# Water Policy Reform in Victoria - A Regional Perspective

Branson, J., Eigenraam, M.
Agriculture Victoria

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*This paper summarises the development of regional models to represent the Goulburn Murray Irrigation System (GMS) of northern Victoria. The models simulate the ability of farms to adapt to water policy reforms subject to biophysical and land constraints. Focus is given to current water property right structures and the impact these have on optimisation of demand for water. Derived demand curves are modelled for 14 Victorian irrigation regions which are used in a spatial model of the Goulburn Murray Irrigation System. Finally a discussion is provided on the future issues arising from water policy reform*

# 1. Introduction

This paper summarises the development of regional models to represent the Goulburn Murray Irrigation System (GMS) of northern Victoria. The models were built as part of a joint research project between Agriculture Victoria and NSW Agriculture. The project arose from the Council of Australian Governments (COAG) national water reform agenda. The joint research project uses a spatial equilibrium model (Eigenraam *et al.* 1996) to address the economic impact of measures suggested in the reform agenda. Derived demand curves produced from the regional models will be used in a spatial equilibrium environment.

The regional models will address the issue of comparing alternative reform mechanisms at the regional level. The following reform issues will be covered by the regional models:

- institutional pricing and tariff structures;
- water property rights;
- the distribution of irrigation; and
- regional adjustment.

The purpose of this paper is to present a detailed description of the approach taken in the development of the regional models.

The paper:

- gives a brief history of the Victorian irrigation industry and the environment under which irrigation policy developed;
- describes the current irrigation sector and the main water products (water right and sales);
- outlines the regional models and illustrates a regional derived demand curve; and
- considers the existing and future role of the regional models in assessing mechanisms for water reform.

# 2. Victorian Irrigation

The Murray Darling Basin covers most of inland south-eastern Australia and includes much of the country's most productive farm land. The gross value of agricultural production in the Basin is estimated to be $3 billion. Total irrigation diversions from the Basin are over 10 gigalitres. Victoria accounts for approximately 3.5 gigalitres.

The management of such a large water resource has led to significant investments in capital and infrastructure. The size and location of these assets were historically determined by the Government's social and political objectives during the expansion of rural Victoria. Problems have subsequently arisen because the life of these assets has exceeded the economic and social objectives under which they were established. Plans for the future of irrigation are now increasingly being rationalised on economic rather than demographic criteria. This change, along with the emergence of some unwanted environmental consequences of irrigation, has nurtured a widely held recognition of the need to accelerate reform.

A significant event leading to the proposed reform of the Victoria Irrigation Industry was the establishment of the Public Bodies Review Committee (PBRC) in 1980. In 1984 the committee tabled its final report, Future Structures of Water Management, a review of the State Rivers and Water Supply Commission. The final report recommended a range of specific institutional and structural initiatives to reform the water sector. These included the abolition of compulsory charges for water right, pricing policies to address full cost recovery and the separation of water right from land titles.

# 3. Existing Irrigation Property Rights and Tariff[1] Structures

Water in Victoria's main irrigation districts is allocated in two parts, water right and sales water.

Water right gives the owner a long term secure legal entitlement to a clearly defined quantity of water. In the past water right was allocated on the basis of property size and the predominant culture of the region. Water rights per hectare currently vary from an average of 2-3 ML/ha for mixed-grazing farms through to 8-9 ML/ha in many of the pumped horticultural districts. Many properties, in particular dairy farms, have since developed a greater water requirement for viability than their water right

Sales water is a variable quantity available on a seasonal basis. The amount of sales water allocated in any one year depends on the volume of water held in excess of fixed commitments[2] and is expressed as a proportion of water right. The total allocation for the year includes water right and any sales water, and is called the seasonal allocation. In years of low water availability, seasonal allocations are adjusted downwards.

An additional form of sales water is 'off-quota' water. This is made available on a short-term basis, usually during the spring, when river flows exceed water harvesting capacity and would otherwise spill from the system. Individual irrigators can increase their water supply by taking advantage of off-quota water.

Most irrigators in the GMS are charged a single tariff for water. The tariff is made up of the fixed and variable costs associated with water supply. The cost of water is calculated by dividing the full cost of delivering water by the system's average delivery volume.

