commodities, 31 industry sectors and four final demand agents. Four types of activities included in the model

[6] A FTE is a worker working on a full-time basis for a period of one year.

were: (i) construction of new off-farm water supply infrastructure; (ii) on-farm irrigation development; (iii) linkages of irrigated production in the region on other farms; and (iv) value-added activities occurring as a result of irrigated farming. Two phases of development—on-farm and off-farm investment were included in this study along with their respective operations and maintenance expenditures.

Elder (1985) constructed an I-O model of Washington state regionalized to include a three-county regional analysis. The I-O model was used to estimate the economic impacts of irrigation resulting from its development during the second half of the Columbia Basin project. The study updated the state of Washington's 1972 I-O model to reflect the 1990 economy. This update included aggregating the original 51 sector model into a 32-sector model, including the household sector. Using the locational-quotient method a 14-sector model was built for the study region. Value added was used as an economic indicator to approximate gross national product (GNP). In addition, another component of GNP, labor income, was estimated to reflect contributions received by each of the various income groups included in the study.

Kulshreshtha and Klein (1989) developed a rectangular input-output model that was applied to review economic impacts of irrigation development in Alberta on the provincial and Canadian economies. The first component of these impacts were associated with current irrigation industry in the province, and its related activities. Results were compared through simulation with dryland production. The second component was a measure of the economic impacts resulting from rehabilitation and expansion expenditures. These components were assessed assuming continued provincial funding and compared with no continued provincial funding.

Kulshreshtha and Grant (2003) provided an I–O model to estimate the economic impacts of irrigation in Manitoba. The study identified that economic impacts of irrigation extend beyond irrigators. The full value of irrigation development, primarily in terms of potato production, included other impacts occurring to other economic agents in the province. These other economic agents included: owners of resources in processing of products of irrigation as well those in other sectors linked to irrigation through economic transactions. The I-O model used in this study estimated economic impacts for five geographical regions or agents: local irrigators, other economic agents within the irrigation region, within the province of Manitoba, other

regions of Canada in an aggregated form, and other international regions, predominately the United States. The I-O model was used to estimate economic impacts for the local irrigators and other economic agents within the province. The impacts for the regions beyond Manitoba were based on interprovincial trade and a region-specific multiplier (although assumed to be the same as that for Ontario due to data limitations). Economic indicators used to assess the total economics of irrigation included: output (gross sales of businesses), Gross Domestic Product (GDP), household income, and employment.

The model was based on the rectangular I-O accounting framework. It was developed by obtaining provincial Make (production of commodities by industry) and Use Tables (use of commodities by industry valued at producers' prices) as well as population data by municipality and sector. The agriculture and manufacturing sectors were further disaggregated using farm level budgets. Regional disaggregation was undertaken by use of location quotients. Linkages were identified as the cause of impacts that were considered in the study. Irrigation development was subdivided into two phases of activities. The first phase included the development of irrigation infrastructure, and the second phase included irrigation operations at the farm level. Each if these resulted in on-farm as well as off-farm impacts. A similar study for other Prairie Provinces or for the entire prairie region was not found.

SECTION 3.4 SUMMARY

Available literature identified three types of impact analysis methods: economic base analysis, income-expenditure analysis and input-output analysis. The I-O analysis is identified as the most comprehensive methodology for economic impacts occurring in a mature economy. Examples of use of this type of modelling show the role played by water application on its own and linked activities. Several other studies were provided as examples of analysis of total economic impacts of irrigation in North America from different types of activities. These include technological development, investment, water-policy programing, and activities related to irrigated production. However, based on this review, it is concluded that the use of I-O model is an appropriate method of analyzing economic impacts of irrigation in Saskatchewan.

CHAPTER 4 CONCEPTUAL MODEL

This chapter presents the conceptual model used in the study. Section 4.1 provides details pertaining to the establishment of a general economic development theory culminating into the neo-classical work of Walrus. Section 4.2 presents a discussion of regional economic impacts resulting from a new investment, such as irrigation development. Section 4.3 presents details on the choice of economic impact analysis method, including reasons for the selection of the I-O model. Section 4.4 describes the concept of economic impacts and their various components that are captured by the I-O model. Subsection 4.4.1 presents impact types while Subsection 4.4.2 discusses various types of linkages that exist in a mature economy. Section 4.5 provides a summary of the chapter.

SECTION 4.1 GENERAL ECONOMIC DEVELOPMENT THEORY

Sharipov (2008) presented a compilation of literature chronicling the development of general economic development theory. This development began with Mercantilism in the 15th century which was followed by Physiocracy during the 18th century. Physiocrats believed the wealth of nations was derived from land, either for agricultural or development uses. This was followed by the Classical Theorists. The Classical theorists began with Smith in 1776 and were followed by Schumpeter's Innovative Growth Theory of 1911. The Keynesian Theories were a development of the 1930s, the Post-Keynesian Theories were a development of the 1950s. These eras were built on by the Neoclassical theories of Leon Walras and others to whom development was based in economic growth and incorporated through the equilibria solutions of agent's maximization problems (Sharipov, 2008).

Sharipov (2008) identified mercantilism, first documented in the 15th century by Antoine de Montechrestien, as the originating theory of economic growth. Mercantilism identified wealth accumulation as the main source of growth and purpose in an economy. This theory was then replaced by Physiocracy during the 18th century. The theory credited wealth to the productive worth of "land agriculture" or "land development" (Sharipov, 2008). Extending from these very

early concepts of economic growth came the classical theories of economic growth originating with the early concepts of Smith (1776).

Smith (1776) presented an early version of the nature of prosperity and economic society (Dang and Pheng, 2015). Contrary to the view that a prosperous and suitable society necessitated public or social ownership and the economy of a nation should be planned, Smith concluded that productivity in processes could be created with the division of labor. Smith proposed that exchange and specialization were important contributing factors to this division of labor. The concepts of private property, competition and free trade were important agents of economic development. It was the output of these factors of production that could present improvement to wealth. Smith identified trade of this output as the source of wealth and not the accumulation of gold (Smith, 1776).

Other important contributions of this classical period for the development of economics include Thomas Malthus, David Ricardo and John Stuart Mill (Sharipov, 2008). These economists contributed to the concepts of diminishing returns of factors of production, comparative advantage and the idea of continuous accumulation of capital, respectively. Mill (1848) posited that long-term population growth stimulates an increase in real wages which is built from an increase in labor demand resulted from an increase in capital (Dang and Pheng, 2015).

Schumpeter introduced the term “innovation” into theory of development (Sharipov, 2008; Schumpeter, 1934). Schumpeter believed development was driven by changes to the steady state of the economy and that the developer was the innovative entrepreneur who undertook development through: (i) introduction of new goods; (ii) introduction of new methods of production; (iii) the opening of a new market; (iv) conquest of a new supply of raw material; and (v) new organization of an industry (Maddison, 1982).

The Keynesian and Post-Keynesian theories of development in economics are based on the work of John Maynard Keynes. Keynes (1936) identified the expansion of demand as a contributor to economic growth. Keynes (1936) showed that an increase in unemployment and the occurrence of a recession (reduction in income) decreases investment, savings and consumption. Keynes

(1936) identified monetary and fiscal policy approaches, such as interest rate reductions and infrastructure investments, as effective stimulants to the economy, specifically during the period of the Great Depression. Keynesian growth theories are based in balanced economic growth from an increase in demand through increases in investment (Sharipov, 2008). Following the theories of Keynesian growth, Harrod (1939) and Doomer (1946), known as post-Keynesian economists (Sharipov, 2008), concluded that the marginal propensity to save and the dynamic market system equilibrium as well as components in the technical conditions of production determine growth. These determinants have elements of instability and require state action for full employment through investment (Dang and Pheng, 2015). The linear function of dependence of economic growth on investment, the exclusion of the concept of technological progress as an influencing factor and the lack of dependence of development on the growth of labor are limiting factors of Keynesian and neo-Keynesian theories (Sharipov, 2008).

Neoclassical economic development theories were established during an era in which technological changes perpetuated development and incorporated the existence of an aggregate production function (Banerjee and Duflo, 2004). Cooper and Andrew (2012) provide the definition of the aggregate production function as the dependence of aggregate output (real GDP) on physical capital, labor, human capital, knowledge social infrastructure, natural resource availability and any other inputs that the output depends on. The basic growth function of this neoclassical model assumes a relationship that continues, and is represented by the production function to describe the output of the area to available capital and labor (Shaffer, 1989).

Leon Walrus (1874) extended the standard treatment of equilibrium of a single market (a partial equilibrium analysis), which was standard during his time and used by Keynesian economists, to the development of a general equilibrium theory. In his theory, Walrus stated that a coherent theory is needed to consider pricing systems and economic behavior in all the markets in the economy behaving simultaneously to establish a general equilibrium (Levin, 2006). General equilibrium theory uses the model of equilibrium pricing to study attempts within an economy to determine under what circumstances general equilibrium assumptions will hold.

In Walras's integration of supply and demand and its application to the economy as a whole, the product market and the factor market were identified. Agents in an economy included households and firms. Each firm uses a production set to produce outputs from inputs. In the product market, households purchase goods from goods producing firms. Income is received by the household as wages in exchange for factor services they provide in the factor market. Product prices and factor prices link goods and service to money payments which flow in opposite of one another (Walras, 1874).

General equilibrium occurs at the point where income flow and household expenditure equate. Walras (1874) assumed that these flows would move towards a stable equilibrium and in a circular flow pattern. The Walrasian stable equilibrium presumed that an economy is in equilibrium, and when disturbed, it would adjust to resume its static position. Equilibrium in the economy exists at the point at which decisions of the profit maximizing firms and the preference maximizing households exist congruently and within their budget. The equilibrium necessitates that the market clearance exists at the point at which demand and supply are equal (Levin, 2006). The Walrasian model and equilibrium is defined in the next section from the perspective of a pure exchange economy.

How productive efforts are coordinated, goods and services are allocated efficiently, and supply and demand are balanced across large amounts of decision makers is approached from a different perspective under the concept of a general equilibrium, as opposed to a partial equilibrium. In a single market the pricing system, acting as the main coordinator, could effectively establish a partial equilibrium, in which market clearing occurs at the point where supply and demand intersect but it is unreasonable to expect that the price of a single commodity is the defining contributor to the equilibrium achieved by all other commodities (Levin, 2006). It was from this limitation of the treatment of commodities with respect to a partial equilibrium that Walras (1874) extended the partial equilibrium to the general equilibrium. The theory of general equilibrium proposed that the simultaneous general equilibrium of all markets in the economy must be considered in a relevant economic theory (Levin, 2006).

Beginning with a pure exchange economy in which there is no production, a finite number of agents and commodities and a bundle of commodities for each agent. This basic model begins with ℓ basic commodities and η agents (consumers). External constraints are conditions to the bundles of goods that are secured by each consumer.

Although Walras was not able to successfully finish the task of a review of a complete economy, he did show mathematically that through a series of simultaneous equations, which represented a hypothetical economy, the price and quantity at equilibrium could be determined. Walras simulated the ability to relate required factors to produce a good to the levels of total product production. This was done with a set of production coefficients that were equal to the number of unknowns within the economy.

Walras' simulations were approximated by Leontief through building on techniques used in Quesnay's Tableau Economique. This resulted in the model interdependence within an economy resulting in the development of the technique of I-O modelling.

SECTION 4.2 REGIONAL ECONOMIC DEVELOPMENT THEORY

When considering a choice of economic development theories relevant for community / regional economic development analysis, a choice should be relevant to the community under evaluation along with an opportunity or intervention within the community. The correct theory should recognize the supply and demand forces around the community and how the community's characteristics, including its structure and present conditions, affect their impacts. There is no general theory of economic development that encompasses all the distinctive needs of the community, although components of theory that are utilized in regional economic development work is discussed by Shaffer (1989). This Section presents a discussion on community economic development theories which are centered on the fundamental definitions and use of supply and demand-oriented theories.

Theories of development through economic growth within a region or community are discussed by Shaffer (1989). These are predominately centered on either supply or demand orientation. An

important assumption of supply-oriented development theories is that all output that is created can be sold, excess supply is not a consideration. Demand-oriented development theories assume the supply of production inputs is limitless. Economic development can be achieved by encouraging external demand for goods and services generated within the community to facilitate unemployed factors of production, believed to be the cause of poor community development. These theories look at the forces that effect demand for a good or service produced within the community and how that manifests into income and employment.

Shaffer (1989) highlights three policy alternatives to encourage development. These include: creating external demand, shifting excess factors of production to the production of goods and services that are experiencing growth, or subsidization of local production of a good or service within the community to encourage competitiveness. Economic impact analysis allows for investors to better understand what will happen if a stimulus, such as a change in production levels caused by external demand, is introduced into an economy with respect to growth.

SECTION 4.3 THE INPUT-OUTPUT MODEL

The general purpose of the I-O model is to quantify the effect of changes in final demand for various commodities for a region based on its economic structure. This type of modelling is commonly used for economic impact analysis.

Section 4.3.1 Early Development of I-O Modelling

Three major works have been credited as major contributors to the foundations of the input-output analysis. These include: Leon Walras' *Elements d'Economie Politique Pure* in 1874; *Tableau Economique* written by Francois Quesnay in 1758 (Muller, 1978); and Wassily Leontief's article entitled *Quantitative Input and Output Relations in the Economic System of the United States* initially published in 1936 (Leontief, 1936), and further exemplified in Leontief (1941).

Economic impact analysis is fundamentally a study of interactions within an economy built upon the interdependence between sectors that exists in an economy. General equilibrium theory, as defined by Walrus, provides a theoretical basis for the analysis. This theory originated in the 1870s. Its initial appearance occurred in the work of Walras (Jaffe, 1977). It is an alternative to the partial equilibrium theory in which only a single market is considered in isolation and the behavior of other markets are assumed to be unchanged. This theory considers the influences of supply, demand and prices and their contributions to the interactive occurrences within all the markets concurrently.

Quesnay has been credited as the first study to formulate the interdependent economic systems precisely (Muller, 1978). Quesnay defined three classes of movers from an economic perspective: the proprietary, the productive and the sterile class. Quesnay argued that it is the flow of agricultural surpluses, in the form of goods and services, among these classes that induces economic change. This was opposed to industry and trade being the primary sources of wealth in an economy, as previously thought. It is the extent of the interdependencies between these classes that is identified as the early introduction of an economic multiplier. Quesnay constructed the Tableau Economique to summarize his theoretical relationships. The Table diagrammed a simulated summary of the theorized relationships and conceptualization of economic equilibrium, at which economic forces are balanced. Quesnay's work established an early construction of a technique of capturing the modelled inter-industry relationships. Quesnay's work was further used by Leontief (1936) in the form of an I-O model. Leontief's work originally focused on the Russian economy in his 1925 work (Leontief, 1925) and further, in 1928, in his doctoral thesis (Leontief, 1928).

The framework of applied input-output modelling for analysis was constructed by Wassily Leontief during the 1930s. Leontief's I-O Table is an approximation of the Walrasian model. The Walrasian model derived consumer demands that are downward sloping to demonstrate a simultaneous existing equilibrium for all markets. Leontief (1936) modified Quesnay's measurement of flow amongst classes to include units of given time and physical measurement and extended Walras' simulated relationships (through the use of a system of simultaneous equations). Leontief's work formed the first model of an actual economy connecting and

constructing the relationships between inputs and outputs and presenting them in a transactions table, which was originally linked to central planning of the Soviet Union in the early 1900s (Aroche, n.d.). He went on to further model the United States, building an I-O model for the period 1919-1929.

Originally undertaking an input-output analysis was labor-intensive and therefore, not practical for all situations. Modern computer technology has changed this and modern representations of input-output modelling are now used extensively in economic impact analysis.

Section 4.3.2 Endogenizing the Household Sector in the Model

Sohn (1986) presents a compilation of existing research which has extended the fundamental basics of the Leontief's model. Sohn (1986) and Miller and Blair (1985) identify fundamental improvements in workability of the Leontief's model. In the context of the present study an extension that is relevant is the endogenization of household spending in the I-O model.

In a typical impact analysis, various goods and services producing sectors are affected by the level of their final demand. In turn, the household spending remains unaffected. The household sector, made up of the purchases of consumers, is generally the largest component of the final demand sectors (Miller and Blair, 1985). Through providing a workforce to various sectors, it is intimately connected to them as well. In addition, the household economy also creates some economic activity directly.

An input-output model can be closed with respect to certain final demand agents, in which their activities allow increased spending in the economy through their spending patterns. This is typically done with respect to the household sector where additional economic impacts are created through their consumption patterns. This creates economic growth in the region in an endogenous manner—the sector creates addition production activities and is also affected by them. Income becomes an additional row within the transaction matrix and the household sector is classified as producing the product of labor which is "sold" for income.

The merit of closing the model with respect to other final demand agencies is less certain because their inclusion, based on the intrinsic assumptions of the model, assumes that these sectors exist within a fixed coefficient. This, according to Miller and Blair (1985), is more difficult to accept when applied to other sectors (such as government spending) that make up the final demand sectors.

SECTION 4.4 CONCEPT OF ECONOMIC IMPACTS

Economic impacts are the result of an event experienced by an economy, such as an investment in infrastructure spending. They are created in an economy through recirculation of spending by various economic agents at the same time. Such impacts are diminished through leakages. Leakages are the result of savings, taxes and imports. Savings are funds for new investments in the future while taxes are used for government spending and investment. Impact assessments present the changes in the economy between an event scenario that has been experienced and one that has not.

An I-O model is based on economic data that show the inter-industry relationships in an economy. These relationships are used to predict the changes caused by an event. Estimates of the changes that are associated with the event, using an I-O model, are generally estimated as economic indicators such as: (i) spending (output, or sales); (ii) income and; (iii) employment changes. These indicators incorporate different types of impacts distinguished by their source. The economic impact types are direct, indirect and induced impacts. These impacts can be converted into multipliers, which quantify the cumulated effect of an event. These concepts will now be discussed.

4.4.1 Impact Types

Impacts that are created using an I-O model are identified by two types – Type I and Type II impacts, which lead to Type I and Type II multipliers. Type I multipliers are based on a sum of direct and indirect impacts expressed as a ratio of direct impacts, as shown in Equation (4.1). Similarly Type II multipliers include all three types of impacts -- direct, indirect and induced impacts as a ratio of direct impacts (see Equation 4.2).

$$\text{Type I Ratio Muliplier} = \frac{(\text{direct impacts} + \text{indirect impacts})}{\text{direct impacts}} \quad (4.1)$$

$$\text{Type II Ratio Multiplier} = \frac{(\text{direct impacts} + \text{indirect impacts} + \text{induced impacts})}{\text{direct impacts}} \quad (4.2)$$

Direct impacts result from the activities of the original event. These events cause change in the demand for various commodities produced within the economy. An example of a direct impact is construction of a piece of infrastructure, such as a dam for irrigation purposes, requiring building supplies, construction workers and other technical employees related to the initial development.

