

Irrigation's Impact on Economic Growth in Alberta, Canada

Kulshreshtha S^{1*}, Paterson B², Hart D³ and Nicol L⁴

¹Department of Agricultural and Resource Economics, University of Saskatchewan, Canada

²Paterson Earth and Water Consulting Ltd, Canada

³Hart Water Management Consulting, Canada

⁴Department of Economics, University of Lethbridge, Canada

Abstract

Irrigation development in semi-arid regions provides benefits for producers as well as many others who reside in the region. Although a common perception exists that irrigation benefits only irrigation producers, a study carried out by Paterson Earth and Water Consulting Ltd showed that irrigation positively impacts many more sectors of the Alberta economy than just irrigation producers. Compared to dry land (rain fed) agriculture, irrigation creates increased employment and economic activity through the purchase of additional farm inputs as well as processing of agricultural products. Multi-use water storage reservoirs, which support irrigation agriculture, provide societal benefits through recreation, hydropower generation, and water supply for habitat development, communities and industries. This study estimated that Alberta's irrigation industry, which represents less than 5% of the cultivated land base, generates about \$3.6 billion to the provincial gross domestic product (GDP), accounting for about 20% of the total agri-food sector GDP. It is also responsible for generating about \$2.4 billion in income and creating about 56,000 jobs. Many of these jobs and incomes are generated in the rural regions of the province, and serves as an important part of the rural development initiatives in Alberta. Almost 90% of the GDP generated by the irrigation sector accrued to the region and the province, and only 10% accrued to irrigation producers.

Keywords: Irrigation; Alberta; Economic impacts; Regional development; Multiplier

Introduction

Economic development can be defined as those activities that lead to greater resource productivity, a wider range of choices for consumers and producers, and broader participation of members of the society in policy formulation [1]. While the overall aim of development is to improve the well-being of society, including health, bio-physical environment, housing, and education, economic development is translated into economic growth. Higher incomes are seen as an improvement in the economic growth of a region, or nation.

Although economic growth of a region can be accomplished through many programs, using available resources efficiently is the most common. In semi-arid regions such as southern Alberta, water is a critical factor in the economic well-being of the region. Irrigation development in this region began more than 100 years ago to help mitigate drought conditions and increase crop production. At present, about 675,000 ha of land are irrigated within Alberta's South Saskatchewan River Basin, representing almost 70% of Canada's total irrigated area [2].

Measuring Regional Economic Development through Economic Impact Analysis

Typical measures of regional economic development include improvement in regional income level, growth in employment, or increased population residing in the region. However, these indicators may only assess macro-level or gross changes for a selected region or province, and the contribution of individual growth sources may not be identified. Data can also be collected gathered at a meso-level, which includes rural and urban communities. These data are also highly aggregate and thus do not permit estimation of economic contribution of a sector, such as irrigation.

The direct effects of any economic activity can be seen relatively easily. The value of product produced or number of people employed are simple ways of measuring such a contribution. However, direct impacts are not the same as total economic impacts, and do not show

the true nature of economic changes that are created by the existence of that economic activity. In order to illustrate the importance of the irrigation sector, its total contribution, including secondary impacts, must be estimated.

Economic impact analysis using an input-output model is the most appropriate and comprehensive methodology for regional economic analysis [3]. These models are based on linkages between economic sectors. Because of a lack of information, such linkages are not always obvious and can be difficult to measure. Other tools such as shift-share analysis and economic base models are available but their value in estimating regional economic impacts is limited, as inter-industry linkages are not recognized. Such models have been applied by Blamko and Thaler, Hamilton and Pontgtanakorn and Hubacek and Sun [4-6].

Although formal beginnings in input-output models were made since the 1930s, some aspects of these techniques can be found in work of Quesnay, Walrus, and Morrison and Smith [3]. These models are based on factual information related to real life situations. According to Leontief, input-output analysis represents a theory of production that reveals the fabric of our economy, woven together by the flow of trade which ultimately links each branch and industry to all others [7].