Currently a single tariff is charged on both water right and sales water. Irrigators are required to pay the tariff on water right whether they use it or not. Sales water is charged the same tariff by the volume consumed. This policy originated in the 1905 Water Act to provide financial security to the newly created State Rivers and Water Supply Commission and has remained despite substantial changes in the irrigation sector.

Recently the Sunraysia Rural Water Authority introduced a two-part tariff for water in the pumping districts of Sunraysia. The tariff consists of a fixed compulsory payment on water right and a variable component based on water use. This reform was of substantial economic significance because high water entitlements in the district meant that water use rarely exceeded water rights. As a consequence, there was little or no incentive to improve crop water use efficiencies.

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[1] In the context of the water market a water tariff is the cost of water.

[2] The fixed commitment includes minimum river flows and any other environmental requirements.

The two-part tariff is a recent and innovative change to the pricing of water. There are significant gains to be made from the remaining regions adopting a similar tariff structure. The following section provides an explanation of the current restrictions on transfers of water.

# 4. Transferable Water Entitlements

Since 1990, regulations governing the trade of water in Victoria have changed dramatically. Many of these regulations are based on physical constraints within the irrigation system. There is also the need to protect existing irrigators where supply rationing exists. All trade must be approved by the relevant water authority.

Although the tie between land and water has been broken, restrictions still exist on the volume of water assigned to an area of land. These volumes are calculated based on the area of land, the quality of drainage and the presence of soil salinity. These restrictions have arisen due to environmental concerns.

In most areas, both water right and sales water can be traded on a temporary basis. A temporary trade does not involve the permanent transfer of ownership. Agreements are generally made on a one to one basis between landholders and do not involve legal representation.

Permanent trade in water right implicitly includes a sales allocation. Sales water cannot be permanently separated from water right and therefore is unable to be sold. Legal representation is necessary for the permanent sale of water right. Mainly as a result of taxation and land title arrangements.

# 5. The Base Model

One base model was developed to represent the regions. The attributes of different regions are changed by modifying land, water and livestock constraints.

## 5.1. The Regions

The Goulburn Murray Irrigation System (GMS) is divided into 14 regions based on earlier work by Read et al. (1991).

The regions are listed below and are shown in Figure 1.

| | | |
|---|---|---|
| Boort | Calivil | Campaspe |
| Cohuna | Dingee | Kerang |
| Murray Valley | Rochester | Rodney |
| Shepparton | Swan Hill | Tongala |
| Tragowel Plains | Pumped Districts | |

The region referred to as "pumped districts" includes the horticultural areas of Tresco, Nyah, Red Cliffs, Robinvale, Merbein and the First Mildura Irrigation Trust (FMIT).

The above regions account for approximately 85% of water used throughout the GMS. Private diverters and water works areas that represent the remainder of total water use have not been modelled due to difficulties in obtaining data and in accounting for the spatial location/distribution of these irrigators.

