Implementation Of A Water Allocation Decision Support System In The Namoi And Gwydir Valleys

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EXTENDED ABSTRACT

Management of water resources often involves significant negotiation with regard to complex social, economic and environmental trade-offs likely to result from changes in policy or access. In NSW, changes to water allocations and access, through the design and implementation of Water Sharing Plans, involved negotiation between stakeholders representing many different interests and concerns. A key gap identified by many stakeholders involved in these negotiations was easy access to integrated, scientifically sound and generally agreed upon information on the socioeconomic trade-offs likely to result from changes in access, allocation and pricing. In addition, estimates of impacts on the flow regime and on river health are also required. This paper describes the Water Allocation Decision Support System (WAdss) developed to consider these types of trade-offs resulting from changes to access and allocation across the three water systems (unregulated, regulated and groundwater), and its implementation to two NSW catchments, the Gwydir and Namoi catchments.

The WAdss has been developed in a modeling platform, ICMS, developed by CSIRO Land and Water. This platform allows for development of a model and data base which can be overlaid by custom built Graphical User Interfaces (GUI). This approach allows for rapid development and testing of both models and interfaces. Model development in ICMS uses a semi-object oriented paradigm, with classes of objects being defined which can be associated with numerous procedural models. An instance of a class (or object) is then associated with a specific model code and a set of data. The WAdss consists of: a generic DSS structure and concept, which is encapsulated in a set of classes and a generic interface, consisting of the code and standard content files; and, specific applications of this generic structure and concept. These applications are defined by an object configuration, a data base and object specific model choice, and a set of application specific files which tailor the interface to the catchment. In this way the DSS concept, structure and interface is able to be reapplied to new catchment situations.

The WAdss has been developed to be used in a workshop situation, allowing for analysis of a library of pre-run scenarios, sharing of scenarios between users, and creation of new scenarios live in meetings and workshops. It also allows for reports to be generated from scenarios. Development of the WAdss has involved substantial stakeholder involvement. This has been aimed at: giving stakeholders a greater sense of ownership of the models, results and WAdss by incorporating their comments and ideas into the system; obtaining information and data necessary for ground-truthing or calibrating the models in the system; and, increasing the awareness of stakeholder groups of the existence of WAdss, its potential uses and limitations.

Overall the development process of the WAdss has been successful, given the maintained engagement of stakeholders in its development and support for its continued use and development. However, the WAdss is now moving into an adoption, extension and reapplication phase and success in this phase will depend on the maintained engagement of stakeholders, and the enthusiasm and input of researchers or other champions within Agencies or Management Authorities continues. Without this, the investment placed in any DSS can only lead to one-off solutions.

1 INTRODUCTION

Water allocation and access arrangements affect the livelihoods and well-being of a diverse range of water users, including irrigators and the environment. Increasing pressures on surface and groundwater resources have seen a shift in water management towards decision processes that attempt to represent the interests of these diverse groups. Decision makers are increasingly being asked to take account of trade-offs between different users of water so as to make fair, equitable and/or efficient decisions that achieve the greatest environmental benefit for the least socioeconomic cost.

This paper describes the Water Allocation Decision Support System (WAdss) that has been developed and applied to two NSW catchments for considering the trade-offs between environmental and socioeconomic outcomes resulting from changes in water allocation, access and pricing in the unregulated and regulated surface water systems and the groundwater system of these catchments.

2 WATER REFORM AND THE DECISION PROCESS

In 1994, the Council of Australian Governments (COAG) began implementing a process of water reform in Australia. Major agreements on changes to water allocation and/or entitlement included (COAG, 1994): adoption of an Integrated Catchment Management approach to management; separation of land and water title; recognition of the environment as a legitimate user of water; appropriate allocations made to the environment to maintain and restore river systems; and, trade of entitlements enabled.

In July 1995 an interim moratorium on further increases in diversions in the Murray-Darling Basin was implemented. The moratorium resulted in the Murray-Darling Basin Cap, which was implemented in July 1997. This Cap limits diversions in the Basin to 1993/94 levels and applies to all sub-basins of the Murray-Darling system, including the Namoi and Gwydir Rivers.

In addition to the Cap, New South Wales has gone through its own reform process implementing the COAG requirements. A recent act of the State Government in implementing these reforms has been to develop a water sharing plan for each of the river management areas in NSW, including the Namoi and Gwydir River Basins. The majority of these plans were finalised and released to the public in 2003. These plans contain rules outlining the ways in which surface and groundwater resources may be accessed. These rules will be revisited five years after the plans are introduced and may be significantly modified after 10 years. In addition, growth and development in the basin can mean that access to water is reduced elsewhere in the basin to ensure that the basin does not exceed the MDB Cap on diversions. One major information gap identified during the drafting of these plans was estimates of socioeconomic impacts resulting from changes in allocations and access. As a result, policy states that these impacts must be considered in the revision of the plans.