The input-output model is based on sales and purchases made by a sector (a group of firms producing similar products) with other sectors or for final disposition. The model, given the level of direct change

***Corresponding author:** Kulshreshtha S, Department of Agricultural and Resource Economics, University of Saskatchewan, Canada, Tel: +306 966-4014; E-mail: suren.kulshreshtha@usask.ca

Received January 25, 2016; **Accepted** February 23, 2016; **Published** February 29, 2016

Citation: Kulshreshtha S, Paterson B, Hart D, Nicol L (2016) Irrigation's Impact on Economic Growth in Alberta, Canada. *Irrigat Drainage Sys Eng* 5: 156. doi:10.4172/2168-9768.1000156

Copyright: © 2016 Kulshreshtha S, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

(impact), can estimate other changes (secondary impacts) that are generated in the economic system. An input-output based economic impact analysis is preferred for the following reasons:

- Every industry's impact is treated as unique, allowing its specific economic impacts to be estimated.
- Different types of economic stimulus can be applied to undertake economic impact analysis. For example, economic impacts of consumer spending, exports, or purchases by other firms could be estimated uniquely.
- Development of the model can also be region-specific, thereby allowing regional differences in the production processes, technology, and trade patterns.
- Results are presented by economic sectors enabling decision maker's distributive effect of the measure.

Total economic impact analysis consists of two types of impacts: (i) backward linked impacts, and (ii) forward linked impacts [8]. The former are a result of inputs that are purchased by a sector to make its production possible, whereas the latter ones are generated through further processing of agricultural products. These are further divided into indirect and induced impacts. Indirect impacts are a result of goods and services purchased from other sectors, whereas induced impacts result from the spending of money earned by workers (and owners of resources) on consumed goods. In both situations, firms face additional demand for their goods and will increase production to meet the demand.

In this study, economic impacts of various facets of irrigation-related activities on the Alberta economy were estimated by developing a disaggregated model (input-output model) both in terms of commodities (goods and services) that are bought and sold by various economic agents in the province, as well as by sectors (groups of firms producing similar commodities). Details on this model can be found in Miller and Blair [9]. It is based on the transactions that took place in the Alberta economy during the year 2011. A list of sectors is shown in Appendix 1. In total there were 43 goods-producing sectors trading with each other. The measure of development was GDP, which consisted of eight items (Appendix 2).

Model development used transactions tables from Statistics Canada. A major limitation of the transactions tables, in the context of this study, was that both the agriculture and manufacturing sectors were treated as a single sector. Furthermore, this model does not estimate employment in the Alberta economy in response to various sectors gearing up to produce more to meet increasing demands for various goods and services (called commodities in input-output terminology). To improve on these limitations, disaggregation of agriculture into irrigation and dry land production was undertaken. Similarly agricultural processing activities related to irrigation were also disaggregated. Since one measure of development is employment generated by a given economic activity, the input-output model was linked with an employment model to estimate the effect of irrigation and related activities on the number of jobs created. Employment coefficients reflected an average change in employment per unit of a sector's output.

All economic transactions in the input-output table are in producer's (producers?) prices, which required that a set of margins be deduced from these values in order to undertake economic impact analysis. These margins include: transportation and storage; wholesale; retail; pipeline; gas; and taxes. For each commodity these margins are

estimated and used in running the economic impact model (if needed). These data were obtained from Statistics Canada.

