LAND USE CHANGE: IMPLICATIONS FOR AUSTRALIAN CAPITAL TERRITORY WATER USE

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Abstract
Managing water resources to ensure environmental values are maintained, whilst allowing for continued economic development is a major challenge facing many areas including the Australian Capital Territory (ACT). This paper reports on a GIS based investigation of the implications of land use change on ACT water use. The paper describes a suite of tools that are collectively termed PLUCA (Platform for Land use Change Assessment).

Areas with the potential for land use change were identified through land capability assessment and by investigation of the suitability of land for development of alternate industries. Spatial data including slope, aspect, a wetness index, climatic surfaces, geology and consideration of the minimum viable scale of industry were analysed in the study.

A coarse land use class – water use relationship estimated for the ACT was used to determine the maximum potential water use resulting from land use change. Three scenarios, based on different levels of land use change were constructed to simulate high, medium and low levels of potential landuse change in the ACT. The estimated reduction in streamflow for the maximum development scenario, was around 6.8% of the average annual runoff from the ACT. This scenario represented modification of only 3.9% of the total land area.

This study demonstrates the potential for the use of GIS in the optimisation of landuse from biophysical characteristics. The implications of such changes should they occur were calculated through investigation of the annual average reduction in streamflow. The study demonstrates the use of GIS techniques in quantifying interactions at appropriate scales for decision making. The development of improved decision support tools is also outlined.
Introduction

The ACT’s Water Resources Management Plan, established under the Water Resources Act 1998, is a key component of the Territory’s water management strategy. The purpose of the plan is to provide the ACT government with a decision-making framework and strategic direction for the long-term management of its water resources.

The Plan aims to:
- ensure that the use and management of the ACT’s water resources sustain the physical, economic and social well being of the people of the Territory while protecting ecosystems;
- protect waterways and aquifers from damage and reverse damage that has already occurred; and
- ensure water resources are able to meet the reasonably foreseeable needs of future generations.

Management of the ACT’s water is made more difficult by the Murray-Darling Basin Commission’s (MDBC) cap on water extraction – and the ACT’s part in this – which was being negotiated in mid-1999. The cap and associated water reforms includes the requirement for States and Territories to set up a comprehensive water allocation system, including the allocation of water for the environment, which encourages the highest value sustainable use of water.

In the context of the final aim of the Water Resources Management Plan, the question of possible water demands from intensive, high-value agricultural and horticultural industries was raised. Viticulture had expanded considerably in the region and had the potential to grow further. Would implementation of the MDBC’s cap impact on the prospects for growth of water-dependent industries? What were the bounds of possible future non-urban water demand in the Territory? Without the luxury of time to conduct a detailed integrated study of future possible water demand, was there a ‘first cut’ method that could give an idea of the possible maximum water demand from intensive agriculture?

The Integrated Catchment Assessment and Management Centre of The Australian National University was contracted by the ACT government to develop and apply an assessment methodology which could give bounds on maximum possible future water use. This paper reports on that investigation. The project was a GIS based desktop study that aimed to determine the maximum potential water use across the ACT given complete development and intensification of agriculture over all available areas.

As background to the study a short description of physical environment of the ACT is presented. Details of the methods of the study, development of land use change scenarios and results follow. The project outcomes are discussed and a description of new and improved decision support tools for land planning under development is then made.
Study Area

The Australian Capital Territory is located in the Southern Tablelands of South Eastern Australia. The Territory is wholly located within the Murrumbidgee River catchment – part of the Murray-Darling Basin. Forestry and agricultural areas presently cover 37% of the total area of the ACT. These areas are available for agricultural intensification.

The average annual water available from ACT’s controlled catchments totals 465 GL (Environment ACT 1999). Of this, 272 GL is designated for environmental flow, leaving 193 GL available for consumptive use. Existing water use totals about 65 GL and provision is made for future allocations of around 1.9 GL due to mounting agricultural demand and a further 6.5 GL for additional water supply over the next 10 years, leaving 120 GL unallocated.

The ACT area has a climate with cool to mild winters with warm summers. Average annual precipitation ranges from 605mm to in excess of 1000mm in the mountainous areas in the southern portion of the territory. Rainfall is generally uniformly distributed throughout the year.