Secondary impacts comprise of indirect and induced impacts. An indirect impact of a reservoir for irrigation would be the change in demand for inputs such as fertilizers and irrigation equipment or storage facilities that are demanded because of the increased production from irrigated production.

Induced impacts are also a part of the secondary impacts and measure changes resulting from households spending of their earned wages and other income they received from direct and indirect impacts. An example of an induced impact would be the effect of spending by an employee whose job was created as a result of change in direct and indirect impacts.

4.4.2 Linkage Types

The above types of impacts – indirect and induced, can be generated under different relationships between the sector being directly impacted and other goods and services producing sectors. These are called linkages. There are two types of linkages: backward and forward linkages.

Purchases by a sector of various goods needed for its own production is regarded as a backward linkage. In contrast, if a sector sells its goods to another sector for further value-added activities, such relationships are called forward linkages.

SECTION 4.5 SUMMARY

General economic development theory began with the early works detailing Mercantilism and Physiocracy to identify determinants of wealth within nations. Building from this Smith (1776) put forward the theory incorporating factors of competition, specialization, private property, labor division and trade as agents of development. Malthus (1806) and Ricardo (1817) provided details on characteristics of these agents and their contribution to the development process. The innovative entrepreneur was introduced by Schumpeter (1934) as an agent of development. Keynes (1936) identified growth theories, incorporating those agents that provide background for policy approaches to stimulate economic development. Post-Keynesian work of Harrod (1939) and Doomer (1946) detailed production determinates of growth and suggested state involvement to maximize their contributions. Keynesian and post-Keynesian theorist's use of the extension of the basic growth function to incorporate a complete equilibrium analysis was built in Walrus' (1874) general equilibrium theory. Walrus' work extended from Quesnay's original work on the interdependence within economic systems. The framework led to the construction of Leontief's I-O model in which demand-oriented development was to be analysed.

Impact types captured in the analysis (through the development of multipliers) include direct, indirect and induced impacts which are made up of forward and backward linkages. Although the technique has limitations, it was chosen for several reasons that make its use relevant to this study as explained in the next chapter. Chapter 5 defines these reasons and the methodology undertaken in developing these concepts for use in this study.

CHAPTER 5 METHODOLOGY

Chapter 5 presents the details on the methodology used in this study. Section 5.1 presents the reasons for the choice of study model. Section 5.2 includes a description of the selected I-O model (rectangular I-O structure). Section 5.3 presents details of important features of the model. Section 5.4 presents the development of the Saskatchewan Irrigation Impact Analyzer (SIIA)--an economic impact analyzer used for simulating the impacts. This model development included disaggregation of particular sectors relevant to the study, the use of a location coefficient for regionalization, the estimation of an average propensity to consume to close the model with respect to households, and to append an employment model to the I-O model. Details on phases of analysis and the selected economic impact indicators are described in Section 5.5, which also provides estimation details on impact generation. Section 5.6 presents details on the survey used for data collection for local impacts. This is followed in Section 5.7 by a summary of the chapter.

SECTION 5.1 SELECTION OF THE STUDY MODEL

As reported in Chapter 3, due to the limitations of the economic base analysis and income-expenditure models, the I-O model was selected as the most suitable method of impact analysis for this study. This selection was based on the following reasons as suggested by Kulshreshtha and Sobool (2006):

One, The agricultural sector in Saskatchewan is mature and complex; therefore a given sector has relationships with several other sectors. Irrigation development should therefore, affect the economic development of the region through changes in many sectors.

Two, The I-O model is demand-driven. Irrigation development creates increased demand for various goods and services, which can be included in this model.

Three, In addition to the direct benefits of irrigation development, the I-O model is capable of estimating secondary (indirect and induced) impacts. These impacts of irrigation development have been shown to be considerable contributors to economic growth

(Kulshreshtha and Grant, 2003) and therefore, are important to incorporate into any evaluation.

Four, Versatility within the I-O model allows for sector, commodity and regional disaggregation as suited for the objectives of the study; and,

Five, The I-O modelling can be supplemented to include additional socio-economic indicators, such as employment level, in addition to resource requirements or environmental indicators.

The construction of the I-O model is the best avenue when assessing a larger and more mature and complex economy requiring a greater level of details to be incorporated to capture the intricacies of its relationships. In this methodology regionalization of the I-O model is also possible. For these reasons, an I-O model was selected for use in this study.

SECTION 5.2 DEVELOPMENT OF THE STUDY INPUT-OUTPUT MODEL

The construction of the study I-O model began with an initial set of transactions data for the province of Saskatchewan for the year 2011, obtained from Statistics Canada (2011b). These transactions data included input and Use transaction Tables. Greater detail on the specifics of these transaction Tables will be reported in Figure 5.1. The transaction Tables included the Use Table incorporating commodities (detailed in matrix U) as well the primary inputs (detailed in matrix Y), the supply/output Table (V), and the final demand Table for commodities (F) or primary inputs (YI). The cells in the Use Table detail the amount of purchase of each commodity (U) and/or primary inputs (Y) of industries by a goods producing sector. Primary inputs included items, such as wages, taxes and subsidies, among others. The transactions are estimated in basic (producer level prices), expressed in 2011 dollars--summarized into millions of dollars ($Mill) Each element such as (u_{ij}) describes the amount of industry *j*'s use of commodity *i*. The cells in the Make Table detail the amount of production of each industry of each commodity (also known as the Make matrix), which is also described in basic prices in millions of dollars ($Mill). This Make matrix is presented through elements v_{ij}, which describe industry *j*'s production of commodity *i*. Elements in each column of these two matrices (U and V) are called intermediate

demand. The final demand Table (F), as also shown in Figure 5.1, details the purchases of commodities by final demand agents, such as investors, government and trade with respect to commodities (detailed in matrix F) and primary inputs (detailed in matrix YF).

	Commodities 1 2 3 . . . n_c	**Sectors** 1 2 3 . . . n_s	**Final Demand Components**		**Total**
Commodities 1 2 3 . . . n_c		**Matrix U** Purchase of Commodities Inputs by Sectors	**Matrix F** Purchases of Commodities by Final Demand Agents	**Vector *e*** A vector of input use by final demand categories	**Vector q** Total Sales of Commodities
Sectors 1 2 3 . . . n_s	**Matrix V** Production of Commodities Inputs by Sectors				**Vector g** Total Production by Sectors
Primary Inputs		**Matrix Y** Purchase of Primary Inputs by Sector	**Matrix YF** Purchase of Primary Inputs by Final Demand Agents		
Total	**Vector q'** Total Value of Commodity Output	**Vector g'** Total Value of Output of Sectors	**Vector e'** Value of Total Inputs (including primary) of Final Demand Agents		

Source: Statistics Canada (1979)

Figure 5.1: Accounting Framework Schematic Diagram of the Rectangular Input-Output Model

Vector (q) is a vector of total sales of commodities by all sectors and final demand components, which is equivalent to its transpose (q'), the latter showing total value of commodity output. Similarly, the vector of total production by sectors (g) when transposed (g') details the total value of the output for each sector.

The shaded areas in Figure 5.1 identify transactions that are not present in an economy and therefore not included in economic impact analysis. These transactions are not included because commodities and sectors cannot purchase other commodities and sectors, sectors cannot purchase from agents of final demand, and commodities produced are not traded by primary input sectors.

As noted in Chapter 3, the assumption of the square I-O model that each industry produces only one commodity is relaxed in the rectangular model. Here, each industry may produce multiple numbers of commodities. To undertake economic impacts, technical coefficients for the input and Make matrices are estimated. This results in direct input coefficient matrix (B), and the market share matrix (D), respectively.

The market share matrix (D) is an industry by commodity matrix. Each cell in a column of this matrix shows the proportion of total regional output produced by it. Thus, transactions in a column of the supply matrix (V_j) are divided by total output of that commodity (q_j). This can be expressed in matrix notation as shown in Equation 5.1:

$$D = V\hat{q}^{-1} \tag{5.1}$$

Where: D is the industry by commodity matrix, the market share matrix
V is the supply matrix
$\hat{q}^{-1}$ is the column vector of commodity output.

The direct input coefficients matrix (B) is a commodity by industry matrix. Each column (j) in the matrix represents an industry. Various column entries in this presents the amount of each commodity used per dollar of the industry's output. To calculate these elements, transactions in column *j* of the Use Table (U_j) are divided by total output of that industry (g_j), as shown in Equation (5.2).

$$B = U\hat{g}^{-1} \tag{5.2}$$

Where: B is the commodity by industry matrix

U amount of purchase of each commodity, the use table

$\hat{g}^{-1}$ is the total output of the industry

The economic impact analysis is based on the assumptions of constant market share and constant technology. According to the first assumption, an "allocation of commodity production among industries as various industries will preserve their observed share of the market for each domestically produced commodity irrespective of the levels of commodity production" (Statistics Canada, 1979). The assumption disregards any changes that may occur to the mix of commodities in total production regardless of its level. Equation (5.3) is based on this assumption, describing that total production (g) of a commodity equals total sales at a rate described in the market share matrix (D). Furthermore, this relationship remains constant—irrespective of any changes to commodity sales (q).

$$g = Dq \tag{5.3}$$

Where: g is sector production

D is the market share matrix

q is commodity output

As noted above, in addition to the market share assumption, the model is also based on the assumption of constant industry technology assumption, which is described in Equation (5.4). The assumption states that the "value of input (U_i) for each industry is used in fixed proportions of the value of output (Bg) for the total industry output and therefore independent of the output composition" (Thompson, 2003). Each unit of output is produced using a combination of inputs. This relationship of inputs to output does not change regardless of the level of output of industries. Therefore, the use values of commodity Ui are independent of j and the direct input coefficient matrix values (B) remain, irrespective of any changes to sector production values (g).

$$Ui = Bg \tag{5.4}$$

Where: Ui is sector production

D is the market share matrix

g is commodity output

The rectangular I-O model requires that total supply (q) and disposition (g) of each commodity and each sector must balance since the economic impacts in the region are determined by the level of output domestically produced. However, the supply of a commodity can be procured from other sources, called leakages. In this study three leakages were identified: imports (m), government production (a) and physical change in inventory (v). Equation (5.5) presents these sources of supply and shows the need for the leakages to be netted out, while equations (5.6) through (5.8) show the composition of disposition, which includes use by sectors and final demand agents.

$$q = g + m + a + v \tag{5.5}$$

Where: q is total supply of all commodities

g is disposition of each commodity

m is import leakages

a is government production

v is the physical change in inventory

$$q' = Bg + e \tag{5.6}$$

Where: e is an error component; other symbols as defined above.

$$q + m + a + v = Bg + e \tag{5.7}$$

$$q = Bg + e - m - a - v \tag{5.8}$$

Each of these leakages is related to economic activity within the region, and are expressed in equations (5.9) to (5.11). Use of these leakages require estimation of parameters -- μ, β, and α, using these equations.

$$m = \mu\,(Bg + e) \tag{5.9}$$

.

$$v = \beta\,(Bg + e) \tag{5.10}$$

$$a = \alpha\,(Bg + e) \tag{5.11}$$

Where: μ, β, and α are parameters of estimation, and B, g, and e as defined above.

Using the estimates for μ, β, and α, Equation (5.8) can be rewritten as presented in Equation (5.12), which is rearranged to form Equation (5.13).

$$q = Bg + e - \mu\,(Bg + e) - \alpha\,(Bg + e) - \beta\,(Bg + e) \tag{5.12}$$

$$q = (I - \mu - \alpha - \beta)Bg + (I - \mu - \alpha - \beta)e \tag{5.13}$$

Where: I is the identity matrix; other symbols as defined above.

Substituting Equation (5.13) into Equation (5.14) results in Equation (5.15). These equations reflect all intermediate and final demand transactions to be met by local supply.

$$g = [I - D(I - \mu - \alpha - \beta)B]^{-1}\mathrm{V}[(I - \mu - \alpha - \beta)e] \tag{5.14}$$

Let: $D^* = D(I - \mu - \alpha - \beta)$; and

$e^* = (I - \mu - \alpha - \beta)e$

This results in Equation (5.15), which is used for economic impact estimation resulting from the change in final demand for various commodities. The inverse of matrix (I-D^*) is called the

multiplier matrix. This matrix represents the change in output of an industry resulting from a unit change in demand of its various goods and services.

$$g = (I - D^*)^{-1} De^* \tag{5.15}$$

Equation (5.15) was incorporated in the development of a simulation model, called the Saskatchewan Irrigation Impact Analyzer (SIIA), which is described in Section 5.3.

SECTION 5.3 SALIENT FEATURES OF THE SASKATCHEWAN IRRIGATION IMPACT ANALYZER

The SIIA is a two-region I-O based simulation model of Saskatchewan with major emphasis on irrigation activity. The major features of the model included:

One, The focus of this study was to estimate economic impacts of irrigation development in the province. The Statistics Canada's transactions table was considered to be too restrictive, as this sector was not identified. It only contained a single sector each for agriculture and manufacturing. For this reason, these sectors were further disaggregated. This methodology is presented in Subsection 5.4.1.

Two, Some of the crops under irrigation are forages, which are used to support livestock on these farms. Therefore, irrigation may induce livestock production (notably cattle production). Since the production of crops and livestock have different input requirements, their economic impacts on the region would also be different. The agriculture sector in the model was further sub-divided into irrigation and dryland first, and then into crop and livestock production. Methodology for undertaking this modification is also described in Subsection 5.4.1.

Three, The province of Saskatchewan was divided into two regions: the LDDA, and the Rest-of-Province. These regions were complements to the model for the Province of Saskatchewan. In all three models, a multi-regional I-O framework was used. Total

provincial interregional feedback effects (PFB) were estimated for the province using Equation (5.16)

$$\sum EI_P - \sum EI_{LDDA} - \sum EI_{ROP} = PFB \qquad (5.16)$$

Where: EI_P are the economic impacts of a stimulus on the province of Saskatchewan;

EI_{LDDA} are the economic impacts of a stimulus on the LDDA region; and

EI_{ROP} are the economic impacts of a scenario on the Rest-of-Province region.

More details on the methodology for regionalization are presented in Subsection 5.4.2.

Four, The study model was estimated with and without impacts of households to create Type I and Type II impacts, respectively. In order to endogenize households, knowledge of their consumption pattern is needed. In fact, economic impacts of household spending are related to their propensity to consume — a portion of income average propensity to consume (APC), which is described in Section 5.4.3.

Five, Improvement in employment is an important socio-political indicator. As noted above, the I-O model was appended with an employment model, which is described in Subsection 5.4.4.

Six, The model is designed to remove marketing margins in its analysis. These included: Retail margins, Wholesale margins, Transportation margins, Storage margins, Pipeline margins, Gas margins and Tax margins. Data for these margins were obtained from Statistic Canada (2011a). Their removal resulted in all transactions being measured in producer prices, as opposed to consumer prices.

The SIIA was developed to have the capability of estimating economic impacts, using Equation (5.15), or three regions separately: the LDDA region, the Rest-of-Province of Saskatchewan

region and the Province of Saskatchewan region. The output of the SIIA included Type I and Type II economic impacts of a given development strategy. These impacts can be used to create aggregate multipliers as well as industry level multipliers for a given development strategy.

SECTION 5.4 DEVELOPMENT OF THE SASKATCHEWAN IRRIGATION IMPACT ANALYZER

The initial step in building the SIIA was procuring Statistics Canada's transactions tables for the province of Saskatchewan. These were available only at the small ("S") level of disaggregation. As reported above, these Tables included three sets of Tables: (1) the Make matrix accounting for commodity outputs, (2) the use matrix accounting for commodity inputs, and (3) the final demand matrix of commodities.

As the province of Saskatchewan has few firms for some sectors, data for several cells in the transactions tables were blanked out on confidentiality grounds. Such cells were found in all three matrices--the Make, Use or final demand matrix of the transactions tables. To fill these cells, estimates were made. A row called residual commodities were added to these matrices. No adjustments were made in the confidential cells if the discrepancy was less than five percent. This residual commodity was used only when the discrepancy was less than five percent. Adjustments were made using the national I-O matrix data.

The "S" level of the I-O Tables received from Statistics Canada contained 35 sectors as a level of aggregation. This is an alternative to the "L" level which contains a greater amount of sectors-unavailable at the provincial level for confidentiality purposes. As noted above, further disaggregation of agriculture and manufacturing was needed to make the model suitable for the present study. After this disaggregation, the study model included 43 sectors. Table 5.1 presents these sectors along with those in the original Statistics Canada's data.

In the SIIA model, the crop and animal producing sector was disaggregated into an irrigated crop, dryland crop, irrigated animal production and dryland animal production sectors. To estimate forward linked economic impacts of irrigation, the manufacturing sector of the provincial I–O model also needed further disaggregation. It was disaggregated into six

manufacturing sectors: non-food manufacturing, other food manufacturing, animal food manufacturing, grain and oilseed milling, dairy product manufacturing and meat product manufacturing. The more disaggregated sectoral representation created the need for a more disaggregated set of commodities as well. Irrigated crops and livestock, and dryland crops and livestock products were added to the original list of commodities. List of study sectors is shown in Table 5.1. The adjustment to the commodity classification changed the original 66 intermediate goods and 8 primary goods in the Statistics Canada I-O Tables to 68 intermediate goods and 4 primary goods in the study model as listed in, Table 5.2, for intermediate commodities and in Table 5.3 for primary goods.

Table 5.1: Sector Disaggregation of the Statistics Canada I-O Transactions Table and Study Model.

