INSIGHT: A Tool for Increasing Coordination in Natural Resource Policy Processes

R.J. Gorddard and P.A. Walker

CSIRO Sustainable Ecosystems, GPO Box 284, Canberra, ACT, Australia 2601 (r.gorddard@cse.csiro.au)

Abstract The Resource Futures program of CSIRO Sustainable Ecosystems is constructing a spatially explicit modelling system called INSIGHT capable of exploring alternative regional land use policies against plausible price and climate scenarios for the next 20 years. The approach complements issue-specific research by exploring how interactions among issues affect policy outcomes. The project focuses on regional level decision making in the Lachlan River Catchment of New South Wales, Australia. The project arose from a RIRDC-funded consultation process on how to improve the input of science into the natural resource policy process. The consultation pointed to several requirements: a need to a) help stakeholders develop an overview of the complete social, economic and natural resource system; b) reconcile the wide range of stakeholder issues and perceptions; c) identify potential conflicts, feedbacks and long term consequences; and d) integrate the available scientific evidence in a way that permits transparent evaluation of the assumptions and exploration of implications. The resulting project aims were to develop a computer modelling system that will provide policy makers with access to integrating data sets and models, and the ability to systematically track interactions and policy consequences throughout the complete environmental and social system. A prototype project was funded to explore the feasibility of developing these tools and techniques. This paper is the first of four on INSIGHT that report on progress, methods and lessons learnt. In order, the papers discuss motivation and methodology, biophysical modelling, and the approach to economic and social modelling. The final paper examines the importance of interactions among issues for NRM policy design and reviews the contribution of this approach to regional policy analysis.

Keywords: Integrated modelling; Systems thinking; Sustainability

1. INTRODUCTION

There is widespread agreement that significant changes need to occur in land use in Australia's agricultural regions if a wide range of natural assets are to be protected. However, there is less agreement about what change is required and how it can be achieved. This paper is the first of four that report on a project called INSIGHT which has the goal of defining and developing a modelling tool for exploring the long-term, regional scale, and systemic implications of different natural resource policy directions.

The project specification was the result of an extensive consultation process, involving government and industry groups concerned with natural resource management, that evaluated the state of natural resource modelling and how its role in policy development could be improved. Subsequently the INSIGHT concept was funded as a prototyping project to explore the feasibility of the project and model design principles that resulted from the consultation.

This paper is the first of four reviewing this project. The first part of this paper presents background and motivation for the project, presents some results from the government and industry consultation process and describes the proposed model specification and objectives. The second part outlines the resulting model structure. The second paper [White et al., 2001] describes the biophysical components of the models, while a third paper [Gorddard, 2001] reviews the economic and social aspects of the model and demonstrates the capabilities of the model. The final paper [van Ittersum and Gorddard, 2001] evaluates the model against the proposed specification, discusses the conceptual, methodological and practical issues raised in the project, and discusses what we have learnt both in terms of modelling objectives and approaches.

2. PROJECT BACKGROUND

Current agricultural systems in Australia are unsustainable on many fronts. Biodiversity decline due to over-clearing and degradation of riverine environments, salinisation of land and surface water, over-exploitation of water resources, degradation of soils, the continuing cost-price squeeze facing agriculture, and the depopulation of small towns and rural areas are some of the key issues that need to be addressed. The number of issues, the numerous connections among them and the various time lags involved make it difficult to plan a balanced policy agenda. In addition there are many community groups, and levels of government, that need to be coordinated. A further trend has been the emergence of regions, or large water catchments, as a key policy making level. This movement in part reflects that regions are a natural scale for many natural resource management issues. Regions are the largest scale at which many of the issues such as salinisation operate. The issues and likely solutions also tend to vary across regions.

2.1 The project development process and objectives

The initial consultation exercise on improving modelling specifications for policy input had several themes:

- how could the existing decision support and expert systems be made more relevant to the policy making process;
- how could the increasing number of spatially explicit data bases be more effectively accessed; and
- how could the interdisciplinary gaps be more effectively bridged, particularly between the social and biophysical sciences?

Consultation with agency and industry people in a range of agricultural fields indicated that there was a need for modelling tools that could support initial phases of policy development by providing an overview and understanding of the working of the catchment as a system [Walker et al., 1996]. Key principles were that the modelling system should:

- include an integrated spatial data base covering environmental, economic and social issues;
- permit rapid identification of the range of potential policy impacts;
- be transparent in its structure and assumptions and as simple as possible; and
- take account of the issues and concerns of the people affected. A key finding was that models were seen as useful not simply for their ability to provide answers, but for their potential to provide insight into the way policy alternatives will affect the system in the years that follow implementation.

