RURAL ECONOMY

Conserving Water in Irrigated Agriculture:
The Economics and Valuation of Water Rights

T.S. Veeman and M.M. Veeman with
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Canada-Alberta Environmentally Sustainable Agriculture Research
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PROJECT REPORT

Department of Rural Economy
Faculty of Agriculture, Forestry
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Edmonton, Canada

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Abstract

The effective management of water resources in Alberta is crucial to sustainable agriculture, industrial development, and environmental management. The historical water allocation mechanism, administrative apportionment, has been viewed in recent years as ineffective and cumbersome. Accordingly, the revision of the Water Act in 1996, included an attempt to improve the efficiency of water allocation. By making the transfer of water rights possible, the revised Act provides many new options for water use and flexibility. The implications of transferable water rights in Alberta water policy must be carefully considered in order to determine the viability and suitability of such a system in the provincial context. This project examines some of the economic aspects of transferable water rights and the potential for effective water allocation by way of transfers in an Alberta setting.

As a major part of this project, a hedonic price model, focusing on land values in southern Alberta, was constructed based on similar models, which have been used elsewhere to value water rights or agricultural products. The hedonic approach to market analysis uses the relationship between the price of land and the attributes of the land, such as water availability, soil quality and location, to explain differences in land prices. In this process, the hedonic model is used to estimate the implicit marginal price or value of each land attribute -- in our case, the marginal value of irrigation water. This value will provide us with an indirect estimate of the value of water rights in the region studied. An advantage of the technique is that it estimates the value that farmers express for irrigation water in the market place for land. Such values, then, give us an indication of the anticipated prices, which might prevail for water rights in southern Alberta.

The focus of the study was an area of southern Alberta encompassing the counties of Wheatland, Newell, Cypress, Forty Mile, Taber, Warner, Lethbridge and Vulcan and the irrigation districts of Western, Eastern, St.Mary’s, Taber, Lethbridge Northern, and portions of Raymond. Information was collected on the physical and economic characteristics of 230 land parcels, which were sold in this region in 1993 and early 1994. A crude comparison of the value of irrigated agricultural land and non-irrigated agricultural land in the sample reveals that irrigated land was worth, on average, $325 more per acre than non-irrigated land. In the ensuing analysis, it was estimated that the value of a parcel of land was determined largely by the buildings on it, the number of acres in the parcel, the proximity of the parcel to a major city (in this case Calgary or Lethbridge), and by the availability of irrigation water. In the hedonic model, the coefficient values of the variables included represent the marginal impact of each of these characteristics on land prices holding all other things constant. For example, the value of water rights represents the average difference between land values of farms that have access to irrigation and farms that do not.

This study estimated that every dollar of improvements to farm buildings translates to a one cent increase in the per acre price of the land parcel, where the addition of one extra acre of land to a land parcel lowers the price per acre by $5.17 per acre. Land prices were seen to increase with the proximity of the parcel to large cities. Similarly, the results of the preferred

model indicate that the implicit value of having access to irrigation water in southern Alberta is approximately $190 per acre, or, using the conventional estimate that irrigating one acre of land requires 1.5 acre feet of water, this translates to $126 per acre foot of irrigation water. Accordingly, it is revealed that the existence of water rights adds approximately 35% to the value of non-irrigated land. Since this value represents the implicit amount farmers are willing to pay for access to water, it could also be construed as an indirect measure of the value of water rights. From these results, it is reasonable to conclude that water rights do have a measurable impact on land values. Accordingly, proper incentives may be needed to ensure that water is used efficiently and not incorrectly treated as a relatively free or cheap good. One possible method of policy reform to achieve such a system would be the institution of a system of transferable water rights, permitting water to be traded, or effectively sold, at its market price or scarcity value.

Further work was done to determine the potential effects of transferable water rights on the Eastern Irrigation District in southern Alberta. Farm budget information was used to gather information and create twelve representative farm types whose financial performance was analysed using linear programming with increasing water quantity constraints. The resulting productive water values were then used to imply potential reallocations of water among farm types and cropping systems. Analysis of the data gathered revealed that all representative farms faced downward sloping demand functions for water. The overall value of water for a 1% reduction ranged from $8 to $250 per acre foot, with the lowest value belonging to largely pasture operations and the highest value attributed to specialty crop producers. This large range in water values for the region indicates that there is sufficient heterogeneity within the EID to accommodate a transferable rights system. Further analysis of the data reveals that the implementation of a transfer system would result in water being transferred to specialty crop producers and the acreage devoted to specialty crops would increase. Small irrigated pasture operations and cereal crop producers would be the first to give up their water allocations under a transfer system. The analysis indicates that there is considerable potential for economic gains from water trade within this district, the main constraint being the market limitations to expanded specialty crop production.

Using these two major studies and other sources, this report concludes with a brief evaluation of the economic advantages, disadvantages and other issues involved in instituting a system of transferable water rights in Alberta. Experience elsewhere, primarily in Australia and the western United States, strongly suggests that transferable water rights, despite some drawbacks and problems of implementation, can be a very worthwhile water policy tool. Now that such tradable water rights are permissible under the revised Water Resources Act of 1996, it is recommended that a pilot project involving transferable water rights be instituted in a water short basin or sub-basin in southern Alberta once a water management plan for that basin is completed.

1. Introduction

Irrigated agriculture is by far the dominant consumptive use of water in southern Alberta. As water scarcity becomes more of a concern and supplying extra water is viewed as too costly, attention has moved to water demand management. The two most obvious economic policy instruments for managing water demand and conserving water are water pricing and water rights trading. As Alberta looks for new ways to manage water demand and improve the effectiveness of the water allocation mechanism, transferable water rights will come under increasing scrutiny.

Alberta's historical system of water rights -- a system based on administrative apportionment -- will prove increasingly inflexible in years to come. This system does not provide for changing environmental goals along with changes in modern demands for water. Since this method of allocation treats water as an essentially free good, and given a licence for a certain amount of water this allocation is guaranteed as long as all older licences receive their water, there is little incentive for conservation or for moving water to its highest valued use. A system of tradable water rights, it is argued, will lead to the reallocation of water to higher-valued users, both within and outside the agricultural sector. As reallocation occurs, the economically efficient use of water, and thereby water conservation, will be encouraged.

After much deliberation, the Alberta government has passed a revised version of the Water Resources Act (August, 1996). This new legislation will replace the outdated and inefficient Water Resources Act with a new set of policies to more optimally guide Alberta's water law for many years to come. Within the new Water Act is the provision for the introduction of transferable water rights. Following the experiences of other geographic areas, the Water Act establishes that, in certain cases, water rights can be transferred independent of land or project. It is important that the economic merits, shortcomings, and problems involved in instituting such a scheme be carefully researched in the Alberta context. An important dimension of such an assessment is to generate better information on the value of water rights and on the value of water in alternative agricultural uses. This project attempts to improve our knowledge of the economics of water rights and of rights trading.

In order to facilitate an understanding of the effects a transferable water rights system might have in Alberta, this project was associated with two major empirical studies. The first involved the construction and estimation of a hedonic price model, focusing on land values in southern Alberta. The study uses the market price of different types of land to estimate the implicit marginal price of attributes of that land. Water is one of those attributes. The study attempts to determine the value farmers place on access to irrigation water. In finding that the marginal value of water per acre of land is approximately $190, the study draws conclusions about the indirect value of water rights and the potential for a system of transfers to be implemented.