Statistics Canada I-O Sectors		Study Model Sectors	
1	Crop and animal production	1	Irrigated Crop Production
		2	Dryland Crop Production
		3	Irrigated Animal Production
		4	Dryland Animal Production
2	Forestry and logging	5	Forestry and logging
3	Fishing, hunting and trapping	6	Fishing, hunting and trapping
4	Support activities for agriculture and forestry	7	Support activities for agriculture and forestry
5	Mining, quarrying, and oil and gas extraction	8	Mining, quarrying, and oil and gas extraction
6	Utilities	9	Utilities
7	Residential building construction	10	Residential building construction
8	Non-residential building construction	11	Non-residential building construction
9	Engineering construction	12	Engineering construction
10	Repair construction	13	Repair construction
11	Other activities of the construction industry	14	Other activities of the construction industry
12	Manufacturing	15	Non-Food Manufacturing
		16	Other Food Manufacturing
		17	Animal Food Manufacturing
		18	Grain and Oilseed Milling Manufacturing
		19	Dairy Product Manufacturing
		20	Meat Product Manufacturing
13	Wholesale trade	21	Wholesale trade
14	Retail trade	22	Retail trade
15	Transportation and warehousing	23	Transportation and warehousing
16	Information and cultural industries	24	Information and cultural industries
17	Finance, insurance, real estate, rental and leasing	25	Finance, insurance, real estate, rental and leasing and holding companies
18	Owner occupied dwellings	26	Owner occupied dwellings
19	Professional, scientific and technical services	27	Professional, scientific and technical services
20	Administrative and support	28	Administrative and support, waste management and remediation services
21	Educational services	29	Educational services
22	Health care and social assistance	30	Health care and social assistance

Source: Statistics Canada (2011a)

Table 5.1 (Cont.): Sector Disaggregation of the Statistics Canada I-O Transactions table and Study Model.			
Statistics Canada I-O Sectors		Study Model Sectors	
23	Arts, entertainment and recreation	31	Arts, entertainment and recreation
24	Accommodation and food services	32	Accommodation and food services
25	Other services (except public administration)	33	Other services (except public administration)
26	Repair, maintenance and operating and office supplies	34	Repair, maintenance and operating and office supplies
27	Advertising, promotion, meals, entertainment, and travel	35	Advertising, promotion, meals, entertainment, and travel
28	Transportation margins	36	Transportation margins
29	Non-profit institutions serving households	37	Non-profit institutions serving households
30	Government education services	38	Government education services
31	Government health services	39	Government health services
32	Other federal government services	40	Other federal government services
33	Other provincial and territorial government services	41	Other provincial and territorial government services
34	Other municipal government services	42	Other municipal government services
35	Other aboriginal government services	43	Other aboriginal government services

Source: Statistics Canada (2011a)

Table 5.2: Commodity Disaggregation of the Statistics Canada I-O Transactions Table and Study Model.			
Statistics Canada I-O Commodities		Study Model Commodities	
Intermediate Goods			
1	Grains and other crop products	1	Irrigated grains and other crop products
		2	Dryland grains and other crop products
2	Live animals	3	Live animals produced under irrigated conditions
		4	Live animals produced under dryland conditions
3	Other farm products	5	Other farm products
4	Forestry products and services	6	Forestry products and services
5	Fish and seafood, live, fresh, chilled or frozen	7	Fish and seafood, live, fresh, chilled or frozen
6	Support services related to farming and forestry	8	Support services related to farming and forestry
7	Mineral fuels	9	Mineral fuels
8	Metal ores and concentrates	10	Metal ores and concentrates
9	Non-metallic minerals	11	Non-metallic minerals
10	Mineral support services	12	Mineral support services
11	Mineral and oil and gas exploration	13	Mineral and oil and gas exploration
12	Utilities	14	Utilities
13	Residential construction	15	Residential construction
14	Non-residential buildings	16	Non-residential buildings
15	Engineering construction	17	Engineering construction
16	Repair construction services	18	Repair construction services
17	Food and non-alcoholic beverages	19	Food and non-alcoholic beverages
18	Alcoholic beverages and tobacco products	20	Alcoholic beverages and tobacco products
19	Textile products, clothing, and products of leather and similar	21	Textile products, clothing, and products of leather and similar materials
20	Wood products	22	Wood products
21	Wood pulp, paper and paper products and paper stock	23	Wood pulp, paper and paper products and paper stock
22	Printed products and services	24	Printed products and services
23	Refined petroleum products (except petrochemicals)	25	Refined petroleum products (except petrochemicals)
24	Chemical products	26	Chemical products
26	Non-metallic mineral products	28	Non-metallic mineral products
27	Primary metallic products	29	Primary metallic products
28	Fabricated metallic products	30	Fabricated metallic products
29	Industrial machinery	31	Industrial machinery
30	Computer and electronic products	32	Computer and electronic products
31	Electrical equipment, appliances and components	33	Electrical equipment, appliances and components
32	Transportation equipment	34	Transportation equipment
33	Motor vehicle parts	35	Motor vehicle parts
34	Furniture and related products	36	Furniture and related products

Source: Statistics Canada (2011a)

Table 5.2 (Cont.): Commodity Disaggregation of the Statistics Canada I-O Transactions Table and Study Model.			
Statistics Canada I-O Commodities		Study Model Commodities	
Intermediate Goods (Cont.)			
35	Other manufactured products and custom work	37	Other manufactured products and custom work
36	Wholesale margins and commissions	38	Wholesale margins and commissions
37	Retail margins, sales of used goods and commissions	39	Retail margins, sales of used goods and commissions
38	Transportation and related services	40	Transportation and related services
39	Information and cultural services	41	Information and cultural services
40	Published and recorded media products	42	Published and recorded media products
41	Telecommunications	43	Telecommunications
42	Depository credit intermediation	44	Depository credit intermediation
44	Real estate, rental and leasing and rights.	46	Real estate, rental and leasing and rights to non-financial intangible assets
45	Imputed rental of owner-occupied dwellings	47	Imputed rental of owner-occupied dwellings
46	Professional services (except software and r&d)	48	Professional services (except software and research and development)
47	Software	49	Software
48	Research and development	50	Research and development
49	Administrative support, head office, waste management, remediation.	51	Administrative support, head office, waste management and remediation.
50	Education services	52	Education services
51	Health and social assistance services	53	Health and social assistance services
52	Arts, entertainment and recreation services	54	Arts, entertainment and recreation services
53	Accommodation and food services	55	Accommodation and food services
54	Other services	56	Other services
55	Sales of other services by Non-Profit Institutions Serving Households	57	Sales of other services by Non-Profit Institutions Serving Households
56	Sales of other government services	58	Sales of other government services
57	Fictive materials	59	Fictive materials
58	Fictive services	60	Fictive services
59	Transportation margins	61	Transportation margins
60	Services provided by Non-Profit Institutions Serving Households	62	Services provided by Non-Profit Institutions Serving Households
61	Education services provided by government sector	63	Education services provided by government sector
62	Health services provided by government sector	64	Health services provided by government sector
63	Other federal government services	65	Other federal government services
64	Other provincial and territorial government services	66	Other provincial and territorial government services
65	Other municipal government services	67	Other municipal government services
66	Other aboriginal government services	68	Other aboriginal government services

Source: Statistics Canada (2011a)

Table 5.3: Primary Goods Disaggregation of the Statistics Canada I-O Transaction Table and Study Model.			
Statistics Canada I-O Primary Goods		Study Model Primary Goods	
67	Taxes on products	69	Indirect taxes
68	Taxes on production		
69	Subsidies on products	70	Subsidies
70	Subsidies on production		
71	Wages and salaries	71	Income
72	Supplementary labor income		
73	Gross mixed income		
74	Gross operating surplus	72	Other operating surplus

Source: Statistics Canada (2011a)

The completion of this disaggregation and other components of the model development required several tasks. The sequence in which these tasks were undertaken is described in Subsection 5.4.1 through Subsection 5.4.4

5.4.1 Disaggregation of the Crop and Animal Production and Manufacturing Sectors

The disaggregation of the crop and animal production sector in the Statistics I-O Table required changing the Use, Make, and Final Demand matrices. Both the crop and the animal production were separated out and further disaggregated into irrigated and dryland production. Methodology for this disaggregation was done using several sources and was different for the Use Tables and for the Make matrices.

This disaggregation of the crop and animal production sector into two sectors, representing crops and livestock, was done based on provincial farm cash receipts obtained from Statistics Canada (2011e). A similar approach was used by Kulshreshtha and Sobool (2006). This disaggregation was based on the following three steps:

One, provincial level shares of crop and livestock cash farm receipts were used to divide the Statistics Canada I-O model's total for that sector. Appendix A shows detailed data used to separate total farm cash receipts into crop production and livestock production types. These classifications were appropriated to either livestock or farm crop cash receipts. Once identified as either livestock or crop cash farm receipts they were then summed and the shares of the two categories used in disaggregation. This led to an estimated share of crop production of 83.53% and the remaining 12.47% was determined to be made up of livestock production. These shares were used to develop the disaggregated portions of the output of crop and livestock production sectors. These data were obtained from Statistics Canada (2011e). For livestock production, it was assumed that all livestock types are associated with irrigation as beef cattle farms. This assumption can be justified considering a very small contribution of other livestock types (other than beef cattle) in the province.

Two, to further divide the crop and animal sector into irrigated and dryland agriculture production in Saskatchewan, value of irrigated production was estimated. Dryland production was obtained by subtracting it from the total for crop type. To estimate value of irrigated production, irrigated yields for various crops were obtained, from the

Irrigated Crop Diversification Corporation (Ewen, 2014). These yields for various crops were applied to irrigated area reported in Table 2.4. Data for estimated area, yield, total production and average farm prices of principle crops were obtained from Statistics Canada (2011d), and are shown in Appendix B for the year 2011. Appendix B also shows total dryland area by crop for 2011, and average yield for dryland production, in addition to average farm price/bushel (or tonne).

The disaggregation of total crop production between irrigation and dryland was based on major crops. Due to lack of data on regional area and yields, all crops could not be included. In addition, there were a large number of crop with a very small area. In the final analysis, the crops used in the analysis included barley, canary seed, canola, chickpeas, durum, flax, forage and grass, lentils, mustard seed, oats, peas, potatoes, rye, and wheat (except durum). These crops accounted for just over 85% of 2011 harvested area in Saskatchewan. The estimated value of total crop production was adjusted to ensure that they matched with actual crop cash receipts for each crop. This crop adjustment is perhaps reflective of production that was not sold to the market. Details on this adjustment are presented in Appendix C. These estimates resulted in the share of irrigated crop production of 1.21% of Saskatchewan crop output in 2011, with and the remaining 98.79% was assigned to dryland production.

Three, the livestock sector was separated into those produced under irrigation and those under dryland production methods. This was done using data obtained from a custom run obtained from Statistics Canada (2011c). These data were used to determine the association between cattle production and irrigation. For this purpose, farms with irrigation and cattle were used as the basis for allocation. Details can be found in Appendix D. Because cattle are the primary livestock component of animal production in Saskatchewan, this was used as a proxy to represent all livestock production activities. This data indicated that 2.57% of cattle producing farms reported irrigation while the remaining 97.43% did not participate in any form of irrigation.

The Use matrix for crop and animal production was also disaggregated into various commodities per list in Table 5.2. This disaggregation was based on cost of production (COP) budgets for irrigated and dryland crops. These COP budgets, for selected crops, are presented in Appendix E. Each item of expenditures in the COP budgets (expressed on a per acre basis) were assigned to a specific commodity in Table 5.2. Because of the enormity of crops in the "Other Crops" category, a composite budget could not be estimated. As a proxy, COP budget for "other" irrigated crops were constructed based on production costs of sunflower production and that for dryland crops using rye production. Each of the value of commodities (which at this stage were on a per acre basis) was multiplied by their respective area to obtain total value. Details on this step are provided in Appendix F. Input shares of irrigated cattle and dryland cattle production were based on the same data as in Step Four above.

The manufacturing sector, as defined in Statistic Canada's provincial transaction Tables, also needed to be disaggregated since some of the agricultural commodities enter into manufacturing sector as inputs. For this reason, this sector was disaggregated into six sub-sectors: non-food manufacturing, other food manufacturing, animal food manufacturing, grain and oilseed milling, dairy products manufacturing, and meat products manufacturing. For disaggregation purposes, a two-step procedure was followed. In step one, employment data for Saskatchewan were used to apportion the total value of production of manufacturing into each of these six sub-sectors. Employment data were obtained from Statistics Canada (2011h). Resulting estimates are shown in Table 5.4. According to these estimates, agriculture (food) processing is a relatively small sector, as only 16.8% of all manufacturing activities belong to this sub-sector. Within the agricultural processing sector, meat products manufacturing dominates, with 7.69% of total manufacturing value of production in the province.

Table 5.4: Manufacturing Sector Disaggregation Output Shares by Sub-Sector.	
Non-Food Manufacturing	83.17%
Other-Food Manufacturing	3.22%
Animal Food Manufacturing	1.26%
Grain and Oilseed Milling	3.37%
Dairy Product Manufacturing	1.33%
Meat Product Manufacturing	7.69%

Source: Employment data shares derived from Statistics Canada (2011h.).

In the second step, the production functions for each of the five-agricultural processing sub-sectors were obtained from the national input-output Tables at aggregation level L (Statistics Canada, 2011a). The non-food manufacturing estimates for the Use matrix were estimated as a difference between total manufacturing for the province minus the sum of the remaining five agricultural processing sectors. This operation was done for each commodity.

5.4.2 Regionalization of the Model

There are two approaches to develop a regional I-O model from a larger area I-O model. These are: survey method, and non-survey method. The former method involves primary data collection from firms, households and government agencies on their purchases and sales of various commodities. This method is very labor intensive and costly. An alternative to this method is to use a non-survey method. Such a method is based on location quotient to estimate regional use matrix coefficients for a smaller region relative to that for the larger region (such as the province). The estimation of the location quotient (LQ) is shown in Equation (5.17)

$$LQ_{ij} = (E_{ij} / E_j)/(E_{ip} /E_p) \quad (5.17)$$

Where: LQ_{ij} is the locational quotient of sector (i) in region (j)

E_{ij} is the total employment in sector (i) in region (j)

E_j is the total employment in region (j)

E_{ip} is the total employment in sector (i) in the province (p)

E_p is the total employment in the province (p)

A LQ greater than or equal to one for a sector indicates that a region is self-sufficient in meeting its per unit requirements while a locational quotient less than one (LQ) means that production is not self-sufficient and it must import at least a portion of its total requirements from other regions of the province. In this study, regionalization of the study model was done using the non-

survey method. The province was divided into two sub-regions – LDDA and Rest-of-the-Province. For each of these separate regions transactions tables were developed.

The LDDA region was demarcated in terms of geographical area by overlaying the map of the Saskatchewan census divisions over the map of various irrigation administrative districts. From this a share of each census division that was contained within the irrigation administrative district was estimated. Details are presented in Table 5.5.

Table 5.5: Shares of Census Divisions Appropriated to Each Development Area.

Development Area	Census Division	Share of the Census Division Appropriated to the Development Area
NDA	18	100%
	17	100%
	16	100%
	15	100%
	14	100%
	13	100%
	12	70%
	11	60%
	10	100%
	9	100%
LDDA	12	30%
	7	65%
	6	20%
SWDA	8	100%
	4	100%
	7	30%
	3	60%
SEDA	11	40%
	7	5%
	6	80%
	5	100%
	3	40%
	2	100%
	1	100%

Source: Estimation based on Statistics Canada (2011f) census regions and Saskatchewan provincial irrigation development areas.

Estimation of the LQ was based on 2011 employment levels for Saskatchewan by sector and for various census divisions. These data were obtained from Statistics Canada (2011h). For those census divisions which fall under the LDDA, an assumption of ubiquitous production was made. A complete list of these calculated locational coefficients, by sector, is found in Appendix G.

5.4.3 Estimation of the APC

The average propensity to consume was needed to endogenize household sector activities into the impact analysis. For this purpose, the average propensity to consume (APC) for the province as a whole was estimated as the relationship between household income and expenditures for various commodities. It was estimated using Equation (5.18).

$$APC(2011) = TEXP_H\ (2011) \div TINC_H(2011) \qquad (5.18)$$

Where: $APC\ (2011) =$

The 2011 average propensity to consume

$TEXP_H\ (2011) =$

Goods and service expenditures during 2011 by the households

$TINC_H(2011) =$

Total income of households during the 2011 from all sources

The average propensity to consume for 2011 in Saskatchewan was found to be 0.87. This value can be interpreted as the proportion of a dollar earned by households during 2011 being spent on purchase of various goods and services. Thus, for every dollar earned, Saskatchewan consumers spent 87 cents on household purchases.

5.4.4 Development of a Linked Employment Model

In addition to monetary value of various economic measures, creation of employment is also a widely-used indicator. For this reason, the study I-O model was appended with an employment model. This model generated employment impacts in all regions resulting from a given irrigation development scenario. The employment generated by a given sector was based on its average employment coefficient multiplied by the level of that sector's output. These coefficients were derived as a ratio of sector employment (which were obtained from Statistics Canada (2011f)) by

total sector output (which were obtained from the Statistics Canada (2011b.)). A complete listing of employment coefficients can be found in Appendix H. As sector sales data are not available at a lower spatial level (census division or rural municipality level), the same employment coefficients were assumed for all regions (LDDA and ROP) and the province.

SECTION 5.5 UNDERTAKING IMPACTS OF IRRIGATION

5.5.1 Phases of Development

In this study, the total economic impacts in Saskatchewan of irrigation development were estimated in two separate phases of development. The first phase of development included investment required to undertake irrigation activities at both levels of on-farm and off-farm activities. This phase of activity occurs prior to producers adopting irrigation on their farm unit. These impacts are particular to that time period and typically short-lived.

The second phase of irrigation development included operation of the irrigation infrastructure and use of water for crop and livestock production by producers. This phase can be assumed to exist over the life of the investment, although in this study simulations were done for a 25-year period. However, in reality such impacts would last over a longer period of time.

5.5.2 Economic Impact Indicators

In this study, all economic impacts were expressed with the use of four economic indicators: total sales (output), gross domestic product at market prices, household incomes, and employment level. The SIIA generated results by sectors for the region of impact selected. These were further aggregated to the provincial or regional level impacts.

5.5.3 Collection of Data for Community Level Impacts

One of the objectives of the study was to assess the economic impact of irrigation development at a local regional (community) level. To meet this objective, a survey of irrigation and dryland producers was undertaken. These data were collected through an interview process during the

December 2015 SIPA Annual Conference. A questionnaire was developed which is shown in Appendix I. The questionnaire asked the producers their spending habits both for the business part as well as for the family expenditures. Further details on the survey are provided in Chapter 8.

5.5.4 Scenario Analysis

The study included a total of three scenarios, each consisting of investment and operational spending at the on-farm and off-farm level, as well as production of goods through irrigation. These scenarios were:

Scenario One, An analysis of total economic impacts of existing level of irrigation;

Scenario Two, An analysis of total economic impacts of expanded irrigation through infill irrigation development and;

Scenario Three, A regional level analysis of irrigation impacts created by hypothetical replacement of irrigated production by dryland production in the LDDA.

The steps in Section 5.5 are visually constructed in Figure 5.2.

SECTION 5.6 SUMMARY

This Chapter provided details on the methodology of the construction of the I-O model and its use in the study. The mechanics of the model construction began with the transactions tables obtained from Statistics Canada. Because of a lack of details on irrigation activity, crop and animal production sector was divided into irrigated and dryland production, further broken down into crop and livestock production. Similar disaggregation was also done for the manufacturing sector which was sub-divided into six sectors. These transactions tables, along with other relevant data were used to develop an economic impact analysis module.

