Drought Impacts, Irrigator Attitudes, and the Potential for Water Trading in the Okanagan

Abstract

Agriculture in the Okanagan is undergoing a substantial restructuring, while facing rapid local population growth. While current water supplies are generally adequate, concerns about water scarcity are growing. The openness of Okanagan irrigators to water trading as a tool for increasing the economic efficiency of water use reflects similar patters seen elsewhere. However, at present Okanagan irrigators are more concerned about protecting their access to water than they are about enhancing the efficiency of water use. Development of a user driven reallocation system like a market must follow or incorporate a mechanism that reassures irrigators about their continued access to sufficient water.

Introduction

Concerns about water scarcity have been on the increase in recent times. In many areas, irrigators are the prime water user, which makes them an obvious target for achieving water conservation goals. While there is currently enough water in the Okanagan to supply most human needs, there is little surplus available, and here too irrigators are the largest single water user group (Harltey, 2005). Climate change creates a particular challenge in the Okanagan, threatening to increase water demands while changing the mix and timing of precipitation (Cohen & Kulkarni, 2001).

A considerable body of economic theory has highlighted how water trading and water markets can create incentives that encourage water conservation, and can facilitate reallocation of water between users and uses (Easter, Rosegrant, & Dinar, 1998). However, in many cases water users are very sceptical about water markets, and often resist efforts to introduce water trading systems (Randall, 1981; Tregarthen, 1983). This is particularly true in Canada (Barlow, 2007; Barlow & Clark, 2003). Water trading is not formally supported in the Okanagan Valley, and it is only vaguely hinted at in current regulatory reform discussions (British Columbia Ministry of Environment, 2010).

The British Columbia government has pledged to consult with stakeholders before reforming the provincial water act (British Columbia Ministry of Environment, 2008). This paper seeks to explore the attitudes of one stakeholder group, irrigators, in reference to one specific reform option, water trading. Superficially, the 76 irrigators interviewed in 2008 have little if any enthusiasm for water trading. However, a closer examination shows that there is a diversity of opinion. While market style reforms along the lines of Australia are neither needed nor acceptable at present in the Okanagan, there may be room for a gradual move towards more user driven reallocation of water.

The literature on the measurement and analysis of farmer attitudes is too extensive for an exhaustive review. A selection of papers related to environmental attitudes and attitudes about water trading are briefly discussed before exploring Okanagan irrigator attitudes. Lynn et al (Lynne, Shonkwiler, & Rola, 1988) found that the amount of conservation effort a farmer undertakes depends on the interaction of stewardship and responsibility attitudes with farming objectives such as profit maximization, risk aversion, and lifestyle. Scott and Willits (Scott & Willits, 1994) show that farmers' alignment with the New Environmental Paradigm (Dunlap & Van Liere, 1978) is only weakly related to environmentally protective behaviour. In contrast, Vogel (Vogel, 1996) does find a strong relationship between attitude and pro-environmental behaviour. However, it is very context specific, relating specifically to the local and on-farm environment. Wilson (Wilson G. A., 1996) finds that attitudes are important when a pro-environmental decision has limited financial impact, but secondary otherwise. Burton et al (Burton, Kuczera, & Schwarz, 2008) make a strong case that farmers must be seen as members of a community, where their relationship with their peers is an important motivator. They demonstrate that the willingness to participate in agri-environmental schemes is dependent on how such participation positions the farmer within their community. While the degree and mechanism by which attitudes influence behaviour remains in dispute, these papers and many others generally find that a relationship does exist.

A number of studies have examined factors influencing irrigator participation in water markets. Tisdell and Ward (Tisdell & Ward, 2003) find that Australian irrigators are not fundamentally opposed to water trading, provided that it is a tool for moving water between those that will use it. They are concerned about the impact on rural communities of permanent water transfers, unmanaged third party effects and concentration of ownership, and they are strongly opposed to the involvement of speculators. Bjornlund (Bjornlund, 2004) finds similar attitudes, and notes a diversity of ways that irrigators make use of water markets. More recently, Kuehne et al and Kuehne and Bjornlund (Kuehne, Bjornlund, & Cheers, 2008; Kuehne & Bjornlund, 2008) further document this diversity, and note that for many irrigators water plays a fundamental role in their community and environment that goes beyond that of an input into production. Results in Hadjigeorgalis (Hadjigeorgalis, 2008) reflect similar issues, with farmers quite willing to use spot markets to adjust for short term needs, but reluctant to engage in permanent water transfers. Wheeler et al (Wheeler, Bjornlund, Shanahan, & Zuo, 2009) treat water trading as an innovation, and find that early adopters are irrigators who largely fit the profile of innovators for other technologies, namely being relatively new to the business, are financially secure, more educated, and generally more innovative in other areas of their business. Finally, Nicol (Nicol, 2005) finds similar results for a newly emerging water market in southern Alberta, namely that more educated irrigators tend to be more aware of their trading options. Both papers find unusual results for age, with older farmers either being more active or more aware of water market options. This may relate to farming knowledge or experience that is not reflected in the other measured variables. Overall, participation in water markets cannot be predicted by economic variables alone. A water reallocation system that will be accepted and used by irrigators must recognize and address irrigator concerns beyond those related strictly to finding and consummating a profitable deal.

Study Area

The 76 survey participants farmed either in the Okanagan valley or the Similkameen valley. The Okanagan and Similkameen valleys lie in British Columbia's southern interior (see Figure 1). The two valleys come together just south of the US border, from where the Okanogan river flows into the Columbia. The northern end of the Okanagan valley lies just beyond the town of Armstrong, approximately 200 kilometers drive north from the border town of Osoyoos, while the Similkameen drainage extends nearly 200 kilometers to the north-west from Osoyoos. The valley bottom is semi-arid, with the southern valley sometimes described as the northernmost extension of the Sonoran desert. Osoyoos receives 317.6 mm of precipitation annually, has a 10.1 degree Celsius average daily temperature, and July average daily maximum of 29.2 (Environment Canada, 2010). Precipitation increases and temperatures decline somewhat as one moves north, with Armstrong receiving 487.7 mm of precipitation, a daily average temperature of 7.2 degrees Celsius, and July average daily maximum of 26.7.

[Figure 1 ABOUT HERE – MAP]

European settlement in the Okanagan began in the last half of the nineteenth century, with orcharding developing as an industry early in the twentieth century. For most of the twentieth century the Okanagan was dominated by orcharding and summer tourism. However, recently this is changing. Figure 2 illustrates some of the dominant trends impacting on the agricultural community in the Okanagan. Panels (a) and (b) highlight the transition taking place within the community itself. Except for cherries, orchard crop area and the number of farms growing orchard crops is declining, particularly in the last decade. However, also over the last decade cherry area has increased somewhat, and the number of farms growing cherries has stabilized. Over the same period, grape area has substantially increased, together with a modest increase in farms growing grapes. This represents a substantial structural change in the industry. The large cherry producers process and manage their own marketing, rather than relying on traditional marketing chains, while grape production is often an input into retail and hospitality services associated with a winery. Businesses in these sectors have found profitable niches to occupy while traditional producers see themselves as struggling to generate a reasonable return from their business.