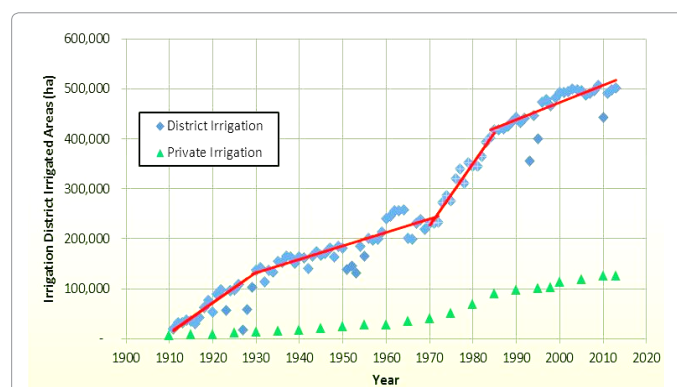
Transactions in the input-output model are based on local purchases only. If any commodity used by economic agents is obtained from outside the region, it is netted out from the total amount spent, since it does not help in the local economic development. International imports, and those from other parts of Canada were also removed from the total expenditures by irrigation producers and associated sectors.

Irrigation in Alberta

Alberta is the major irrigation area in Canada having almost 70% of the reported irrigation area of Canada in 2011. The development and management of irrigation in Alberta began about 130 years ago. As settlement began on the Prairies, farmers were quick to realize the need for and benefits of irrigation in increasing and stabilizing crop yields. The first irrigation project in Alberta was reportedly developed in 1878. In 1915, the province passed the Irrigation Districts Act providing the mechanism for co-operative farmer-owned irrigation districts. At present, about 565,000 ha of land are irrigated within 13 irrigation districts. An additional 124,000 ha are irrigated throughout the province as private developments. The growth of irrigation district and private irrigation in Alberta is shown in Figure 1.

All of Alberta's irrigation utilizes surface water is diverted from rivers and constructed water storage reservoirs. Runoff from Rocky Mountain snowmelt and early summer rainfall is critical to sustainable irrigation within the irrigation districts, and about 50 on-stream and off-stream water storage reservoirs are located in southern Alberta to store the spring and early summer runoff for use throughout the summer growing season. These reservoirs also supply water to about 50 urban and rural municipalities, numerous industries and more than 35,000 ha of wetland habitat. Most of the reservoirs also serve as prime recreational sites for thousands of visitors each year.

More than 60 crop varieties are grown under irrigation in Alberta, including numerous high value specialty crops. Many of these crops are processed at facilities located throughout southern Alberta, and the finished food products are shipped to national and international markets. Irrigation districts and producers have long recognized the need to become increasingly efficient and productive in the use of limited water supplies. At present, about 50% of the 8,000 km of the surface canals that supply water to irrigation producers have been converted to buried pipelines through an ongoing partnership between the Alberta Government and the irrigation districts. Irrigation



Data Sources: AARD 2014; Irrigation Water Management Study Committee 2002

Figure 1: Historical growth of district and private irrigation in Alberta.

producers have replaced less efficient on-farm irrigation systems with state-of-the-art low-pressure drop tube pivot systems, which could increase on-farm irrigation efficiency to at least 85% by 2025.

Connection between irrigation and regional economic development

The importance of an economic or non-economic activity is typically measured in dollar terms, because money acts as a standard of value and simplifies aggregation. However, some activities may not be monetized easily. Both monetized and non-monetized contributions of irrigation are equally important in the context of measuring its total contribution.

Irrigation activities can be divided into two interrelated groups: (1) Irrigation infrastructure development and maintenance, and (2) Production of agricultural commodities. Each of these activities generates a number of changes in the regional economy, and has an impact on non-irrigated components of society as shown in Figure 2.

The development of needed infrastructure to store and deliver water for irrigation producers and other water users consists of irrigation reservoirs and a system canals and pipelines. This infrastructure requires construction, operation, maintenance and periodic upgrading, which require inputs to be purchased from non-irrigation sectors, from regional, national, or international locations. These activities create employment in the region, additional income which creates a ripple effect in the regional economy.

Most crop products resulting from irrigation are either sold to outside interests (processors, exporters, other agricultural producers),

or used on the farm as livestock feed. Thus, irrigation generates two types of forward linkages: (1) Crop products, and (2) Livestock products.

