Economic instruments and irrigation water management – a comparative study of private and district irrigators in Alberta, Canada

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Abstract

Irrigation activity in Alberta accounts for 71% of consumptive use of surface water in the province. Pressures on water resources are acute and are expected to intensify. Alberta's answer to its water problems is contained in the Water for Life strategy which aims for a 30% increase in water use efficiency and productivity and the implementation of economic instruments if necessary. Irrigators' contribution towards this endeavour will be imperative. But the foundation of irrigation activity in Alberta is grounded in a private and irrigation district water management system that has resulted in the development of two very distinct irrigation groups. The differences in the production activity and water management practices between private and district irrigators are striking. This study attempts to identify these distinguishing characteristics relating specifically to the adoption of irrigation technology and management practices and ascertain the effect of economic instruments which Alberta, until recently, has largely avoided using.

Keywords: economic instruments, water efficiency, water productivity, irrigation, private irrigation, irrigation districts.

1 Introduction

The majority of irrigation activity in Canada is concentrated in Alberta (64%) (Statistics Canada [8]). Within the province itself, irrigation is by far the major water consumer, accounting for 71% of consumptive use of surface water

WIT Transactions on Ecology and the Environment, Vol 112, © 2008 WIT Press
www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/SI080011

(AENV [3]). For purposes of irrigation, the South Saskatchewan River Basin (SSRB), located in the southernmost area of the province is the most important of the province's seven river basins. 82% of the irrigated area lies within the SSRB.

In Alberta, water is managed under a licensing system. Licenses are legally tied to specific parcels of land and historically have remained with the property when the land is sold. The date the license was issued establishes its seniority and the first-in-time, first-in-right principle ensures that during times of water shortages, licence holders obtain access to their water in accordance with their seniority.

For irrigation purposes, licenses are held by two distinct types of irrigators: private irrigators and irrigation districts. Private irrigators are issued individual licenses just like other private or public landowners needing water for purposes such as golf courses or parks. Licensing is regulated by Alberta Environment. Almost 2,900 private irrigators exist in Alberta, accounting for 18% of the irrigated area (AAFRD [1]). Water for private irrigation is mainly extracted from ten different rivers within the SSRB, along which most of the private irrigators are located (Figure 1). Private irrigators are responsible for the installation and maintenance of the infrastructure needed to pump the water from the river and convey it from the river to the field as well as the irrigation equipment used on the field itself. Private irrigators do not pay for the water. When a license is approved, a one-time payment of the license is levied, based on the volume of water involved. These irrigators are governed by the Water Act (1999).

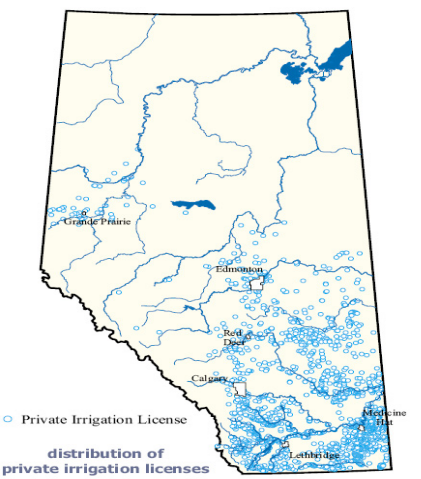

Figure 1: Private licences. Source: AAFRD, 2000.

The provinces' 13 irrigation districts, which account for 82% of the irrigated area, operate very differently from private irrigators (Figure 2). The districts hold water licenses and the irrigators within them have their irrigable area on the district's assessment role (acres approved for irrigation for which an annual water rate is paid to the district). These irrigators constitute the district's ratepayers. Irrigators pay a flat fee per hectare for administration costs and some rehabilitation of infrastructure, varying from as high as almost $45.00 per hectare in the St. Mary River Irrigation District to as low as $18.50 per hectare in the Eastern Irrigation District (AAFRD [1]). The variation in rates is reflective of whether or not the irrigators have piped and pressurized water supply and whether the districts have access to other sources of income. Irrigators do not pay for the water itself and they also do not pay for the cost of head works and the supply infrastructure delivering the water to the districts off-take from the river. Some districts also supply water to municipalities, golf courses, feedlots, as well as oil and gas and other industries, resulting in a complex fee structure among districts. The districts are governed by the Irrigation Districts Act (2000).