[Figure 2 ABOUT HERE – CROP AND POPULATION TRENDS]

Panels (c) and (d) illustrate two important and related pressures from outside agriculture. Panel (c) shows population growth in the Okanagan. This population growth, particularly rapid in the central Okanagan, contrasts with the decline in farm numbers. Those involved in agriculture naturally see their concerns becoming less important in the overall development of the valley. Associated with the population increase is the increase in property values. This has been particularly striking in the last decade, where the price of agricultural land has approximately tripled. This has made land acquisition virtually impossible for most irrigators, ushering in a further transition towards leasing by those businesses which are expanding. Traditional orchardists represent the largest number of irrigators, and are therefore heavily represented in our sample. These are the farmers who feel most intensely the triple pressures of industry restructuring, political marginalization, and capital cost escalation, and interpretation of the survey results must bear this in mind.

Methods

In the summer of 2008 a series of interviews were conducted with a sample of Okanagan irrigators. The sample was generated by collecting volunteers at three farmer meetings, inviting participation as part of an industry group mailing, and by collecting contact information from the internet.[1] After completion of the contact list, potential participants were sent a letter providing some information about the survey and informing them that they would be contacted by phone in the near future and asked to participate. The subsequent telephone call confirmed participation and established meeting time and location.

Interviews were conducted at a time and location convenient to the participant. The survey instrument (available on request) formed the basis of a semi-structured interview, where participants were lead through the survey. The survey had six sections, measuring farm details, water system details, information sources, water shortage adaptations, attitudes, and demographic information. Water shortage adaptation questions related to the 2003 drought and hypothetical future water shortages. Attitude questions focussed on Okanagan water issues, but were designed to permit a range of farmer objectives, from environmental steward through to profit maximizer. Survey questions were informed by previous survey work and in consultation with academic and water system experts. The survey was pre-tested with irrigator volunteers, and the wording of about 2% of the survey questions were modified after preliminary results suggested some confusion.

Results

Drought Impacts

There was a serious drought in the Okanagan in 2003. Among other things, the drought lead the federal Department of Fisheries and Oceans to require the District of Summerland to release water into Trout creek to protect the fish (Sellars & Smith, 2005), and it contributed to the Okanagan Mountain Fire that destroyed 239 homes south of Kelowna (Protection Branch, BC Ministry of Forests, 2003). Respondents were asked to list the activities that they took to deal with the drought. Figure 3 displays the impacts reported, as the area represented by the farm, relative to the total area of respondents in each indicated region, for number of actions taken, and by major crops. The survey did not resolve actions

[1] Provincial privacy legislation prevented government officials from providing contact information for Okanagan farmers, and other groups also refused access to their member lists.

taken to the area where those actions had to be applied, but rather includes total farm area. Thus, the graphs likely indicate more area than was actually impacted.

[Figure 3 ABOUT HERE – DROUGHT IMPACTS]

From panel (a), it is clear that except for South Other, the dominant response was one action taken, which typically was reducing water application relative to normal. Several areas had irrigators reporting more than one action taken. However, in all areas, some farmers indicated that they had plenty of water, even during the drought year, while other farmers, sometimes on the same system, had to take a number of actions to conserve water and protect their business.

Except for South Other and None, apples and pears are the dominant crop. In all but one area where respondents grew apples, some apple growers indicated no impact. This is similar for the other crops, where there are cases for each crop where normal water rates could be applied. The 2003 drought did not have a consistent impact across irrigators or crops. Differences in irrigation technology may explain this. However, the survey measures technology in 2008, not 2003. Overall, the variation in drought impacts suggests that there were opportunities to move water between irrigators in a way that could have reduced the overall impact of the drought.

Irrigator Attitude Clusters

Cluster analysis assigns individuals to groups based on some measure of similarity. Numerous studies have used cluster analysis to group farmers based on attitudes and other variables (Tait, 1991; C. Solano, 2001; Sutherland, 1998; Latruffe, 2008; Enneking, 2009; Fairweather, 2009), with several specifically considering water markets (Hadjigeorgalis, 2008; Kuehne, Bjornlund, & Cheers, 2008). A range of clustering algorithms have been developed. For many, the number of clusters identified is a largely subjective judgement by the researcher. A subset of these algorithms are model based, providing a statistical means of choosing the number of clusters.

The 22 attitude questions were measured using a seven point Likert scale. They were divided into two groups, one set with questions that explicitly relate to water trading and a second set that explore other aspects of the relationship between irrigators and water. Missing values, largely refusals, were coded following Raaijmakers (Raaijmakers, 1999). The **mclust** package (Raftery, 2010), implemented in R (R Development Core Team, 2010) was used to compare six different model based clustering solutions for one to nine final clusters. The Bayesian Information Criterion (BIC) compared models and selected the best number of clusters. Clusters were formed using the first and second set of questions. Clusters based on the first set were markedly different, while those formed on the second set were largely indistinguishable. Thus, results are reported for clusters based on the first set of attitude questions.

The algorithm selected two clusters as the best solution. These can be labelled 'NO' for strongly opposed to water trading ($n = 36$), and 'OPEN' for less opposed or able to recognize some of the benefits of water trading ($n = 40$). The reader should keep in mind that the algorithms assign each individual to one or the other cluster. Individuals can be quite different from the cluster average, and two individuals assigned to different clusters may be closer to each other than either is to their respective cluster mean. In this analysis clustering is used to identify some general properties, and it is not meant to suggest that there are only two types of individual.

Figure 4 shows box and whisker plots for each of the eight market related attitude questions, together with the significance level of a Kruskal-Wallis test for equality between the two groups. The central thick line marks the median, the box encloses a quartile each side of the median, and the whiskers mark the range of observations, unless the graphing system considers some to be outliers. The identified groups are different at the 5% significance level for all but the preference for trading water only with people the respondent knows.

[Figure 4 ABOUT HERE – BOX AND WHISKER MARKET ATTITUDES]

The responses to "Water is so essential that it would be wrong to sell it" item highlights the difference between the NO and OPEN groups. The former all agree to some degree with the statement, while the latter have a diversity of opinion. However, even for the OPEN group, the median response is 'somewhat agree'. The OPEN group is certainly not demanding market style reforms.

