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Proportional water sharing vs. seniority-based allocation in the Bow River basin of Southern Alberta

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ABSTRACT

We analyze the implications of switching from existing seniority-based allocations to proportional water sharing policies in times of water shortage in the Bow River Sub-Basin in Southern Alberta. In particular, we simulate three variations of the proportional water sharing concept: (1) irrigation districts' permissible diversions are reduced in proportion to each district's licenced allocations; (2) the diversions are reduced in proportion with each district's past five-year average diversions; and (3) the diversions are reduced proportionately with each district's diversion in a single prior year. Compared to the seniority-based allocations, all three alternative policies produce unambiguously better results. With trades, the prospect of overall economic gain improves further. However, the distribution of potential monetary gains varies across scenarios.

1. Introduction

The possibility of increased water scarcity in Southern Alberta has motivated a number of suggestions for alternative policy reforms that could change or complement the province's existing allocation rules for water use in times of shortage. The Government of Alberta has recently taken some steps to change the way water is managed and is pursuing a strategy to encourage water conservation, increased on-farm efficiency and reallocations of water through voluntary actions by the existing users (Alberta Environment, 2008a).

Under Alberta's historical "first-in-time-first-in-right" approach, some water licence holders have large senior allocations that are not fully used even during periods of moderate water scarcity. In this situation, junior licence holders might be denied the use of any water at all. A recent suggestion is to allocate water during times of shortage in proportion to the size of each licence instead of according to the licences' seniority (Droitsch and Robinson, 2009; Zilberman and Schoengold, 2005). Under such proposals, the historical system of appropriative water licences would continue in force, but the role, value, and effect of those licences could be altered substantially when water is scarce.

Droitsch and Robinson make a specific recommendation regarding proportional sharing for Southern Alberta. Their Recommendation 3 states, "... *water licences should be converted to water "shares" that entitle the holder to a portion of the water available for diversion in each time period. While water licences currently provide the right to withdraw a fixed volume of water, a water share would provide the right to withdraw a percentage of water available on a seasonal basis up to a specified maximum volume limit*" (2009, p. 23).[1] This recommendation responds to the interest expressed by the government to review the current water allocations and licencing practices in Alberta and to explore alternative options for better water management during scarcity (2009, p. 6). Although proportional water sharing could clearly benefit those who might

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[1] Without providing specifics, the report offers a number of suggestions for the initial allocation of shares such as offering larger shares to those licensees with senior licences, and adjusting the size of the shares to reflect such factors as actual historical usage and projected future usage (2009, p. 24). The report does not quantify the effects of such reforms for any of the regional river basins.

be denied any annual diversion in periods of expected water shortage, it is less clear that this would bring overall gains, and it is unclear how large these gains might be. Since there are alternative systems for determining users' initial shares, there could be a range of outcomes with respect to the efficiency of water and land use.

The Government of Alberta's concern for improving the efficiency of water use is articulated in its Water for Life strategy (Alberta Environment, 2003). This strategy sets a target to improve the conservation, efficiency, and productivity of water usage in Alberta by 30% in 2015 from its 2005 level (AWC, 2007). Since irrigation is one of the largest (60–65%) water consuming sectors in Alberta, any small gain in efficiency can generate large volumes of saved water. Recent estimates suggest that a 4.6% efficiency gain in the irrigation sector could save enough water for a full year's supply for all municipalities in the South Saskatchewan River Basin (SSRB) (AIPA, 2010).

A proportional sharing strategy is not a new idea in the context of water management during shortage years – similar approaches have been followed by other jurisdictions. For example, in the Colorado Big–Thompson system, a unit or share of water is defined as 1/310,000th of the available 382.38 million m^3 of water, i.e., each unit or share is 1233.48 m^3 but could be less in shortage years (Libecap, 2005). In Mexico, even though the water rights are specified in volumes, they are effectively converted to proportional streamflow rights during years of shortage because each holder's right is reduced by the same percentage of the shortfall below a normal-year flow. In Chile, water rights are specified as shares of stream flow rate (l/s or m^3/year) and are proportionally reduced during low streamflow conditions (Rosegrant and Gazmuri, 1994). In Australia, water rights are called water entitlements (on permanent water) and provide owners access to a share of the consumptive pool, but actual extraction depends on the seasonal allocations (of temporary water) expressed as a percentage of the water entitlements (Wheeler et al., 2009; Grafton et al., 2009).