While there has been considerable flux in institutional arrangements in NSW over the past decade, future decisions and revision of the Water Sharing Plans are likely to be done through participatory management bodies such as the Catchment Management Authorities. Negotiation between Authority representatives requires access to information on the socioeconomic and environmental trade-offs of changes to the Plans. To best support negotiation, this information must be produced in a repeatable, accessible and defensible way. This paper describes such a system and its application to the Namoi and Gwydir River basins.

3 NAMOI AND GWYDIR RIVER BASINS

The Namoi River Basin (Figure 1) covers approximately 42,000 km^2 in northern New South Wales (NSW) and is an important irrigation area. The major storages are Keepit, Chaffey and Split Rock dams and the main towns are Tamworth, Gunnedah, Narrabri and Walgett. The Namoi River stretches for over 350 km, flowing from east to west. Major tributaries are the Manilla River, Peel River, Mooki River and Cox's Creek. Pian Creek is a downstream anabranch of the Namoi River. The Basin sustains substantial irrigated cotton, lucerne and mixed cropping areas.

The Gwydir River Basin (Figure 1) sits immediately to the north of the Namoi River and covers an area of 25,900 km^2. Copeton dam is the major storage supplying irrigation water. The Gwydir River Basin is less developed than the Namoi River Basin but sustains a substantial irrigated cotton industry and well as large-scale pecan production and increasingly horticultural crops. The Basin also contains small-scale grain and lucerne producers.

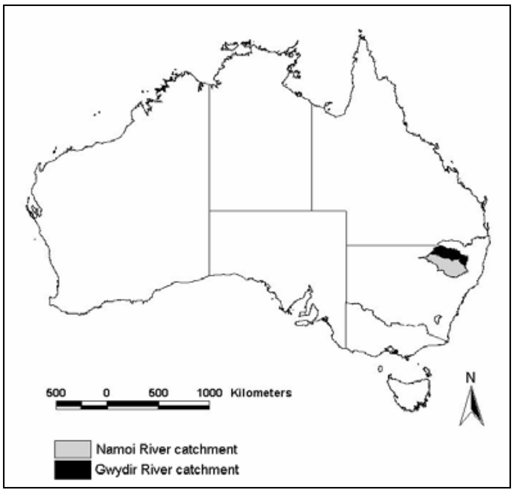

Figure 1. Namoi and Gwydir River Basins

4 MANAGEMENT QUESTIONS

The WAdss has been designed to allow users to consider a broad range of changes to water allocation and access conditions. Specific changes to be considered included: changes in regulated, unregulated, groundwater and supplementary allocations or entitlements; changes in commence and cease to pump thresholds for unregulated and supplementary water as well as changes in daily extraction limits, including the option for multiple pumping regimes throughout the year; changes in carryover rules for regulated, unregulated and groundwater including the option of no carryover; changes in the cost of water for different systems; and, the influence of climate on the impact of these changes. These issues were identified in consultation with stakeholder groups (see Letcher et al. 2003).

The system had to be designed to be able to incorporate the different allocation systems present in these catchments. This has meant that the model and WAdss design has had to be flexible enough to incorporate a range of options for change but structured enough to allow non-technical users to easily design and implement scenarios.

A scenario is essentially a unique set of inputs and resultant outputs. Scenarios are designed by users and can be saved and accessed later by the same or other users of the system. The system allows comparison against a selected 'base case' scenario. A default scenario, containing current policy settings, is included for comparisons but may be updated in the future.

In order to affect decisions the WAdss had to be capable of considering tradeoffs between the impacts on different types of irrigated agriculture (economic) and on streamflow under changes to policies in any of the three water systems in the Namoi or Gwydir catchments; accessible to staff at regional State government agencies and to members of Catchment Management groups; and understood and accepted by users and stakeholder groups. This meant that government agency staff, industry representatives and other stakeholders had to be given opportunities to comment on underlying assumptions and to understand the underlying operation of the system.