A second major study supported in part by this project, involved the creation of a model of twelve representative farms in the Eastern Irrigation District and the use of linear programming to evaluate the actions of farms with increasing water quantity constraints. This process evaluated the water demand functions for a variety of different farm types and found vast differences in the value placed on water resources. Accordingly, conclusions were drawn as to what types of farms valued water more than others and what direction transfers would take place if a system were implemented that permitted the sale of water rights. Similarly, the potential changes in farm production that may occur if water is not treated as a free good were also examined.

This project begins with a brief examination of the historical background of water rights in Alberta and some examples of transferable water rights in the United States and Australia. The body of the project contains detailed analysis of the empirical results obtained in the two studies mentioned above. Finally, the advantages and disadvantages of transfer systems are briefly discussed. It is intended that this information is then used to draw conclusions about the merits and difficulties of such a system and issues involved in instituting a transferable water rights policy in the Alberta context.

1.1 Objectives

The general objective of the research is to provide an improved economic and information base from which to evaluate a proposed system of transferable water rights, which might be instituted in Alberta. Such a tradable water rights system could now be instituted in Alberta given the changes to the province's Water Act, which has been enacted since much of the empirical research in this project was completed. The specific objectives of the research are:

1. To analyse the case for modifying Alberta's historic system of water rights, drawing on Australian and American experience. (Section 2.2)

2. To review alternative economic methodologies, which might be used to estimate the value of water rights, including the hedonic approach. (Sections 3.1 and 3.2)

3. To collect primary data on recent land sales for both irrigated and adjacent dryland parcels in southern Alberta, as well as pertinent socio-economic and agronomic characteristics of these land parcels. (Section 3.4)

4. To construct a hedonic price model to isolate the implicit marginal value of the water (irrigation) attribute of land and to use these hedonic values in an economic assessment of a system of transferable water rights. (Sections 3.5 and 3.6)

5. To collect farm budget information from a restricted sample of irrigation farmers to derive the economic value of water in alternative crops via the farm budget residual method. (Section 4.2)

6. To use the preceding estimates of the productive value of water in alternative crop uses to

study the potential reallocation of water among farm types and cropping systems if water availability were increasingly constrained, as well as to estimate the possible economic value of water transfers if water were to be transferred to higher-valued agricultural use. (Section 4.2)

7. To outline and analyse the major problems which would be involved in the possible introduction of a system of transferable water rights. (Section 5.3)

8. To draw conclusions and policy recommendations concerning the relative merits of a system of tradable water rights. (Section 5.2)

1.2 Format of the Report

The report is organized into five main sections along with the introductory section. Section 2 contains a brief overview of the history of water rights in Alberta and some of the reasons changes to the existing legislation were proposed. The section goes on to provide examples of water rights systems in the United States and Australia and the implications they have for Alberta's water law.

Section 3 focuses on research done using a hedonic price model to determine the value of water rights in southern Alberta. This section includes background on hedonic studies, details of the study itself and empirical results calculating a monetary value for existing water rights. Section 4 contains a study of the Eastern Irrigation District in Alberta. It includes an analysis of farm water demand given decreasing availability of water and the alterations in crop production that would result from changing quantities of water. This section also discusses the financial risk for farmers involved in crop alteration because of transferable water rights.

Section 5 discusses the potential advantages and disadvantages of transferable water rights. Using the examples of existing transferable systems in other countries as well as characteristics and concerns unique to Alberta, this section includes potential problems for implementing a system of transfers in Alberta and the advantages of doing so. The final section of the report, Section 6, presents the conclusions and implications of the research.

2. Water Use in Alberta[1]

Water law in Alberta began as a system of riparian rights where a land owner had the right to extract and use the water adjacent to his land. This right was restricted only in that a riparian's use must not substantially interfere with the use of any downstream riparians. The difficulty with a riparian system in Alberta is that it was unable to "maximize economic potential of the water in (the) conditions of scarcity" (Percy, 1977, 143). Riparian rights, though more suitable for areas

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[1]Sections 2 and 2.1 draw, in part, on a lengthier discussion in Veeman (1985), Freeman and Veeman (1993), and Freeman (1996).

with abundant water supply, were not an efficient method of water allocation for more arid regions like Alberta. Accordingly, the Northwest Irrigation Act of 1894 was created to place control over water allocation in the hands of the government and to implement the concept of prior appropriation, which allocated water in times of scarcity to the user with the longest held licence.

The basic ideas of the Northwest Irrigation Act were continued in the Water Resources Act of 1931, which directly placed ownership of water rights in the hands of the Crown. Land owners and other potential users could only obtain water for non-domestic uses if they acquired a licence from the government. Two forms of licences were granted, those appurtenant to a project and those appurtenant to a parcel of land. If the licence was issued to a parcel of land, it was transferred with the ownership of the land. For a licence tied to a project, however, the rights could, in theory, be transferred with the approval of the Minister. The licence, however, remained linked to and "inseparable from the undertaking, so it must ...be necessary to purchase the entire undertaking in order to acquire the water right" (Percy, 1977, 149). Water rights were secured in times of scarcity by the date that the licence was first issued. Older licences, regardless of their use, were given priority over newer licences, which could extract their water only if it did not interfere with existing licences' use of water.

In evaluating the economic impact of water law, it is important to focus on the security and flexibility of water rights (Ciriacy-Wantrup, 1956). Alberta's historic system provided security for users in that they had priority in water use over all licences issued after their own. However, in times of great shortage, there was no provision for dealing with modern demands in the existing rights. Thus, licensees were faced with an increased potential for uncertainty. Adequate flexibility, or allowing a license to change the type of use or location of use is crucial to an efficient allocation system. This was not present in the current system. The approved transfer priority list did not ensure transfer to a use of higher value and the inflexibility of existing rights, being anchored to land or project, limited the potential for water to be transferred to its use of highest value. Also, the unrevised Act limited management of water resources by issuing licences in perpetuity and being unable to guide the allocation of water to higher and better uses. More flexibility is necessary to achieve more efficient water use.

2.1 Examples of Water Rights in the United States and Australia

The desire for more flexible water allocations, resulting in increased efficiency in usage, has led the United States and Australia to implement systems of transferable water rights. Both of these systems provide examples of the possibilities open to Alberta for revising its system of water rights. Transferability aids in the creation of a market for water and the effective allocation of water according to demand. The existence of a market also places a value on water which has historically been undervalued and hence over used.

In the Western United States, the semi-arid environment makes water use especially comparable to use in Alberta. Like Alberta, the United States vests water ownership in the hands of the state. However, the rights to water use in the United States belong not to the government but to the user. Government control over water use and allocation is limited to ensuring that use does not exceed supply and that the rights of all users are protected. In all states, a forum for hearing objections to water allocation exists and applications to governing bodies must be made in order to divert water or to transfer the water right from one user to another. In this way, the rights of other users are protected by the requirement for state approval.