All of the attitude differences are largely consistent with the group labels. Relative to the OPEN group, those in the NO group tend not to think that water trading can encourage conservation, don't see it as giving them more options in a shortage, don't believe credible water market institutions can be developed, fear an increase in the water price, and worry that developers will use a water market to take water from agriculture.

However, while there are strong statistical differences on almost all of these attitude items, it is important to recognize that often the differences are not that large. In particular, members of both groups tend to agree that if water can be traded, the price will be higher, and that developers will use a water market to secure water for themselves at the expense of agriculture. Thus, any attempt to introduce a market like reallocation mechanism must ensure that it does not increase irrigator costs and does not become a means for water to leave agriculture.

The second set of attitude items are shown in Figure 5. Only two of these items are significantly different between the two groups at the 5% level. Those assigned to the NO group more strongly agree that water saved through conservation must remain in agriculture and that water for the environment must first come from outside of agriculture. Those in the NO group are also somewhat more likely to agree that they would save water to help another farmer, that agricultural water is best managed by irrigators, and to disagree with the idea that there is presently plenty of water in the Okanagan. There is little grounds to say that there is any indication of differences on the other attitude items.

[Figure 5 ABOUT HERE – BOX AND WHISKER OTHER ATTITUDE]

While there is little difference between the groups on many of the items, for some items this is because there is general agreement among those surveyed. Thus, respondents tend to agree that climate change will cause problems, that the growth of cities and towns is a threat, that irrigators should be compensated if they have to forego water to benefit the environment, that groundwater pumping needs to be regulated, and that people who waste water should pay more for it. Even among the items where there is a statistical difference, there is a degree of agreement that water saved by increasing efficiency should remain in agriculture, and that environmental needs should first be met by savings outside of agriculture. The observed differences are a matter of degree, not opposing opinions.

Thus, this block of responses both confirms the difference between the groups – in that some items which are different in this block are logically consistent with the differences used to make the group assignments – and confirms many of the concerns that most respondents agree on. Irrigators generally agree that urban expansion poses a threat, and agree that they should not be made to suffer in order to protect the environment. However, they also generally approve of some features that a water market can provide, financial incentives to encourage efficiency and a mechanism for compensating irrigators who provide water for the environment.

Univariate Cluster Comparisons

Survey responses were categorized by cluster membership, with pairwise statistical tests performed to identify those variables where there is a difference between the clusters. As no adjustment was made for multiple pairwise comparisons, together with the fact that the sample is very small, the *P* values are best interpreted as identifying those variables that may have an influence, rather than highlighting a strong statistical relationship.

Figure 6 shows the difference between the clusters on a range of measured and calculated binary variables. Counts for each group are found in appendix Table 2. Only two of the variables are close to significant at the 10%, RISK_WAT and SRC_PURV. A greater share of those in the NO group report the risk of water shortage as at least as great as any other business risk, and a greater share receive water from a purveyor. This may reflect the fact that those served by a purveyor are subject to the annual water allocation from their purveyor, while groundwater users and licence holders have more control over their supply. It may also reflect communication from their purveyor, which keeps irrigators more alert to water supply issues, rendering them both more aware of water supply risks, and more concerned that a water market may not serve their interests. It may also correlate with the concern about water lost from agriculture, as it is the purveyor, not the irrigator, that decides how to split the available water between agricultural and non-agricultural users.

[Figure 6 ABOUT HERE – BINARY VARIABLE LINE PLOT]

The remaining variables illustrate properties of the sample. Only about a quarter of the respondents have children under 16, and a slightly larger fraction can identify a successor. While attitude items show that most irrigators worry a water market will be used by developers to secure water, few identify urban pressure when asked to name risks more important than water scarcity. The vast majority earn at least half of their revenue from crop production, with about a quarter engaged in some form of direct selling. Somewhat surprisingly, given the serious concern about water scarcity, only a small fraction of respondents could identify a use for additional water, were it available. Few in the sample have their own licence, and even less have at least two water sources. About a third can provide an estimate of the volume of water used. About two thirds use an efficient (drip, low pressure, etc.) technology on at least half of their irrigated land. For most, the main crop is a horticultural crop. More than half will ask for or offer water, if they need it or a neighbour does, but less than a quarter would expect payment to be anything more than costs or a gesture of appreciation. About half of the respondents had to take actions to deal with the 2003 drought, with a somewhat higher rate for those in the NO group. Finally, less than a quarter of respondents are renting more than half of their land. The sample is largely composed of farmers who rely on a purveyor, own most of their land, and typically don't have children and don't have anyone who is obviously interested in taking over the farm.

Figure 7 plots the median and distribution for a selection of measured and constructed integer and continuous variables, where values have been scaled to lie between zero and one. Mean and variance are reported in appendix Table 3. The most striking feature of these results is the strong statistical significance of education. Levels of education are 1 = Did not complete high school, 2 = completed high school, 3 = some college or university, 4 = completed a college diploma, 5 = completed a university degree, and 6 = education beyond a first university degree. To confirm these results, the effect was also tested treating education as a categorical variable, and using a contingency table. Education continued to be strongly significant ($\chi^2_{df=3} = 14.348, P = 0.0135$). Those with more education are less likely to be opposed to water trading.

[Figure 7 ABOUT HERE – BOX AND WHISKER FOR INTEGER AND CONTINUOUS VARIABLES]

None of the remaining variables are significant at the 10% level. Drawing value from the appendix, the average respondent is 55 years old, has been farming for almost 26 years, with more than 25 of those years in the Okanagan, earns about 10% of farm revenue from something other than crop production, and farms almost 27 hectares (66.7 acres). The amount of farmed land is highly skewed, reflecting the inclusion of a small number of ranchers who farm large rangeland areas. For horticultural producers alone ($n = 69$), average farm size is a bit over 17 hectares. For NO group farmers, average farm size is just over 10.5 hectares, while for the OPEN group, it is 23 hectares. These differences are significant at the 10% level ($F_{1,67} = 3.334, P = 0.0723$). Larger farms are more likely to be in the OPEN group.

In addition to education, income, country of birth, water source and main crop were examined using contingency tables. These variables were either categorical by definition, or in the case of income, the survey asked for income ranges, rather than a dollar value. Only education was significant.

Multivariate Cluster Comparisons

An exploratory logistic regression of cluster membership was conducted using a subset of the variables just described, with a stepwise analysis done to identify that group of variables which generate the smallest AIC value. The model correctly predicts 76.1% of group memberships, has a McFadden pseudo R^2 of 0.278, and a significant likelihood ratio test ($\chi^2_{df=8} = 27.344, P = 0.0006$).