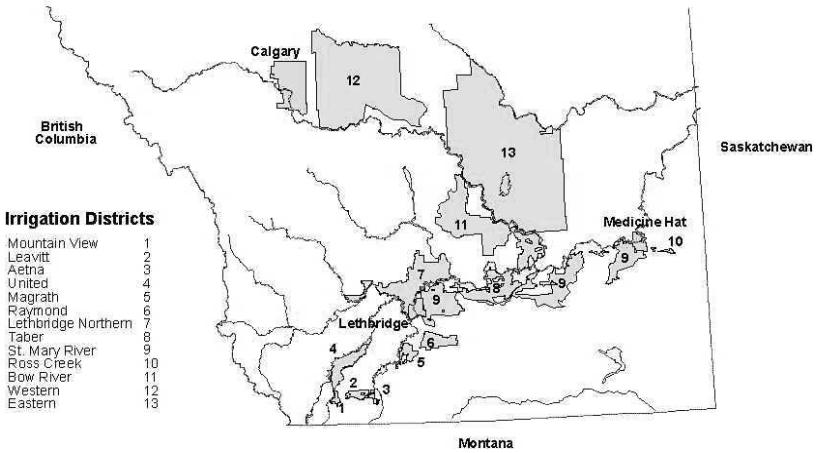

Figure 2: Irrigation districts in Alberta. Source: http://www.agric.gov.ab.ca/irrigate/irrbase.htm.

Water use efficiency in Alberta, measured as the fraction of water delivered to the farm that actually reaches the root zone of crops, has improved over time through the gradual movement away from surface irrigation (30% water use efficiency) to wheel-move and ultimately to the most efficient, low pressure centre pivots (80% water use efficiency). Under existing irrigation techniques efficiency overall was estimated in 1999 at 71% across the irrigation districts (AIPA [5]).

Economic instruments found their way tentatively into water management in Alberta when the new Water Act in 1999 and Irrigation Districts Act in 2000

provided for the introduction of trading in water rights and allocations. During the drought of 2001 the value of allocation trading proved itself when it assisted irrigators in the St. Mary River Irrigation District to manage the drought conditions (Nicol and Klein [6]). Discussions with irrigation district managers reveal, however, that little or no allocation trading has taken place since then. Water right trading has also not been widely used, mainly due to the complexity of administrative procedures and lack of effective communication systems between buyers and sellers (Nicol et al. [7]).

Shortly after the introduction of this legislation the government embarked on a public review process with the view of establishing a long-term provincial water management strategy. This review process occurred between November, 2001 and June, 2002. The result was the Water for Life strategy that was released in November 2003 (AENV [2]). The strategy confirms that water resources in the SSRB are fully or over committed and that demand for water is likely to continue to increase due to Alberta's population and economic growth as well as increased demand from in-stream uses. The strategy projects that water use efficiency and productivity can be increased by 30% by 2015 and that economic instruments will be used to achieve this if necessary. Although water markets and water pricing are two main economic instruments often discussed in the literature (Johannson et al., 2002; Brisco, 1997; Haddad, 2000; Dinar et al., 1997), many other options exists such as various types of subsidies and taxes that can be used to provide incentives for the introduction of best management practices or more efficient technologies. Except for trading of water allocations and water rights, use of other economic instruments applied to irrigation water has been largely avoided in Alberta.

2 Survey design and methods

In 2005, the managers and board members of the 13 irrigation districts were surveyed to determine the irrigation industry's perception of the Water for Life strategy and its main objectives and policy instruments (Bjornlund et al. [4]). That study found that there was very little support for the use of economic instrument and the expectation of further efficiency gains was far below the 30% target outlined in the Water for Life strategy. It also was found that further adoption of improved technologies or management practices likely would vary across the 13 districts depending on physical production conditions and other factors.

That survey was followed up by two additional surveys which obtained the views and practices of private irrigators and irrigators within two irrigation districts. The surveys, the results of which are presented here, delved more deeply into issues relating to water use efficiency measures and reaction to the use of economic instruments. The survey asked irrigators: 1) what they have done in the past and what they intend to do in the future to improve water use efficiency on their farms; 2) what were the drivers and impediments to make such improvements; 3) what has influenced their decision making about improved technologies and management practices; and 4) their likely responses

to economic instruments including subsidies, greater opportunities to obtain specialty crop contracts, and trading water allocation and water rights. Many of the questions sought information on irrigator's historical, recent past and future intended technological and management practices in three distinct time periods: historical (prior to 2001), recent past (2001–2006), and future (2007–2012).

The private irrigators' survey was conducted by telephone between March 1 and March 31, 2006. A list of private irrigator names and locations was obtained from Alberta Environment, Lethbridge office. Names were randomly selected from the list. One hundred and fifty surveys were conducted. The irrigation district survey was conducted by mail with questionnaires sent on December 14, 2006 to 810 irrigators: 320 in the Raymond Irrigation District and 490 in the Taber Irrigation District. A reminder postcard was mailed 10 days later. One hundred and fifty questionnaires were returned, representing a 19% response rate. The Raymond and Taber Irrigation Districts were chosen because they have quite distinct production characteristics and technology adoption patterns due to differences in soil type, number of frost-free days, heat units, and geography.

