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The hydrological and economic impacts of changing water allocation in political regions within the peri-urban South Creek catchment in Western Sydney I: Model development

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SUMMARY

In this paper an integrated model of the hydrological and economic impacts of deploying water within the political divisions in the South Creek catchment of the 'peri-urban' region of Western Sydney is presented. This model enables an assessment of the hydrological and economic merits of different water allocation-substitution strategies, both over the whole catchment and in each political region and jurisdiction within it, to be undertaken. Not only are the differences in the water allocated to each region and use revealed, but also the net present values associated with each use within each region. In addition, it is possible to determine measures of equity in water distribution using this approach. It was found that over a period from 2008 to 2031 the South Creek catchment in total would on average use approximately 50,600 ML of potable water a year, the vast majority of this is used in the two urban regions of Penrith and Blacktown. Agricultural water use was also greatest in these two regions. Over this period the allocation system was estimated to have a small net present value of approximately $A301 million and the Benefit-Cost ratio was estimated to be 1.06. The urban regions of Penrith and Blacktown and the rural region of Hawkesbury were estimated to have returned a net positive benefit of $A76 million, $A246 million and $A39 million (respectively), while water to Liverpool and Camden was delivered at a loss of $A7 million and $A52 million over the period assessed. It was found that across the catchment a fair degree of both physical and economic equity occurred between regions, with the exception of Liverpool, which was over endowed with water and paid a high cost for it.

1. Introduction

Research and development in water resources management usually involves separate investigations of the technical, institutional, environmental and social spheres on how to allocate limited supplies of water to those who would appear to have an unlimited demand for it. Spingate-Baginski et al. (2003) argue that 'hard-engineering' solutions to water resource problems have been implemented without any consideration of the overall economic and environmental impacts that might result, or of the social implications associated with these projects. With the increasing discourse on sustainability issues that have arisen in recent decades, there is a realization that if any solutions are considered to be a success, technical aspects of water resources management need to be addressed within an immediate understanding of the environmental, economic and social interactions of the catchment. Increasingly, studies of hydrological problems have included economic and environmental aspects in them (Pittock and Lankford, 2010). However, considerations regarding the allocation of water in a catchment also have a political element to them that has not been captured by current hydro-economic modelling efforts. Prior to modelling the political processes that underlie decision making in a catchment, it is necessary to evaluate whether the impacts of decisions on water allocation can be captured on a political jurisdiction basis. If these jurisdictional impacts cannot be measured, then modelling the political process is not possible either.

The aim in this paper is to measure the hydrological and economic impacts of water allocation decisions on different political jurisdictions within a single catchment; South Creek in Western Sydney. The single element that needs to be present throughout this multidisciplinary approach, and which binds the various other elements together, is the purely physical and hydrological activity

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Abbreviations: KL, kilolitre (1.0 m^3); ML, megalitre (1000 m^3); IPART, Independent Pricing and Regulatory Tribunal; BAU, business as usual; $A, Australian dollar currency units (exchange rate on 6 July 2012 $US1: $A0.97).

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of allocating collected and controllable supplies of water to its various end uses, within some well defined geographic region. Where this model differs from others is that it is segregated internally within the catchment on political frontiers, while accounting for the hydrological limits imposed by topography and the whole-of-catchment. The modelling approach also accounts for the economic impacts of making changes to the resources in that catchment and depicts them according to the political regions within which they occur in the catchment. Within the model six different uses of water are identified in five distinct Local Government Areas (LGAs)[1]. The model can be used to analyse the hydrologic and economic impacts different water allocations have on different political regions within the catchment and on the catchment as a whole.

The premise underlying the development of this model is that decisions regarding the spatial, temporal and geographic allocation of water are based principally on the assumption that water security in the South Creek Catchment is an integral consideration to the issue of land use policy. In this catchment, decisions that need to be made on meeting water demand have arisen from the desire of the State Government to settle an additional one million people in the catchment in the next 30 years (see NSW Department of Planning, 2007a, 2007b and Davidson et al., forthcoming for more details on the policies and developments planned for the catchment). This model will be used to assess the hydrological and economic impacts of this policy on the political jurisdictions within the catchment. The complexity facing policy makers in each jurisdiction is immense. Not only is there the possibility of settling one million people in the catchment, but numerous suggestions and policies are in play to supply those people with water, including stormwater harvesting, effluent recycling and improving the efficiency of water use in the agricultural sector. Further adding to the complexity is that combinations of the policies and nuances within them are being suggested and these will affect people in different ways depending on how they use water and where they are located. All these scenarios are assessed in the companion paper to this study (Davidson et al., forthcoming).