[Table 1 ABOUT HERE – LOGISTIC REGRESSION RESULTS]

While the only variable that shows up as significant in the pairwise comparisions is education, when controlling for interactions, a number of variables show up as significant. Education (EDUC_NUM) continues to be the strongest explanatory variable, in terms of *P* value, with higher education correlating with a greater probability of being in the OPEN group. Along with education, irrigators who can identify a successor and those who rent land are more likely to be in the OPEN group. Irrigators who know how much water they are using and who have children are less likely to be in the OPEN group. Further, the more actions taken in response to the 2003 drought, the more things computers are used for, and the older the respondent is, the less likely the respondent is in the OPEN group.

The survey also asked respondents if they were short of water, would they ask their neighbour for water, or if their neighbour was short and they had excess, would they supply their neighbour. The variable NOT_TRADE is true if the respondent refuses both. For those that would trade, they were also asked about compensation. Responses were categorized as costs or favour, or a negotiated 'market' price. The variable WILL_TRADE is true if the responses fell into the latter category. These two variables were then combined into an ordered variable, from zero for won't trade, to two for will trade at a market price, and an ordered logit regression conducted.

After a stepwise elimination, four variables remained: number of drought response actions taken (DR_ACTS), whether any were taken (DR_AFFECT), whether the irrigator has a second water source (HAS_OTHER) and age. The overall fit was not as strong as the previous ($R^2_{McFadden} = 0.105,\ \chi^2_{df=4} = 15.7,\ P = 0.0034$). DR_ACTS and AGE enter as for the previous regression. DR_AFFECT and HAS_OTHER both enter positively, indicating that after controlling for the severity of the drought reaction, those who had to take action during the 2003 drought were more willing to contemplate trading water.

Discussion

At one level, the results presented confirm previous work. More progressive and/or innovative irrigators are more likely to see water trading as a tool they can use, and therefore more open to it. However, this result must be clearly placed within the Okanagan context. The industry is undergoing a major internal restructuring towards specialized enterprises often with some degree of off the farm marketing in place of traditional commodity production. At the same time, there is tremendous pressure on land prices, and an effective marginalization of irrigators within the overall Okanagan population.

Okanagan irrigators seem to see a greater role for economic incentives in water management, particularly where those incentives lead to a respect for the value of water. This lies both in having people pay for the foregone value when water is wasted, and in compensating those who must forego water for environmental purposes. However, the scope of such incentives that is acceptable to irrigators is tightly confined by their concerns about the loss of water to developers and the diversion of water to satisfy the interests of the non-agricultural community. Overall, irrigators seem to view water trading as an instrument that will work against their interests, increasing the price of water and giving the non-agricultural community a way to divert water out of agriculture.

If any water reallocation mechanism is to be acceptable to Okanagan irrigators, it must account for their concern about water being diverted out of agriculture. At present, only when irrigators own their own senior water licences are they able to retain water for agriculture. Within the Okanagan, most irrigators receive their water from purveyors. These purveyors are typically a level of local government charged with water delivery to all farms, business, etc. within the boundaries of their service area. For example, the South East Kelowna Irrigation District is overseen by a five member board of trustees elected from land owners in the district (South East Kelowna Irrigation District, 2010). Most purveyors supply a mix of agricultural and urban/residential water users. Purveyors hold a number of licences, typically for a mixture of purposes such as irrigation, waterworks, storage, etc.. The purveyors determine how much water each user in their service area is allotted. While the purveyors hold prior appropriation water licences, they normally divide water shortages among those supplied proportionately. There is seldom any formal mechanism to ensure that water delivered is used in line with the purposes set out in the licences. This creates a situation where water can 'seep' out of agriculture, if there is high non-agricultural demand in the serviced area. Given the nature of purveyor governance, there is also a growing threat that the elected trustees will turn their focus to the concerns of non-agricultural water users, as in many areas such users now make up by far the majority of property owners serviced.

Moving Okanagan water purveyors towards an Australian style of water market within their service area could address a number of concerns irrigators expressed. Following the Australian model (Bennett, 2005), purveyor clients would have a water entitlement that depends directly on water inflows, and is not subject to adjustment by purveyor management, except to reflect measurement errors or other physical contingencies. As a starting point, the size of the allotment and its relative priority could flow from the volumes and priorities set out in the water licences held by the purveyor. Allowing some form of decentralized, voluntary rebalancing of entitlements between water users would ensure greater overall efficiency of water use. Transfer of water to other purposes, particularly out of agriculture, should also be voluntary, and either arranged or mediated by the purveyor, between the parties involved. If the agricultural community has a collective interest that is adversely impacted by moving water out of agriculture, then use changes of this form would have to pass some larger hurdle, to ensure that the adverse impacts on agriculture are minimized. An obvious candidate for such a reallocation mechanism is a water market, implemented in the way that many Australian water purveyors do.

A clear delineation of that water intended for agricultural purposes and a transparent process for accounting for that water is closely aligned with a recent call by the Okanagan Basin Water Board for an Agricultural Water Reserve (AWR) (Okanagan Basin Water Board, 2008). The basic idea is seen as a natural complement to the provincial Agricultural Land Reserve (ALR) (Runka, 2006), particularly in the Okanagan where most agricultural activities require irrigation. No details for the AWR proposal are given, leaving many questions. As water is a fluid, with availability a consequence of precipitation, an AWR cannot declare that a particular volume of water belongs to agriculture the way that the ALR defines particular land parcels as protected for agricultural purposes. By necessity an AWR will have to be an administrative reserve, where accounts are kept of water use, with some process to determine when reserve assignments have been violated, and procedures and sanctions to deal with such violations. If the administrative entity holds the water rights and has the ability to make adjustments to these rights, then an AWR is functionally little different from the current system. At best, it will operate like the Agricultural Land Commission, granting permission for reallocation between uses after a review process to ensure that the agricultural community is not harmed.

The fluid nature of water means that any reserve will have to define a boundary within which the volume for agriculture is protected. Should this be at the watershed scale, so that as long as the same quantity of water is available for agriculture within the entire Okanagan valley, the reserve is being honoured, or should it be for smaller sub-watersheds? In the former case, locally irrigators may not have their water access protected. However, if the scale is small, it will become difficult to reallocate water around the basin in response to changing opportunities and demands. However, even a relatively small scale reserve need not protect an individual irrigator's access to water if a specified right is not allocated to that individual irrigator. The most effective way to implement an AWR is probably to specify clear agriculture specific water rights for each irrigator or each parcel of land. To deal with natural variations, this right would be to a share of the available water. This is essentially the Australian model without water trading. This would be relatively easily to implemented by purveyors. Where users hold individual water licences, there is a de-facto reserve in place already via the purposes set out in the licences, and the fact that agricultural licences are generally senior to almost all others.