Potential uses and benefits of such modelling systems would include improved integration and targeting of policies, improved sequencing of policies, the assessment of the likely impact of research funding strategies, assessment of the collective impact of strategies and programs being implemented at the local level, and evaluation of the costs of implementing regional and state wide policies.

The resulting project's aims were: to develop a catchment scale spatial simulation model of natural resource use in the Lachlan catchment in central New South Wales, to use a systems approach that emphasises learning about the catchment as an integrated system, exploring the implications of time lags, feedbacks and interactions across processes and spatial scales, to use scenario modelling techniques to explore the potential long term consequences of current policies and potential interactions among them, to include social and economic issues and drivers, and to model the effects of actual policy interventions (as opposed to hypothetical land use changes).

2.2 Stakeholder Concerns and Model Specification

Other findings from the initial consultation were that there is widespread interest in understanding the forces that determine land use and land use change, and that there are a wide range of views on what these forces might be. Table 1 indicates the extent of divergence in beliefs about key drivers of land use change in the cattle industry. This result was typical of other agricultural industries. It suggests that building a common understanding about the key issues and questions is a necessary first step in the development of a widely supported integrated natural resource management plan. To this end the project trialled a workshop methodology based on mental mapping.

Table 1: Key determinants of land use change in the cattle industry as identified by different groups	Research	Industry	State	Federal
Commodity prices and fluctuations	X	X	X	X
Farm debt		X	X	X
Public concern about contamination	X	X	X	
Age of farmers	X	X		
Public preference for quality assured products	X	X		
Trade barriers to Australian exports	X	X		
Degradation of renewable land resources	X		X	
Overseas demand for agricultural products	X			X
Dryland salinity		X		X
Productivity through high-tech breeding		X		X
Public concern for biodiversity			X	X
Corporatisation of farms	X			
Spread of exotic weeds and pests	X			
Drought severity	X			
Disparity between urban and rural views of land use		X		
Interest rates		X		
Water pollution			X	
On-farm conservation of biodiversity			X	
Requirement for a farm plan			X	
Land conversion to non-livestock uses (eg rice)			X	
Climate trend and variability				X
Soil erosion				X
Direct assistance (incentives etc)				X
Public concern about high fat foods				X

Participants included state agency people, and agricultural industry representatives from different agricultural sectors and regions. Mental mapping involves expressing the point of view of different stakeholders as flow diagrams. The visual presentation of causal logic of different parties' concerns on the same whiteboard permits the relationships between different parties' views to be readily identified. The visualisation encourages learning across groups. In adversarial situations, a common outcome is that disagreements that appear to be about matters of fact can be traced to different groups focusing on different parts of the system and placing different weights on different outcomes, or that critical facts about which there is disagreement are identified. In this workshop one outcome reported by participants was a raised awareness of issues outside of their sector or region that only affected them in the long term or indirectly. One of the resulting diagrams is reproduced in Figure 1.

Note that the workshop participants perceived strong links between the social, economic and biophysical aspects of the catchment. The complex yet incomplete nature of the diagram suggests that a quantitative approach could be valuable in adding a systematic identification of the issues and evaluating which links may actually be important when considering policies focused on particular aspects of the system. From a modelling perspective the mental mapping process serves two functions. First, it provides the modeller with a detailed picture of the range of issues and connections that are considered important by the different stakeholders.