In addition to farm and non-farm economic impacts of irrigation, a number of quantitative and qualitative benefits also accrue to the regional economy. Quantitative benefits include dry land (rain fed) farm sale of inputs (feed and calves) to irrigation-supported feedlots, and reduced cost of water supply to communities and industries. Qualitative benefits include agricultural diversification opportunities and regional agricultural stabilization during drought events. A more detailed list of irrigation impacts on society is shown in Table 1.

Economic Assessment

This study assessed actual irrigation activity in Alberta during the 2000 to 2011 period. The total average irrigated area during this period was 600,795 ha, including 491,017 within the 13 irrigation districts and 109,778 ha under private irrigation. Table 2 provides the detailed results of the total (direct, indirect and induced) economic impacts related to irrigation and related activities.

Infrastructure rehabilitation, operation and maintenance

About 75% of the operation and maintenance costs of Government of Alberta (GOA) owned infrastructure supports irrigation-related activities. During the 2000-2011 periods the GOA provided an average of \$22.4 million annually to fund operation and maintenance of government owned infrastructure. The GOA provided an additional \$23.7 million annually to the irrigation districts to support rehabilitation of irrigation district owned infrastructure. The irrigation districts provided an additional \$52.27 million annually for rehabilitation, operation and maintenance of district-owned infrastructure. These expenditures generated a total of \$102 million of GDP, including \$66 million in the form of income (workers, managers, and owners of resources) (Activity 1, Table 2). In addition, these activities generated almost 1,400 jobs (direct, indirect or induced).

Farm level activities

There are four ways farm-level irrigation impacts a regional economy such as the province of Alberta: (1) Irrigation of crops; (2) Feeding farm-grown grains and forages to livestock (mainly beef cattle); (3) Purchase of machinery and equipment; and (4) Drought mitigation.

Irrigated crop production: The study showed that net economic returns for irrigated crops are greater than dry land (rain fed) crops. For example, spring wheat returns \$311 ha⁻¹ as against only \$61 ha⁻¹ under dry land conditions—a five-fold increase. Irrigated crops require higher inputs such as fertilizer, which creates additional benefits to the non-farm economy. Irrigated crop sales during the study period were \$689 million annually, and accounted for almost 22% of Alberta's total crop sales. This generated \$166 million to the annual provincial GDP, and created 10,262 jobs on a full-time equivalent (FTE) basis (Activity 2, Table 2).

Irrigated livestock production: Irrigated agriculture in Alberta supports a large livestock industry, particularly the more intensive livestock feeding operations. Irrigation provides a consistent supply of irrigated forage, silage, and water for the livestock operations. These operations support ranchers and dry land farmers through purchase of calves and feed grains.