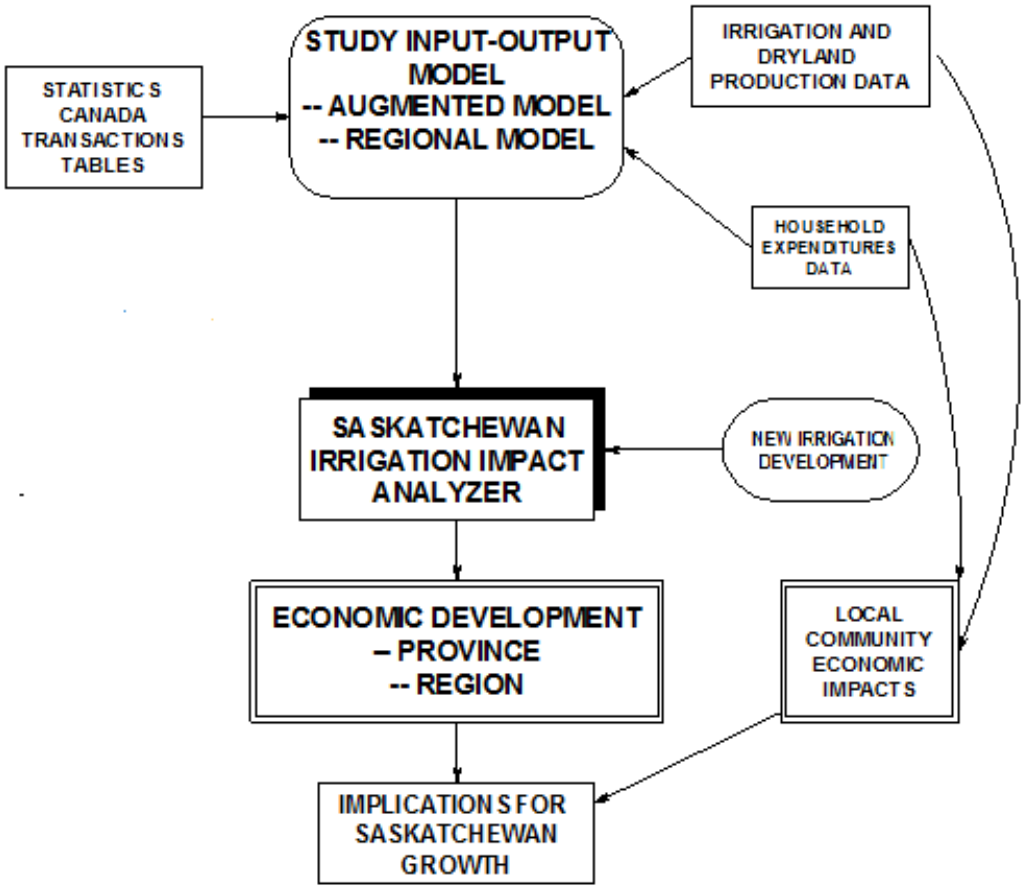


Figure 5.2: Overview of Methodology

For each scenario, direct economic activities impacts were estimated by model commodities. These included commodities purchased for investment as well as operational phases of development each for the on-farm and off-farm direct impacts. Direct impacts also included employment created by a given scenario.

The direct economic impacts and employment contributions were inputted into the SIIA. Since these purchases are typically in purchasers' prices, and may include imports, both imports and margins were removed. The SIIA estimated both Type I and Type II economic impacts by sector for a given region, and for the four indicators noted above.

CHAPTER 6 TOTAL ECONOMIC IMPACTS OF IRRIGATION DEVELOPMENT BETWEEN 2011-2016

This chapter presents total economic impacts of irrigation development in Saskatchewan that took place between 2011 and 2016. Irrigation infrastructure development during this time was limited to infill type development in the LDDA. Such development took place in the SSRID, the Luck Lake Irrigation District (LLID), and the Riverhurst Irrigation District (RID). Infill type development is an extension of existing infrastructure.

This chapter is structured as follows: details on the irrigation infill development potential in Saskatchewan is provided in Section 6.1. Section 6.2 provides the total economic impacts of off-farm infrastructure investment that took place between 2011 and 2016. Section 6.3 presents the total economic impacts of on-farm irrigation infrastructure investment of the developed acres, followed by, Section 6.4 which provides the results of the total economic impacts of on-farm irrigated crop and livestock production of the developed irrigated area during the 2011-2016 period. Section 6.5 is a summary of the chapter.

SECTION 6.1 IRRIGATION INFILL DEVELOPMENT POTENTIAL IN SASKATCHEWAN

Given the availability of water and suitability of soil in Saskatchewan. Saskatchewan has a large potential for irrigation expansion. Some of this expansion is through several new irrigation infill projects. Three areas of infill potential have been identified in Saskatchewan as offering further irrigation development potential in Saskatchewan (Clifton and Associates, 2008a). These areas include: The South Saskatchewan River Irrigation District (SSRID), the Luck Lake Irrigation District (LLID) and the Riverhurst Irrigation District (RID).

Existing areas that have been identified as suitable for expansion include areas both north and south of the existing irrigated area within the district of the SSRID. The SSRID project details identified the primary source of water as coming from Lake Diefenbaker (Clifton and Associates, 2008a) in addition to some from the South Saskatchewan River. The proposed expansion of this

project was of 28,000 acres[7]. The project costs of the proposed expansion were estimated at $61.59 million, in 2007 dollars (Clifton and Associates, 2008a).

West of Lake Diefenbaker is the Luck Lake Irrigation District. Costs for this expansion were estimated at $27 million (in 2007 dollars), resulting in 9,400 acres of additional irrigated area[8]. The project cosnists of three stages of infill and development in different parts of the district and in a fourth stage of an expansion of a pump station and some remaining areas.

Irrigation development in the Riverhurst irrigation district includes a proposal of infill leading to expansion of irrigated area by an additional 10,000 acres, divided between the north and the south of the district. The area can support up to an additional 17,000 acres of irrigation expansion without requiring an increase in pumping capability (Clifton and Associates, 2008a). Drawing on water from Lake Diefenbaker primarily, the project has been estimated to cost $40 million dollars and best suited to be undertaken over several phases. The first phase of infill development would increase irrigated area by 1,800 acres in the north and 2,000 acres in the south. Phase two is proposed to provide additional infrastructure to twin the pipeline into the north of the region. This would allow additional pumping capacity for further expansion in the northern part of the district. Phase three requires a twinning of the pipeline into the south which leads into stage four requiring further pump station development [9].

SECTION 6.2 OFF-FARM IRRIGATION INFILL INFRASTRUCTURE INVESTMENT IN SASKATCHEWAN DURING 2011-2016

Although there is potential for more then 50,000 acres of irrigation infill expansion in the three districts (SSRID, Luck Lake and the Riverhurst), only 8,472 acres have been developed during 2011-2016 (Lowen, 2017). Table 6.1 details the breakdown of funding and developed acres in each year during this period. Of the total, 90% of the funding was provided by the federal

[7] Further discussion on the project can be found in A Time to Irrigate (Clifton and Associates, 2008a. p.42).

[8] Further discussion on the project can be found in A Time to Irrigate (Clifton and Associates, 2008a. p.45).

[9] Further discussion on the project can be found in A Time to Irrigate (Clifton and Associates, 2008a. p.48).

government, while the remaining 10% was contibuted by the various irrigation districts. In total $26.54 million was spent over the time-period through federal government and irrigation districts leading to an expansion of 8,472 acres.

Table 6.1: Irrigation Infill Development Cost in Saskatchewan. By Source. 2011-2016.				
Year	Irrigated Acres Added	Funding Amount by Source, in $Mill.		
		Federal Funding	Irrigation Districts	Total
2011	843	$0.08	$0.01	$0.09
2012	3,769	$12.71	$1.27	$13.98
2013	1,000	$1.94	$0.19	$2.14
2014	1,258	$3.69	$0.37	$4.06
2015	1,248	$3.91	$0.39	$4.30
2016	354	$1.80	$0.18	$1.95
Total	8,472	$24.13	$2.41	$26.54

Source: Loewen, E. (2017)

In order to estimate indirect and induced economic impacts of this investment, data were needed on the manner this money was spent. Based on information provided by Loewen (2017), 70% of this funding was spent on water supply construction, which included electrical infrastructure, pumps, pipelines, turnouts and stilling wells. The remaining 30% of the funding was used for irrigation drainage development, which included ditching and additional pipeline. Table 6.2 presents the breakdown of each item's share of the total spending[10].

Table 6.2: Breakdown of Off-farm Irrigation Infill Development Funding.	
Water Supply Construction (70% of Total Spending)	
Water Supply Construction Spending by Item (% of Total Water Supply Construction)	
Electrical Infrastructure	16%
Pumps	19%
Pipelines	55%
Turnout	5%
Stilling Wells	5%
Irrigation Drainage Spending (30% of Total Spending) by Item	
Irrigation Drainage Spending by Item (% of Total Irrigation Drainage)	
Ditches	80%
Pipelines	20%

Source: Loewen, E. (2017)

[10] Details on these shares were provided though personal communications with Zimmatic Technicians in Outlook Saskatchewan (Dec., 2014) as well as through details provided by Ed Loewen, Irrigation Technologist with the Government of Saskatchewan Crops and Irrigation Branch at the Ministry of Agriculture (March 2017).

Each of these items, except the pipeline, was sourced in Saskatchewan (Lowen, 2017). Most distributors of irrigation goods and services can be found in the town of Outlook, as detailed in Section 2.5.2. Based on the total expenditure of $26.54 million to develop the 8,472 acres, the per acre cost is $3,132.67. The breakdown of this per acre cost is shown in Table 6.3.

With the exclusion of the pipeline purchases, the per acre development cost incurred in the LDDA was $1,926.59 or $16.32 million in 2011 dollars. Thus the direct sales of various goods and services producing sectors increased by $14.73 million on account of this development in output (sales), while the remaining $11.81 million was imported in the form of pipline purchases from outside Saskatchewan.

Total economic impacts of the scenario was estimated using the SIIA. Since the expenditures noted above were in consumer dollars and measured in terms of total purchases (local and non-local) for all commodities, these are netted out to reflect local purchases in producers' pricesonly.

Table 6.3: Breakdown of Off-farm Irrigation Infill Development Funding. Per Category and Per Acre. 2011 dollars.

		Total of Item (in $Mill)	Per Acre
Water Supply Construction (70% of Total Spending)		$18.58	$2,192.87
Water Supply Construction Spending by Item (% of Total Water Supply Construction)			
Electrical Infrastructure	16%	$2.97	$350.86
Pumps	19%	$3.53	$416.65
Pipelines	55%	$10.22	$1,206.08
Turnout	5%	$.93	$109.64
Stilling Wells	5%	$.93	$109.64
Irrigation Drainage Spending (30% of Total Spending) by Item		$7.96	$939.80
Irrigation Drainage Spending by Item (% of Total Irrigation Drainage)			
Ditches	80%	$6.37	$751.84
Pipelines	20%	$1.59	$187.96
Total Per Acre Cost of Development, Including Both Water Supply Construction and Irrigation Drainage Spending			$3,132.67

The spending information provided by Loewen (2017) (detailed in Table 6.2) are produced by sectors which result in direct employment impacts. These impacts were estimated for each sector by multiplying the spending by the sectors employment coefficient. Information was not

available, however, on what share of this spending in each sector was used as wages in the production of the item. This labor paid makes up the direct household income impact of the spending. This was estimated based on the average wage by sector in Saskatchewan (Statistics Canada, 2011k). These average wages were multiplied by the calculated direct employment impacts per sector.

Total economic impacts for the LDDA estimated by the SIIA model are presented in Table 6.4 and for the province as a whole in Table 6.5. The results show that the direct impacts on Saskatchewan of the off-farm irrigation infrastructure investment of $26.54 million resulted in a direct employment impact of 56 full-time equivalent (FTE) workers. Since these expenditures are spread over six years, on an annual basis it would mean that 9.3 workers were directly employed by this activity.

Table 6.4 Total Economic Impacts of Off-farm Irrigation Infrastructure Investment for the LDDA. 2011-2016.

Impact Type	In $Mill. 2011 dollars.			Employment (#FTE)
	Output (Sales)	GDP Market Prices	Household Income	
Direct Impacts	$26.54	$1.76	$1.57	56
Indirect Impacts	$9.36	$5.42	$3.78	51
Induced Impacts	$1.49	$0.84	$0.55	12
Total Impacts	$37.39	$8.02	$5.90	119

Table 6.5 Total Economic Impacts of Off-farm Irrigation Infrastructure Investment for Saskatchewan. 2011-2016.

Impact Type	In $Mill. 2011 dollars.			Employment (#FTE)
	Output (Sales)	GDP Market Prices	Household Income	
Direct Impacts	$26.54	$1.76	$1.57	56
Indirect Impacts	$11.37	$6.50	$4.16	110
Induced Impacts	$4.34	$2.60	$1.75	59
Total Impacts	$42.26	$10.85	$7.48	225

The indirect impacts, at the provincial level, of the output of various sectors resulting from off-farm irrigation infrastructure investment amounted to $11.37 million, with a corresponding impact of $6.50 million in GDP gains, $4.16 million in contribution to household incomes from employment of 110 workers in FTE terms. The induced impacts of off-farm irrigation

infrastructure investment added another $4.34 million in output (sales), $2.60 million in GDP gains, $7.75 million in household income increases and 59 FTE employment to these totals. The total economic impacts of output (sales) are therefore then $42.26 million result in $10.85 million in GDP gains, which incorporates $7.48 million in household income contributions generated from 225 FTE years of employment.

The direct impacts are the largest share of total economic impacts due to the nature of the spending which is predominately based on construction and engineering services. These industries rely relatively more on imports, thereby reducing indirect impacts. There is a considerable import component as the PVC pipes are not produced in Saskatchewan. This results in the outsourcing of indirect and induced impacts.

SECTION 6.3 ON-FARM INVESTMENT ON DEVELOPED IRRIGATION ACRES BETWEEN 2011-2016 IN SASKATCHEWAN

As noted earlier, 2011-2016 off-farm investment resulted in an additional 8,472 acres under irrigation. These areas were reported to be under active irrigated production (Loewen, 2017). These farms then needed to invest in on-farm irrigation equipment and machinery to make irrigated production a reality on the farm. These investments included equipment to obtain water from a public location to separate field locations, expenses incurred to purchase equipment and machinery needed to distribute that water to crop production, as well as accessing the electrical grid for pumping purposes. For the production of some crops, not typically grown under dryland production, this also required purchase of specialized machinery and equipment. Direct impacts of these investments were estimated based on replacement values at 2011 prices.

Itemized budgets for on-farm irrigation infrastructure investment were obtained from an update produced by the Saskatchewan Ministry of Agriculture's Irrigation Branch (Ewen, 2014) and supplemented through personal communication regarding industry specifics from Zimmatic Ltd. technical representatives (Zimmatic Technician, 2014). Only pivot irrigation area was developed in the expansion (Loewen, 2017). All irrigated areas were assumed to be under pivot irrigation at a capacity of 133 acres per system. Total per acre capital expenses for sprinkler irrigation

development are presented in Table 6.6. These estimates show that to develop of on-farm sprinkler irrigation costs $1,209.65 per acre in 2011 dollars.

The total direct costs of the on-farm irrigation infrastructure, needed for the 8,472 irrigated acres in the LDDA in 2011 dollars, were estimated at $10.25 million. This value represents direct impacts of this phase of irrigation development. This total cost was further disaggregated by major commodities. All pivots were manufactured outside of Canada, and thus imported from international sources. The pipes were also imported inter-provincially. The remaining items (electrical infrastructure and wire, pumps, intake wells and screens and installation) were supplied from distributors in the town of Outlook (Loewen, 2017). The irrigation certificates were supplied by the provincial government.

Table 6.6. On-Farm Sprinkler Irrigation Budget. 2011 Dollars.

Item	Total Cost of Item to Develop 133 Acres	Cost	
		Total of Item Spent to Develop 8,472 Acres (in $Mill)	Per Acre
Irrigation Certification	$1,300.00	$0.08	$9.77
Pump	$6,007.61	$0.38	$45.17
Electrical Infrastructure to Field	$5,076.61	$0.32	$38.17
Pipe and Wire	$17,000.00	$1.08	$127.82
Intake Well/Screen	$1,500.00	$0.10	$11.28
Pivot	$130,000.00	$8.28	$977.44
Total	**$160,884.00**	**$10.25**	**$1,209.65**

Source: Ewen (2014) and Zimmartic Technician (2014).

The direct employment was estimated by assigning all these purchases as ‘other manufactured products and custom work’. The employment coefficient of ‘non-food manufacturing’ was used to estimate the direct employment impact, using average income of this sector (Statistics Canada, 2011k). Employment estimation was done using a similar methodology as reported above. The SIIA model was used to estimate the total economic impacts of these direct contributions. The model removed imports and margins for various commodities purchased for this investment. Total economic impacts for the LDDA estimated by the SIIA model are presented in Table 6.7 and for the province as a whole in Table 6.8.

Table 6.7 Total Economic Impacts of On-farm Irrigation Infrastructure Investment for the LDDA. 2011-2016.				
Impact Type	In $Mill. 2011 dollars.			Employment (#FTE)
	Output (Sales)	GDP Market Prices	Household Income	
Direct Impacts	$10.25	$0.93	$0.91	20
Indirect Impacts	$0.32	$1.09	$1.01	22
Induced Impacts	$0.43	$0.24	$0.16	3
Total Impacts	$10.99	$2.26	$2.08	45

Table 6.7 shows that of the $10.25 million in total direct output (sales) generated from on-farm investment on irrigation infrastructure resulted in a total economic impact of $10.99 million in output (sales), $2.26 million GDP gains, $2.08 million in household income increases and created 45 FTE jobs in total. The small amount of indirect and induced impacts results because of the high amount of imported goods used in this phase of development.

Table 6.8 Total Economic Impacts of On-farm Irrigation Infrastructure Investment for Saskatchewan. 2011-2016.				
Phase	In $Mill. 2011 dollars.			Employment (#FTE)
	Output (Sales)	GDP Market Prices	Household Income	
Direct Impacts	$10.25	$0.93	$0.91	20
Indirect Impacts	$0.38	$1.12	$1.03	22
Induced Impacts	$1.15	$0.69	$0.46	12
Total Impacts	$11.77	$2.73	$2.40	55

Table 6.8 shows that in Saskatchewan as a whole, on-farm irrigation infrastructure expenditures resulted in additional 55 jobs in total and $2.40 million in household incomes, $11.77 million in output (sales), which amounted to an increase of GDP by $2.73 million.

SECTION 6.4 ON-FARM IRRIGATED CROP PRODUCTION DURING 2011-2016

Direct economic impacts of irrigating additional area were based on cost of production budgets as reported in Appendix E. These budgets included cost of operating and manaitaining on-farm irrigation infrastructure. In addition, direct impacts of water use for irrigation were also included in these direct impacts. These impacts depend on the crop being irrigated. Analysis was undertaken for the total area thus developed during the period of 2011-2016. In these direct

impacts, the following activities were included: production inputs of irrigated crops; maintenance of on-farm irrigation infrastructure; and production of inputs to support cattle feed production.