5 STAKEHOLDER INVOLVEMENT IN THE DESIGN OF THE DSS

Stakeholders were involved in the design of the WAdss in several ways. Stakeholder involvement varied from a co-design role where stakeholders were asked to provide feedback on project directions, model assumptions and interface design, to information gathering and communication of results. The main stakeholder involvement and communication activities undertaken during the design of the WAdss were:

- A Project Steering Committee provided a formal mechanism for stakeholder involvement. It involved representatives from government agencies, catchment management boards, irrigators associations and local councils.
- Face to face interviews and meetings with farmers (on a one-to-one basis) to collect basic data and information relating to model assumptions and to give farmers an opportunity to present their concerns as context for the research.
- Interviews and meetings with technical specialists in industry groups and government agencies were used to collect data and information required for the WAdss.
- Newsletters and feedback sessions. Infrequent project newsletters and local media stories were released to provide information on the project progress and contact details where further information could be sought
- Workshop based feedback sessions at critical times and on demand. These were

generally held with groups of 5-50 stakeholders, including general public representatives, irrigators, other researchers and government representatives.

Overall the aims of stakeholder involvement in the project were to: give stakeholders a greater sense of ownership of the models, results and interface by incorporating their comments and ideas into the system; obtain information and data necessary for ground-truthing or calibrating the models in the system; and, increase the awareness of stakeholder groups of the existence of WAdss, its potential uses and limitations. Stakeholder involvement in the design of the WAdss has influenced model assumptions, the spatial structure of the model, the look and feel of the interface, the way in which the WAdss is being delivered, the level of access offered to different groups, and the underlying data used to parameterise the system.

6 WADSS DESIGN

The WAdss was designed and implemented in the Integrated Component Modelling System (ICMS), developed by CSIRO Land and Water (Cuddy *et al.*, 2002). This system allows models to be developed and connected using an object oriented paradigm.

ICMS has several main advantages that were utilized in the DSS design:

- the compiled code runs rapidly.
- models are able to be developed, shared, re-used and updated easily in the system. This reduces development time and allows other users to be trained in model development and coding and means that component models developed in WAdss can be exported and used for other purposes.
- custom built Graphical User Interface (GUI) can be built to complement the Model Builder. These GUI are relatively cheap to construct, requiring only weeks rather than years of programmer time. Programmers are able to build the GUI without any knowledge of the working of the underlying models. Additionally modellers are able to write and debug their own model code, rather than relying on iteratively testing code written for them by programmers.
- the system contains a number of in-built visualisation tools and functions. These include a range of charting tools, a raster view and a simplex algorithm function capable of solving linear programming problems.

A 'lean interface' (or GUI) has been designed to open over the top of an ICMS project file to allow for DSS features including scenario creation, saving and comparison with base case scenarios. Figure 2 illustrates the WAdss design, including a generic structure and concept, incorporating the classes and model code (part of the project file or .icm) and generic interface code and standard interface files (referred to as the DLL). The WAdss is then implemented for a particular catchment through the creation of a specific .icm, which contains a configuration of objects and a data base, as well as through a set of interface tailoring files, which instruct the DLL on the interface content specific to that catchment.

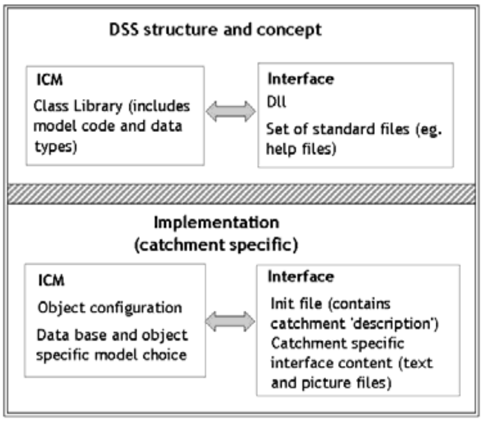

Figure 2. DSS design and implementation components

ICMS allows for 'parent' and 'child' layers, such that parent objects can contain numerous child objects with which they communicate. In the WAdss the parent layer has been used to capture the spatial structure of the catchment reflected by the nodal network, while each child layer represents the interactions between component models at the node (eg. rainfall runoff, policy, crop and economic production models).

Table 1 summarises the main classes (types of objects) used in the system. As demonstrated in this table, each class can have many different models which may represent different situations. Detailed descriptions of the models used in the system are given in Letcher et al. (2004) and Letcher (2005). Models vary in complexity from a few lines to many hundreds of lines of code.