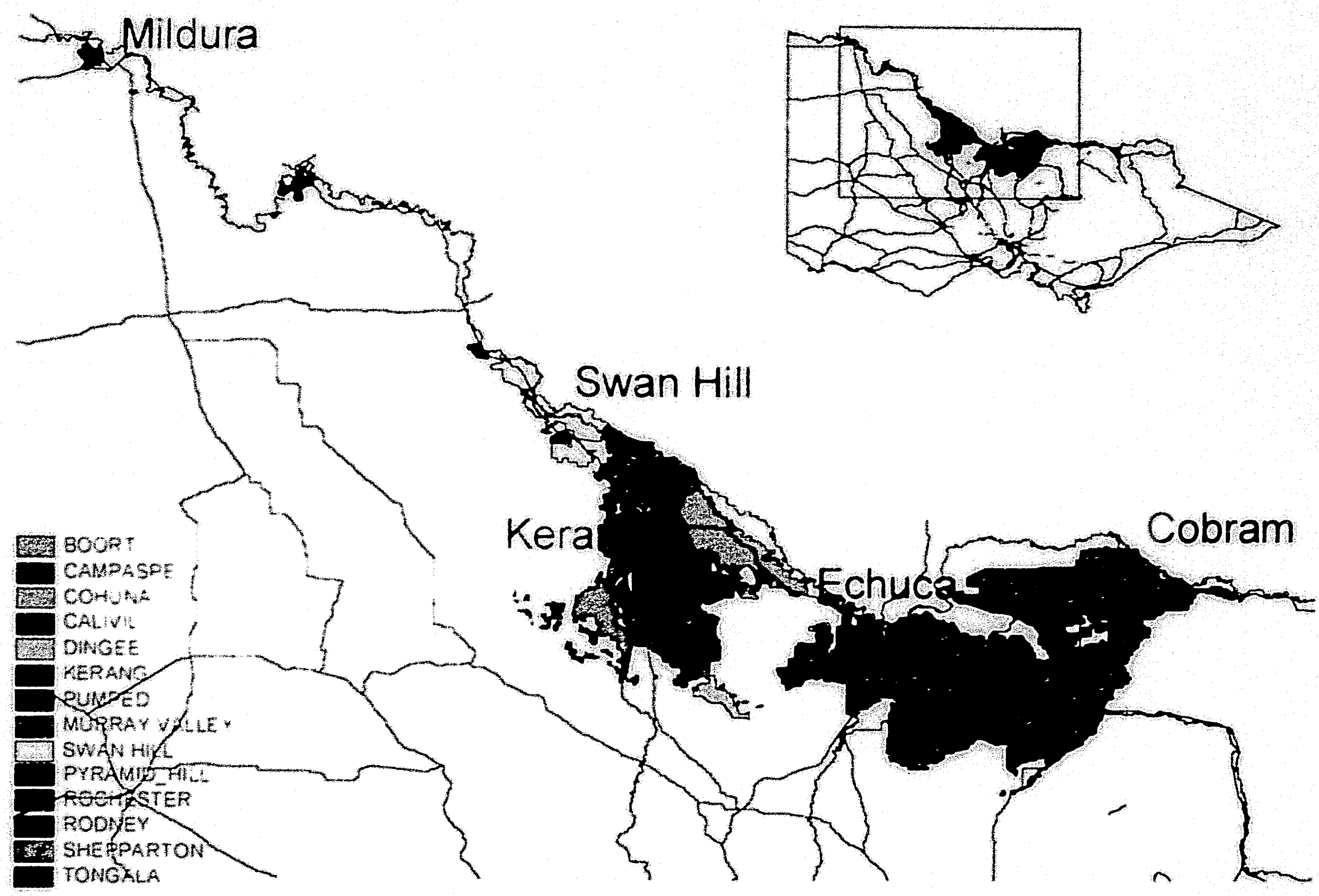


**Figure 1: Irrigated Regions of the GMS**

## 5.2. Methodology

To emulate regional farming a linear programming (LP) approach was adopted and modelled using *What's Best* software. LP is a mathematical technique for optimising a linear function subject to a number of constraints[1]. Variants of LP such as integer, quadratic or multi-period programming can incorporate the stochastic nature of farming systems, however increased data requirements often render them unsuitable.

There are two approaches to regional simulation: the ***representative farm approach*** and the ***regional model approach***. As the name suggests the representative farm approach involves modelling a region using a number of discrete representative farm types. The regional model approach involves modelling the region as one entire farm.

A representative farm approach was adopted to allow for differences in the technology and production coefficients of different farm types to be modelled. The farm model approach allows important variables that reflect different levels of management to be modelled. For example, perennial pasture is grown and grazed more intensively on dairy farms than mixed grazing farms. Not only do inputs change between management systems, but pasture quality, production and utilisation. Further, this approach has the added benefit of allowing intra-regional substitution to be identified.

Three representative farms were chosen: mixed-grazing, dairying and horticulture.

The LP models maximise regional gross margin (M) according to:

$$M = \sum_{j=1}^{n} (c_j - a_{ij}.x_j.p_i)$$

where,

| | |
|---|---|
| $c_j$ | denotes all the revenue from activities j, |
| $x_j$ | is the magnitude of activity j, |
| $a_{ij}$ | is the amount of resource i used per unit of activity j, |
| $p_i$ | is the cost of resource i, |
| n | is the number of activities j; |

subject to: $$\sum_{j=1}^{n} a_{ij}.x_j \le a_i (j = 1,........, m)$$

# 6. Industry Overview

Regional experts were consulted throughout the modelling phase to ensure all technology and resource coefficients were representative of an "average farm". These experts were again involved in validating the models at a single farm level. Further, the direction and magnitude of responses for a range of input and output prices were validated.