Based on this methodology, the total direct impacts of on-farm irrigated crop operation were estimated to be valued at $3.58 million annually for the development that took place during 2011-2016. The share of these direct impacts for the LDDA region was estimated using a survey of producers[11]. Using these survey responses, it was estimated of this total $3.25 million was incurred in the LDDA region, while the remaining $0.33 million was incurred in other parts of Saskatchewan. Direct employment were determined using the employment coefficients as reported. The SIIA removed the international and interprovincial imports as well as margins for various commodities. The results of the analysis of these direct impacts are found in Table 6.9 for the LDDA region and Table 6.10 for the province.

Table 6.9 Total Economic Impacts of On-farm Irrigation Crop Production for the LDDA. 2011-2016.

Impact Type	In $Mill. 2011 dollars.			Employment (#FTE)
	Output (Sales)	GDP Market Prices	Household Income	
Direct Impacts	$3.25	$0.75	$0.69	10
Indirect Impacts	$1.81	$1.64	$1.12	16
Induced Impacts	$0.45	$0.26	$0.17	4
Total Impacts	$5.51	$2.65	$1.97	30

Table 6.9 shows that the resulting annual direct impacts on output (sales) resulting in GDP at market price contributions and household incomes impacts through employment impacts in the LDDA were, respectively $3.25 million, $0.75 million, $0.69 million and 10 workers (# in FTE basis). Including indirect and induced impacts, the total economic impacts of irrigation farm level crop production amounted to $5.51 million, $2.65 million, $1.97 million and 30 workers (# in FTE basis) for output (sales), GDP market price and household incomes and employment, respectively.

[11] Survey responses were only drawn from producers residing in the LDDA. They were asked about the place of their purchases. It was assumed that these producers are representative of all irrigators in the region. For items included in the budget that were not considered in the survey, the average of the included items was applied.

Table 6.10 Total Economic Impacts of On-farm Irrigation Crop Production for Saskatchewan. 2011-2016.				
Impact Type	In $Mill. 2011 dollars.			Employment (#FTE)
	Output (Sales)	GDP Market Prices	Household Income	
Direct Impacts	$3.58	$0.83	$0.76	10
Indirect Impacts	$2.36	$1.98	$1.30	20
Induced Impacts	$1.40	$0.84	$0.57	15
Total Impacts	$7.34	$3.65	$2.63	45

Resulting direct economic impacts, annually, of irrigated crop production in the province are shown in Table 6.10, which shows that irrigation activities resulted in an increase of output (sales), GDP market price and household income contribution and the number of jobs (in FTE). These values were $3.58 million, $0.83 million, $0.76 million and 10 jobs, respectively. Combining these with indirect and induced impacts, the total economic impacts of on-farm investment for irrigation in the new infill areas were $7.34 million, $3.65 million, $2.63 million and 45, in terms of output (sales), GDP market price and household incomes and employment, respectively.

According to industury representatives an anticipated lifespan of a pivot apparatus is twenty-years (Zimmatic Technicion, 2014). Assuming full production for twenty-years these values is used in this thesis as a conservative estimate. Detailing results in this way would allow the impacts of the three phases of irrigation development (off-farm investment, on-farm investment, and on-farm operations) to become meaningful.

Of the three categories of impacts (off-farm investment, on-farm investment, and on-farm irrigated crop production), on-farm irrigated crop production generates the highest level of indirect and induced impacts. This is due to the lower amount of importation and hiring of local workers, resulting in a higher re-circulation of spending within the community.

SECTION 6.5 SUMMARY

Table 6.11 and 6.12 present the summarized results of analyzing the direct impacts with the SIIA model. Table 6.11 presents the summary of the economic impacts of irrigation infill development during 2011-2016 to the LDDA region, by the three phases of activities, whereas Table 6.12

presents the impacts during the same time frame and project scope to Saskatchewan. The economic impacts of on-farm operation have been compounded to reflect a project lifespan of twenty-years.

Table 6.11: Summary of Total Economic Impacts of Irrigation Infill Development During 2011-2016. LDDA. Assuming a Twenty-Year Project Horizon.				
Impact Type/Economic Indicator	Output (Sales)	GDP	Household Income	#FTE
	In $Mill. 2011 dollars.			Years
Off-farm Capital Investment				
Direct Impact	$26.54	$1.76	$1.57	56
Indirect Impact	$9.36	$5.42	$3.78	51
Induced Impact	$1.49	$0.84	$0.55	12
On-farm Capital Investment				
Direct Impact	$10.25	$0.93	$0.91	20
Indirect Impact	$0.32	$1.09	$1.01	22
Induced Impact	$0.43	$0.24	$0.16	3
On-farm Irrigated Crop Production				
Direct Impact	$65.00	$15.00	$13.80	200
Indirect Impact	$36.20	$32.80	$22.40	320
Induced Impact	$9.00	$5.20	$3.40	80
Total Economic Impacts by Indicator, all Phases				
Direct Impact	$101.79	$17.69	$16.28	276
Indirect Impact	$45.88	$39.31	$27.19	393
Induced Impact	$10.92	$6.28	$4.11	95
Total Economic Impact	$158.59	$63.28	$47.58	764

According to these estimates, the total economic impact of irrigation (through various activities) on the economy of the LDDA were estimated at output (sales) of $158.59 million in terms of sales of various sectors, $63.28 million in terms of provincial GDP, $47.58 million in the form of household incomes to the people, in addition to creating 764 jobs-over the twenty-year project horizon.

Table 6.12, provides similar details for the province. This summary captures the provincial interregional feedback effects (PFB) as well as the impacts incurred outside of the LDDA, well excluding the impacts of imported good.

Table 6.12: Summary of Total Economic Impacts of Irrigation Infill Development During 2011-2016. Saskatchewan. Assuming a Twenty-Year Project Horizon.				
Impact Type/Economic Indicator	Output (Sales)	GDP	Household Income	#FTE
	In $Mill. 2011 dollars.			Years
Off-farm Capital Investment				
Direct Impact	$26.54	$1.76	$1.57	56
Indirect Impact	$11.37	$6.50	$4.16	110
Induced Impact	$4.34	$2.60	$1.75	59
On-farm Capital Investment				
Direct Impact	$10.25	$0.93	$0.91	20
Indirect Impact	$0.38	$1.12	$1.03	22
Induced Impact	$1.15	$0.69	$0.46	12
On-farm Irrigated Crop Production				
Direct Impact	$71.60	$16.60	$15.20	200
Indirect Impact	$47.20	$39.60	$26.00	400
Induced Impact	$28.00	$16.80	$11.40	300
Total Economic Impacts by Indicator, all Phases				
Direct Impact	$108.39	$19.29	$17.68	276
Indirect Impact	$58.95	$47.22	$31.19	532
Induced Impact	$33.49	$20.09	$13.61	371
Total Economic Impact	$200.83	$86.60	$62.48	1,179

Table 6.12 shows that the total economic impacts in Saskatchewan to be estimated as $200.83 million in output (sales), $86.60 million in GDP contributions, $62.48 million in household income impacts as well as providing for 1,179 jobs (#FTE).

Table 6.13: Type I and Type II Ratio Multipliers for LDDA and Saskatchewan of Irrigation Infill Development. 2011-2016.				
LDDA				
Economic Multipliers	Output (Sales)	GDP	Household Income	#FTE
Total Type I Multiplier	1.45	3.22	2.67	2.42
Total Type II Multiplier	1.56	3.58	2.92	2.77
Saskatchewan				
Total Type I Multiplier	1.54	3.45	2.76	2.93
Total Type II Multiplier	1.85	4.49	3.53	4.27

As previously discussed, in Subsection 4.4.1 of this thesis, the Type I multipliers are constructed by summing direct and indirect impacts and expressing them as a ratio of direct impacts while Type II multipliers are direct, indirect and induced impacts expressed as a ration of direct impacts. Table 6.13 summarizes the Type I and Type II multipliers constructed based on impacts detailed in Tables 6.11 and 6.12.

CHAPTER 7 TOTAL ECONOMIC IMPACTS OF EXPANDED IRRIGATION IN SASKATCHEWAN

As noted earlier, available water in Lake Diefenbaker can support irrigation of up to 500,000 acres. Many proposals have been made for expanding current irrigation towards this goal. Some of these have been funded through infill development, which were reported in Chapter 6. Many others are in study stages, with no final decisions made at the time of writing this thesis.

As mentioned earlier, in the LDDA, there is a potential to develop 50,000 acres of irrigation through infills, of which 8,472 has already been developed. An estimate of the total economic impacts of the remaining 32,250 acres of irrigation infill development potential, if they were to be developed, is presented in this chapter. These infill areas are called 'new infill' development in this chapter.

In Section 7.1 the resulting total economic impacts of irrigation in the new infill area are presented. A summary of the chapter is presented in Section 7.2.

7.1 Total Economic Impacts of New Infill Irrigation Development

In order to expand further irrigation through new infill areas, additional expenditures are to be incurred for off-farm investment by government or irrigation districts, on-farm investment expenditures by producers, plus impacts through the use of water for crop and livestock production. Each of these were analyzed separately.

7.1.1 Off-Farm Investment Impacts of Irrigation in New Infill Areas

The off-farm investment cost to establish the infill development during the 2011-2016 period amounted to $3,132.67 per acre of development. It was assumed that the future cost of the new infill in 2011 dollars would remain the same as this value. It should be noted that may underestimate the total cost since typically less expensive investment is undertaken first. The commodity breakdown of this investment was also assumed to be similar with that reported in Chapter 6. As was evident in Chapter 6, only a portion of the total expenditures impacts

Saskatchewan since a portion is leaked out to other regions or to other countries. An example of this type of expenditure is the PVC pipe. All of the total per acre cost is for the PVC pipes, which are imported and therefore do not generate direct impacts. Resulting total impacts are reported in Table 7.1 for the LDDA and in Table 7.2 for Saskatchewan.

Table 7.1 Total Economic Impacts of Off-Farm Irrigation Infrastructure Investment in the LDDA of Remaining Infill Development. 2011.

Phase	In $Mill. 2011 dollars.			Employment (#FTE)
	Output (Sales)	GDP Market Prices	Output (Sales)	
Direct Impacts	$101.05	$6.69	$5.98	212
Indirect Impacts	$35.62	$20.63	$14.38	196
Induced Impacts	$5.66	$3.20	$2.10	46
Total Impacts	$142.32	$30.52	$22.46	453

Table 7.1 shows that the total economic impacts of off-farm investment in developing the new infill potential in the LDDA is $142.32 million in output (sales), $30.52 million in GDP contributions, $22.46 million in household income impacts and 453 FTE employment years.

Table 7.2 Total Economic Impacts of Off-Farm Irrigation Infrastructure Investment in Saskatchewan of Remaining Infill Development. 2011.

Phase	In $Mill. 2011 dollars.			Employment (#FTE) GDP Market Prices
	Output (Sales)	GDP Market Prices	Output (Sales)	
Direct Impacts	$101.05	$6.69	$5.98	212
Indirect Impacts	$43.29	$24.73	$15.82	420
Induced Impacts	$16.54	$9.88	$6.67	223
Total Impacts	$160.88	$41.29	$28.47	855

Table 7.2 shows that the total economic impacts on the provincial economy of off-farm investment in developing the new infill potential in the LDDA is $160.88 million in output (sales), $41.29 million in GDP contributions, $28.47 million in household income impacts and 855 FTE employment years.

7.1.2 On-Farm Investment Impacts of Irrigation Infill Development

Total cost of on-farm investment was also based on per unit cost of development as used in Chapter 6, as no new information was available. Using a per acre cost of $1,209.65 per acre for sprinkler irrigation resulted in a total of $39.01 million for the 32,250 acres. All of the direct impacts are incurred in the LDDA, as detailed in Chapter 6, with the exception of the irrigation licensing which are incurred in other areas of Saskatchewan. Results of this scenario are presented in Table 7.3 for the LDDA region, and in Table 7.4 for Saskatchewan.

Table 7.3 Total Economic Impacts of On-farm Irrigation Infrastructure Investment in the LDDA of Remaining Infill Development. 2011.

Phase	In $Mill. 2011 dollars.			Employment (#FTE)
	Output (Sales)	GDP Market Prices	Phase	
Direct Impacts	$39.01	$3.53	$3.46	77
Indirect Impacts	$1.22	$4.16	$3.86	83
Induced Impacts	$1.62	$0.92	$0.60	13
Total Impacts	$41.85	$8.61	$7.92	173

Table 7.4 Total Economic Impacts of On-farm Irrigation Infrastructure Investment in Saskatchewan of Remaining Infill Development. 2011.

Phase	In $Mill. 2011 dollars.			Employment (#FTE)
	Output (Sales)	GDP Market Prices	Phase	
Direct Impacts	$39.01	$3.53	$3.46	77
Indirect Impacts	$1.44	$4.25	$3.91	84
Induced Impacts	$4.38	$2.61	$1.77	47
Total Impacts	$44.82	$10.40	$9.13	208

Table 7.3 shows that the total economic impact of on-farm irrigation infrastructure investments in Saskatchewan of the remaining infill development acres amounts to $41.85 million in output (sales), $8.61 in GDP contributions, $7.92 in household income impacts and 173 FTE employment years. Table 7.4 shows that the total economic impact of on-farm investment, specifically impacting the region of the LDDA, amounts to $44.82 million in output (sales), $10.40 million in GDP contributions, $9.13 million in household income impacts and 208 FTE employment years.

7.1.3 On-Farm Investment Impacts of Irrigated Crop Production Development

The estimation of the direct impacts of on-farm irrigated crop was also based on the same information as presented in Chapter 6. It was assumed that the current crop mix for the LDDA and the crop production budgets would apply to these new irrigated areas. Although the area would likely develop using a graduated scale of development, the analysis was undertaken for all the area as a single project and a twenty-year project horizon was applied. Table 7.5 details the annual cost, by item, for on-farm investment spending to develop these acres for crop production. Total cost was estimated at $13.63 million, in 2011 dollars.

Table 7.5 Total Economic Impacts of On-farm Irrigation Infrastructure Investment in the LDDA of Remaining Infill Development. In $Mill. 2011 dollars.

Seed	$2.19
Fertilizer	$3.49
Chemical	$1.91
Fuel	$0.88
Property Tax	$0.19
Repairs	$0.76
Irrigation and Water Use	$1.44
Other Utilities	$0.18
Insurance and Other Financing Costs	$1.59
Labor Spending	$1.00
Total Direct Impact	$13.63

Distribution of these items by commodities was obtained in the same way as in Chapter 6. The total direct impacts to the LDDA region when these distributions are applied amount to $12.36 million in direct output (sales) incurred specifically in the LDDA.

The direct employment and household impacts were estimated using the SIIA. The SIIA model removed imports from the direct purchases which were used to estimate the total economic impacts. Results for the LDDA region are presented in Table 7.6, while those for the Province of Saskatchewan in Table 7.7.

Table 7.6 Annual Total Economic Impacts of On-farm Irrigated Crop Production in the LDDA of Remaining Infill Development. In $Mill. 2011 dollars.				
Phase	In $Mill. 2011 dollars.			Employment (#FTE) Output (Sales)
	Output (Sales)	GDP Market Prices	Phase	
Direct Impacts	$12.36	$2.87	$2.62	37
Indirect Impacts	$6.90	$6.26	$4.25	63
Induced Impacts	$1.72	$0.97	$0.64	14
Total Impacts	$20.98	$10.10	$7.51	114

Table 7.6 shows the total economic impacts of the full development of infill potential of 32,250 acres of irrigated production. Development of On-farm irrigated crop production results in total economic impacts of $20.98 million in output (sales), $10.10 million in GDP market contributions, $7.51 million in household income and 114 FTE employment years in the LDDA region.

Table 7.7 Annual Total Economic Impacts of On-farm Irrigated Crop Production in the LDDA of Remaining Infill Development. In $Mill. 2011 dollars.				
Phase	In $Mill. 2011 dollars.			Employment (#FTE) Output (Sales)
	Output (Sales)	GDP Market Prices	Phase	
Direct Impacts	$13.63	$3.18	$2.90	37
Indirect Impacts	$8.98	$7.53	$4.96	75
Induced Impacts	$5.34	$3.19	$2.15	57
Total Impacts	$27.95	$13.90	$10.01	169

Table 7.7 shows the total economic impacts of d the full development of infill potential of 32,250 acres of irrigated production. Development of On-farm irrigated crop production annually results in total economic impacts of $27.95 million in output (sales), $13.90 million in GDP market contributions, $10.01 million in household income and 169 FTE employment years in Saskatchewan. Values in Table 7.5 and 7.6 are an annual total, for each year of production. A project horizon of twenty-years, as in Chapter 6, would compound these values and is included in the summary Section of this Chapter.

7.2 SUMMARY

In summary, the total economic impacts of the expansion of new infill development consisting of 32,250 acres of irrigation is presented in Table 7.8 for LDDA for all the phases of development. In estimation, a 20-year project horizon was assumed.

Table 7.8: Summary of Total Economic Impacts of Irrigation Infill Development During 2011-2016 by Impact Type, LDDA. Assuming a Twenty-Year Project Horizon.				
Impact Type/Economic Indicator	Output (Sales)	GDP	Household Income	#FTE
	In $Mill. 2011 dollars.			Years
Total Direct Impacts, All Phases	$387.48	$67.34	$61.97	1051
Total Indirect Impacts, All Phases	$174.65	$149.64	$103.50	1496
Total Induced Impacts, All Phases	$41.57	$23.91	$15.65	361
Total Economic Impacts, by Indicator	$603.70	$240.89	$181.12	2,908

Table 7.9 shows that the total economic impact over the development of the infill acres and twenty-years of irrigated production is $603.70 million in output (sales), $240.89 in GDP impacts, $181.12 in household impacts and provides 2,908 FTE employment years with the incorporation of twenty years of production (not accounting for inflation). Per acre this would amount to $6,734.88 per acre in impacts of output (sales) in Saskatchewan which would amount to $2,604.96 per acre in impacts to GDP provincially. $1,900.47 per acre in impacts to household income would result annually from the 0.03 in FTE employment impacts per acre, or 30 FTE employment impacts for every 1,000 acres developed.

Table 7.9: Summary of Total Economic Impacts of Irrigation Infill Development During 2011-2016 by Impact Type, Saskatchewan. Assuming a Twenty-Year Project Horizon.				
Impact Type/Economic Indicator	Output (Sales)	GDP	Household Income	#FTE
	In $Mill. 2011 dollars.			Years
Total Direct Impacts, All Phases	$412.66	$73.82	$67.44	1,029
Total Indirect Impacts, All Phases	$224.33	$179.58	$118.93	2,004
Total Induced Impacts, All Phases	$127.72	$76.29	$51.44	1,410
Total Economic Impacts, by Indicator	$764.70	$329.69	$237.80	4,443

The Type I and Type II multipliers is consistent with those presented in Chapter 6 due to the linearity of the input-output model.