Table 1. Main classes and models in the WAdss

Icon	Class	Use	Models
	Crop	Simulate crop yield and water use in response to climate.	1 model
	Dam	Simulates dam inflows, evaporation and allocation announcements.	1 model
	Extraction	Simulates the effect of extraction decisions on streamflow at the node.	2 models, no. regions at a node
	IHACRES	Simulates rainfall-runoff generated in response to rainfall and temperature time series.	1 model
	Musk	Route flows from upstream to downstream nodes.	1 model
	Policy	Simulates the impact of daily extraction rules for supplementary and unregulated water on water available to extract	4 models, different access regimes
	RegProd	Simulates farmer planting and extraction decisions.	5 models, different access
	Regulated_flow	Simulates dam releases, calculates regulated flows from environmental releases and irrigation demands.	1 model

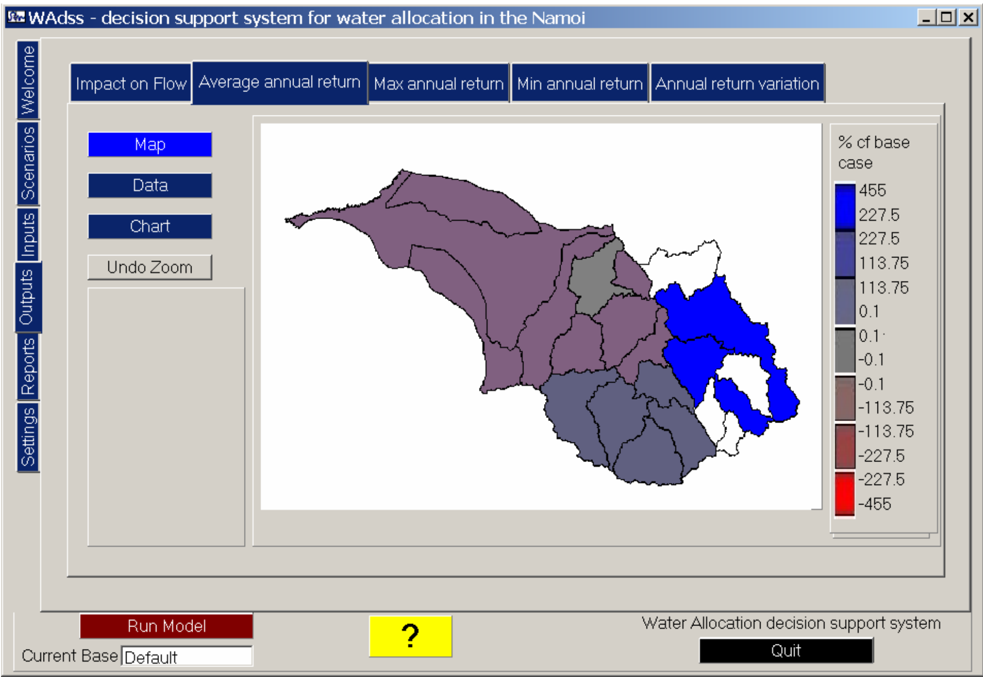

Figure 3. Output page showing the impact of a scenario on average annual returns in different regions

The WAdss has been designed with two types of users in mind: those who use the system as is; and, those that have the ability to maintain and extend the system. The first group of users would be expected to access the system entirely through the interface provided. To make this easier it was decided to avoid having a separate user guide for the system. Instead help for each page is provided within the system. In addition information describing the nodes and regions in the model, including maps (or potentially photographs) of these regions is displayed in a pop-up window when users click on output maps. This information is easily modified by users. As can be seen in Figure 3 the interface uses a tab based approach to lead users through the system. Vertical tabs on the side of the interface control the main ‘steps’ in opening a scenario, changing input values, exploring outputs and creating reports. Horizontal tabs and buttons then allow for options within these pages. Various impacts on returns to agriculture and flow are given in the interface (generally as a percentage change from the base case scenario).

The WAdss may be used in two ways. It may be used to explore pre-run scenarios or can be used to generate and explore new scenarios. Once scenarios have been saved they can be distributed and read by other users of the system. Figure 4 demonstrates the way in which the WAdss operates.

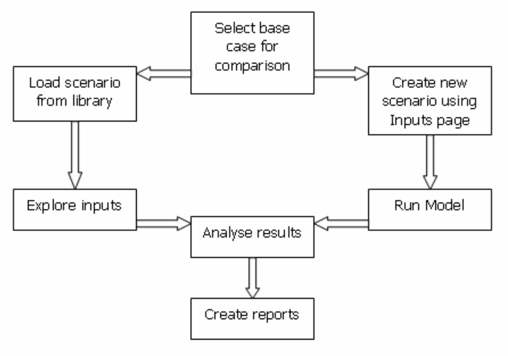

Figure 4. Operation of WAdss

This Figure shows that users first select a base case scenario for comparison (they can choose to retain the default scenario provided for these purposes). Note that the WAdss only allows analysis of results in comparison with a base case. This design relates to the relative accuracy of such a complex model in producing relative impacts as opposed to predicting absolute outcomes (see Letcher et al. (2004) for a more detailed discussion of this issue).