The transfer of water rights is possible in most states, although the amount of freedom of transfer permitted differs from state to state. In Colorado, water rights are considered owned in the same manner as land and can be transferred independently. In most western states, however, water rights can be transferred according to the type of use, place of use, point of diversion or time of use. Application for transfer must still be made with the state and all transfers are subject to approval and possible restrictions placed on them by the state. In some states, such as Wyoming, short term lease or transfer of water is available but long term leasing is precluded by laws that approve transfers for a maximum of two years. Transfer within irrigation districts or water user associations in the United States is regulated slightly differently from private users. For the most part, transfers within irrigation districts are governed by the district itself with some requiring the approval of all voters in the area. This maintains the quality and quantity of water within the district while protecting the interdependent users of the irrigation water. Since Alberta has many large irrigation organizations, this example is particularly relevant to proposed changes to Alberta water law.

Water law in Australia was originally based on riparian rights and evolved into a licence system much like the current system in Alberta. As it became apparent that the development of new water sources was becoming too expensive and time consuming, water regulation in Australia shifted from attempts to develop new sources to programs that focus on efficient management of existing water sources (Birch and MacLock, 1990). The reforms to Australia's water system abolished all remaining private ownership of water with the exception of some domestic use and transferred control to the government. This increased control is mitigated by broader rights to appeal the government's decisions. Legislation was put in place to protect the environment and in stream flows as well as to provide adequate water for human use. Several Australian states also incorporated the opportunity to transfer water rights within their water legislation. The sale of these rights has also been used to recover costs from water conservation projects. The water law has been amended to allow water rights to be sold or leased on a temporary basis, allowing for either short or long term transfers depending on the needs of those involved. All proposed transfers must be reviewed and approved before they can take place, thus ensuring the protection of other water rights. While conditions on where a right can be transferred and approval of the transfer are enforced by the state, the price of water is determined by the market. The incorporation of transfers provides right holders with more control and flexibility over the use of their asset and an incentive to promote the efficient use of water.

The Australian and American systems of water rights and transferability provide examples for Alberta as water rights here are evaluated. As the existing system of water rights allocation becomes increasingly obsolete considering water shortages, increased demand and limited flexibility in rights distribution, Alberta will continue to look for alternatives. The experiences of Australia and the United States will show how Alberta can implement a water transfer system that will provide security and flexibility to the licensees as well as promote the efficient allocation of the water without jeopardizing existing rights or environmental quality.

3. Valuing Water Rights in Southern Alberta: the Hedonic Pricing Model

3.1 Introduction

Alberta is revising its existing system of water rights in favour of the possible introduction of a system where water rights are transferable. The costs and benefits of the merits of such a new system cannot be accurately assessed until a better understanding is gained of the value of water rights in Alberta. Research conducted by Royer (1995), through the Department of Rural Economy at the University of Alberta, attempted to calculate this value. The information gained from research into the value of water rights in southern Alberta will help policy makers and farmers gain a better understanding of the potential value of water as an input into agricultural production and as an environmental good. This information is pertinent for aiding policy makers in determining the economic merits, shortcomings and problems associated with instituting a system of transferable water rights in Alberta.

3.2 Hedonic Price Model

A hedonic price model was used in this study to ascertain the implicit value farmers place on having access to irrigation water in southern Alberta. The hedonic approach to market analysis uses the relationship between the price of the land and the characteristics of the land, such as water availability, soil quality and other attributes, to explain differences in land prices (Crouter, 1987). An important assumption of the hedonic technique is that regions are treated as a single land market (Freeman and Veeman, 1993). It is also assumed that individuals have perfect information on all the alternative types of land available and that they are free to choose any land plot within the market for production. Therefore, the object of this theory is to describe how prices of various highly differentiated land plots would be determined under conditions of perfect competition with the market in equilibrium. Although it may be unrealistic to assume that consumers are fully informed and have zero transaction costs, this does not affect the validity of the hedonic pricing model. Markets that are not in equilibrium may only introduce random errors into the estimates of marginal willingness to pay. However, if market forces are continually moving in one direction, then biased estimates of the marginal implicit prices may result.

A second concern is the issue of market segmentation. If the structure of demand, supply or both is differentiated across geographic regions or the land purchasers in one market segment do not participate significantly in other market segments, the hedonic estimates of land values may reflect this segmentation rather than the desired values (Freeman and Veeman, 1993). This does not invalidate the hedonic technique; however, it may make its application more difficult. Careful examination of the data may help to determine if market segmentation is present. In the case of water rights in southern Alberta, the empirical analysis, using regression techniques, found market segmentation was not a statistically significant concern in the land market (Royer, 1995).

A final consideration of the hedonic model involves the cost of resolving the difficulties in identifying the supply and demand characteristics from the hedonic price function. It is not always realistic to assume identical preferences and income. Also, achieving identification through market segmentation may substantially increase collection costs. In some cases, the use of several markets may force the researcher to restrict the specification of attributes to only those characteristics that different markets have in common. Despite these considerations, the application of the hedonic technique to value aspects of goods (or land) is potentially useful and becoming increasingly common.

3.3 Findings of Related Hedonic Studies

The conclusions of previous hedonic models used to value land attributes indicate that there are a number of different factors involved in determining rural land values. Dunford et al. (1985) identified the following main categories: external forces, expectations about future conditions, seller characteristics, buyer characteristics and land characteristics. The external forces include interest rates, subsidy programs and foreign exchange rates as well as several others. Expectations about future conditions can include any expectations about future price, yields, costs, population size, distribution of urban sprawl into rural areas, re-zoning and changes to road or rail access (Coelli *et al.,* 1991). The characteristics of the buyers and sellers relate to the individual attributes of each that may affect the buyers' bid function and the sellers' offer function. King and Sinden (1988) identify these as any factors influencing farmer incomes, production levels, or utility functions. These can include such things as age, the investment skill of the farmer, whether the sale was forced or not, or whether the buyer was a close neighbour or relative (Coelli *et al.,* 1991).

The first two categories identified by Dunford et al. (1995), external forces and expectations, are most relevant for temporal or wide ranging spatial analysis (Coelli *et al.,* 1991). The third and fourth categories of buyer and seller characteristics are more relevant to studies intent on proceeding to Rosen's second stage where implicit prices are used as endogenous variables in supply and demand equations. The last category, characteristics of individual farms, is the one of most interest to this study. These characteristics include soil quality, area of cultivation, value of buildings and improvements (in particular, if access to water is present on the land), location characteristics and other physical traits of the land. These attributes as well as several others will be the focus of the hedonic model used to estimate the value of water rights in southern Alberta.

3.4 Methodology and Model Specification

The focus of this study is an area located in the southeastern portion of the province of Alberta encompassing the counties of Wheatland, Newell, Cypress, Forty Mile, Taber, Warner, Lethbridge and Vulcan and the irrigation districts of Western, Eastern, St. Mary's, Taber, Lethbridge Northern and portions of Raymond. Information was collected on the economic and physical characteristics of 230 land parcels sold in 1993 and early 1994 in this region. This specific area was chosen because data was easily accessible and it represents one of the most heavily irrigated regions in the nation.

The data used for this study was collected in two stages. In the first stage, information was collected from Land Information Alberta on the total sale value of the land, the per acre sale value of the land, the size of the land and the Canadian Land Inventory Classification. This data was used to develop the dependent variable PRICE. In the second stage, information was collected from county land assessors on the characteristics of each parcel such as the size of pasture, the soil type, the soil depth, distance to market and the size of the nearest market, the average annual rainfall and, most importantly, the presence or absence of irrigation on the parcel. This information was used to develop the explanatory variables of our hedonic price model.