While protecting water for agriculture is one issue that can lead irrigators to oppose a water market, a second is that it creates one more area where irrigators become competitors. Irrigators played an important role in the transition of irrigation from a necessary investment by land development companies to a critical piece of public infrastructure (Wilson K. W., 1989; Ruzesky J. , 1988). This history has helped cement a sense of community and strengthened the view that water is a common resource that should be shared. Were agriculture not experiencing serious internal and external pressures at present, irrigators might be more open to the idea that cooperation does not require equality.

However, in the present situation, many farmers will see anything that appears to weaken the common cause with great suspicion. Irrigators will have to themselves on mass see some gain from water trading before it becomes acceptable, and in the present environment a careful consideration of the implications of water trading is not a priority.

Conclusions

Water trading is an idea that receives at best a luke-warm reception by those Okanagan irrigators who do not outright reject the idea. Among the younger and more educated, the reception is less cold. However, a decentralized, market style reallocation mechanism is likely some ways off in the Okanagan. Policy makers will have to consider where a water market fits into the overall institutional environment that Okanagan farmers operate in. At present, that environment is sufficiently challenging for many irrigators that there is little apatite for another source of variation. The best approach right now would be to ensure that reforms to the water act create mechanisms that can enable a water market to be implemented in the future. Failure to do so could tie the hands of regulators for the next century, the length of time between the introduction of the water act and current efforts to reform it.

Appendix

[Table 2 ABOUT HERE – BINARY VARIABLE RESULTS]

[Table 3 ABOUT HERE – CONTINUOUS AND INTEGER VARIABLE RESULTS]

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Table 1: Stepwise logistic regression results. Dependent variable cluster identity.

Variable	Estimate	St. Error	*z*	*P* value
(Intercept)	4.92932	2.59620	1.899	0.05761
TENANT	1.82091	1.31838	1.381	0.16722
DR_ACTS	-1.26106	0.49273	-2.559	0.01049
KNOW_VOL	-1.83887	0.83051	-2.214	0.02682
COMP_USES	-0.36909	0.20709	-1.782	0.07470
SUCCESSOR	1.21194	0.70001	1.731	0.08339
EDUC_NUM	0.90124	0.28475	3.165	0.00155
HAVE_KIDS	-2.22031	0.95436	-2.326	0.01999
AGE	-0.08059	0.03636	-2.216	0.02667
	n	70	AIC	88.96
	LLF_{Model}	-35.478	LLF_{Null}	-49.150
	$\chi^2_{df=8}$	27.344	*P* value	0.0006
	$R^2_{McFadden}$	0.278	R^2_{Count}	0.761

Table 2: Binary variable counts for sample and cluster groupings, with test results for equality of groups. Variables discussed in detail are highlighted.

		All		Group #1		Group #2			
Variable	*N*	True	False	True	False	True	False	χ^2	*P* value
TENANT	76	12	64	4	32	8	32	0.5566	0.4556
DR_AFFECT	**76**	**36**	**40**	**20**	**16**	**16**	**24**	**1.2680**	**0.2601**
WILL_TRADE	76	14	62	6	30	8	32	0.0061	0.9378
NOT_TRADE	76	31	45	17	19	14	26	0.7205	0.3960
HORT_MAIN	76	69	7	32	4	37	3	0.0214	0.8836
IS_EFFIC	71	45	26	20	12	25	14	0.0117	0.9139
KNOW_VOL	73	21	52	11	23	10	29	0.1390	0.7093
SRC_PURV	**76**	**63**	**13**	**33**	**3**	**30**	**10**	**2.6295**	**0.1049**
HAS_OTHER	76	6	70	4	32	2	38	0.3142	0.5751
HAS_LIC	76	15	61	6	30	9	31	0.1221	0.7268
USE_MORE	76	12	64	6	30	6	34	0.0135	0.9076
DR_SELL	73	17	56	8	26	9	30	0.0538	0.8166
OTH_MAIN	76	8	68	2	34	6	34	0.9318	0.3344
RISK_WAT	**76**	**34**	**42**	**20**	**16**	**14**	**26**	**2.4602**	**0.1168**
RISK_URB	76	4	72	3	33	1	39	0.3878	0.5335
SUCCESSOR	**76**	**25**	**51**	**9**	**27**	**16**	**24**	**1.3115**	**0.2521**
HAVE_KIDS	76	19	57	11	25	8	32	0.6333	0.4261

Table 3: Descriptive statistics for integer and continuous variables, for sample and cluster groupings. Test statistic for pairwise comparison of means. Variables discussed in text body are highlighted.

		All		Group #1		Group #2			
	n	Mean	Var.	Mean	Var.	Mean	Var.	*F*	*P* value
LAND	75	66.24	37,950	77.78	71,636	55.58	7680	0.2405	0.6253
DR_ACTS	**76**	**0.71**	**0.82**	**0.86**	**0.98**	**0.58**	**0.66**	**1.9104**	**0.1711**
AR_EFFIC	71	0.64	0.17	0.63	0.18	0.65	0.16	0.0291	0.8650
OTH_SHARE	**76**	**0.11**	**0.08**	**0.06**	**0.04**	**0.15**	**0.11**	**1.9374**	**0.1681**
IRR_INFO	76	3.53	2.84	3.53	3.06	3.53	2.72	0.0001	0.9943
FARM_INFO	76	4.05	6.18	3.89	6.67	4.20	5.86	0.2938	0.5894
COMP_USES	76	4.16	3.57	4.31	2.85	4.03	4.28	0.4139	0.5220
RISK_ALL	**76**	**1.72**	**1.91**	**1.47**	**1.74**	**1.95**	**2.00**	**2.3047**	**0.1332**
RISK_PROD	**76**	**1.11**	**1.22**	**0.89**	**1.13**	**1.30**	**1.24**	**2.6942**	**0.1050**
YRS_FARM	71	25.98	252.46	27.54	243.91	24.54	262.87	0.6298	0.4301
YRS_OK	71	25.20	254.20	26.96	257.55	23.59	252.64	0.7851	0.3787
EDUC_NUM	**76**	**2.70**	**2.16**	**2.19**	**1.59**	**3.15**	**2.28**	**8.8452**	**0.0040**
HOUSEHOLD	75	2.85	2.07	3.03	2.43	2.69	1.74	1.0166	0.3167
AGE	**71**	**55.17**	**157.86**	**56.85**	**120.80**	**53.62**	**191.08**	**1.1749**	**0.2822**