Data were entered into SPSS for analyses. Frequencies and descriptive statistics were produced. To identify statistically significant differences in survey outcomes cross-tabulation between private and district irrigators were performed using Pearson's Chi-Square tests or Fishers Exact tests. Outcomes are reported in the tables.

3 Private and district irrigator features

Study results reveal striking differences in production and personal characteristics between private and district irrigators. A factor of particular importance, one liable to affect virtually all decision making, is the prominence of dryland farming among private irrigators (Table 1). A significantly higher percentage of private irrigators have large amounts of land under dryland farming compared to district irrigators – 39% of private compared to 16% of district irrigators have dryland area greater than 260 hectares (Pearsons Chi-Square $p<0.01$). Alternatively, only 13% of private irrigators have irrigated areas greater than 260 hectares compared to 24% of district irrigators (Pearsons Chi-Square $p<0.05$). This suggests that private irrigators are probably less reliant on irrigation to generate farm revenue.

Table 1: Dryland and Irrigation Farming: Private and Irrigation District Irrigators (%).

	Dryland[1]		Irrigation[2]	
Size (hectares)	Private	District	Private	District
< 65	38	60	55	42
65 and <130	9	16	20	16
130 and <260	14	9	13	18
260 and >	39[1]	16	13	24
[1] Sign. different at the 0.01 level; Sign. different at the 0.05 level				

There is also a noticeable difference in production. A significantly higher proportion of private diverters grow forage (Pearsons Chi-Square $p<0.01$). The vast majority of private irrigators use their relatively small irrigated area to grow forages in support of secondary production – primarily cow-calf and feedlot operations. Fully 93% of irrigators indicated this is the case. 55% of private irrigators indicate all their irrigated area is dedicated to forage production. So prominent is forage production that 64% and 87% of private irrigators indicate they have no irrigated area dedicated to cereal or specialty crop production, respectively. While 31% of district irrigators dedicate all their area to forage, a significantly higher proportion have more land in specialty crops and cereal (for both, Pearsons Chi-Square $p<0.01$). About 40% indicate they have some irrigated area under both cereals and specialty crop production. Reflecting these differences it is not surprising that 43% of private irrigators report that the weather is the most important factor determining when to irrigate, while 57% of district irrigators report that the crop growth stage is the most important factor – a significantly higher percentage than for private irrigators.

Comparing additional production and personal characteristics between the two groups' results indicate that, compared to district irrigators, private irrigators seem to:

- have significantly more land under less advanced surface ($p<0.01$) and wheel move irrigation systems ($p<0.05$) – 21% have all irrigated land under surface irrigation compared to 8% of district irrigators; 28% have all irrigated land under wheel move irrigation compared to 21% of district irrigators; 5% of have all irrigated land under high pressure pivot compared to 8% of district irrigators ($p<0.01$);
- have less off-farm work (52% private, 61% district, $p<0.1$) and depend less on off-farm income (21% of private irrigators derive over 75% of household income from off-farm work compared to 40% of district irrigators, $p<0.1$));
- have less formal education (29% have college education compared to 32% irrigation district; 6% have a university graduate degree compared to 14% irrigation district, $p<0.1$));
- are significantly older (67% are 55 years or older compared to 45% of district irrigators, $p<0.01$);
- have a significantly higher level of family background in farming (91% private, 84% district, $p<0.05$);
- have significantly greater expectation of family continuity of the farm (33% v. 48% do not expect family continuity, $p<0.01$);
- participate almost equally with irrigation district irrigators in government programs (44% of private irrigators on average compared to 42% irrigation district irrigators).

4 Adoption of irrigation technology and management practices

Relative to district irrigators, private irrigators have invested less in irrigation technology in the past and have less intention to invest in the future. As table 2 shows, across most initiatives, a significantly lower percentage of private irrigators have undertaken these measures compared to irrigation district irrigators. For the time periods of before 2001 and 2001–2006, the percentage of district irrigators implementing these measures was significantly higher, in many cases more than double the percentage of private irrigators. The rate of adoption for three measures slowed considerable for both groups from the first to the second time period – converting from surface to wheel move, wheel move to pivot and surface to pivot. The percentages for the remaining two measures – converting from high to low pressure and purchasing a computer panel – increased for both groups, probably prompted by increasing energy costs and a desire to adopt recent computer innovations. In the future, the rate of adoption will slow considerably for both groups, with the highest percentage continuing to change to low pressure pivots and purchase a computer panel. These percentages are low but district irrigators will continue to adopt most of these measures at a significantly higher pace.