From the information supplied by Land Information Alberta and the county land assessors, the following variables were specified:

AREA - area of cultivated land (acres)
PRICE - price per acre of cultivated land (dollars $)
WATER - farm land has access to irrigation water (1=yes, 0=no)
BUILD - estimated contributory value of buildings to the sale price
PASTURE - area of land that is in pasture (acres)
DBR - indicates that land has dark brown soil (1=yes, 0=no)
TB - indicates that land has thin black soil (1=yes, 0=no)
WDBR - indicates that land is irrigated and has dark brown soil (1=yes, 0=no)
WTB - indicates that land is irrigated and has thin black soil (1=yes, 0=no)
SOILDEPT - depth of top soil on land (inches)
VGS - indicates that topography of land is gently sloping (1=yes, 0=no)
VGU - indicates that topography of land is gently undulating (1=yes, 0=no)
STONES - indicates the presence of stones on the land (1=yes, 0=no)
DIST - distance to nearest market (km)
VLC - nearest market is a very large city (Calgary) (1=yes, 0=no)
LC - nearest market is a large city (Lethbridge) (1=yes, 0=no)
MC - nearest market is a medium sized city (Medicine Hat) (1=yes, 0=no)
LT - nearest market is a large town (1=yes, 0=otherwise)
AT - nearest market is an average sized town (1=yes, 0=otherwise)
DISTRD - distance to the nearest paved road (km)
HOME - Producer's home is located on land parcel (1=yes, 0=no)
CANAL - direct access to irrigation canal (1=yes, 0=no)
RAIN - average annual rainfall (mm)

The variable of most interest to this study is WATER, which is a dummy variable that indicates whether or not a farm has access to irrigation water. If a farm has access to irrigation water, irrigation can occur throughout the season and moisture is not a limiting factor to crop yields. Irrigation is particularly important for the profitability of the specialty crops grown in the irrigation districts, which are the focus of this study. The variable of WATER is represented as a dummy variable where 1 indicates access to irrigation water on the land and 0 indicates no irrigation access. Having access to irrigation water is expected to have a positive influence on land prices. A comparison of the mean value of irrigated agricultural land and non-irrigated agricultural land in our sample reveals that irrigated land was worth, on average, \$324.53 more per acre than non-irrigated land in 1993.

Some of the methodological difficulties in developing the hedonic price model in this analysis are inherent in the data itself. To begin with, the rating factors used by land assessors did not have any direct economic interpretation. To avoid imposing restrictions on the marginal relationship between rating factors, dummy variables had to be used in many cases to attach economic meaning to many of the land characteristics. The impact of soil texture on land prices had to be ignored completely because the rating scale used to assess the relative value of soil texture could not be adapted for our purposes. Finally, no information was directly available on the contributory value of buildings or improvements to land values or prices. This would be a serious omission from our model since land values often include the value of buildings placed on it. To compensate for this, a sales comparison approach was adopted to estimate the contributory value of buildings in each sale.

Despite these difficulties, the hedonic model used in this analysis includes many of the important variables seen in other hedonic land-based studies similar to this one (Xu, et al. 1993; Coelli et al, 1991; King and Sinden, 1988; Ervin and Mill, 1985; Gardner and Barrows, 1985 and Miranowski and Hammes, 1984). Therefore, it should provide a reasonable estimation of the value of water rights.

The hedonic model used in this study can be specified by the following general equation:

$$Price = f(\text{AREA, WATER, BUILD, PASTURE, DBR, TB, WDBR, WTB, SOILDEPT, STONES, DIST, VLC, LC, MC, LT, AT, DISTRD, CANAL, RAIN})$$

More specifically, in linear form, the basic estimating model is:

$$\begin{aligned} Price = {} & \beta_0 + \beta_1(\text{AREA}) + \beta_2(\text{WATER}) + \beta_3(\text{BUILD}) + \beta_4(\text{PASTURE}) + \beta_5(\text{DBR}) + \beta_6(\text{TB}) \\ & + \beta_7(\text{WATER})(\text{DBR}) + \beta_8(\text{WATER})(\text{TB}) + \beta_9(\text{SOILDEPT}) + \beta_{10}(\text{STONES}) + \\ & + \beta_{11}(\text{DIST}) + \beta_{12}(\text{VLC}) + \beta_{13}(\text{LC}) + \beta_{14}(\text{MC}) + \beta_{15}(\text{LT}) + \beta_{16}(\text{AT}) + \beta_{17}(\text{DISTRD}) \\ & + \beta_{18}(\text{CANAL}) + \beta_{19}(\text{HOME}) + \beta_{20}(\text{RAIN}) + \varepsilon \end{aligned}$$

Where the β_i's are the regression coefficients and ε is the error term.

3.5 The Empirical Results

The basic model described above was estimated using the Ordinary Least Squares (OLS) (White, 1993) procedure for our cross section sample of 230 observed land sales. Some degree of multicollinearity was expected, particularly between such variables as BUILD and HOME. To determine how serious the problem is, the correlation coefficients between each of the property attributes were calculated and all those correlations that exceeded the arbitrarily chosen value of 0.4 are listed in Table 1.

Table 1. Sample correlation coefficients between attributes

Attribute A	Attribute B	Correlation
HOME	BUILD	0.45654
RAIN	TB	0.63887
RAIN	DBR	0.49967
WDBR	DBR	0.48647
WDBR	SOILDEPT	0.51633
SOILDEPT	DBR	0.66229
VLC	DIST	0.68704
WDBR	WATER	0.51266

These correlations seem reasonable given the properties of the variables. The correlation between VLC and DIST may be an artifact of the data since the county of Wheatland is considered to have Calgary as its nearest market even though it is 50 - 100 km away. The correlation between WDBR and WATER is not surprising since WDBR is an interaction term of the WATER variable and DBR. However, since the main focus of this study is to determine an accurate estimate of WATER, WDBR was taken out of the model. The collinearity problem occurring between the other variables was not acted upon at this stage, since, as will be discussed shortly, none of these variables were significant enough to be included in the preferred model.

Using the statistical package Shazam (White, 1993), the model was estimated using Linear, Log-Linear and Log-Log functional forms. The F-values for all the functional forms were significant at the 5 percent level, indicating that the models are significant over all. The Ramsey Reset test (White, 1993) was used to determine if the model is specified correctly. According to our results, the linear model is the only one that is not mis-specified. The modified J-test (White, 1993) was used to test for a non-nested hypothesis. The results of this test indicate that none of the calculated statistics indicated significant heteroscedasticity. In accordance with these results, the Linear functional form was selected as the best form with which to model the data. Using this method, the hedonic model was estimated using all of the variables and then the significance of each variable was examined using t-ratios. A large number of the variables mentioned above have coefficients with t-ratios that are insignificant.