[1] LP provides a simple normative framework for scenario analysis while maintaining the exclusivity of producer and government goals (McCarl 1980). The implicit assumptions of linear programming are risk neutrality, infinite divisibility and a fixed number of planning horizons (short-run).

## 6.1. Land Classes

All land in the GMS has been broadly classified according to two soil types (heavy and light), two land categories (land formed and non-land formed) and three salinity classes (A, B and C, D, see Appendix I). Further disaggregation was not possible with available data.

## 6.2. Dairy Farm Matrix

The dairy farm matrix is not representative of any one farm, nor does it incorporate the entire range of production possibilities on a dairy farm. The matrix and the technology coefficients used are characteristic of a "typical" farm in the GMS .

The dairy farm matrix consists of 187 columns and 166 rows. It represents a 500 kg Friesian, spring calving herd producing 5300 litres per cow over a 287 day lactation. Calving is spread over an eight week period, from August through to October. The number of cows and calves sold annually is determined endogenously using birth rate, replacement rate and death rate assumptions, so that a static herd is maintained.

Livestock are predominantly offered a grass based diet comprising perennial, annual and dry pasture. Other activities modelled include millet, pasture hay (bought and conserved), and supplements bought including lupins and barley. The application of nitrogenous fertilisers at strategic times throughout the year is also available as feeding option.

The growth patterns for perennial pasture, annual pasture and millet are shown in Figure 2.

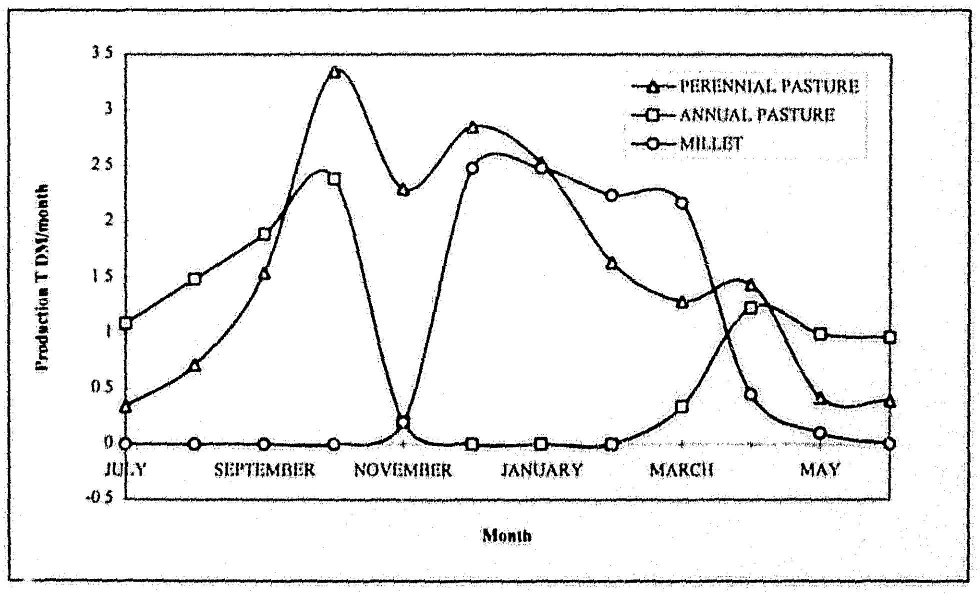


**Figure 2. Growth patterns for selected landuse activities**

The graph indicates how annual pasture growth falls to zero from November through to February and that the growing season for millet is from November through to May.

Monthly livestock dietary requirements are expressed in terms of megajoules of metabolisable energy (MJ) and protein (crude protein percentage). Artificial constraints are placed on daily grain and hay intakes. This is done to prevent extremely high proportions of grain in the diet that can cause serious health problems (potentially fatal) in cows including fatty udder syndrome (in young stock) and acidosis. The entire ration is constrained by maximum dry matter intakes.

## 6.3. Mixed-Grazing Farm Matrix

The mixed-grazing farm matrix consists of 221 columns and 149 rows. The following six livestock enterprises were modelled to represent the plethora of livestock enterprises run throughout the GMS.

| | |
|---|---|
| ***Beef:*** | Vealers |
| ***Sheep:*** | Autumn Prime Lambs |
| | Spring Prime Lambs |
| | Self Replacing Merino |
| ***Agistment:*** | Dairy Cow |
| | Dairy Heifers |

In addition to pasture, livestock are offered a lucerne (dryland and irrigated), pasture and lucerne hay, and bought supplements including barley and pasture hay.