Table 2: Implementing irrigation technologies, percentage of irrigators.

Type	Before 2001		2001-2006		2007-2012	
	Private	District	Private	District	Private	District
Surface to wheel move	20[1]	37	1[1]	6	2	3
Wheel move to pivot	13[1]	33	7[2]	20	2[1]	10
Surface to pivot	7	10	1	3	1	2
High to low pressure	5[1]	16	10[1]	23	3[1]	12
Purchase computer panel	5	7	6[1]	16	1[1]	12
[1] Sign. different at the 0.01 level; [2] Sign. different at the 0.05 level						

The disparity in adoption of improved management practices between the two groups (Table 3) is even more apparent than the adoption of improved technologies. In virtually all categories across all time periods, the differences are statistically significant. It appears that private irrigators started to adopt improved management practices quite aggressively prior to 2001 then the number dropped off substantially from 2001 to 2006 followed by very little activity planned for the future. Compared to district irrigators, private irrigators therefore had a much greater rate of adoption before 2001 across all measures except hand auger and feel method. During the 2001–2006 period, like private irrigators, the rate of initiation for district irrigators also dropped but only for two measures -initiating visual monitoring and using the hand auger and feel method. For the additional four initiatives – starting to use monitoring instruments, computers or phones to change the position of pivots, website sources like AIMM (Alberta Irrigation Management Model) or IMCIN (Irrigation Management Climate Information Network) and private consultants – the

percentage increased. Thus the percentage of district irrigators who started these practices in the 2001 to 2006 period surpassed the percentage of private irrigators across all measures. Noticeably similar, however, is the relatively small percentage of both groups who had undertaken three relatively new measures during the 2001–2006 period – the use of monitoring instruments, computer or phone to change the position of pivots, and internet sources such as AIMM (Alberta Irrigation Management Model) or IMCIN (Irrigation Management Climate Information Network), suggesting a reluctance to try new methods. In the near future, a larger percentage of district irrigators plan to initiate all measures compared to private irrigators, with the highest percentage planning to begin using monitoring instruments (9%) and computers and phones to change the position of pivots (10%). For private irrigators, the percentages for the future are very small, are in all but one instance significantly different from district irrigators, and involve 3% or less of those irrigators.

Table 3: Start to implement improved management practices, percentage of irrigators.

Type	Before 2001		2001-2006		2007-2012	
	Private	District	Private	District	Private	District
Visual Monitoring	74[1]	47	3[2]	9	1	1
Hand auger and feel method	27[3]	36	3[1]	19	1	1
Monitoring instruments	11[2]	3	2	5	1[1]	9
Computer/Phone	3	1	2[3]	6	1[1]	10
AIMM/IMCIN	6[3]	2	1[1]	7	1[3]	5
Private consultants	19[2]	10	2[1]	9	1[3]	4
[1]Sign. different at the 0.01 level; [2] Sign. different at the 0.05 level; [3] Sign different at the 0.10 level.						

When asked to identify from a list of reasons, the most important reason for improving water management, the differences in ratings were all statistically significant. The vast majority of irrigation district irrigators, almost 60%, identified "to improve crop yield and quality". For private irrigators, the reasons not only related to improving crop yield and quality, where 30% identified this reason as being the most important, an additional 27% identified "to reduce labour costs" and a further 24% identified "to reduce energy costs". This response suggests that while irrigation district irrigators are undoubtedly cognizant of costs, the extra energy and labour costs involved in water management for private irrigators would result in those factors being particularly relevant in their decision making.

When asked to identify from a list of reasons, the main reason inhibiting them from improving water management, the differences between district and private irrigators are again notable. The largest percentage of district irrigators, 25% identify "I already use all the water saving practices that are practical". This factor is rated as most important by a significantly lower number of private irrigators, just 15%. This suggests that private irrigators believe they have more room to improve water saving practices which is not

unexpected since a significantly lower proportion of these irrigators has or plans to invest in improved irrigation efficiency. The main reason inhibiting private irrigators is that "physical field conditions limit system improvements" which was rated by 28%. The second reason noted by both district and private irrigators relates to finances – for 21% of district irrigators it was that "my financial situation does not permit the investment" and for 16% of private irrigators it was that "improvements will reduce costs but not enough to cover installation costs".