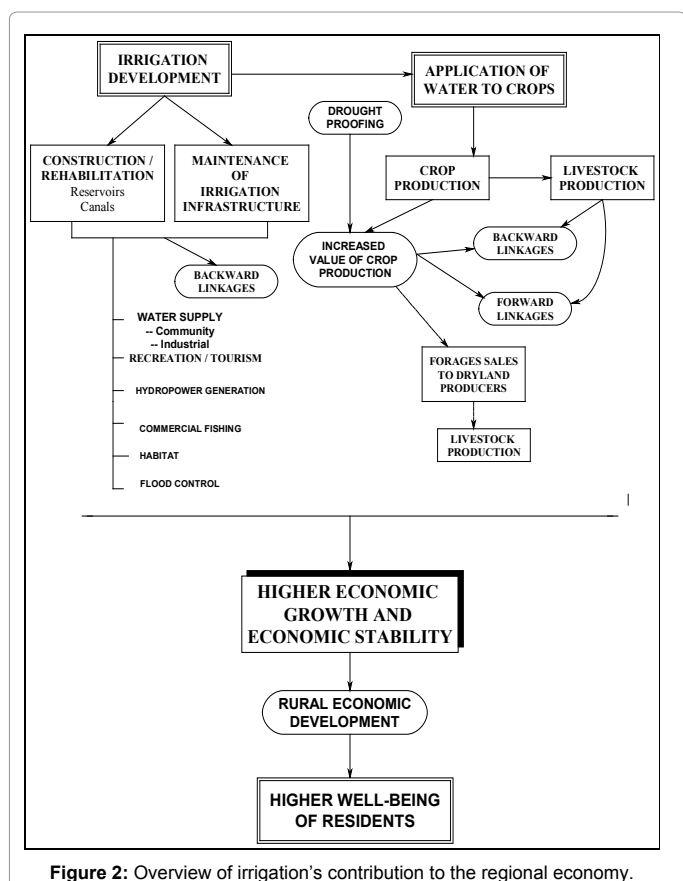


Figure 2: Overview of irrigation's contribution to the regional economy.

Parties Affected	Direct Impact	Impact Type		
		Source	Indirect Impact	Induced Impact
Farm Sector				
Irrigation producers through crop production	X	Direct		X
Drought mitigation	X	Direct		
Farm level investment in irrigation equipment	X	Backward Linged	X	X
Livestock production on irrigated farms		On-farm Forward Linked	X	X
Non-Farm Sectors				
Construction industry	X	Backward Linked	X	X
Suppliers of irrigated crop inputs			X	X
Suppliers of livestock inputs			X	X
Agricultural processing industries	X	Forward Linked	X	X
Input suppliers to agricultural processing industries		Backward Linked	X	X
Energy producing firms	X		X	
Non-farm Residents				
Recreation and tourism	X			
Flood mitigation		Qualitative		
Aggregate Economy				
Diversification opportunities		Qualitative		X
Wetland habitat		Qualitative	X	
Regional economic stabilization		Qualitative		X
Community water supplies	X	Direct		X
Manufacturing industries		Qualitative	X	X

Table 1: Sectors affected by irrigation in Alberta.

Activity	Description	GDP (\$ Million)	Income (\$ Million)	Employment (FTEs)
1	Infrastructure	102	66	1,387
2	On-farm crop production	166	104	10,262
3	On-farm livestock production	214	182	10,369
4	Machinery and equipment	59	36	654
5	Drought mitigation	9	9	0
6	Backward linkages (crop production)	686	421	6,879
7	Backward linkages (livestock production)	635	451	8,918
8	Forward linkages – Crops and Livestock (value-added processing)	1,693	1,047	17,093
9	Recreation	15	9	222
10	Hydropower generation	14	7	99
11	Commercial fishing*	0.6	0.4	6
12	Water use (non-irrigation)	46	46	--
Total Economic Impacts		3,639.6	2,378.4	55,889

* Effective August 1, 2014, all lakes in Alberta was closed to commercial fishing.

Table 2: Total (direct, indirect and induced) economic impacts related to irrigation and related activities

During the study period, livestock sales on irrigated farms were \$746 million/year, and accounted for 17% of Alberta's total livestock sales. This generated \$214 million/year to the annual GDP, and about \$182 million in labor income (Activity 3, Table 2). An estimated 10,369 jobs were created, with about 50% of these jobs located on irrigated farms and the remainder in non-agriculture sectors.

On-farm investment in machinery and equipment: During the study period, it was estimated that irrigation producers annually spent about \$132 million on replacement and upgrading of farm machinery, including irrigation systems [9]. Some of these expenditures were incurred regionally while others were outside of Alberta. The total farm machinery expenditures generated about \$59 million towards the

provincial GDP including \$36 million in labor income and 654 FTE jobs (Activity 4, Table 2).