2. The modelling framework

The modelling framework used in this study is based on the principles enunciated within the System Harmonisation framework developed in Davidson et al. (2007), Khan et al. (2008); and Malano and Davidson (2009) and a subsequent coupled hydro-economic modelling approach presented in George et al. (2010a and 2010b). In this approach the individual hydrological and economic components of the model and the factors that link them together are specified. The capability of the proposed modelling framework must be adequate to represent the complex nature of problem and issues confronting it, one that not only accounts for the catchment's hydrology and the economic components, but also reveals what the impact may be on its different political entities.

The hydro-economic modelling approach employed in this study is depicted in Fig. 1. The inputs into each modelling component are specified in the left hand side of the diagram, while the outputs from each modelled component are specified on the right hand side. The individual components that need to be modelled are specified in the middle section of Fig. 1. In addition, in the middle component of Fig. 1 the mechanism through which this model can be simulated is shown. The arrows in Fig. 1 represent the flows of information that exist in this integrated model. They originate from the physical features of the catchment, which are required for the hydrological model. The outputs from the hydrological model (principally surface water flows and stormwater) are combined with a range of water supply and demand factors to estimate a water allocation and substitution model. The outputs from the water allocation and substitution model are the quantities of water allocated to each sector within each LGA. These water allocations are combined with a range of economic variables to become the inputs into the economic component of the model. This integrative approach yields a range of hydrological and economic information, on a sector and regional basis, which can be used by policy makers to determine the impacts of a range of policy innovations on the catchment. Thus, this framework is designed to represent the key bio-physical and economic processes involved in the evaluation of water security and the economic performance of alternative water allocation and substitution strategies.

There are three main modules to the modelling framework. First, a distributed hydrologic module which reflects the impacts of spatially distributed land use and climate changes on runoff. The model is used to estimate stream flows and storm water runoff (Nawarathna et al., 2006).

Second, a water allocation-substitution module that balances quality specific water supplies and demands based on agreed supply priorities. This module links multiple water sources with its multiple users on a "fit-for-purpose" basis. This component of the model is the tool that is manipulated to reflect the desires of policy makers and stakeholders regarding constraints, preferences and priorities where supplies are sourced and where they are used. The framework used to estimate the water allocation–substitution model in this study is REALM (Perera et al., 2005). The outputs from this module become the water quantity inputs in the economic component of the model. In addition the water security, which in this paper is defined as the amount of water available at a particular point in the system with an associated level of probability of supply, is derived as an output of interest to policy makers.

Third, an economic model, based on Davidson et al. (2007) is used to evaluate the economic cost and benefits for different water allocation and substitution scenarios. This component of the framework measures the economic outcomes of allocating water of different quality to different uses in each LGA. In this model, the outputs from this economic component are the net present values and Benefit-Cost ratios over a lengthy period of time. These are derived by taking the gross benefits derived from using water from each use away from the total costs of supplying water to each use. In addition, these regional costs and benefits are divided by the number of households in each, in order to determine the degree of equity across the catchment.

3. The South Creek catchment-water supply and demand

The South Creek catchment (Fig. 2) is located approximately 50 km west of the City of Sydney. This catchment is a smaller component of the much larger Hawkesbury-Nepean Catchment, which surrounds Sydney, entering into the South Pacific Ocean (to the north of Sydney).

The South Creek catchment contains portions of eight LGAs. Five of these political entities (Blacktown, Camden, Hawkesbury, Liverpool and Penrith) account for a significant proportion of the catchment. In addition, all five extend well beyond the boundaries of the catchment. Conversely, the remaining three LGA's (Baulkham Hills, Fairfield and Campbelltown) fall only slightly within the physical boundaries of the catchment. For all practical purposes, these remaining three LGAs can be ignored from the analysis and their small contribution merged with the adjoining LGAs.

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[1] LGA: Local Government Area – The smallest unit of elected government in Australia, constituted under State Government statures and responsible for local land and water planning issues, minor roads, rubbish collection, collection of property rates, etc. There are five such entities in this catchment which are analysed in this study: Hawkesbury, Penrith, Blacktown, Liverpool and Camden.