5 Economic instruments

5.1 Financial incentives

Irrigators were first asked to identify which option they would choose if financial assistance were available to assist in investing in more efficient irrigation equipment. Of the three options – cash subsidy, subsidizing borrowing rates and accelerated depreciation – both private and district irrigators by far favour cash subsidy – 74% and 71% respectively. In terms of the amount of assistance needed to do so, private irrigators appear to require more economic incentive. Although the differences are not statistically different, between about 60% and 70% of private irrigators would require the highest level of subsidization, compared to about one-third of district irrigators (table 4). Close to a majority of district irrigators would require the mid-range level of subsidization.

Table 4: Level of subsidization based on 65 hectares (percent of irrigators).

Improve existing equipment			Invest in new low pressure pivot		
Level	Private	District	Level	Private	District
<$5,000	23	18	<$10,000	12	20
$5,000-$10,000	18	47	$10,000-$30,000	16	49
>$10,000	59	34	>$10,000	68	31

5.2 Processing opportunities

The data suggests financial constraints exist for both groups of irrigators but especially private irrigators. Irrigators when first asked if new processors were to locate nearby and contracts were available, would they increase production of high value speciality crops. Irrigators were then queried as to whether such opportunities would lead to investment in improved water use efficiency measures. Of seven specialty crops listed, an average of 12% of private irrigators would begin or increase production of these types of crops compared to 19% of district irrigators, perhaps reflecting restrictions to irrigation of such crops due to physical field constraints and the need to continue to dedicate land to growing forages in support of their cow-calf and feedlot operations. Not surprisingly, less private irrigators, about half, would therefore invest in improved water use efficiency measures – only 28% of private irrigators compared to 53% of district

irrigators. Although not statistically significant, this result underlines differences in the characteristics of private and irrigation district irrigators.

5.3 Water allocation and rights trading

As noted, activity in the water allocation and water rights market among irrigators in Alberta is very limited. However, if supply pressures intensify, such activity may grow. Irrigators were asked whether if someone was available to purchase their water allocation for a year and the offered price made economic sense, they would consider selling it. An almost equal number, approximately 37% of private and district irrigators indicated they would. But when asked if such circumstances existed for the selling of a permanent water license, a much higher percentage of private irrigators, 22%, compared to district irrigators, 7%, would do so and convert to dryland. This is perhaps not an unexpected result given private irrigators' experience and custom of dryland farming and reduced reliance on irrigation. Finally, irrigators were asked if they were in a situation where they wanted to expand or maintain their irrigated area, whether they would consider buying additional water licenses to do so. Not surprisingly, less private irrigators, 42% indicated they would do so, compared to 61% of district irrigators.

6 Conclusions

The differences between private and district irrigators extend to numerous facets of personal characteristics, production methods, water management, motives for decisions, and ultimately, responses to the use of economic instruments. Compared to district irrigators, private irrigators seem to be much more conservative and grounded in traditional methods of farming. They are older, have less formal education, depend much less on off-farm income, more often have parents involved in farming and have greater expectation of family taking over the farm. They have large dryland farming areas and much smaller areas of irrigated land which is dedicated primarily to forage production in support of cow-calf or feedlot operations. District irrigators have a significantly higher proportion of their land in specialty production reflecting their better growing conditions, more reliable water supply and the presence of processing facilities Given the prominence of dryland farming relative to irrigation farming, it is not surprising that private irrigators are much less inclined to adopt more advanced irrigation technology relative to irrigation district irrigators. Private irrigators adoption of improved management practices seems to have been undertaken prior to 2001 with very little intent to adopt in the future. These irrigators, and perhaps to a lesser but still substantial extent, district irrigators, do not plan on initiating improved water management practices. The highest percentage is 10% who plan to begin using computer or phone to change the position of pivots. This suggests there may be potential for extension work to promote greater water efficiency through use of management practices which often involve minimal cost to the user. In the case of private irrigators, where a large number believe

they do not use all the water saving practices that are practical, this approach may be particularly fruitful.

Left on their own recognisance, adoption of more efficient technologies in the future will be modest. This is especially true for private irrigators. Physical field conditions for private irrigators seem to be a major factor inhibiting adoption. In addition lack of financial capability is a factor. Generally, private irrigators will be a difficult group to motivate unless monetary incentives are very generous. Processing opportunities that allow for more speciality crop production and enhanced finances to purchase improved technologies, appear to be a non-starter. Few would venture into, or increase production of, specialty crops, resulting in a limited number investing in improved water use efficiency measures. Given an opportunity to sell their water license, a higher number of private irrigators than district irrigators would do so and relatively less would buy additional water licenses to expand or maintain their irrigated area, reinforcing what appears to be private irrigator's proclivity to dryland farming.

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