Drought mitigation: Droughts are a common phenomenon on the prairies. In addition to the prairie-wide drought of 1930s, several droughts have been observed during 1961, 1984, 1985, 2001 and 2002 [10]. Reduced crop production during a drought can generate large adverse impacts on producers, rural communities, and the regional economy. Based on the study by Samarwickrema and Kulshreshtha the estimated incremental revenue over cost was estimated at \$0.040 per m³, which results in a total benefit to irrigated producers of \$116 million during a drought year [11,12]. From 1901 to 2001 there were eight major droughts in western Canada - a probability of 8%. Based

on this probability, the annual irrigation benefits are estimated to be about \$9 million. No indirect and induced impacts of this change were estimated.

Backward linkages to crop and livestock production

The combined annual sales (gross and value-added) of irrigation crops and livestock products generated about \$1.7 billion to the Alberta GDP. This was equal to about \$2,400/ha, compared with about \$329/ha for dry land production. Irrigated crop and livestock production also generated about \$872 million in labor income, and about 16,000 jobs (Activities 6 and 7, Table 2).

Forward linkages to crop and livestock production

Irrigation-related agricultural processing provided almost \$1.7 billion to the provincial GDP, which accounts for 17% of the total GDP generated by Alberta's food processing industry. It also generated about \$1 billion in labor income, and about 17,000 jobs. Slaughter and meat processing was the major contributor, accounting for almost 50% of the total agri-food processing sectors' employment.

Economic impacts of water storage reservoir-based activities

In addition to water for irrigation, water storage reservoirs provide numerous other benefits to society as a whole. These benefits include: (1) Use of reservoirs for recreational purposes; (2) Generation of hydropower; (3) Commercial fishing; and (4) Water supply to communities and industries in the region (Table 2).

Recreation: About 435,000 annual visitor user-days of activity related to irrigation were associated with the 57 water storage reservoirs in southern Alberta. The total annual expenditure of these visitors on recreation activities was about \$18.5 million. These expenditures generated about \$15 million annually to the provincial GDP, including \$9 million in labor income. About 222 jobs were also created.

Hydropower generation: Irrigation-related hydropower plants annually generated about \$15.5 million of green energy, which provided \$14 million to the provincial GDP. About \$7.0 million in labor income was generated, and 99 jobs were created.

Commercial fishing: Irrigation reservoirs annually generated about \$650,000 in commercial fish sales, which added about \$600,000 to the provincial GDP and about \$400,000 in labor income. However, as of August 1, 2014 commercial fishing on Alberta's lakes and reservoirs were terminated.

Non-irrigation water use: Irrigation canals, in addition to supplying water for irrigation, also provide water for about 50 communities and numerous industries located in southern Alberta. About \$47 million was saved each year by supplying water through irrigation infrastructure for commercial, industrial and municipal uses. These savings generated about \$46 million annually to the provincial GDP, which was mainly related to labor income.

Total Economic Impact of Alberta's Irrigation Industry and Multipliers

Combining all of the above economic benefits, Alberta's irrigation industry annually generated about \$3.6 billion to the provincial GDP, \$2.4 billion in labor income, and created about 56,000 jobs (Table 2). Gross domestic product multipliers¹ show that for every \$1.00 of irrigation sales (crops and livestock), the total GDP increased by \$2.54

¹ An economic multiplier is a measure of transmission of initial stimulus to other sectors inside and outside a given region.

and labour income increased by \$1.64. Total employment increased by about 39 jobs for every \$1.0 million of irrigation sales. Every cubic metre of water delivered for irrigation and other related uses generated about \$3.00 to the provincial GDP and \$2.00 in labour income. Every \$1.00 invested by the GOA in irrigation-related activities generated \$3.00 in added revenue to Alberta and Canada. For every \$1.00 of income for irrigation producers generated about \$8 of income in the region.

Summary and Conclusion

This study provided a comprehensive assessment of the economic impacts that Alberta's irrigation industry has on the provincial economy and quality of life for Albertans. It analyzed the economic effects of primary and value-added irrigation production, including backward and forward linkages related to that production. It also assessed the contribution of irrigation water storage and canal infrastructure on Government of Alberta revenues, and to non-irrigation water users in southern Alberta.