Parent material and topography are the major determinants of soil distribution in the Canberra region (Sleeman et al. 1979). The geology of the area is diverse and generally Palaeozoic in age (Strusz 1979). It includes a range of felsic, igneous and volcanic rocks and slightly metamorphosed sediments. The area in the north east of the territory is largely low lying, undulating country with an average elevation of 600m. The southern and central western regions are more dissected and elevated. Generally soils display a texture contrast and range from shallow and stony soils with red subsoils on crests and ridges, to deeper yellow colluvial and alluvial duplex soils that are often sodic in the A2 and B1 horizons in drainage lines. Soils on lower and mid-slope sections have the most potential for agricultural development.

Data

Three base data sets were used for the spatial analysis of the study: a 40m digital elevation model (DEM), digital geology and land use coverages. This data was supplied by Environment ACT. Annual average runoff figures, used in the water modelling, were taken from the ACT’s Water Resources Management Plan (Environment ACT 1999).

Research Approach

Figure 1 provides a schematic diagram of the analysis undertaken in this study. All spatial data analysis, excluding generation of BIOCLIM surfaces, was performed using ArcInfo.
Figure 1 Schematic diagram of data sets and analysis undertaken to estimate the reduction in ACT streamflow consequent on land use intensification scenarios.

Digital elevation data was analysed to derive a number of derivative layers. BIOCLIM surfaces of rainfall and minimum annual temperature were computed using the BIOCLIM program. BIOCLIM is a bioclimatic prediction system that uses parameters derived from mean monthly climate estimates, to approximate energy and water balances at a given location (Nix 1986). Two outputs from BIOCLIM were used in the study, a mean annual rainfall surface and a surface of the mean minimum temperature of coldest week.

A topographic wetness index (TWI) adapted from Moore et al. (1993), Equation 1, was calculated for the study area. This index is related to the wetness of a site and thus is also correlated with a number of other physical processes associated with plant growth, species occurrence and soil characteristics (Moore et al. 1993).

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TWI = \ln \left( \frac{A_s}{\tan(\beta)} \right),
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where \( TWI \) is the Topographic Wetness Index; \( A_s \) is the specific area of the catchment and \( \beta \) is slope in radians.

Slope and aspect data layers were also produced from the DEM.
Land Use Intensification

Analysis of land tenure, land capability assessment and the development of a viticulture suitability index were used to identify land available for intensification of use. Analysis of tenure simply excluded urban and conservation areas from further analysis. Only existing forestry and rural areas of the ACT were considered in this study. Land capability assessment aimed to identify the potential of land for intensification of agricultural activity. Viticultural suitability analysis identified areas within the ACT with a high potential for viticultural development.

Land Capability Assessment

The land capability classification scheme of the NSW Department of Land and Water Conservation was adopted in this project, see Emery (1988). Land capability classes were derived from characteristics of parent material and topography – the major determinants of soil characteristics in the region (Sleeman et al. 1979). Slope classes were produced from the slope surface in accordance with the Emery classification scheme. These slope classes were combined with the geology coverage to create a layer of unique combinations of slope and geology – 33 combinations in total. Using expert knowledge, each of these unique combinations of slope class and geological type were ascribed to a land capability class to reflect their potential for land use intensification. A map of the land capability classification is shown in Figure 2. The map extends over the whole of the forestry and rural areas of the ACT.

The land capability classes were re-categorised into two categories of water use and one category where it was assumed that no potential for a change in land use exists. Land with potential for intensive agricultural development was derived directly from the most productive class of the land capability classification – Class 1. This class is characterised by slopes less than 2% with geological substrate that develops productive soils. By aggregating classes 2, 3 and 4 of the land capability classification, a second class, suitable for horticultural development was derived. This class comprised land that was excluded from intensive agricultural development, land with a slope of up to 15%, with geological substrate that develops more productive soils and land with slope no greater than 5%, with less productive soils. The remaining classes were deemed to have no potential to support land use with higher water use than at present. However, rural areas in these poorer classes were included in the calculation of reduction in streamflow caused by construction of farm dams.