CHAPTER 8 REGIONAL LEVEL IMPACT ANALYSIS OF IRRIGATION IN THE LAKE DIEFENBAKER DEVELOPMENT AREA

Irrigation development, in addition to economic impacts as described so far, can have other socio-economic impacts on rural communities / regions. A recent study for southern Alberta irrigation projects, for example, has suggested several non-irrigation benefits from irrigation projects (Paterson Earth and Water Consulting Ltd., 2015). These benefits included: Water available for communities and rural areas, provision of good quality water to industries (thereby resulting in attraction of such industries), forward linkages based economic development, creation of water based recreation, hydropower generation, commercial fishing, flood control habitat development, among others. This type of investigation for the LDDA region is very labor intensive and was considered beyond the scope of this study. This Chapter estimates the marginal economic impacts to the region of the LDDA if the 116,485 acres of irrigation under production in 2011 (Subsection 2.2.2) were to be alternatively farmed under dryland production methods.

This chapter is divided into five Sections. Section 8.1 presents the interrelationship between irrigation and community growth. This is followed by a description of the survey instrument developed for community growth in Section 8.2. Direct change in the income of producers because of irrigation is estimated in Section 8.3. This change is marginal in nature – in other words, it is the change in producer incomes over and above dryland production. In Section 8.4, total (direct and secondary) impacts on the community are reported, followed by a summary of the chapter in Section 8.5.

SECTION 8.1 INTERRELATIONSHIP BETWEEN IRRIGATION AND REGIONAL GROWTH

Without irrigation production, producers will continue farming using dryland methods. Since net returns from irrigation have been found to be higher in this study, and furthermore since business-related purchases for irrigated production are higher than those for dryland farming, they would have some impact on the economy of the region. To estimate these impacts, the following methodology was followed:

One, Gross income of dryland and irrigated production in the LDDA were estimated based on crop prices, yield and crop mix for 2011. The difference between the two values was taken as the additional contribution of irrigation to value of marginal production (output or sales). This amount is spent either on on-farm inputs (farm level spending) or on household goods and services. The marginal change in the total farm level spending was based on the difference between the major commodities (farm inputs) purchased under the two methods of production. For this purpose, cost of production budgets were used. The total farm level spending was deducted from the total value of marginal production to obtain household spending. This amount was also distributed by various commodities using data on household sector in transaction Tables.

Two, Since purchases could be made locally or outside the region, information was needed for location of these purchases. This information was obtained through a survey of irrigators in the region. This survey was undertaken to determine shares of various commodities purchased in the LDDA. Categories not included in the survey were estimated using a mean share for all commodities in the survey.

Three, Total economic impact of the marginal changes brought about by irrigated production in the LDDA region were estimated using the SIIA model. Both Type I and Type II impacts were estimated.

SECTION 8.2 SURVEY OF LOCAL PRODUCERS

A survey of producers in the LDDA region was conducted to determine share of local purchases of selected goods and services. Initially a survey was sent by mail to producers located in the SSRID. As the largest irrigation district within the LDDA, this district was considered a good source of information. Unfortunately, of the 103 questionnaires sent out, only one was returned, making it a response rate of almost one percent. The decision was then made to interview irrigating and dryland producers in person, who were in attendance at the Saskatchewan

Irrigation Project Association (SIPA) Annual Conference. This conference was held in December 2015 at Moose Jaw, Saskatchewan.

8.2.1 Spending Patterns of Producers in the LDDA

Distribution of total value of marginal change in output of irrigation was obtained for four location choices: LDDA, Other areas of Saskatchewan other than the LDDA, Outside of Saskatchewan (excluding LDDA) but within Canada, and Foreign sources. Responses were provided by the primary operator of the farm, as he/she was considered to be the person responsible for most of the management decisions. A complete listing of questions applied in the survey can be found in Appendix I.

8.2.2 Survey Results

Combined responses from mail-in and interview were twenty-seven in total. Of these twenty-three participants used both dryland and irrigation production methods (considered irrigating producers for the purpose of this analysis) and four were only dryland producers. There were no producers in attendance at the conference whose entire operation was conducted under irrigated production. These twenty-seven participants represented 84,650 acres of production and were all located in the LDDA region. Approximately 85% of this total area was under dryland production with the other 15% being irrigated.

Table 8.1 presents the share of each farm input or household item that was purchased in each of the four locations. These shares were based on weighted averages of responses, weighted by irrigated acres reported by each producer. The items in Table 8.1 describe four components of farm spending (seed, chemical, fertilizer and fuel) and two categories of household spending (groceries and clothing and footwear). The average in farm spending categories spent in the LDDA by irrigating producer was 90.23%, and the average for household spending in the LDDA by irrigating producers was 84.16%.

Table 8.1: Survey Results of Spending Shares of Producers with Irrigated Acreage in the LDDA				
Share of Total Purchases Made by Location				
Item	LDDA Region	Rest of the Province	Outside SK.	Foreign Purchases
Business Goods and Services				
Seed	91.96%	7.61%	0.43%	0.00%
Chemical	91.61%	8.39%	0.00%	0.00%
Fertilizer	90.17%	9.70%	0.13%	0.00%
Fuel	87.17%	12.61%	0.22%	0.00%
Average*	90.23%			
Household Goods and Services				
Groceries	90.35%	9.00%	0.65%	0.00%
Clothing and Footwear	77.96%	15.45%	6.59%	0.00%
Average*	84.16%			

*Average of all previous categories used for determining shares spent regionally of commodities which were not included in the survey questionnaire.

SECTION 8.3 REGIONAL DIRECT IMPACT ESTIMATION OF IRRIGATION DEVELOPMENT IN THE LDDA AT 2011 LEVELS

8.3.1 Direct Marginal Impact of Irrigation in the LDDA

Based on cost of production budgets, distribution of gross income by I-O commodities were estimated for irrigation and dryland production separately. The difference between the values for each commodity was the marginal contibution of irrigation in the region. As mentioned earlier, to determine the direct impacts of irrigation at the regional level, the 2011 level of 116,485 acres in the region of the LDDA was used.

In 2011, total regional irrigated production generated a total revenue of $126.23 million. Had the same amount of land been put into dryland production revenues would have amounted to only $32.40 million. The difference between the two values is a result of using irrigation technology resulting in a different crop mix, and yields. Details on this calculation are presented in Table 8.2. The difference in output between the two types of production is estimated at $93.83 million with $27.53 million of this on farm input spending and the remaining attributed to household spending.

Table 8.2: Details of Income Expenditure Estimates of Production in the LDDA. By Crop and Production Method. 2011.								
Production Method	**Irrigated Production**				**Dryland Production**			
Crop	Area (Acres)	Price	Yield	Total Value (in $Mill)	Production Area (Acres)	Price	Yield	Total Value (in $Mill)
Barley	6,989	$5.45	100 bu./ac	$3.81	7,292	$5.45	53 bu./ac	$2.11
Canola	44,730	$11.00	75 bu./ac	$36.90	35,784	$11.00	30 bu./ac	$11.81
Flax	8,154	$14.00	55 bu./ac	$6.28	1,771	$14.00	21 bu./ac	$0.52
Alfalfa and Mixed Hay	10,717	$85.00	2.5 t./ac	$2.28	15,562	$85.00	1.25 t./ac.	$1.65
Lentils	582	$16.80	60 lbs./ac	$0.59	8,270	$16.80	21 lbs./ac	$2.92
Oats	582	$3.12	135 bu./ac	$0.25	4,706	$3.12	44 bu./ac	$0.65
Field Peas	4,543	$6.50	85 bu./ac	$2.51	5,696	$6.50	36 bu./ac	$1.33
Wheat, Except Durum	25,394	$7.44	90 bu./ac	$17.00	25,743	$7.44	45 bu./ac	$8.62
Potato	8,037	$640.00	10.3 t./ac	$52.98	0	$640.00	0	$0.00
Durum	6,756	$6.32	85 bu./ac	$3.63	11,660	$6.32	38 bu./ac	$2.80
Total	116,485			$126.23	116,485			$32.40

Of the difference of $93.83 million, $27.53 million, is accounted for as farm input spending for irrigating the 116,485 acres. These values are presented in Table 8.3 as categories of farm input spending. These amounts were determined using the crop production budgets constructed for the earlier analysis. The remaining $66.30 million is classified as household spending.

Table 8.3: Marginal Difference in Farm Input Spending with Irrigated Production. In $Mill.	
Seed	$5.15
Fertilizer	$7.28
Chemical	$2.64
Fuel	$1.64
Repairs	$1.70
Irrigation and Water Use	$1.80
Other Utilitites	$2.42
Insurance and Other Financing costs	$2.54
Labor Spending	$2.37
Total Marginal Farm Input Spending Difference	$27.53

As noted in Subsection 5.4.3, the APC, of the time-period has been estimated as 0.87. Considering this, only $57.68 million was used to account for the share of households earnings that were spent in the region. To estimate how this would be spent, data from the provincial transaction Table were obtained. Shares of household consumption by expenditure were used to represent the distribution of additional household spending generated by irrigation. Table 8.4 presents the shares of labor income spent on each commodity.

Since economic impacts are generated by the manner in which the marginal change in revenue are spent, it was necessary to obtain information on goods and services puchased within the LDDA region. Results from the survey questionnaire were used to determine the proportion of total expenditures for each commodity spent regionally (in the LDDA). These shares and their value are presented in Table 8.5 for farm business spending, and Table 8.6, for household spending.

Water use expenses are incurred entirely in the LDDA because the infrusture in the the region supplies the entire irrigated area. The regional share component for the remaining categoreis was determined using the the average of the these four largest components of production spending. The average spent regionally was estimated as 90.23% for these remaining categories.

Estimates in the last column of Table 8.5 were used as the direct impact in the SIIA. Table 8.6 presents the shares of household spending incurred regionally. Again, survey responses were used to determine these values. Commodities that could be classified as either “groceries” or “clothing and footwear” were separated out and their share of LDDA spending were estimated using direct survey responses while for the remaining categories an average of the survey response for household spending was used. This proportion was 84.16%.

Of the $57.68 million in total household spending that occurs due to irrigation (over and above dryland production method), $49.06 million is spent locally. The remaining $8.62 million in household spending is incurred in other regions of Saskatchewan.

Table 8.4: Commodity Distribution of Household Spending. In $Mill.					
Commodity	**Share of Spending**	**Total Spent**	**Commodity**	**Share of Spending**	**Total Spent**
Grains and other crop products	0.59%	$0.34	Industrial machinery	0.28%	$0.16
Live animals	0.25%	$0.14	Computer and electronic products	0.83%	$0.48
Other farm products	0.17%	$0.10	Electrical equipment, appliances and components	0.57%	$0.33
Forestry products and services	0.02%	$0.01	Transportation equipment	4.00%	$2.31
Fish and seafood, live, fresh, chilled or frozen	0.02%	$0.01	Motor vehicle parts	0.40%	$0.23
Support services related to farming and forestry	0.00%	$0.00	Furniture and related products	0.58%	$0.34
Mineral fuels	0.43%	$0.25	Other manufactured products and custom work	1.30%	$0.75
Metal ores and concentrates	0.00%	$0.00	Wholesale margins and commissions	4.16%	$2.40
Non-metallic minerals	0.01%	$0.00	Retail margins, sales of used goods and commissions	11.65%	$6.72
Mineral support services	0.00%	$0.00	Transportation and related services	1.31%	$0.76
Mineral and oil and gas exploration	0.00%	$0.00	Information and cultural services	0.14%	$0.08
Utilities	2.45%	$1.41	Published and recorded media products	0.47%	$0.27
Residential construction	0.00%	$0.00	Telecommunications	2.97%	$1.71
Non-residential buildings	0.00%	$0.00	Depository credit intermediation	3.44%	$1.99
Engineering construction	0.00%	$0.00	Other finance and insurance	4.16%	$2.40
Repair construction services	0.04%	$0.02	Real estate, rental and leasing and rights to non-financial intangible assets	4.60%	$2.65
Food and non-alcoholic beverages	5.26%	$3.03	Imputed rental of owner-occupied dwellings	16.93%	$9.77
Alcoholic beverages and tobacco products	0.60%	$0.35	Professional services (except software and research and development)	0.46%	$0.27
Textile products, clothing, and products of leather and similar materials	1.71%	$0.99	Software	0.01%	$0.01
Wood products	0.03%	$0.02	Research and development	0.00%	$0.00
Wood pulp, paper and paper products and paper stock	0.31%	$0.18	Administrative and support, head office, waste management and remediation services	0.28%	$0.16
Printed products and services	0.04%	$0.02	Education services	0.92%	$0.53
Refined petroleum products (except petrochemicals)	2.85%	$1.64	Health and social assistance services	2.90%	$1.67
Chemical products	1.51%	$0.87	Arts, entertainment and recreation services	2.25%	$1.30
Plastic and rubber products	0.36%	$0.21	Accommodation and food services	5.84%	$3.37
Non-metallic mineral products	0.13%	$0.07	Other services	2.67%	$1.54
Primary metallic products	0.02%	$0.01	Sales of other services by Non-Profit Institutions Serving Households	0.15%	$0.08
Fabricated metallic products	0.21%	$0.12	Sales of other government services	0.31%	$0.18

Table 8.5: Share of Farm Purchases of Farm Inputs by Irrigators Spent within the LDDA.			
Item	Total Irrigator Spending of Production Inputs (in $Mill)	Share of Spending by Irrigators in the LDDA for Each Category[12]	Total Direct Impacts of Each Category in the LDDA from Irrigated Production (in $Mill)
Seed	$5.15	91.96%	$4.73
Fertilizer	$7.27	91.17%	$6.63
Chemical	$2.64	90.61%	$2.39
Fuel	$1.64	87.17%	$1.43
Repair Expenses	$1.70	90.23%	$1.53
Irrigation and Water Use Expenses	$1.80	100%	$1.80
Other Utility Expenses	$2.42	0%	$0.00
Insurances and Other Financing Costs	$2.54	90.23%	$2.29
Labor Spending	$2.37	90.23%	$2.14
Total	$27.53		$22.94

Table 8.6: Share of Farm Purchases of Household Spending by Irrigators Spent within the LDDA.			
Item	Share of Spending by Irrigators in LDDA for Each Category[13]	Total Spending of Category by Irrigators (in $Mill)	Total Direct Impacts of each Category of Household Spending in LDDA from Irrigated Production (in $Mill)
Groceries	90.35%	$10.11	$9.13
Clothing and Footwear	77.96%	$1.73	$1.35
All Other Household Spending	84.16%	$45.84	$38.58
Total		$57.68	$49.06

[12] These shares are based on survey results. Commodities that were not included in the survey were determined using the average of 90.23%.

[13] These shares are based on survey results. Commodities that were not included in the survey were determined using the average of 84.16%.

SECTION 8.4 TOTAL REGIONAL ECONOMIC IMPACT OF IRRIGATED PRODUCTION ON THE LDDA

The total direct impacts from additonal purchases of farm inputs within the LDDA on account of irrigated production were previously estimated at $22.94 million. Similarily the additional $49.06 million spent by the households in the region would also create additional direct impacts. Their spending of $72 million (considering both farm input and household spending) in the region would also bringforth output (sales) as well as additional income. The direct employment created by these expenditutes were estimated using labor wage by sector. The total economic impacts of these changes were analysed using the SIIA model, taking into account imports and commodity margins. The household spending was estimated using the SIIA model as a separate scenaro from the farm input spending scenario. Resulting impacts to the LDDA are presented in Table 8.7 for farm input spending and for household income spending.

Table 8.7: Total Economic Impacts in the LDDA Region from Irrigated Production. 2011.

Impact Type	**Total Economic Impacts of Farm Input Spending. In $Mill.**			Employment (#FTE)
	Output (Sales)	GDP Market Prices	Household Income	
Direct Impact	$22.94	$5.71	$5.29	59
Indirect Impacts	$12.46	$11.62	$8.13	113
Induced Impacts	$3.30	$1.87	$1.23	27
Total Impacts	$38.70	$19.20	$14.65	199
	Total Economic Impacts of Household Spending. In $Mill.			
Direct Impact	$49.06	$21.51	$16.89	448
Indirect Impacts	$19.10	$32.28	$23.59	597
Induced Impacts	$9.67	$5.47	$3.59	78
Total Impacts	$77.83	$59.27	$44.07	1,124
	Total Economic Impacts, Both Categories. In $Mill.			
Direct Impact	$72.00	$27.22	$22.18	507
Indirect Impacts	$31.56	$43.90	$31.72	710
Induced Impacts	$12.97	$7.34	$4.82	105
Total Impacts	$116.53	$78.47	$58.72	1,323

Since the two types of spendings are mutually exclusuve, they can be added together. Irrigation directly adds to the economy of the LDDA $72.00 million in ouput sales, $27.22 million in GDP contributions at market prices, $22.18 million in household income and creates 507 full-time employment positions annually. When indirect and induced impacts are included the total economic impacts of the irrigated land in the LDDA regionincreases to $116.53 million in terms of output, which includes $78.47 million as GDP, as well as $50.26 million household income. These incomes are generated through employment creation – some 1,323 full-time employment positions in the region are as aresult of irrigation development annually.

Figure 8.1 presents the distribution of total economic impact of various indicators, by impact type, for the development of irrigation in the LDDA. Each impact type is expressed as a percent of the total impact.