The model was re-estimated with the following insignificant variables omitted: PASTURE, DBR, TB, SOILDEPT, WTB, STONES, CANAL, DIST, DISTRD, MC, LT, AT, RAIN, and HOME. The lack of significance in these variables could be due to the relative unimportance of these factors in determining land values or the approximate way in which the information was defined, or a combination of both. The restricted model is presented in Table 2. The joint test of the fourteen restrictions (the variables that were omitted) yields an insignificant F-value of 0.53 indicating that these variables did not add significantly to the explanatory power of the model.

Therefore, the restricted model is preferred.

Table 2. OLS estimates of the preferred linear model

VARIABLE	COEFFICIENT VALUE	T-RATIO
WATER	189.98	5.007
BUILD	0.93130E-02	12.08
AREA	-5.1751	-2.728
VLC	122.61	2.390
LC	216.09	4.734
CONSTANT	1226.7	4.073
R-SQUARED	.05390	

In our earlier less desirable model, the value of having access to irrigation water is approximately $178.30 per acre and the influence of proximity to a very large city or a large city is more marked. The interpretation of the coefficients in the restricted model leads to the following conclusions. The coefficient of WATER is 189.98. That is, farms that have access to irrigation are worth $190 per acre more than farms that do not have access to irrigation. Other coefficients can be interpreted the same way. For example, AREA has a coefficient of -5.1751 meaning that at the margin, an additional acre of land decreases the value per acre of the land parcel by $5.17; apparently smaller parcels of land have commanded a higher value per acre. Proximity to Calgary and Lethbridge, denoted respectively by VLC and LC, are also positively and statistically significant influences on land values. Only a portion, then, of the raw difference (nearly $325) between irrigated and non-irrigated land values in 1993 and early 1994 in southern Alberta is accounted for by the access to irrigation (WATER) variable if the influence of other land value determinants is accounted for.

3.6 Conclusions

The hedonic model is a potentially useful tool in determining the value of water rights. The advantage of this technique is that it estimates the value that farmers express for irrigation water in the market place for land. Such values can give us an indication of the anticipated prices that might prevail in a transferable water rights market in southern Alberta. In short, the hedonic price function represents an interaction of what buyers are willing to pay and sellers are willing to accept in the market place for access to irrigation.

The results of the preferred model (Table 2) indicate that the implicit value of having access to irrigation water in southern Alberta is approximately $190 per acre. Using the conventional estimate that irrigating one acre of land requires 1.5 acre feet of water, this translates to the value of water access being approximately $126 per acre foot in southern Alberta. Since this value represents the implicit amount farmers are willing to pay for access to water, it could also be construed as an indirect measure of the value of water rights. This value was estimated by first specifying a hedonic model with land prices as a function of a number of factors, which may influence these prices (such as presence of irrigation on the land, the size of farm, the value of buildings on land, the proximity of land to major cities and so forth). Once the model was estimated, the coefficient values of the variables included in the model represented the marginal impact of each of these characteristics on land prices holding all else constant. Therefore, in the hedonic model, the value of water rights represents the average difference between land values of farms that have access to irrigation and farms that do not, *ceteris paribus.* A caveat to be remembered, of course, is that the estimated value of $190 per acre (or $126 per acre foot) is conditional on the particular economic and market conditions pertaining in 1993 and early 1994; a time when beef prices were relatively high but when several specialty crop markets were weak and the general crops economy remained relatively depressed.

An examination of the data reveals that the values of water rights estimated in the preceding analysis add approximately 35% to the value of non-irrigated land. This may not represent a dramatic increase in the value of non-irrigated land, however, it is reasonable to conclude that water rights do have a measurable impact on land values. Therefore, this resource can no longer be treated as a relatively free or inexpensive good. Proper incentives may be needed to ensure that water is used in the most efficient manner possible. A system of transferable water rights has been suggested as a means of doing this. However, before policy makers can accurately assess the economic merits and costs of such a system, more information is needed on the value of water rights. In the preceding analysis, the hedonic approach to valuation has been outlined and an empirical estimate of the value of water rights has been provided. The next step, which involves an economic assessment of a system of transferable water rights, is somewhat beyond the scope of this study, but a brief overview of the potential advantages and disadvantages of a tradable water rights system is presented in Section 5.

4. Transferable Water Rights: Farm Water Demand and Risk Analysis

4.1 Introduction

In Alberta today, agriculture irrigation systems place the largest demand for water resources. Changes in water rights allocation have the potential to significantly affect the agriculture industry. In most of Alberta, the rights to the water used in agriculture are vested in irrigation districts rather than individual farmers. The irrigation districts then allocate water to each farmer. In order to determine what effect increasing external water demands and potential water trading would have on an irrigation district, a detailed study of an irrigation district was performed (Viney, et al. 1996) and is briefly summarized here.

4.2 Alberta's Eastern Irrigation District: A Case Study

The irrigation district chosen for this part of the research project was the Eastern Irrigation District (EID), located in the Bow and Red Deer River sub-basins. Irrigation water for this district is diverted at the Bassano Dam on the Bow River near the district's western boundary. There are competing demands on the river flows from the Western Irrigation District, The Bow River Irrigation District, Trans Alta Utilities Ltd. and the City of Calgary water users. Agriculture in the EID is limited by a relatively short growing season (110 frost free days) and the dominance of solonetzic soils, both of which provide a natural constraint to speciality crop, cereal and oilseed production. Farms in the EID tend to be small relative to other irrigated and dryland farms in Alberta. In fact, approximately half of the EID farms are in the 100 to 300 acre range, implying their operators rely extensively on off-farm income. Wheat, barley, alfalfa, canola, peas and oats are the primary crops with grass hay a source of fibre for cattle. Speciality and vegetable crops have not been produced in substantial quantity. Figure 1 shows the crop breakdown in the EID for 1994. Farmers in the EID have generally developed well diversified production patterns, which reduce the total farm income effects of a crop failure or a negative commodity price move. From the information gathered on the farm types in the district, 12 representative farms were created to model the agricultural activity of the district. Aggregated, these farms became a model representing the entire irrigation district. An overview of the 12 representative farm descriptions is presented in Table 3.

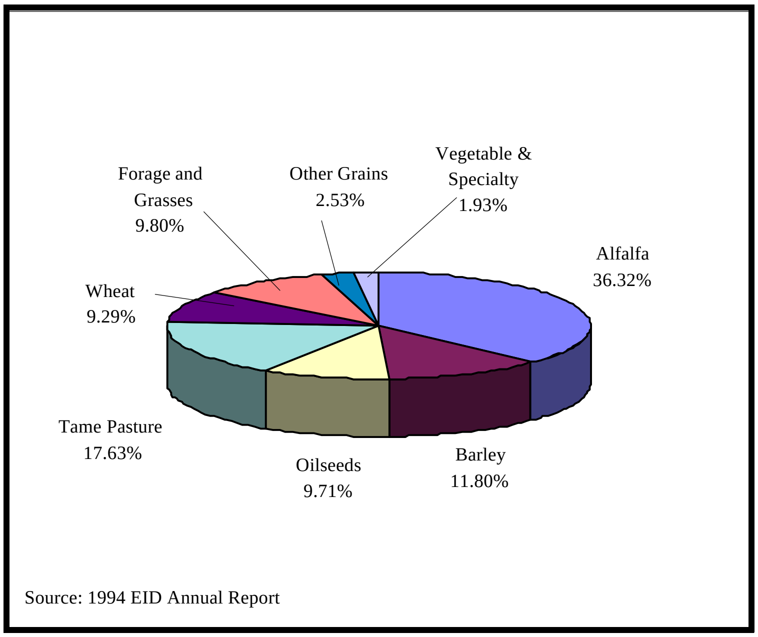

Fig. 1. Irrigated crops produced in the EID (1994)

Income statements for the 12 representative farms were derived from typical revenue and expense situations. Linear programming was then used to determine the optimal output mix and productive value of irrigation water to each farm given a profit maximizing objective that is subject to agronomic constraints and changes in water availability. The resulting individual farm water demands are then discussed in terms of the potential for water reallocation given transferable water rights and water quantity restrictions.