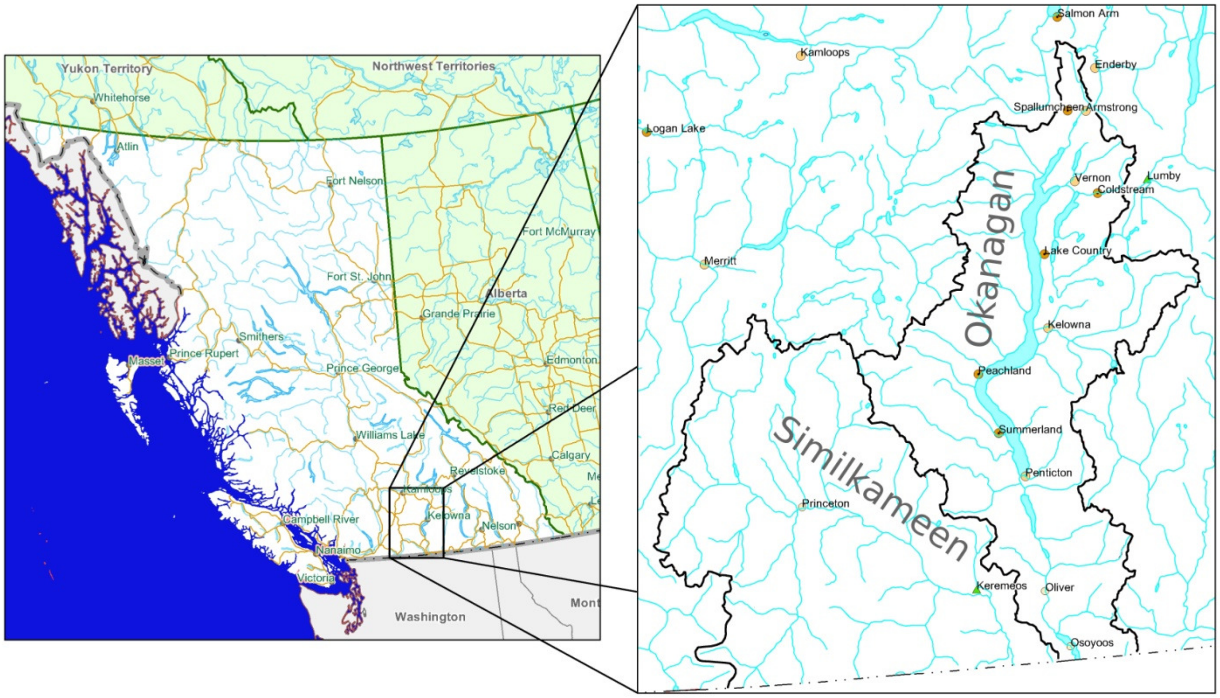

Figure 1: The Okanagan and Similkameen watersheds.

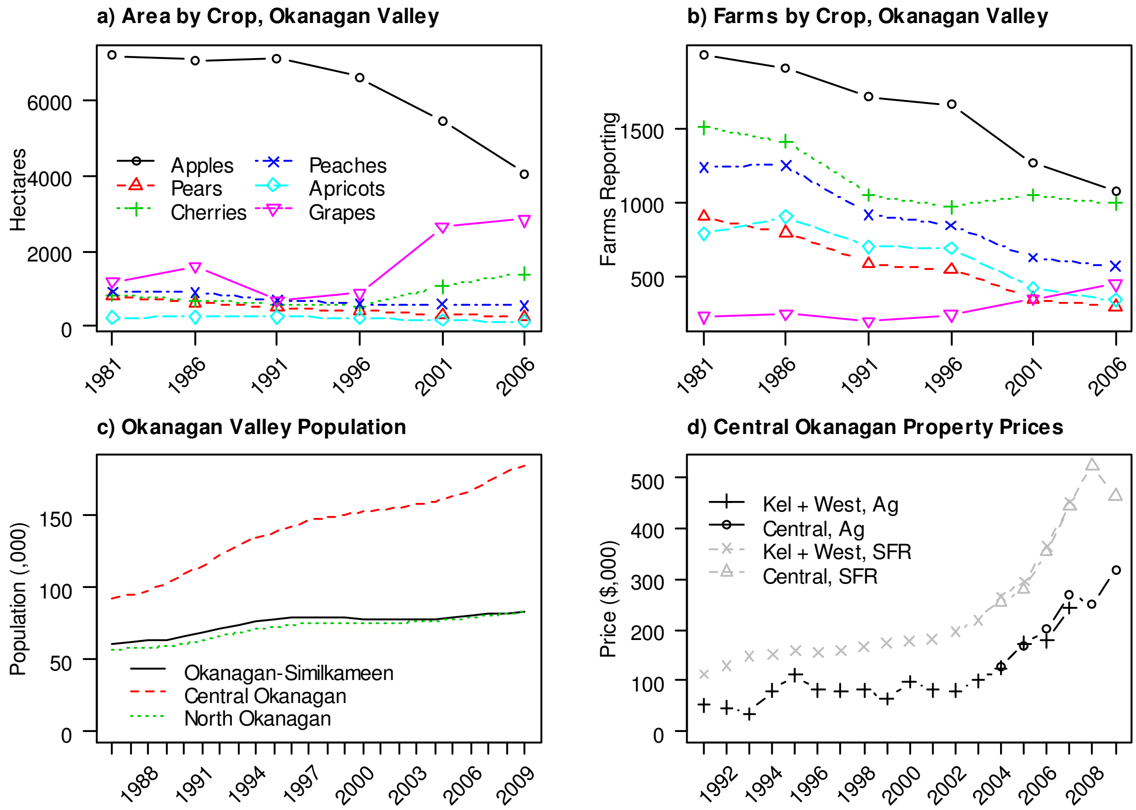

Figure 2: Okanagan Valley agricultural, population, and property value trends. Property value trends are per hectare of agricultural land (Ag) and for single family residential property transactions (SFR). Sources: Statistics Canada Census of Agriculture, BC Stats, and BC Assessment (via Landcor).