Pasture hay is made in the spring from paddocks that are closed from September 1. Irrigated lucerne is primarily grown for hay production; although from March to August it is available for grazing. Dryland lucerne is grazed only.

The following three cropping enterprises are modelled to represent the range of crops grown throughout the GMS.

| | |
|---|---|
| ***Winter:*** | Barley (irrigated and dry) |
| ***Summer:*** | Soybeans |
| ***Horticulture:*** | Tomatoes |

The crops are not grown as part of a rotation, although maximum area constraints have been included because of the short-run nature of the regional models.

Monthly livestock energy requirements are expressed in terms of metabolisable energy (ML) only. Artificial constraints have been set on hay consumption to prevent the model using unrealistic diets during critical times of the year such as early lactation, and when fattening livestock.

## 6.4. Horticulture

The horticultural matrix is simplified by its lack of livestock and pasture activities. It consists of only 52 columns and 31 rows. The following seven landuse activities were modelled as a proxy for all horticultural crops grown throughout the GMS.

| | |
|---|---|
| ***Grapes:*** | fresh table grapes |
| | dried table grapes |
| | wine grapes |
| ***Citrus:*** | Valencia oranges |

***Stone Fruit:*** fresh apricots

***Canned fruit:***

***Vegetables:***[2]

The citrus activity uses a weighted gross margin to account for fresh and juice markets. The canned fruit activity is not representative of any one crop, but includes a weighted return for the range of fruits canned including: peaches, apricots, pears, plums and apples. Likewise, vegetables are not representative of any one crop, but represent a weighted average of the range of vegetables and nuts grown throughout the GMS.

Only two land types exist in the horticultural matrix, developed land (suitable for planting) or undeveloped land. All of the farm models include an activity for substituting undeveloped land for developed land. Not surprisingly, the costs associated with this are much higher for horticultural farms.

## 6.5. Regional Links

The regional farm models are linked by a number of activities and constraints. Both land and water can trade freely between farm types within the regions. Agistment of dairy cows and heifers is linked by the following condition:

$dx_j \geq mx_j$

where:

$dx_j$ is the demand for activity j by dairy farms, and

$mx_j$ is the demand for activity j by mixed-grazing farms.

Inherent in this equation is the assumption that agistment is only available intra-regionally.

Channel constraints limit monthly regional water use. The constraints reflect the maximum historic water use by each region. This approach has replaced the need to model the very complex system of channels and other supply constraints that exist throughout the GMS.

## 6.6. Water in the model

Water is modelled as a homogeneous product comprising water right, sales water and "other water" which incorporates groundwater.

In the model, water can be charged as a single or two-part tariff as described above. The model allows for different pricing tariffs to be run simultaneously for water right, sales water and other water.

# 7. Derivation of the demand curve

This section outlines the method used to obtain the derived demand curves from the regional models. For this project the derived demand curves are based on a single part tariff.

[2] The vegetable land use activity, specifically does not refer to tomatoes. It is assumed that tomatoes are grown as part of mixed farming systems.

Irrigators seek to consume water up until the point where their marginal return equates the marginal cost of the water. The price of water is varied between zero and $120 /ML and the impact on water use is observed. The resulting price and quantity information are plotted and a linear regression line applied. A derived demand curve is shown in Figure 3 below.