The results of this study show that Alberta's irrigation industry continues to play a significant role in growing the province's economy and increasing the social well-being of Albertans. The Alberta's irrigation industry annually generated about \$3.6 billion to the provincial GDP, about \$2.4 billion in labor income, and created about 56,000 jobs.

Irrigation also provided significant benefits for non-irrigation purposes, including recreation, hydropower generation, drought mitigation and commercial fishing, generated an additional \$75 million to the provincial GDP and \$62 million in labor income. While an economic value was not determined for the 32,000 hectares of habitat development in the irrigation districts, their value in enhancing wildlife populations and biodiversity is considered to be priceless.

For every \$1.00 of irrigation sales, the provincial GDP increased by \$2.54 and labour income increased by \$1.64. Total employment increased by about 39 jobs for every \$1.0 million of irrigation sales. Every cubic metre of water delivered for irrigation and other related uses generated about \$3.00 to the provincial GDP and \$2.00 in labour income. Every \$1.00 invested by the GOA in irrigation-related activities generated \$3.00 in added revenue to Alberta and Canada. For every \$1.00 of income for irrigation producers generated about \$8 of income in the region. Alberta's irrigation districts along with private irrigators are an excellent template for what a strong, vibrant rural economy can accomplish. Climate change may provide opportunities and challenges for Alberta's irrigation industry in southern Alberta. However, this issue needs further investigation.

Acknowledgement

Funding for this study was provided by the Canada-Alberta Growing Forward 2 Program, through the Alberta Irrigation Projects Association, which is gratefully acknowledged.

References

1. Shaffer R (1989) Community Economics: Economic Structure and Change in Smaller Communities. Iowa State University Press, USA.
2. Alberta Agriculture and Rural Development (2014) Alberta Irrigation Information: Facts and Figures for the year 2011. Basin Water Management Branch, Canada.
3. Morrison W, Smith P (1977) Input-Output Methods in Urban and Regional Planning: A Practical Guide. Progress in Planning 7: 59-151.
4. Blamnko C, Thaler T (2014) An Input-Output Assessment of Water Productivity in the Castle and Leon Region (Spain). Water 6: 929-944.

5. Hamilton J, Pontgtanakorn C (1983) The Economic Impact of Irrigation Development in Idaho: An Application of Marginal Input-Output Methods. *The Annals of Regional Science* 17: 60-70.
6. Hubacek K, Sun L (2005) Economic and Societal Changes in China and their Effects on Water Use A Scenario Analysis. *Journal of Industrial Ecology* 9: 187-200.
7. Leontief W (1966) *Input-Output Economics*. Oxford University Press, New York.
8. Zygadlo L, Niehaus R (1978) *Regional Development and Plan Evaluation*. The use of input-output analysis.
9. Miller R, Blair P (1985) *Input-Output Analysis – Foundations and Extensions*. Cambridge university press, New York.
10. Study of Investment Levels and Costs of Production of Irrigated Specialty Crops in Alberta for the 2009 Crop Year (2011) *Economics and Competitiveness Division*. Department of Agriculture and Rural Development.
11. Wheaton E, Kulshreshtha S, Wittrock V (2004) *Canadian Droughts of 2001 and 2002: Climatology, Impacts and Adaptations*.
12. Samarwikrema A, Kulshreshtha S (2008) Value of Irrigation Water for Drought Proofing in the South Saskatchewan River Basin (Alberta). *Canadian Water Resources Journal* 33: 1-10.

Citation: Kulshreshtha S, Paterson B, Hart D, Nicol L (2016) Irrigation's Impact on Economic Growth in Alberta, Canada. *Irrigat Drainage Sys Eng* 5: 156. doi:[10.4172/2168-9768.1000156](https://doi.org/10.4172/2168-9768.1000156)