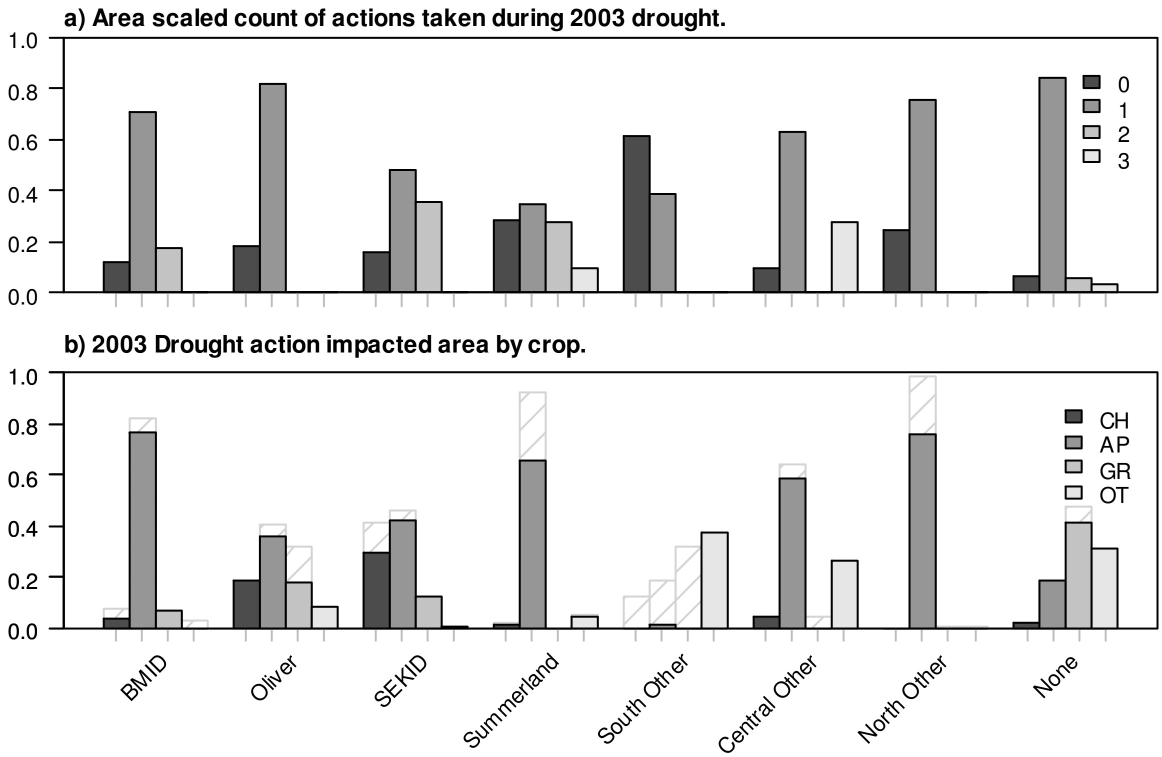

Figure 3: Impacts of 2003 drought. Panel (a) plots number of actions taken on farms, with bar height representing relative areas for each farm in each area. Panel (b) plots relative area for each crop (hashed) and portion of that area where farm indicated some actions taken. CH = cherries, AP = apples and pears, GR = grapes, OT = all others.

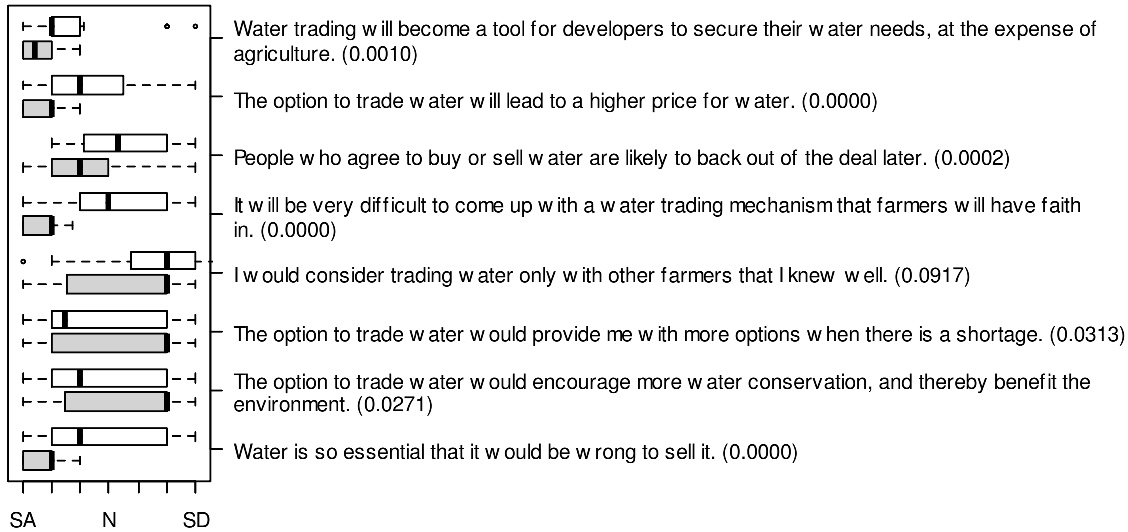

Figure 4: Responses to water trading related attitude questions, for the two clusters identified by mclust. Numbers in parentheses are *P* values for a Kruskal-Wallis test of equality between the groups. Scale ranges from strongly agree (SA) through neither agree nor disagree (N) to strongly disagree (SD).