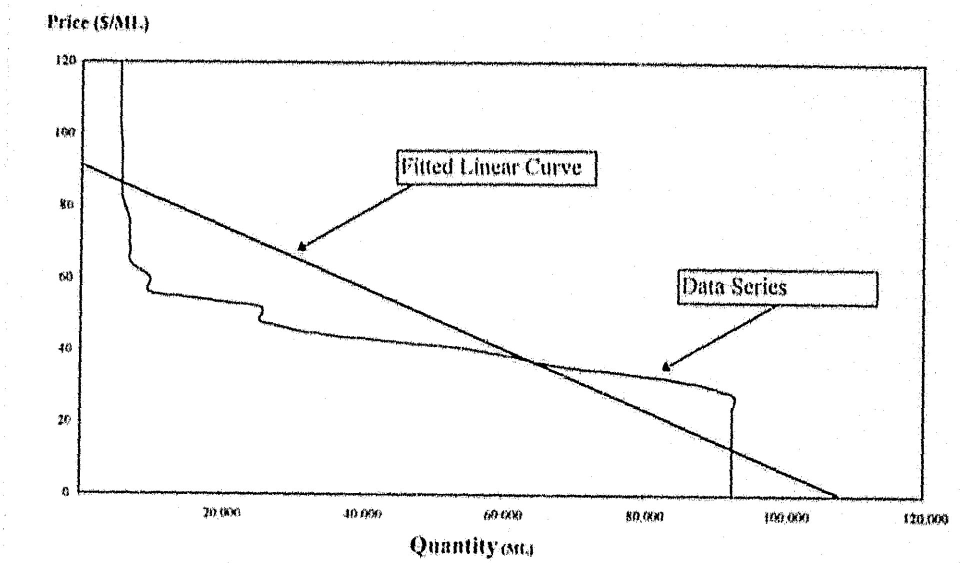


**Figure 3. Linear Derived Demand Curve**

The regional demand schedules for water are given in Table 2. They are in the format:

$y = mx + c$

where:

| | |
|---|---|
| y | is the price of water in ($/ML), |
| x | is the quantity (ML) of water demanded, |
| m | is the slope |
| c | is the intercept |

**Table 1 Regional Demand Curves**

| | Coefficient | Intercept | *Adj. $R^2$ |
|---|---|---|---|
| Boort | 0.001 | 99.2 | 0.79 |
| Calivil | 0.003 | 139.4 | 0.86 |
| Campaspe | 0.010 | 273.0 | 0.74 |
| Cohuna | 0.002 | 296.1 | 0.93 |
| Dingee | 0.006 | 172.9 | 0.74 |
| Kerang | 0.001 | 147.4 | 0.83 |
| Murray valley | 0.001 | 212.0 | 0.93 |
| Rochester | 0.001 | 179.2 | 0.88 |
| Rodney | 0.001 | 217.6 | 0.87 |
| Shepparton | 0.001 | 171.5 | 0.88 |
| Swan hill | 0.002 | 146.8 | 0.82 |
| Tongala | 0.001 | 255.2 | 0.88 |
| Tragowel plains | 0.001 | 112.2 | 0.79 |

* The adjusted $R^2$ provides a measure of the fit of the regression line to the derived demand schedules

The size of the intercept indicates the ability of a region to pay for water. The magnitude of the intercept is determined by the marginal revenue per ML of water. This is reflected in Campaspe, Cohuna, Rodney and Tongala which have a greater proportion of dairying and horticulture whereas, Boort, Tragowel Plains and Calivil are predominantly mixed farming.

The size of the coefficient provides an indication of the mix of farm types within a region. The coefficient also indicates the willingness of a region to give up water as price changes.

The derived regional demand curves are used in the spatial equilibrium model to determine the equilibrium value and volume of water.

## 8. Scope

The regional models provide a framework where different policies influencing property rights and tariff structures can be expressed as derived demand curves. Incorporating the demand curves in a spatial equilibrium framework enables economic impacts at a state or basin level to be determined for each policy scenario.

Currently, water is modelled as a homogenous product without quality or security attributes. Adjustments to the regional models to incorporate water quality and water security productivity relationships will allow the economic benefits associated with improving property rights to be estimated.

The following issues are considered priorities for future modelling work. They will be addressed within an economic and policy framework to ensure water is allocated efficiently and equitably.

## 8.1. Water Quality

Water quality is an important issue to all irrigators, but particularly those in the Boort, Kerang and Swan Hill regions. In Boort, over 60% of total water use originates from Loddon storages. The remainder is Goulburn water which enters the region via the Waranga Western Main Channel (WWMC). Loddon River water quality averages 800 $EC_e$ (dS/m) throughout the irrigation system, although it can get as high as 1800 $EC_e$ in the spring with "salt slugs". Goulburn water is typically in the range of 150 to 200 $EC_e$.

Any water trade by Boort irrigators can only occur back along the WWMC, which infers that only good quality Goulburn water can be traded. Any trade in water out of the Boort region will impact on water quality across the entire region. Demand for Goulburn water in Boort is much greater than that for Loddon River water due to qualitative differences.