Any reform of water rights would have effects on both the efficiency of water use and the equity or fairness with which the benefits of water use are shared. In primarily agricultural water basins with diverse crops and water uses, it is difficult to predict the effects of these policy changes on water use efficiency. For instance, the allocative effects of such a reform might depend upon how active is the trading of water allocations both with and without the proposed reforms, or upon differences in the historical productivity of water use among senior licence holders. Fortunately, these issues are amenable to analysis using computational models of water allocation that have been developed and calibrated for this region.

Our goal in this study is to investigate the effects of proposed alternative water allocation strategies on water diversions, crop production, and economic impacts (producers' net margin) in three irrigation districts: the Bow River Irrigation District (BRID), the Eastern Irrigation District (EID), and the Western Irrigation District (WID) of the Bow River Sub-Basin (BRSB) of Southern Alberta. Our specific objectives are:

(a) to compare the impacts on cropping patterns and producers' net margin of a proposed proportional sharing of water when water is scarce, within the current seniority-based allocation. The sharing is based on the reduction of users' permitted water diversions in proportion to each district's licenced entitlement;
(b) to compare the impacts of the proposed proportional sharing rule if it is implemented differently, where the reduction is not in proportion to the total licenced amount (as in (a)), but in proportion to the actual average water diversions in the past five years; and
(c) to compare the impacts if the reduction as in (b) is implemented in proportion to the actual water diversions in a single prior year instead of the past five-year average.

In each of these cases, the reforms are examined in periods of moderate to severe water shortage, with and without trading among licencees after the seasonal restrictions have been announced. We call this 'short-term' trading to indicate that it involves only the temporary transfer of water for the current irrigation season as opposed to a 'long-term' or permanent transfer of licenced water rights.

A description of the models for analyzing water policies in Southern Alberta and other parts of the world is provided in Section 2 and specific methods followed in this study are presented in Section 3. Definitions of water allocation policy scenarios are detailed in Section 4, followed by model results and discussion in Sections 5 and 6.

2. Review of models used to analyze water policies

A number of computational models have been developed in recent years to analyze the physical allocation of water as well as to estimate the economically optimal allocation of water in Southern Alberta. Physical allocation models, discussed only briefly since they are not particularly relevant to the model in this paper, deal with the movement of water starting from the diversion at the head works, through the networks of storage basins, canals and pipelines, to the distribution of water at the irrigated fields. Two such models are the Irrigation District Model (IDM) (AAFRD, 2002a) and the Water Resources Management Model (WRMM) (Alberta Environment, 2002). The IDM determines daily farm delivery requirements based on crop growth parameters and translates them into canal flow and diversion requirements while the WRMM determines if the requirements set by the IDM could be met following the licence priorities and meeting other major delivery requirements in the non-irrigation sectors such as municipal, industrial, recreation, wetlands, instream flows, and inter-provincial apportionment commitments in the SSRB. The output of the WRMM characterizes the frequency and magnitude of the irrigation water deficits on a weekly basis. These deficits form the inputs to a third model, the Farm Financial Impact and Risk Model (FFIRM) (AAFRD, 2002b), that analyzes the risk and water shortage impacts on the incomes of representative farms across the basin using both an optimization routine and a farm risk management simulation routine.

The economic optimization models that have some methodological relevance to the model used in this paper discussed in greater length below include Horbulyk and Lo (1998), Mahan et al. (2002), and He and Horbulyk (2010). The earliest model (Horbulyk and Lo, 1998) was a basin-scale model with the objective of maximizing economic gains from alternative water allocations in four sub-basins (Red Deer River, Bow River, Oldman River, and South Saskatchewan River) of the South Saskatchewan River Basin (SSRB). These gains were realized from short-term water transfers from rural-to-urban sectors within and across sub-basin of the SSRB.

Mahan et al. (2002) used a similar mathematical programming approach, but extended the previous model by adding more water user categories (irrigation, domestic, general use, industrial, hydro, and total urban), and a sub-model that analyzed irrigation water demands of six major crops (soft wheat, hard spring wheat, barley, canola, potatoes, and alfalfa). Allowing trade in water among irrigation regions for one growing season, the relative efficiency gain for introducing market pricing was about 3% for a water surplus season, 6% for an average flow season, and 15% for a drought season.