Table 3. Representative farm descriptions in the Eastern Irrigation District

Farm #	1	2	3	4	5	6	7	8	9	10	11	12
Weighting	0.0400	0.0172	0.0216	0.0230	0.0417	0.0532	0.1193	0.0920	0.1322	0.1322	0.1638	0.1638
Total Acres	1793	955	847	731	642	548	461	344	255	255	143	143
Cattle	4280	1110	120	120	100	250	150	80	114	80	40	40
Past, Forage, Hay	1143	615	407	551	392	388	361	224	155	90	0	143
Grains, Oilseeds	650	340	220	180	100	130	70	120	50	55	30	0
Specialty Crops	0	0	220	0	150	30	30	0	50	110	113	0

Source: Viney, et al. (1996).

In determining the demands for water, the farms were subjected to consecutive 2mm decreases in available irrigation water, which were expressed as a percentage of the beginning or full irrigation amount. The farm models were subjected to a maximum water decrease of 50%. With each incremental 2mm decrease in water, the optimal output mix was determined for each farm and the farms were allowed to shift production away from irrigation to dryland farming practices if net income maximization would result. Variance calculations were undertaken to determine if a shift in profit maximizing output mix results in alterations in the farm's risk exposure as measured by portfolio variance.

The results of this analysis showed that when confronted with a reduction in water quantity, crop yields and farm incomes dropped while production patterns changed. All 12 representative farms showed downward sloping demand functions for water. Farms producing traditional output combinations were seen to have water values from $40 to $100 per acre foot given a 1% water quantity reduction. The overall value of water for a 1% reduction ranged from $8 to $250 per acre foot, depending on the enterprise mix. Table 4 shows the per acre marginal water values for each of the 12 representative farms for, respectively, a 1% water reduction, a 25% water reduction, and a maximum 50% water reduction for each of three scenarios: net income maximization with average prices and yields over 1984 to 1994 (NI Max); 1994 output mix and 1994 prices and yields (94 Y&P); and 1994 output mix with average prices and yields (Ave Y&P).

Those farms with largely pasture operations (such as Farm Type 12) had the lowest marginal water values and the highest values belonged to farms whose output mix included a significant portion of speciality crops (such as Farms 9, 10, or 11). This large range in water values for the region indicates that there is sufficient heterogeneity within the EID to accommodate a transferable rights system. Such a system should provide social gains since one of the most important requirements for the functioning of a transferable rights market is heterogeneity in demands among users (NERA, 1992).

Table 4. Per acre marginal water values

Farm		1	2	3	4	5	6	7	8	9	10	11	12
	NI max	54.6	59.4	112.2	73.0	112.3	73.0	119.4	11.6	180.2	237.7	313.6	12.0
1%	94Y&P	43.9	36.9	48.2	61.9	70.0	49.3	62.0	82.5	144.4	298.7	446.4	12.2
	Ave Y&P	40.2	33.8	43.5	62.0	67.1	48.3	65.5	81.7	85.0	184.2	251.4	12.2
	NI max	54.5	60.9	109.6	82.8	109.6	72.0	116.7	30.6	212.4	227.3	357.3	16.1
25%	94Y&P	51.5	44.6	53.4	67.3	70.5	54.6	65.0	89.7	183.3	374.7	553.2	16.1
	AveY&P	47.1	40.9	48.6	66.5	69.3	53.2	61.1	87.5	110.8	234.3	321.8	16.1
	NI max	93.5	88.4	102.5	101.2	102.5	90.7	115.7	39.7	213.6	280.2	342.5	-
50%	94Y&P	50.9	44.6	50.1	65.4	65.5	53.2	61.4	87.8	186.6	383.6	539.5	15.9
	AveY&P	46.6	40.1	45.8	64.0	64.1	51.2	50.0	84.9	114.1	241.5	318.5	15.9

The marginal values for water determined in the linear programming analysis indicate that water would be traded to the speciality crop farms given a water shortage or increased prices. In general, the EID would see an increase in the number of speciality crop farms or an increase in acreage of specialty or higher valued crop production. With transferable water rights and increased water costs, the specialty crop producing farms will have the net income to purchase nearly all of the water that they demand from the traditional farms, everything else being equal. This conclusion is based on productive water values of approximately $100 to $350 per acre-foot for specialty crop farms and $10 to $68 per acre foot for traditional farms. Small irrigated pasture operations and cereal crops producers will be the first to give up water in favour of dryland production in the event of water quantity reductions or prices for water that include sales of water rights. It is worth noting, however, that the demand curve for water is relatively inelastic and that very little transfer of water is undertaken for any value less than $10 per acre foot. Figure 2 shows the variable rate of water quantity decreases with increasing prices as farms decrease or cease to irrigate crop land. At a zero price for irrigation water, the full demand for irrigation water would be 37 411 acre feet, the point at which the demand curve cuts the horizontal axis. Movement along the demand curve shows the response of water quantity reductions that is simulated in response to increasing water prices, or alternately, the introduction of transferable water rights.

Specialty crop production may, however, be limited by market demand. Specialty crops have very limited markets, which may result in generally lower prices given a large expansion in production. Financial risk is another potential limiting factor to the transfer of water rights to specialty crop production. However, the risk return trade-offs are not unreasonable given the capital market comparison, although the probability of observing larger negative returns will be a deterrent to expanded specialty crop production.