Users can then either load a pre-run scenario from the scenario library or can generate a new scenario. A scenario is a unique combination of values entered into the input pages. These inputs for each node or region are: the area laid out to irrigation; on-farm storage capacity; on-farm storage area; regulated and groundwater irrigation efficiency; crop and water prices; crop production costs; selection of one of several climate sequences; commence to pump thresholds and daily extraction limits in the unregulated reaches; unregulated, regulated and groundwater shares and carryover allowances; and, supplementary surface water access rules including commence and cease to pump thresholds for any number of periods during the year. If a scenario is created then the model must be run before outputs can be analysed. Otherwise the user can explore the inputs associated with the pre-run scenario. The user can then analyse maps, charts and tables showing impacts of changes on flow duration curves and user specified flow percentiles; average, maximum and minimum annual returns; and the annual return variation (as shown in Figure 3).

Users are then able to save the new scenario and create reports from new and pre-run scenarios. Reports are html files containing maps, charts, tables and text describing the scenario in comparison with the base case. These can be used to document the scenarios considered and their results for later use in other applications.

7 USING WADSS IN A WORKSHOP SITUATION

The WAdss has been specifically designed to allow for group negotiation and to be used in a workshop setting. The WAdss is able to be used to explore a library of pre-run scenarios as well as to develop and analyse scenarios that are designed and run live. Scenarios are able to be saved and distributed as text files. This means that in a workshop situation, a set of scenarios could be run before the workshop commences and either distributed before the meeting commences or simply loaded and projected to the group during the workshop. The WAdss can then be used during the workshop to explore the impacts associated with these options and to focus discussion on the nature of these impacts. Several questions should then be considered by the group: What impacts does the WAdss suggest are likely to occur as a result of the scenario being implemented? Are these impacts expected or unexpected by the group? Do they accept these as realistic? Do they consider the impacts to be desirable or at least acceptable?

Once any pre-run scenarios have been considered, the group is able to design new scenarios which may change some of the rules in these existing scenarios or which may be entirely different to those scenarios already considered. These scenarios are then able to be run live in the meeting (run time is less than 5 minutes) and can be added to the discussion. Scenarios can be analysed in comparison with a default base case (usually current conditions) or may be compared directly, two at a time. This enables comparison of any differences between scenarios. Discussion can then focus on the desirability of different options given these systematically estimated impacts rather than disagreement on the nature and extent of impacts. The WAdss can be used to iteratively define a set of acceptable and/or desirable options which could be implemented or further investigated, depending on the extent to which stakeholders feel the WAdss has captured pertinent impacts. The stakeholder involvement process was undertaken in part to reduce the chances of WAdss results being misunderstood or misused, and to increase adoption for group negotiation purposes.

8 FUTURE DEVELOPMENT OPTIONS

While the WAdss has been developed in light of the allocation issues in these two catchments, the system is flexible enough to be reapplied in a range of catchment situations.

The object oriented design of the system has advantages in future extensions of the WAdss. Further components, particularly considering the impact of the change in flow on the ecology or river health of the network, are being considered. These components can be developed and tested outside the system then imported and implemented in future versions in a relatively simple way. Further work is currently being undertaken by a PhD student on modeling the linkages between surface and groundwater systems (particularly the impact of groundwater extractions on surface water flows). Another student is developing a model of the response of the Gwydir wetlands to inundation. This will be able to be incorporated directly into the WAdss in the future as well as being able to be used as a stand-alone model.

9 LESSONS FOR GROUP DECISION SUPPORT

To date, development of the WAdss can be considered a success. Key stakeholders have maintained their engagement in the development of the system and have expressed enthusiasm over the potential benefits of the system in meeting their needs. The WAdss has also found the champions necessary for its continued adoption and development through association with the Cotton Catchment Communities CRC. The process of development of the WAdss has certainly been validated and found to have had many positive outcomes in its own right (Letcher et al., 2004; Letcher et al, 2004). However success or failure of any DSS cannot be considered as a static achievement. The WAdss is currently moving from a strong development focus to an extension, adoption and reapplication focus. While the case appears to be strong for success in these areas given that there is significant stakeholder and institutional support, as well as clearly identified pathways for further development and adoption, it is too early at present to be definitative. What is clear however is that future success of the WAdss will only be found where the engagement of stakeholders is maintained, and the enthusiasm and input of researchers or other champions within Agencies or Management Authorities continues. Without this, the investment placed in any DSS can only lead to one-off solutions.

10 ACKNOWLEDGMENTS

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