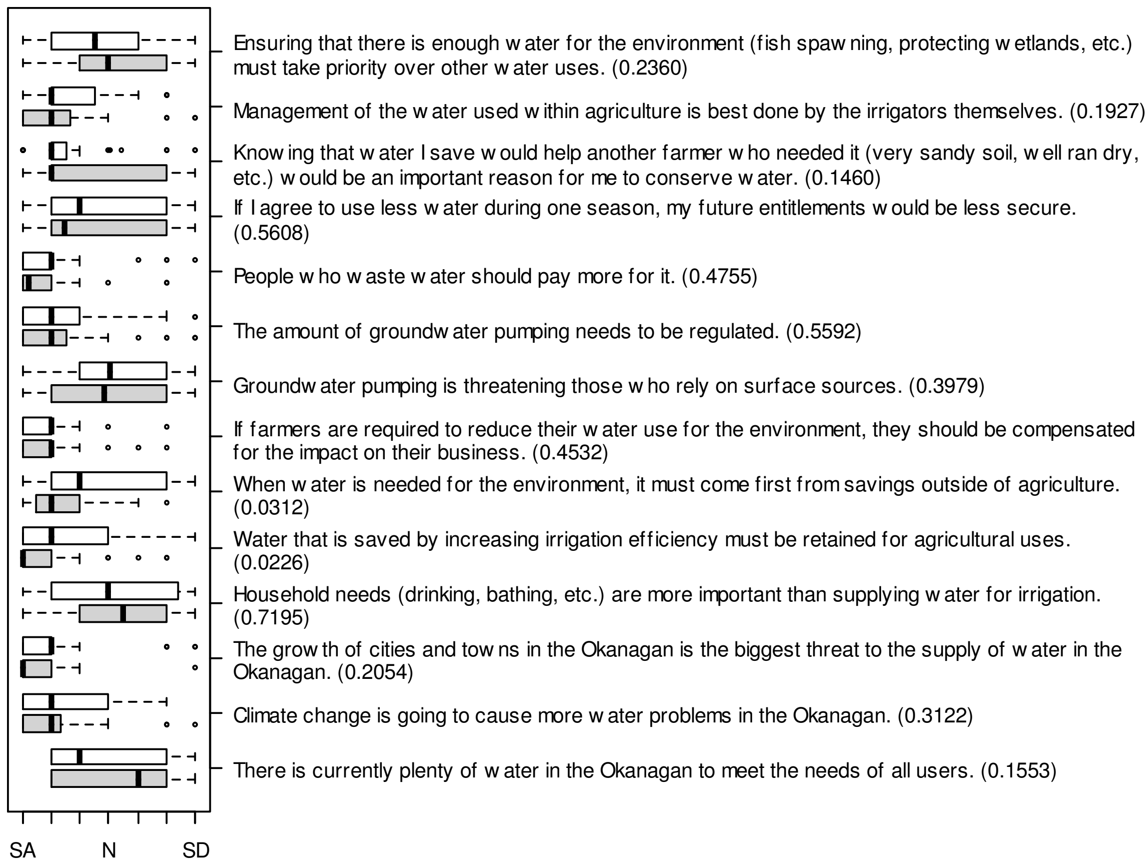

Figure 5: Responses to items capturing irrigators' relationship with water, absent reference to water trading. Numbers in parentheses are *P* values for a Kruskal-Wallis test of equality between the groups. Scale ranges from strongly agree (SA) through neither agree nor disagree (N) to strongly disagree (SD).

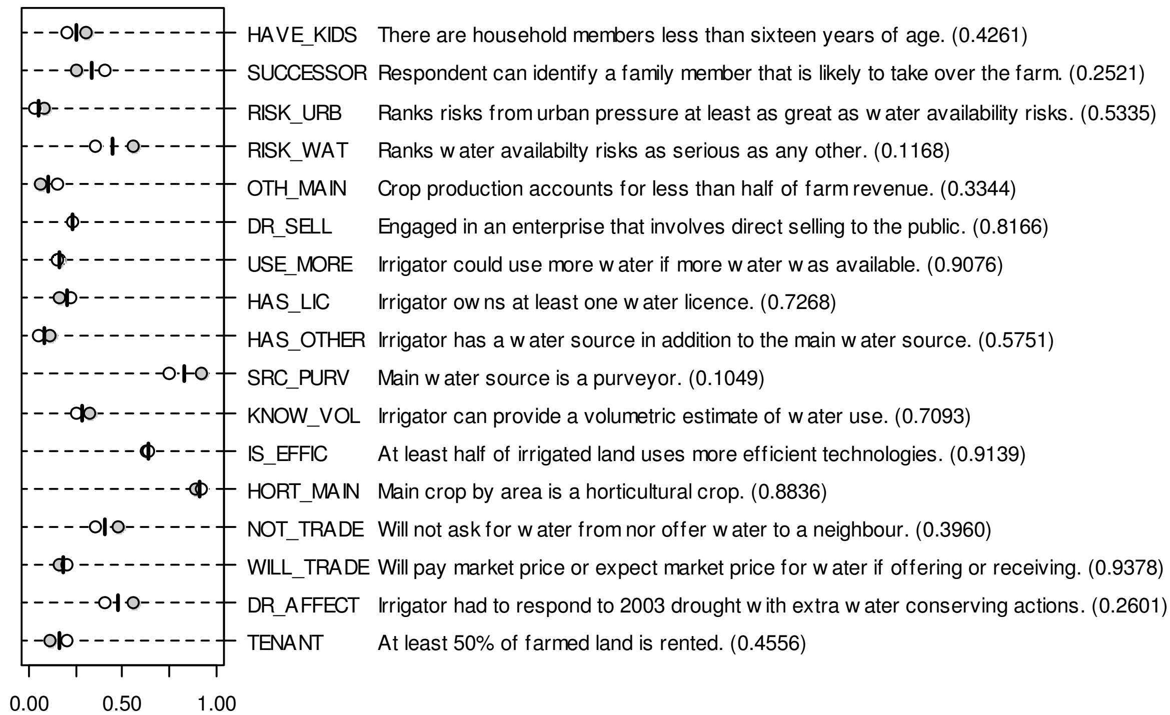

Figure 6: Line plot of proportion of positive responses to binary questions or true values to constructed binary variables. Short labels are for reference purposes elsewhere in text. Filled circles represent group least in favour of water trading. Vertical line marks overall average. *P* values for contingency table comparison.

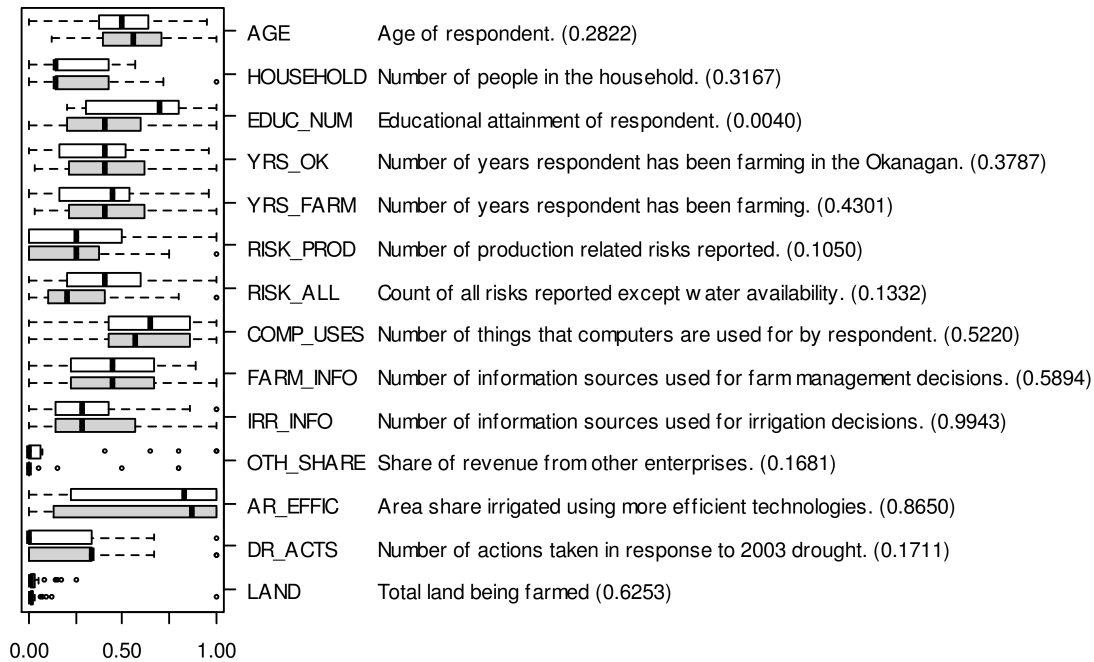

Figure 7: Box and whisker plot for integer and continuous variables, where variables have been scaled to lie between zero and one. Short labels used as reference in main text. Grey boxes represent group more opposed to water trading. Numbers in parenthesis indicate significance of a pairwise comparison of means.