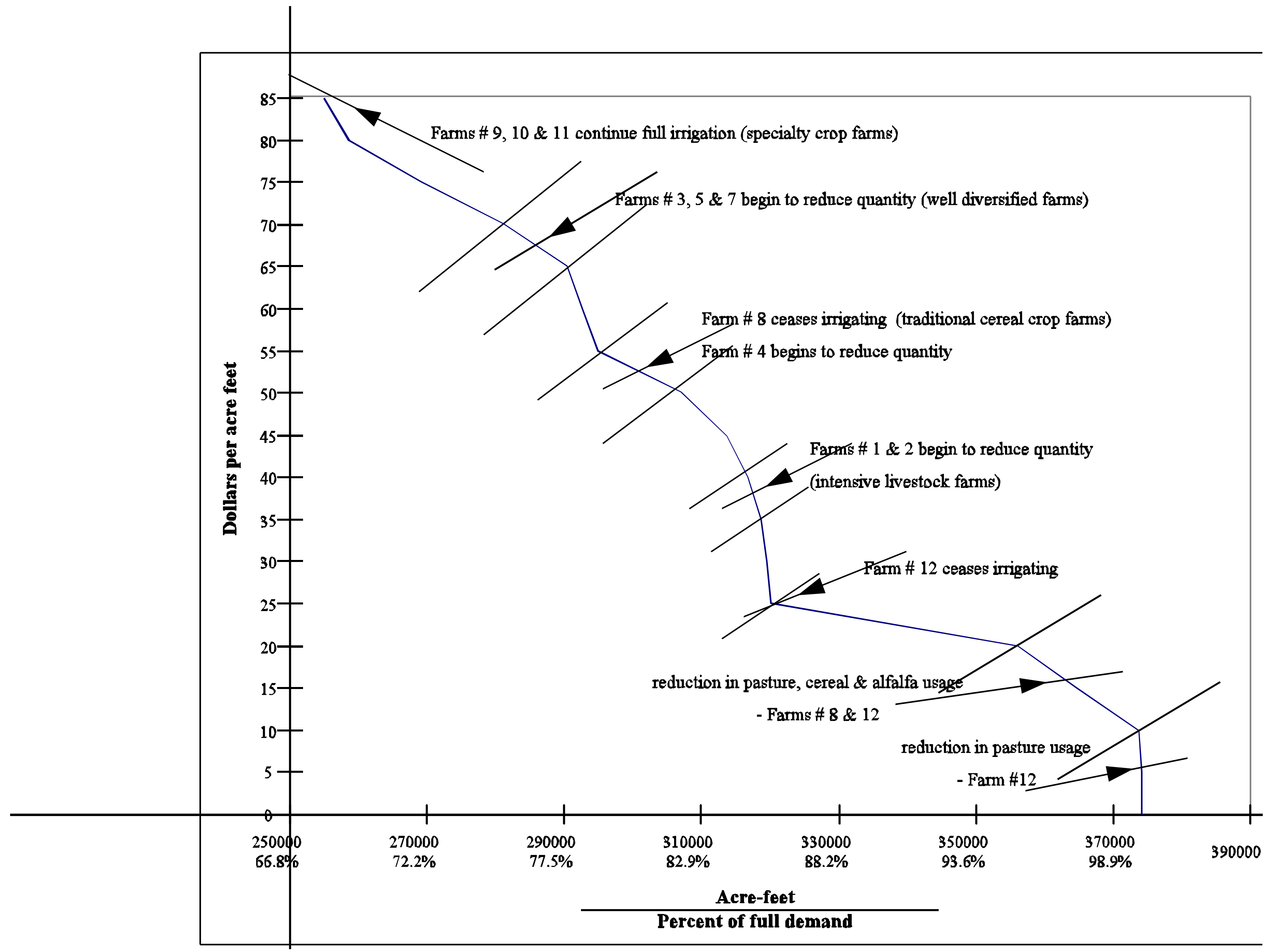

Fig. 2. EID water demand

4.3 Summary

With a mechanism for changing water allocations, traditional agricultural practices in the Eastern Irrigation District may change with increased outside demand for water. The potential changes in agricultural production may have significant social and economic consequences. Theoretically, the tradable permit scheme will de-couple the value of water from the value of the farm land and users of water will only purchase or maintain large enough allocations to maximize profits. Accordingly, water shifts from lower valued uses, in the case of the EID-- pasture or traditional grain mixes, to higher valued uses such as vegetable production. Based on the results of the farm budget water demand analyses, the introduction of transferable water rights will facilitate a proportional increase in the use of irrigation water for the production of high valued specialty crops in relation to traditional pasture and cereal crops. In conclusion, the analysis indicates that there is considerable potential for economic gains from water trade within the EID, the main constraint is this potential being possible market limitations to expanded specialty crop production.

5. Potential Advantages and Disadvantages of Transferable Water Rights

5.1 Introduction

The system of water rights used in Alberta has been under review (Water Management Review Committee, 1995). Presently, water is owned by the crown and its services are licenced to various farmers, irrigation districts, companies, municipalities and other users. The licences issued to date have been tied to land parcels or specific projects and can not be transferred to different properties or uses. In times of shortage, the allocation of water supplies is determined on a basis of ‘first in time, first in right’, with the oldest licences having the greatest priority. Since water rights are tied to either land or project and could not be sold separately, their value is intrinsic to the value of the land or use itself. The absence of a specific market or price for water alone results in inefficient allocations of a valuable good. Without economic incentives, users are unlikely to conserve water that would benefit the environment or transfer water from lower valued uses to higher valued uses. The lack of water prices results in the effective subsidization of irrigation (the largest user of water in Alberta) with the price of water resources held below marginal cost.

In order to obtain a more efficient method of water allocation, it has been suggested that Alberta adopt a program of transferable water rights. The revised Water Act now permits the possible introduction of tradable water rights, something which was not legislatively sanctioned prior to August, 1996. Such a system of transferable water rights has many costs and benefits that need to be examined before it might be instituted. What follows is a brief discussion of the advantages and disadvantages of a system of transferable water rights.

5.2 Potential Advantages of Transferable Water Rights

In theory, a market based system of water rights should result in a more economically efficient allocation of water resources. This is a consequence of water having a market value or price. When a specific price is attached to water, with current owners able to sell and other parties able to buy at that price, market forces will move water from lower valued uses to higher valued uses. When water is no longer free good, it will cease to be treated as one. Giving water resources a value will result in them being treated as something of value. If the value of water use in a specific endeavour exceeds the price, water will be used; if the value of using water is lower than its price, water will not be used. This leads to water being transferred away from uses whose benefits are low and towards those whose benefits are high. Indeed, there is "a belief that efficiency of water use will be enhanced by the adoption of market-based policies for water allocation. The argument is that, under a market system, water resources will move in response to economic incentives from existing uses to higher value uses" (Pigram *et al*, 1992, p. 7).

According to Pigram *et al.*(1992) , in order for a workable and efficient system of transferable water rights, the following criteria must be met:

1. Water must be owned independently of land.
2. The volume of water that an individual has available for transfer and special conditions on its use must be clearly specified in legal statute.
3. Tenure of water rights must be secure so that legal right exists to transfer water at a privately negotiated price as if it were a privately owned good. That tenure must be transferred with the purchase of the water right.

When these conditions are met, the possibility for economic efficiency in water allocation exists.

Another potential benefit of tradable water permits is their application to sustainability and conservation. Given that water is no longer a free good, it is more likely to be conserved and efforts to develop more efficient uses of water are more likely to be considered. Improvements in irrigation efficiency encouraged by market prices for water can result in increasing amounts of water available for other uses. Technological improvements also contribute to the sustainability of a water source for future use. Environmentally, decreased consumption of water in agriculture has the potential to reduce negative environmental impacts of irrigation such as waterlogging and soil salinity (Pigram *et al*, 1992).

Issues of equity under a system of transferable permits have both advantages and disadvantages. Here we will examine the possible benefits. Market transactions guarantee fairness between the buyer and the seller since each is participating freely. Each party must be made better off by a transaction or they would choose not to participate. Markets also insure flexibility in allocation as well as security since no one is required to trade their water rights but all are able to participate in the market if they so choose. Transferability of water rights grants increased flexibility to land owners wishing to alter their operations. By being able to sell water rights separately from land, farmers are increasingly free to determine their output mix, buying and selling water rights as required. Management flexibility of water rights is a great advantage of market based systems of allocation.