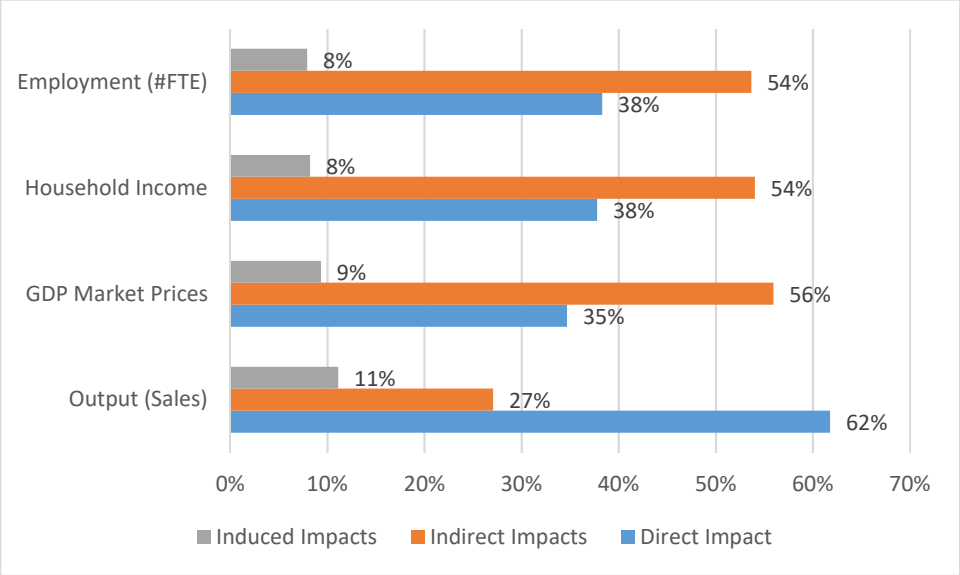


Figure 8.1: Distribution of Total Economic Impact by Indicators and Impact Type, Irrigation Development in the LDDA, by Impact Type. 2011

SECTION 8.5 SUMMARY

This Chapter estimated the economic impacts of producers irrigating 116,485 acres of land in the LDDA during 2011. Impacts are over and above those from dryland production on the same amount of land. Both farm level (inputs) and household income spending patterns were

estimated. Survey results were used to estimate purchases within the LDDA. This amounted to an additional $22.94 million in farm spending and $49.06 million in household spending within the LDDA. These regional expenditures were analyzed using the SIIA model to determine the regional total economic impacts of this production. The analysis determined that from these direct impacts, a total economic impact in output (sales) of $116.53 million, $78.47 in GDP gains and $58.72 million in household income, and 1,323 full-time employment annually is generated. The Type I and Type II multipliers for the LDDA of the marginal contribution of irrigated production in the LDDA is presented in Table 8.8 for each indicator.

Table 8.8: Type I and Type II Ratio Multipliers for the LDDA of the Marginal Contribution of Irrigation in the Region. 2011.

Economic Multipliers	Output (Sales)	GDP	Household Income	#FTE
Total Type I Multiplier	1.44	2.61	2.43	2.40
Total Type II Multiplier	1.62	2.88	2.65	2.61

Table 8.8 presents that for each dollar of direct input to output (sales) of irrigation in the LDDA $1.44 is generated as Type 1 impacts and $1.62 as Type II impacts. This results in GDP contributions of $2.61 in Type I impacts and $2.88 in Type II impacts. It also shows that for each direct number of FTE employment from these output (sales) 2.40 in Type I employment impacts result and 2.61 in Type II employment impacts result. This results in a household income impact of $2.43 in Type I impacts for each $1.00 in direct household income contributions and $2.65 in Type II impacts.

CHAPTER 9 SUMMARY AND CONCLUSIONS

Irrigation has been noted as an avenue for regional economic development as well as a good adaptation to climate change. The province of Saskatchewan has a potential of up to 500,000 acres of irrigation through the development of Lake Diefenbaker. However, up until now only a fraction of it (116,485 acres or 23.3%) has been developed in the LDDA. It was hypothesized that this lack of development might be contributed by a lack of knowledge on irrigation's potential for regional economic development by produces as well as public decision-making bodies. With this objective, this study was undertaken.

Although the province is divided into four administrative areas for water resources, and although irrigation is undertaken in all four areas of the province, the Lake Diefenbaker Development Area (LDDA) has the higher proportion of provincial total irrigated area. In this study more emphasis, therefore was provided to this area.

The major objectives of this study were threefold: First, to estimate the economic impacts of existing levels of irrigation in Saskatchewan and the local (LDDA) region; Second, to estimate the economic impacts of expanded levels of irrigation in Saskatchewan and the local (LDDA) region; and Third, to estimate regional (community) impacts of conversion from dryland farming to irrigation in the entire region of LDDA.

Impacts of irrigation in Saskatchewan (including the LDDA) were estimated for four types of expenditures required for irrigation development. The first type is development of off-farm infrastructure, followed by type two expenditures which includes its operations and maintenance. However, since in this study only infill development was studied, this cost was excluded. Type three expenditures are incurred after off-farm investment has been completed. This stage involves on-farm development of infrastructure for delivery of water to crops. The last type of expenditures involves the actual use of water for crop irrigation, and through that raising of livestock. However, raising of livestock was not included in this study.

Total economic impacts of irrigation development were estimated using an input-output model for the province. In addition, this model was regionalized into two regional models using non-survey methodology. The two regions selected were the LDDA region, and Rest of the Province region. The model included 43 sectors producing 68 commodities. In addition, four primary inputs and several final demand agents were also included in the model. The original model data were obtained from Statistics Canada. Since in this data set, irrigation was not identified as a separate sector, crop and animal production sector was disaggregated into four sub-sectors: (i) Irrigated crop production; (ii) Irrigated livestock production; (iii) Dryland crop production; and (iv) Dryland livestock production. To enable the model to estimate impacts of further agricultural processing, the manufacturing sector was also disaggregated. However, such forward-based linkages and their impacts were not included.

For each type of expenditures in the region (as listed above), direct economic impacts were estimated by model commodities from published and unpublished sources of information. These impacts were used in the Saskatchewan Irrigation Impact Analyzer (SIIA) to estimate total (direct, indirect and induced) economic impact of each type of activity. The model was appended with an employment model capable of generating employment levels for a given set of expenditures. Impacts were measured in terms of four indicators: total output (sales), gross domestic product (GDP), household income, and employment (jobs in full-time equivalent).

SECTION 9.1 KEY FINDINGS

The major findings of this study as related to its various objectives. All reported results are measured in terms of four economic indicators -- output (sales), contributions to GDP at market prices, impacts to household incomes, and employment.

Irrigation development in the LDDA started since the completion of Lake Diefenbaker and its related infrastructure. However, in this study, emphasis was placed on recent and possible future irrigation development. In particular, irrigation development though infills was the focus of this study.

- During the 2011-2016 period, 8,472 irrigated acres were developed. This occurred as a result of infill development, an extension of water uses from the existing irrigation infrastructure. This development included expenditures on only three of the four phases of development (off-farm investment, on-farm investment, and on-farm operation) due to the nature of the development. The total cost of this development was $26.54 million. Of this $21.13 million was provided federally while $2.41 million was the responsibility of various irrigation districts where such infill opportunities existed. The total economic impacts of this development in Saskatchewan over a twenty-year period were estimated to be $200.83 million in output (sales), $86.60 million in GDP impacts, $62.48 million in impacts to household income. Associated with these changes, another 1,179 FTE jobs were estimated to have been created as a result. On a per irrigated acre, this amounts to $1,185.26 in terms of change in annual output (sales) of various industries, generating $511.10 in annual GDP, (which includes $368.74, in annual, value for household income). And for every 1,000 acres of irrigation 7 jobs (#FTE) are sustained over this twenty years of project horizon.

- There are 32,250 acres of irrigation development that has been identified in the LDDA region of Saskatchewan as feasible acres for further irrigation expansion. If these acres were to be developed as a single project, over a twenty-year project horizon this would result in a total economic impact in Saskatchewan of a total of $603.70 million in output (sales) impacts, $240.89 million in GDP impacts, $181.12 million in household income impacts and 2,908 FTE employment positions.

- For assessing the contributions made by irrigation in the LDDA region, comparison was made with a scenario in which no irrigation has been developed. All this area would then be under dryland production method. To estimate these impacts, additional gross revenue was estimated first. This was broken down into two types of expenditures: (i) those for farm input purchases, and (ii) those for household expenditures. In order to estimate impacts on the LDDA, information on the place of purchase of various commodities was needed. This information was obtained through a survey of producers in the region.

Using this methodology, the impact of the total existing 116,485 irrigated acres over and above dryland production methods, totaled $116.53 million in output (sales), $78.47 million in GDP impacts, $58.72 million in household income impacts and created 1,323 FTE jobs. On a per acre basis, this amounted to $1,000.39 in output (sales) impacts, $78.47 in GDP impacts, $58.72 in household income impacts and 0.011 jobs (in FTE basis) annually or 11 jobs per 1000 areas of irrigation).

In Saskatchewan, on account of limiting or highly variable level of moisture, irrigation can be used as a tool for economic stability and regional / community economic growth. There is a potential for further irrigation expansion in Saskatchewan, which can bring forth significant economic impacts. These impacts are not only received but also extend beyond direct impacts. However, such developments are rather capital intensive. Such developments would also help the province to meet its export targets

Demand for crops and their production are expected to increase in the future and Saskatchewan can capitalize on this potential with the use of irrigation offering a source of both provincial level and regional levels of economic development.

SECTION 9.2 LIMITATIONS OF THE STUDY

In order to estimate local area economic impacts of irrigation development, a survey of producers was instituted. This data collection suffered through two problems. The first limitation was that the response rate was very poor with respect to the initial mail survey. A greater response, specific to a local community as opposed to a larger region, which was originally planned was not achieved. This level of depth in detail would have benefited the research. Secondly, once the alternatively administered questionnaires were undertaken there were very few dryland producers were in attendance as it occurred at an irrigation meeting. In order to improve this type of analysis a new survey of both irrigation and dryland producers is needed with extensive response from the local community.

SECTION 9.3 AREAS FOR FURTHER RESEARCH

On account of limited resources, this study did not address all the economic impacts of irrigation development. The following lists these areas:

Further Value-Added Impact Assessment

The analysis in this study was confined to backward linkages of irrigation and only to the potential infill areas. Many other types of impacts, such as those through the forward linkages of irrigation, community (towns) level impacts, and non-irrigation benefits could not be included.

Further research is needed to estimate forward-linked economic impacts of irrigation. This should include irrigation as a contributor to supplying a stable and increased level of production of feed, such as alfalfa and hay, raw material for several food processing industries (notably slaughtering and meat processing) and developing a path for encouraging the development of such value-added industries to Saskatchewan.

Community Level Impacts

In this study, community (town or smaller community) level analysis could not be undertaken. Such information may be deemed important for local community decision makers.

Further Analysis of Expansion Potential

Several potential irrigation expansion projects have been identified but their undertaking is somewhat problematic. Further analysis of such projects would help understand the potential contribution of irrigation to economic development of Saskatchewan.

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APPENDIX A: ANALYSIS OF FARM CASH RECEIPT DATA BY SECTOR. 2011.

Shares of Farm Cash Receipts for agriculture (83.53%) and livestock (16.47%) were used in disaggregation.

Farm Cash Receipts (dollars x 1,000) in Saskatchewan, 2011			
Crop		Livestock	
Wheat, excl. Durum	1,387,537	Cattle	695,287
Durum Wheat	462,916	Calves	289,426
Oats	305,685	Hogs	260,875
Barley	262,578	Sheep	..
Rye	24,245	Lamb's	10,348
Flaxseed	147,126	Dairy Products	169,040
Canola	3,872,259	Hens and Chickens	88,606
Soybeans	..	Turkeys	11,376
Potatoes	39,213	Total Eggs	34,158
Greenhouse Veg	1,267	Wool	
Field Veg	2,349	Honey	26,034
Vegetables		Furs	..
Total Fruit Nuts	189	Mare's urine	..
Floriculture, nursery	24,801	Horses	..
Mustard Seed	57,055	Embryos	..
Sunflower Seeds	..	Hatcheries	104
Lentils	631,975		
Canary Seed	97,708		
Dry Peas	576,943		
Chick Peas	51,511		
Forage and Grass	18,968		
Hay and Clover	21,341		
Forest Products	1,723		
Miscellaneous	50,459		
Ginsing	..		
Christmas Trees	533		
Total Crop Farm Cash Receipts	8,038,381	Total Livestock Farm Cash Receipts	1,585,254
Crop's Share of Total	83.53%	Livestock's Share of Total	16.47%

Source: Statistics (2011e).

APPENDIX B: AREA, YIELD AND PRICE OF MAJOR CROPS IN SASKATCHEWAN. 2011. BY IRRIGATED AND DRYLAND AREA.

Crop	Estimated Area (Acres)				Yield (bu/acre)			Price/bushel
	Irrigation Total	District Irrigation	Private Irrigation	Dryland	District Irrigation	Private Irrigation	Dryland Irrigation	
Barley	13,755	5,709	8,046	2,161,264	100	100	53	$5.45
Canary Seed	0	0	0	275,028	0	0	21	$12.00
Canola	52,713	21,720	30,992	9,847,302	75	75	30	$11.00
Chickpeas	0	0	0	105,020	0	0	60	$15.00
Durum	13,734	5,717	8,017	3,461,304	85	85	38	$6.32
Flax	14,654	6,029	8,625	520,328	55	55	21	$14.00
Forage and Grass Seed	52,299	22,891	29,408	4,608,101	2.45 tonnes	2.45 tonnes	1.25 tonnes	$85.00/ tonne
Lentils	1,843	791	1,052	2,458,087	60	60	21	$16.80
Mustard Seed	0	0	0	265,144	0	0	15	$11.50
Oats	2,241	972	1,269	1,397,856	135	135	44	$3.12
Peas	8,164	3,359	4,805	1,691,671	85	85	36	$6.50
Potatoes	14,445	5,943	8,502	0	10.31 tonnes	10.31 tonnes	0	$640.00/tonne
Rye	0	0	0	129,977	0	0	34	$3.40
Wheat, except Durum	46,830	19,317	27,514	7,638,135	90	90	45	$7.44

Source: Irrigated area based on details provided in Table 2.4. Residual dryland production, average yield price/bushel from Statistics Canada (2011j). Irrigated yield complied from Ewen (2014)

APPENDIX C: ANALYSIS OF PRODUCTION VALUE DETAILS BY IRRIGATED AND DRYLAND PRODUCTION. 2011.

Crop	Estimated Crop Production Value (in $Mill) $((Price * Yield) * Acres)$				Ratio of Estimated to Actual Farm Receipts	Adjusted Production Values (in $Mill)			Total Production Value (in $Mill)
	District Irrigation	Private Irrigation	Dryland Production	Total Production Value		District Irrigation	Private Irrigation	Dryland Production	
Barley	$3.11	$4.39	$624.28	$631.78	0.46	$1.44	$2.04	$289.94	$293.42
Canary Seed	$0.00	$0.00	$69.31	$69.31	1.41	$0.00	$0.00	$97.71	$97.71
Canola	$17.92	$25.57	$3,249.61	$3,293.10	1.18	$21.07	$30.07	$3,821.12	$3,872.26
Chickpeas	$0.00	$0.00	$94.52	$94.52	0.54	$0.00	$0.00	$51.51	$51.51
Durum	$3.07	$4.31	$831.27	$838.64	0.81	$2.49	$3.50	$674.59	$680.58
Flax	$4.64	$6.64	$152.98	$164.26	0.9	$4.16	$5.95	$137.02	$147.13
Forage and Grass Seed	$4.77	$6.12	$489.61	$500.50	0.04	$0.18	$0.23	$18.56	$18.97
Lentils	$0.80	$1.06	$867.21	$869.07	0.73	$0.58	$0.77	$630.63	$631.98
Mustard Seed	$0.00	$0.00	$45.74	$45.74	1.25	$0.00	$0.00	$57.06	$57.06
Oats	$0.41	$0.53	$191.90	$192.84	1.59	$0.65	$0.85	$304.19	$305.69
Peas	$1.86	$2.65	$395.85	$400.36	1.44	$2.67	$3.83	$570.44	$576.94
Potatoes	$39.21	$56.10	$0.00	$95.31	0.41	$16.13	$23.08	$0.00	$39.21
Rye	$0.00	$0.00	$15.03	$15.03	1.61	$0.00	$0.00	$24.25	$24.25
Wheat, except Durum	$12.93	$18.42	$2,557.25	$2,588.61	0.65	$8.45	$12.04	$1,670.94	$1,691.43
Total Adjusted Production Values						Irrigated: $20.49		Dryland: $1,670.94	Total: $1,691.43
Share of Total Production						Irrigated Production: 1.21%		Dryland Production: 98.79%	

Source: Author calculations based on production value estimated from details provided in Appendix B and Statistics Canada (2011j).

APPENDIX D: STATISTICS CANADA-CUSTOM RUN. NUMBER OF FARMS CLASSIFIED BY CATTLE AND IRRIGATION STATUS.

Share of Farms Reporting Both Cattle and Irrigation in Saskatchewan. 2011.		
	Amount Reporting	Share of Total
Total Farms Reporting Cattle	15,372	
Farms Reporting Both Cattle and Irrigation	398	2.59%
Farms Reporting Cattle but No Irrigation	14,974	97.41%

Source: Based on custom run details provided by Statistics Canada (2011k).

APPENDIX E: ESTIMATED COST OF PRODUCTION (COP) BUDGETS FOR SELECTED CROPS. 2011. PER ACRE.

BARLEY, CANOLA AND FLAX.

	Barley			Canola			Flax		
Cost Item	District Irrigation	Private Irrigation	Dryland Production	District Irrigation	Private Irrigation	Dryland Production	District Irrigation	Private Irrigation	Dryland Production
Seed	$8.25	$8.25	$8.25	$39.00	$39.00	$39.00	$11.72	$11.72	$11.72
Seed treatment	$4.30	$4.30	$4.30	$0.00	$0.00	$0.00	$2.85	$2.85	$2.85
Soil Test	$0.65	$0.65	$0.65	$0.65	$0.65	$0.65	$0.65	$0.65	$0.65
Fertilizer – N	$58.85	$58.85	$26.00	$105.00	$105.00	$45.00	$62.39	$62.39	$26.00
Fertilizer – P	$24.33	$24.33	$15.90	$24.00	$24.00	$10.00	$24.33	$24.33	$7.95
Fertilizer K & S	$6.70	$6.70	$0.00	$6.70	$6.70	$4.50	$6.70	$6.70	$0.00
Herbicide	$22.40	$22.40	$25.29	$29.94	$29.94	$29.94	$18.00	$18.00	$20.91
Insecticide	$0.00	$0.00	$0.00	$24.00	$24.00	$24.00	$0.00	$0.00	$0.00
Fungicide	$15.00	$15.00	$15.00	$24.00	$24.00	$0.00	$15.00	$15.00	$15.00
Equipment Fuel	$17.85	$17.85	$12.18	$18.90	$18.90	$13.05	$19.95	$19.95	$13.92
Equipment Repair	$5.64	$5.64	$5.64	$5.64	$5.64	$5.64	$7.52	$7.52	$7.52
Custom Work	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Irrigation Power	$17.15	$17.15	$0.00	$22.40	$22.40	$0.00	$21.00	$21.00	$0.00
Irrigation Repair	$11.28	$11.28	$0.00	$11.28	$11.28	$0.00	$11.28	$11.28	$0.00
Irrigation Service	$22.97	$0.00	$0.00	$24.07	$0.00	$0.00	$23.78	$0.00	$0.00
Crop Insurance	$6.26	$6.26	$7.74	$10.76	$10.76	$14.92	$6.48	$6.48	$10.91
Hired Labor	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
Building Repair	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25
Property Tax	$5.95	$5.95	$5.95	$5.95	$5.95	$5.95	$5.95	$5.95	$5.95
Insurance and Licenses	$2.26	$0.00	$0.00	$2.26	$0.00	$0.00	$2.26	$0.00	$0.00
Machinery Depreciation	$18.80	$18.80	$18.80	$18.80	$18.80	$18.80	$18.80	$18.80	$18.80
Building Depreciation	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25
Utilities and Misc.	$5.67	$5.67	$5.67	$5.67	$5.67	$5.67	$5.67	$5.67	$5.67
Operating Interest	$5.74	$5.74	$2.83	$7.94	$7.94	$3.84	$5.98	$5.98	$2.83
Total Production Expenses	$272.55	$247.32	$166.70	$399.46	$373.13	$233.46	$282.81	$256.77	$163.18

Source: Irrigation budgets provided by Ewen (2014) and dryland budgets provided by Government of Saskatchewan Crop Planning Guide (2011).