Including water quality in the models will better define Boort's demand for water with differing levels of salinity. The cost of trade in water out of the region is greater than can currently be estimated. Results will be extremely sensitive to the impact water quality has on the production functions.

## 8.2. Water Security

Many of the permanent trades in TWE (water right) have occurred because irrigators want to improve the security of their supply. Irrigators who have fully developed their property with land cultures that require high irrigation intensities (>10 ML/ha), under current G-MW policies, are prevented from owning water right above a maximum of 5 ML/ha. In high allocation years, the demands of these irrigators are met by water right and water sales. In low allocation years, the irrigators are unable to purchase enough water to fully irrigate their properties and therefore must make substitution decisions which incur production costs. Where horticultural crops are involved, substitution options are small or absent, and the costs of not having water can be considerable. Horticulture is particularly prone to capital losses from damage to vines, and trees.

Areas with horticultural farms and or fully developed dairy farms, have a high demand for secure water (90-100% probability of supply) compared with mixed farmers who have a greater ability to modify their annual irrigation demand according to the likely supply. This is largely due to the pasture types used in each industry.

Historically water right and water sales have represented high and low security water respectively. If these two products were allowed to trade separately, irrigators would be able to adjust their own aggregate level of water security. Irrigators requiring a high level of security will primarily own water right and sell their sales water entitlement.

## 8.3. Tariff Structures

All irrigation districts in Victoria are on line to achieve the "year 2001 deadline" for full cost recovery. The calculations for full cost recovery are based on renewals accounting where irrigators are being asked to pay for the replacement of sunk costs associated with irrigation assets. Credible arguments against this form of accounting are prevalent and have been for some time. Watson (1995) states, "Renewals accounting is an illogical way of dealing with the capital costs of irrigation because in effect it assumes that the existing system should always be maintained where and how it was previously created".

The final decision on full cost recovery is going to influence the mix and distribution of farming enterprises throughout the GMS.

## 8.4. Investment in Irrigation Infrastructure

One of the issues identified by the COAG water reform agenda was the need for future irrigation investments to be subject to vigorous economic and environmental appraisal. The regional and spatial equilibrium model will be able to investigate in economic terms, the benefits of changes to the irrigation infrastructure. For example, it will be possible to estimate the benefits of:

- increasing channel capacity in any part of the irrigation system;
- modifying existing rules for water rationing in the WWMC;
- renewing any part of the irrigation infrastructure; or
- of further integrating/disaggregating the water delivery network.

## 8.5. Stranded Assets

A reduction in water used in a region will reduce the revenue available to cover the costs of operation maintenance and renewal of infrastructure. This will result in an increase in the cost per ML of water used. While close to 2000 ML of permanent water and over 14,000 ML of temporary water was traded out of the Pyramid-Boort area during 1994/95, the net impact on total water used within the region was negligible. Stranded assets will emerge as a problem as the water market develops and the transfer of water right increases.

The financial implications of "stranded assets" are of major concern to all parties involved with water from water supply authorities to irrigators. The regional models can be modified to take into account the dynamic nature of stranded assets so that the impacts of trade in water can be estimated.

# 9. Concluding Comments

The efficiency and equity with which water is allocated in the future is going to depend heavily upon the outcomes of the COAG reform process. The modelling environment presented here and developed as an across-border program, can play a significant role in evaluating policies for implementation. The regional and spatial model combined can address the fundamental property right issues associated with trade in a commodity.

# 10. References

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# 11. Appendix I

Soil salinity is classified according to the Draft Tragowel Plains Salinity Management Plan (1989) as is shown in Table 1.

**Table 2. Soil salinity classes based on soil salinity status.**

| Salinity Class | Salinity Status | Rootzone (0-30 cm) - Salinity | | |
|---|---|---|---|---|
| | | TDS• (ppm dry soil) | EC 1:5# (dS/m) | $EC_e$● (dS/m) |
| A | low | <1800 | <0.60 | <3.8 |
| B | moderate | 1800-3000 | 0.60-1.01 | 3.8-6.5 |
| C | high | 3000-4000 | 1.01-1.35 | 6.5-8.6 |
| D | extreme | >4000 | >1.35 | >8.6 |

• TDS = Total Dissolved Salts (ppm)

# EC 1:5 - Electrical conductivity as measured in a 1 soil : 5 water extract (dS/m)

● $EC_e$ - Electrical conductivity of a saturated extract (dS/m).