5.3 Potential Disadvantages of Transferable Water Rights

The possibility exists that placing a market value on water rights will increase the amount of water used. This is a result of "sleeper" licences. These licences are those issued to land or projects in the past that have not been used in many years. The institution of a price for these rights and the opportunity to sell them in the market, may result in dormant licences being marketed and their water allocations being put to use where before that water was unused. This would result in increased water usage rather than the desired decrease in water consumption.

This is a potential problem only if management agencies do not take the amount of water supplied to “sleepers” into account when they determine the amount of water available. Activation of “sleeper” licences was a particular problem in Australia when transferable water permits were instituted (Pigram *et al*, 1992).

The existence of transactions costs may detract from the efficient workings of a system of marketable water rights. If each transaction must be government approved and legal costs are involved in buying and selling water resources, the cost of transferring permits exceeds the marginal cost of the water right itself. This leads to economic inefficiencies in the allocation of water. Another component of economic efficiency, financial risk, can also be increased by the presence of marketable permits. Water pricing has the potential to change a farm’s optimal crop mix resulting in changes to the farm’s financial risk and debt levels. Such changes may have a negative impact on farmers as risk adverse individuals and result in opposition to transferable water rights (Viney, et al. 1995).

Third party interests in water rights also have the potential to alter the market structure of water permits. Third parties may wish to purchase water rights for a variety of reasons not intended by the regulatory body. For instance, environmental groups may purchase water rights in order that the water not to be used at all. Although this does not necessarily undermine economic efficiency (if water has a higher value in a river than as irrigation, efficiency is not necessarily compromised), it does have implications for policy objectives. The removal of water from productive uses has the potential to be socially inefficient and third party effects may detract from the goals of a system of transferable water rights.

Perhaps the largest potential problem for a market based system of water transfers arises when large volumes of water are transferred out of or into a specific geographic region. Large transfers of water out of an area could severely affect the economic base of the region. Such shifts have the potential to adversely affect small service communities who supply labour, fertilizer, chemicals or other inputs to the traditional farm enterprises. A decline in the infrastructure of the community (roads, services etc.) is likely to occur as is a reduction in the quality of water distribution infrastructure (canals, drainage etc.). Accordingly, the few irrigation farmers who remain will face higher delivery and maintenance costs as the fixed costs are distributed between fewer and fewer farmers. Environmental affects of significant water removal from one area and the subsequent rise of water use in another area have the potential to be far reaching as well. The area that receives increased quantities of water could incur costs of excessive stress on delivery and drainage systems as well as the need for improved infrastructure and crop alteration. These concerns are considerable since “substantial shifts in water allocation are unavoidable in the interests of efficient water use and amelioration of environmental damage in the future” (Pigram *et al*, 1992, p.150).

The alleged threat to the small family farm is an increasing concern for policy makers considering the implementation of a system of transferable water rights. Since pricing water rights creates the potential for large corporations to take advantage of economies of scale, many farmers fear that pricing water will lead to large enterprises dominating the agricultural sector. The possibility that speculators too will enter the permit market and bid the price of water up even higher is also a concern for small farm operators. Another issue stemming from separating water rights from the land, is the anticipated decrease in land values. Since, in most cases at this time, water rights are intrinsic to the land, their value is part of the value of the land. Were the water to be separated from the land, the value and hence market price of the land would decrease to the detriment of the land owner (ignoring the dis-associated value of the access to water). Indeed, the greatest opposition to the implementations of transferable water rights comes from small farm operators.

Further obstacles to achieving a beneficial system of transferable permits may exist as impediments to the free market for water transfers. Market imperfections may result in misleading economic signals that improperly reflect that direction needed for economic efficiency to occur. If there is uncertainty with regards to tenure or security of water rights, their market price will not reflect the true resource value of the good but will incorporate the risk of lost ownership or changing dimensions of the permit. Stringent regulations, including those aimed at eliminating third party effects, have the potential to contribute to continued attenuation of property rights. Transactions costs, environmental regulations, conditions and caveats that limit transfer and restrict the scope of transferability result in the mispricing of water assets.

In conjunction with the issues mentioned above, there are several concerns that must be addressed before an effective system of transferable water rights can be implemented. It must be decided if existing water rights should be protected. This is a dilemma that can be coupled with the equity concern that farmers who have historically used the water would be harmed by a licence system. In that context, if the existing rights are to be preserved, a method for doing so without interfering with the economic functioning of a transferrable system is needed. Should it be decided that farm use be exempt from the need for licencing, a question arises as to how much water use (for example, 5 acre feet per year) should be exempt. Environmental considerations for transferable licence systems include how instream flow needs would be provided for, be it a hold back from all transactions or another method of instream protection. Finally, a significant area of concern centres around what, if any, terms should be placed on licences. This becomes a trade off between government control and market flexibility that requires careful consideration to derive the correct combination of terms or restrictions.

5.4 Conclusions

The pressure to implement a system that allocates water more efficiently and promotes effective water use stems from increased scarcity of water supplies, both in existing sources and in the potential for developing new sources. The proposed system of transferable water rights clearly has both advantages and disadvantages to consider. The underlying justification for such a system is that it would promote the transfer of water to its most highly valued use (Pigram *et al*, 1992). Transferable water rights are also more flexible than the existing system that ties water rights to either land or project. In addition, placing a value on water rights may lead to conservation and technological developments that would further both sustainability and environmental goals. However, the disadvantages of a market based system of water rights are also prevalent. Concerns as to the viability of the family farm and small communities when faced with increased costs of water and the potential transfer of water out of their district are not to be ignored. Third party affects, changing land values, transaction costs, sleeper licences and market imperfections are all issues that create potential problems for the implementation of transferable water rights. Before proceeding with changes to Alberta's system of water rights allocation, all of these advantages and disadvantages should be considered.

6. Final Conclusions

Irrigated agriculture is by far the dominant consumptive user of water in southern Alberta. Continued access and effective management of Alberta's water resources is necessary for the agri-food industry within the province to be both a profitable and sustainable part of the economy as a whole. As water scarcity becomes more of a concern and supplying extra water is viewed as too costly, attention has moved to water demand management. The two most obvious economic policy instruments for managing water demand and conserving water are water pricing and water rights trading. Both of these economic instruments were under consideration in the context of the recent revision of Alberta's Water Act. However, the agricultural sector in Alberta has a mixed view of transferable water rights and the irrigation community is currently lobbying against the use of water pricing.

An economic assessment of the advantages, disadvantages, and problems of water pricing and continued economic evaluation of transferable water rights in Alberta, are, therefore, both timely and pertinent. A key problem in assessing the potential merits of water pricing is gaining a much better idea than we currently have of the likely impact of higher water prices on water use, production patterns, cost structures and farm welfare. Similarly, several important policy issues -- ranging from the protection of existing water rights to various transferability options -- have arisen in the current discussion of the possibility of introducing transferable water rights in the revised Water Act.

The objectives set out in this report were developed with the aim of furthering the understanding of the possible implications of changes in the structure of water rights in Alberta. The advent of a system of transfers with the finalized Water Act (1996) makes this research pertinent for examining the possible trends that may develop in the agri-food sector as a result of these changes. In the sections above, all eight of the stated objectives are discussed, providing an improved economic information base from which to evaluate a system of transferable water rights in the Alberta context.

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