APPENDIX E (CONT.): ESTIMATED COST OF PRODUCTION (COP) BUDGETS FOR SELECTED CROPS. 2011. PER ACRE.

FORAGE AND GRASS SEED, LENTILS AND OATS.

	Forage and Grass Seed (in tonnes)			Lentils			Oats		
Cost Item	District Irrigation	Private Irrigation	Dryland Production	District Irrigation	Private Irrigation	Dryland Production	District Irrigation	Private Irrigation	Dryland Production
Seed	$2.61	$2.61	$2.61	$36.00	$36.00	$36.00	$12.50	$12.50	$12.50
Seed Treatment	$0.00	$0.00	$0.00	$3.20	$3.20	$3.20	$3.80	$3.80	$3.80
Soil Test	$0.00	$0.00	$0.00	$0.65	$0.65	$0.65	$0.65	$0.65	$0.65
Fertilizer – N	$11.63	$11.63	$11.63	$0.00	$0.00	$0.00	$29.59	$29.59	$23.40
Fertilizer – P	$30.24	$30.24	$30.24	$24.33	$24.33	$7.95	$11.06	$11.06	$15.90
Fertilizer K & S and other	$20.71	$20.71	$20.71	$6.70	$6.70	$0.00	$0.00	$0.00	$0.00
Herbicide	$0.62	$0.62	$0.62	$34.65	$34.65	$34.65	$15.88	$15.88	$12.54
Insecticide	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Fungicide	$0.00	$0.00	$0.00	$15.00	$15.00	$15.00	$5.00	$5.00	$5.00
Equipment Fuel	$20.04	$20.04	$16.04	$23.10	$23.10	$13.92	$17.00	$17.00	$12.18
Equipment Repair	$7.92	$7.92	$7.92	$9.32	$9.32	$9.32	$5.64	$5.64	$4.86
Custom Work	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Irrigation Power	$19.41	$19.41	$0.00	$19.60	$19.60	$0.00	$14.00	$14.00	$0.00
Irrigation Repair	$11.28	$11.28	$11.28	$9.32	$9.32	$0.00	$11.28	$11.28	$0.00
Irrigation Service /Water Charge	$23.44	$0.00	$0.00	$23.48	$0.00	$0.00	$26.38	$0.00	$0.00
Crop Insurance	$0.00	$0.00	$0.00	$12.14	$12.14	$25.97	$6.34	$6.34	$5.92
Hired Labor	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
Building Repair	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25
Property Tax	$5.95	$5.95	$5.95	$5.95	$5.95	$5.95	$5.95	$5.95	$5.95
Insurance and Licenses	$2.26	$0.00	$0.00	$2.26	$0.00	$0.00	$2.26	$0.00	$0.00
Machinery Depreciation	$18.80	$18.80	$18.80	$18.80	$18.80	$18.80	$18.80	$18.80	$18.80
Building Depreciation	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25
Utilities and Misc.	$5.67	$5.67	$5.67	$5.67	$5.67	$5.67	$5.67	$5.67	$5.67
Operating Interest	$4.33	$4.33	$4.33	$5.44	$5.44	$3.80	$3.69	$3.69	$2.55
Total COP	$197.41	$171.71	$148.30	$268.11	$242.37	$193.38	$207.99	$179.35	$142.22

Source: Irrigation budgets provided by Ewen (2014) and dryland budgets provided by Government of Saskatchewan Crop Planning Guide (2011).

APPENDIX E (CONT.): ESTIMATED COST OF PRODUCTION (COP) BUDGETS FOR SELECTED CROPS. 2011. PER ACRE.

PEAS, WHEAT (EXCEPT DURUM) AND POTATOES

	Peas			Wheat, except Durum			Potatoes	
Cost Item	District Irrigation	Private Irrigation	Dryland Production	District Irrigation	Private Irrigation	Dryland Production	District Irrigation	Private Irrigation
Seed	$20.10	$20.10	$20.10	$10.50	$10.50	$10.50	$572.10	$572.10
Seed treatment	$11.40	$11.40	$11.40	$4.40	$4.40	$4.40	$78.47	$78.47
Soil Test	$0.65	$0.65	$0.65	$0.65	$0.65	$0.65	$0.65	$0.65
Fert-N				$70.76	$70.76	$26.00	$64.66	$64.66
Fertilizer – P	$21.29	$21.29	$7.95	$24.36	$24.36	$15.90	$36.49	$36.49
Fertilizer K&S	$6.70	$6.70	$0.00	$6.59	$6.59	$0.00	$13.39	$13.39
Herbicide	$19.00	$19.00	$28.50	$18.55	$18.55	$23.19	$62.17	$62.17
Insecticide	$0.00	$0.00	$0.00	$0.00	$0.00	$1.49	$22.00	$22.00
Fungicide	$15.00	$15.00	$15.00	$5.00	$5.00	$5.00	$144.98	$144.98
Equipment Fuel	$19.95	$19.95	$13.92	$17.88	$17.88	$12.18	$142.09	$142.09
Equipment Repair	$10.44	$10.44	$9.32	$6.50	$6.50	$5.64	$75.00	$75.00
Custom Work	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$80.00	$80.00
Irrigation Power	$25.20	$25.20	$0.00	$19.72	$19.72	$0.00	$18.20	$18.20
Irrigation Repair	$11.28	$11.28	$0.00	$11.40	$11.40	$0.00	$11.28	$11.28
Irrigation Service /Water Charge	$24.65	$0.00	$0.00	$23.82	$0.00	$0.00	$23.19	$0.00
Crop Insurance	$4.39	$4.39	$6.53	$4.96	$4.96	$7.79	$164.68	$164.68
Hired Labor	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$225.00	$225.00
Build. Rep	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25
Property Tax	$5.95	$5.95	$5.95	$5.95	$5.95	$5.95	$5.95	$5.95
Insurance and Licenses	$2.26	$0.00	$0.00	$2.26	$0.00	$0.00	$2.26	$0.00
Machinery Depreciation	$18.80	$18.80	$18.80	$18.80	$18.80	$18.80	$18.80	$18.80
Building Depreciation	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25
Utilities and Misc.	$5.67	$5.67	$5.67	$5.67	$5.67	$5.67	$5.67	$5.67
Ops Int.	$5.39	$5.39	$2.64	$6.01	$6.01	$2.96	$42.10	$42.10
Total COP	$240.62	$213.71	$158.93	$276.28	$250.20	$158.62	$1,811.63	$1,786.18

Source: Irrigation budgets provided by Ewen (2014) and dryland budgets provided by Government of Saskatchewan Crop Planning Guide (2011).

APPENDIX E (CONT.): ESTIMATED COST OF PRODUCTION (COP) BUDGETS FOR SELECTED CROPS. 2011. PER ACRE.

DURUM, IRRIGATION "OTHER" AND DRYLAND "OTHER"

	Durum			**Irrigation "Other", Used Sunflower Budget**		**Dryland "Other", Used Rye Budget**
Cost Item	District Irrigation	Private Irrigation	Dryland Production	District Irrigation	Private Irrigation	Dryland Production
Seed	$15.00	$15.00	$15.00	$25.00	$25.00	$8.25
Seed treatment	$4.70	$4.70	$4.70	$0.00	$0.00	$0.00
Soil Test	$0.65	$0.65	$0.65	$0.65	$0.65	$0.65
Fertilizer – N	$87.91	$87.91	$26.00	$55.20	$55.20	$26.10
Fertilizer – P	$24.33	$24.33	$15.90	$11.20	$11.20	$15.90
Fertilizer K & S and other	$6.70	$6.70	$0.00	$2.70	$2.70	$0.00
Herbicide	$18.50	$18.50	$23.29	$20.00	$20.00	$25.29
Insecticide	$10.00	$10.00	$10.00	$0.00	$0.00	$0.00
Fungicide	$5.00	$5.00	$5.00	$0.00	$0.00	$0.00
Equipment Fuel	$17.85	$17.85	$12.18	$12.00	$12.00	$12.18
Equipment Repair	$5.64	$5.64	$5.64	$10.00	$10.00	$5.64
Custom Work	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Irrigation Power	$21.00	$21.00	$0.00	$16.80	$16.80	$0.00
Irrigation Repair	$11.28	$11.28	$0.00	$11.28	$11.28	$0.00
Irrigation Service /Water Charge	$23.78	$0.00	$0.00	$18.00	$0.00	$0.00
Crop Insurance	$4.43	$4.43	$5.24	$4.33	$4.33	$7.74
Hail Insurance	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Hired Labor	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
Building Repair	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25
Property Tax	$5.95	$5.95	$5.95	$5.95	$5.95	$5.95
Insurance and Licenses	$2.26	$0.00	$0.00	$2.26	$0.00	$0.00
Machinery Depreciation	$18.80	$18.80	$18.80	$18.80	$18.80	$18.80
Build Dep.	$1.25	$1.25	$1.25	$1.25	$1.25	$1.25
Utilities and Misc.	$5.67	$5.67	$5.67	$5.67	$5.67	$5.67
Operating Interest	$6.76	$6.76	$3.02	$5.35	$5.35	$2.83
Total COP	$308.71	$282.67	$169.54	$237.69	$217.43	$147.50

Source: Irrigation budgets provided by Ewen (2014) and dryland budgets provided by Government of Saskatchewan Crop Planning Guide (2011).

APPENDIX F: IRRIGATED AND DRYLAND SHARES OF CROP PRODUCTION INPUT USE APPLIED TO CORRESPONDING IO CATEGORY TOTALS, 2011.

The following presents the components of the COP budgets that corresponded to categories in the I-O model. The use shares of these components by irrigated and dryland production found in analysis of these budgets were applied to the corresponding I-O category for disaggregation purposes. Not all items corresponded to I-O categories. Averaged shares of use of the remaining aggregate items of the COP found irrigation average use to be 1.17% and dryland's average use of these remaining items to be 98.83%. This ratio was applied to the remaining I-O categories for which a correspondence could not be identified directly within the COP budgets.

Production Type	Items Included in Category		Total of Items in Category	Share of Total by Production Type	Corresponding IO Category Title	Corresponding IO Category Total	Share of Category
	Seed	Seed Treatment/Inoculant					
Irrigation Use	$7.68	$1.00	$8.68	1.08%	Grain and other crop products	$327.70	$3.55
Dryland Use	$699.72	$93.25	$792.97	98.92%			$324.15

Source: Author calculations.

Production Type	Items Included in Category				Total of Items in Category	Share of Total by Production Type	Correspond -ing IO Category Title	Correspond ing IO Category Total	Share of Category
	Fertilizer N	Fertilizer P	Fertilizer K, S & Micros	Other Chem.					
Irrigation Use	$9.94	$4.57	$1.92	$6.97	$23.40	0.83%	Chemical Product	$1,380.10	$11.39
Dryland Use	$909.79	$521.02	$139.85	$1,241.00	$2,811.66	99.17%			$1,368.71

Source: Author calculations.

Production Type	Items Included in Category	Total of Items in Category	Share of Total by Production Type	Corresponding IO Category Title	Corresponding IO Category Total	Share of Category
	Equipment Fuel					
Irrigation Use	$4.43	$4.43	0.96%	Refined Petroleum Products	$429.10	$4.13
Dryland Use	$456.10	$456.10	99.04%			$424.97

Source: Author calculations.

APPENDIX F (CONT.): IRRIGATED AND DRYLAND SHARES OF CROP PRODUCTION INPUT USE APPLIED TO CORRESPONDING I-O CATEGORY TOTALS, 2011.

Production Type	Items Included in Category			Total of Items in Category	Share of Total by Production Type	Corresponding IO Category Title	Corresponding IO Category Total	Share of Category
	Equipment Repair	Irrigation Repair	Soil Test					
Irrigation Use	$1.81	$2.13	$0.09	$4.03	1.36%	Professional Services	$179.00	$2.43
Dryland Use	$220.90	$51.98	$19.50	$292.38	98.64%			$176.57

Source: Author calculations.

Production Type	Items Included in Category		Total of Items in Category	Share of Total by Production Type	Corresponding IO Category Title	Corresponding IO Category Total	Share of Category
	Custom Work	Hired Labor					
Irrigation Use	$0.67	$3.68	$4.35	1.24%	Wages and Salaries	$3.41	$0.04
Dryland Use	$0.00	$346.13	$346.13	98.76%			$3.37

Source: Author calculations.

Production Type	Items Included in Category		Total of Items in Category	Share of Total by Production Type	Corresponding IO Category Title	Corresponding IO Category Total	Share of Category
	Irrigation Power	Utilities and Misc.					
Irrigation Use	$3.72	$1.07	$4.79	2.38%	Utilities	$97.10	$2.31
Dryland Use	$0.00	$196.26	$196.26	97.62%			$94.79

Source: Author calculations.

Production Type	Items Included in Category			Total of Items in Category	Share of Total by Production Type	Corresponding IO Category Title	Corresponding IO Category Total	Share of Category
	Crop Insurance	Insurance and Licences	Operating Interest					
Irrigation Use	$2.21	$0.24	$1.38	$3.83	0.83%	Other Finance and Insurance	$161.50	$1.35
Dryland Use	$336.71	$0.00	$118.16	$454.87	99.17%			$160.15

Source: Author calculations.

APPENDIX G: EMPLOYMENT BASED LOCATION QUOTIENTS FOR THE L.D.D.A. REGION OF SASKATCHEWAN

Sector	SK and LDDA
1 Irrigated Crop Production	1.0000
2 Dryland Crop Production	1.0000
3 Irrigated Animal Production	1.0000
4 Dryland Animal Production	1.0000
5 Forestry and logging	0.0026
6 Fishing, hunting and trapping	0.0000
7 Support activities for agriculture and forestry	0.0304
8 Mining, quarrying, and oil and gas extraction	0.2270
9 Utilities	0.1706
10 Residential building construction	0.1942
11 Non-residential building construction	0.0777
12 Engineering construction	0.1145
13 Repair construction	0.6490
14 Other activities of the construction industry	0.5390
15 Non-Food Manufacturing	0.5779
16 Other Food Manufacturing	0.0273
17 Animal Food Manufacturing	0.0051
18 Grain and Oilseed Milling Manufacturing	0.0092
19 Dairy Product Manufacturing	0.0000
20 Meat Product Manufacturing	0.0233
21 Wholesale trade	0.5571
22 Retail trade	1.0000
23 Transportation and warehousing	0.7008
24 Information and cultural industries	0.3935
25 Finance, insurance, real estate, rental and leasing and holding companies	0.6967
26 Owner occupied dwellings	0.0178
27 Professional, scientific and technical services	0.5800
28 Administrative and support, waste management and remediation services	0.3492
29 Educational services	1.0000
30 Health care and social assistance	1.0000
31 Arts, entertainment and recreation	0.2625
32 Accommodation and food services	0.9136
33 Other services (except public administration)	0.7224
34 Repair, maintenance and operating and office supplies	0.2527
35 Advertising, promotion, meals, entertainment, and travel	0.0213
36 Transportation margins	0.7008
37 Non-profit institutions serving households	0.2372
38 Government education services	1.0000
39 Government health services	1.0000
40 Other federal government services	1.0000
41 Other provincial and territorial government services	1.0000
42 Other municipal government services	1.0000
43 Other aboriginal government services	1.0000

Source: Author calculations.

APPENDIX H: EMPLOYMENT COEFFICIENTS (PERSON-YEARS PER $1,000 OUTPUT), 2011, SASKATCHEWAN.

Sector	Saskatchewan and LDDA
1 Irrigated Crop Production	0.002085
2 Dryland Crop Production	0.004361
3 Irrigated Animal Production	0.004361
4 Dryland Animal Production	0.004361
5 Forestry and logging	0.001592
6 Fishing, hunting and trapping	0.045000
7 Support activities for agriculture and forestry	0.009753
8 Mining, quarrying, and oil and gas extraction	0.000716
9 Utilities	0.002365
10 Residential building construction	0.002600
11 Non-residential building construction	0.001607
12 Engineering construction	0.000619
13 Repair construction	0.017402
14 Other activities of the construction industry	0.002423
15 Non-Food Manufacturing	0.001979
16 Other Food Manufacturing	0.001589
17 Animal Food Manufacturing	0.002974
18 Grain and Oilseed Milling Manufacturing	0.002602
19 Dairy Product Manufacturing	0.000674
20 Meat Product Manufacturing	0.002238
21 Wholesale trade	0.003741
22 Retail trade	0.013330
23 Transportation and warehousing	0.004366
24 Information and cultural industries	0.005697
25 Finance, insurance, real estate, rental and leasing and holding companies	0.008842
26 Owner occupied dwellings	0.026523
27 Professional, scientific and technical services	0.009699
28 Administrative and support, waste management and remediation services	0.617493
29 Educational services	0.039856
30 Health care and social assistance	0.014047
31 Arts, entertainment and recreation	0.014511
32 Accommodation and food services	0.002776
33 Other services (except public administration)	0.005828
34 Repair, maintenance and operating and office supplies	0.002824
35 Advertising, promotion, meals, entertainment, and travel	0.000218
36 Transportation margins	0.000296
37 Non-profit institutions serving households	0.000296
38 Government education services	0.000296
39 Government health services	0.000296
40 Other federal government services	0.000296
41 Other provincial and territorial government services	0.000296
42 Other municipal government services	0.000296
43 Other aboriginal government services	0.000296

Source: Author calculations.

APPENDIX I: SURVEY QUESTIONNAIRE

Of your purchases made of each category, what share is spent in each of the four locations. This can be an average estimate.

		Where Was the Money Spent?								
Category		**In Canada**						**Outside of Canada**		
		# 1		**# 2**		**# 3**		**# 4**		
		In the LDDA		**In Sk. but Outside of the LDDA**		**Outside of Sk. but in Canada**		**Outside of Canada**		
Example Category		***%50***	+	***% 10***	+	***% 40***	+	***% 0***	***=100%***
Seed	**Of the Money Spent on the Category**		+		+		+		=100%
Chemical			+		+		+		=100%
Fertilizer			+		+		+		=100%
Fuel			+		+		+		=100%
Groceries			+		+		+		=100%
Restaurants			+		+		+		=100%
Clothing and Footwear			+		+		+		=100%