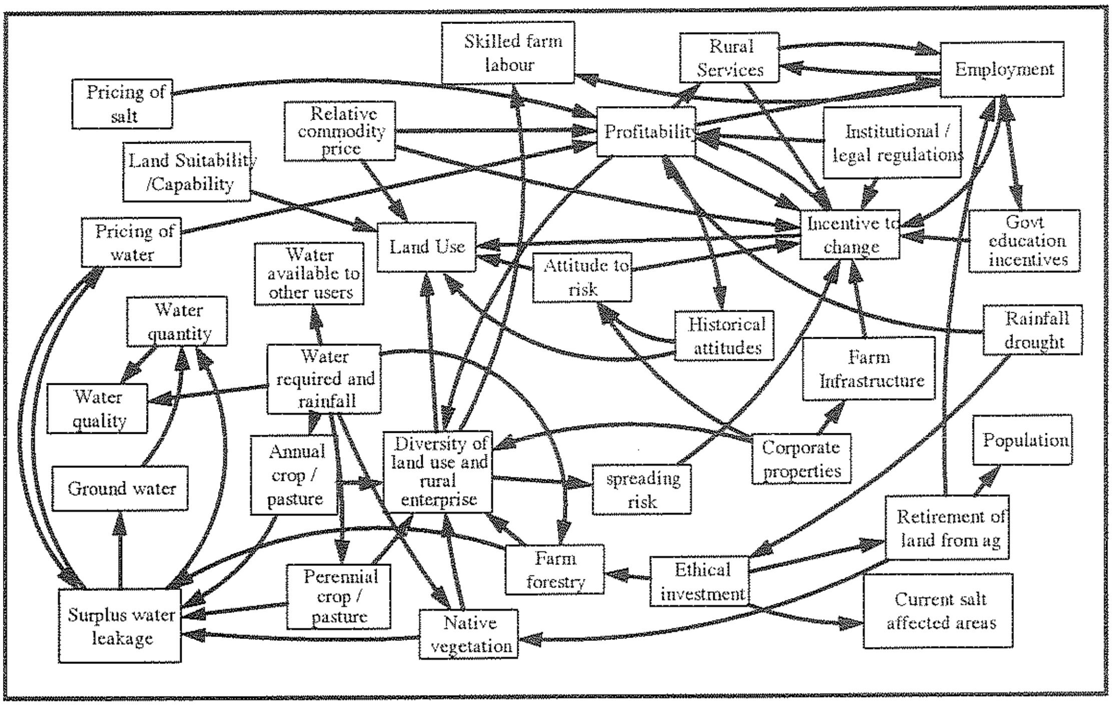

Figure 1. An example of the mental mapping diagrams identifying stakeholder views of land use issues.

Even if this process reveals no new understanding of the physical system to the modellers, it suggests which aspects of the model require the most emphasis, the type of questions that will be asked, and ways for presenting the results. Secondly, it encourages participants to think about the region as a system, and to understand the range of issues that interact with their day-to-day concerns. The workshop is therefore a first step in facilitating learning about the catchment as a system, and in preparing people to effectively use the quantitative models.

3. MODEL OVERVIEW

The model, outlined in Figure 2, and briefly described here, is developed to proof of concept stage. The aims were to develop the model to the stage where it links the social, economic and environmental aspects of the catchment for a limited number of issues and policy options. These issues include native vegetation degradation and biodiversity decline, soil acidification, the water balance of the catchment, salinisation of the Lachlan river, farm profitability, and rural population adjustment.

The model is written in the Vensim simulation software package, (Ventana Systems Inc.; http://www.vensim.com) which is linked to data stored in an Excel workbook. The model covers the Lachlan catchment, an area of approximately 84,700 km^2 . A mapping unit defines the smallest spatially explicit area in the model. Mapping units are defined by the intersection of 14 local government or statistical local areas (SLA), 12 sub catchments of the Lachlan river and 4 different land capability groups. After merging small units into adjacent regions, 100 mapping units remained. Agricultural land in the mapping units areas were further divided into three different farm types to define decision units. Six parameters of each decision unit (and for the entire system) are tracked over time: area of cleared land, area with vegetation, area with fenced vegetation, groundwater level, soil pH and vegetation condition. The number of farms by farm type in each mapping unit are also tracked over time. Non farm population age cohorts are modelled at the SLA level.

The minimum time step in the model is currently one week. Crop and pasture growth are also run at this minimum time step (which would ideally be daily). River flows and salinity loads are modelled with a monthly time step, while native vegetation condition, farm land use decisions and population and employment models run on annual time steps. Starting values for the system are calibrated to 1996 data, and the model runs for 20 years into the future. Model runs specify a period of rainfall history to replay, policy variables and assumptions about parameters that determine biophysical and producer behaviour.

Central to the simulation model is a decision module that explores how dryland farming decisions respond to price changes, new technologies, resource degradation, and natural resource policies. The farm decision module describes allocation of investment funds and non-irrigated land among crop options, grazing options, and native vegetation. The farmer's response depends on farmer objectives and constraints. Farm constraints vary by farm type, and include management ability, financing, and on-farm labour. Farmer objectives are defined as a weighted mixture of maximising the net present value of production, maintaining the productive capability of the natural resource base (sustainability) and biodiversity conservation. The various biophysical, social and economic modules calculate how the dryland farming options affect the rest of the system, and how the different parameters of the system evolve over time. Biophysical models draw on crop models developed by O'Leary and Connor [1996] and the I-Wheat model of Meinke *et al.* [1998]. Details of these and other biophysical models are described by White et al. [2001]. The economic and social models are described in more detail by Gorddard [2001].

3.1 Model Interface

The model is designed to track trends in key variables over time, to explore the causes and implications of the trends, and to determine the impacts of different policy options, external drivers and critical parameters on the behaviour of the system. A scenario modelling philosophy is adopted, emphasising 'what-if' questions, the summarising of different possibilities in consistent themes, and learning about the behaviour of the system to overcome the problems of complexity and large and irreducible uncertainties. The key variables reported are the number of employment opportunities and job seekers, population, farm number, river water flows and salt loads, farm profitability, and the fraction of farm areas that are considered to have adequately areas of protected native vegetation.

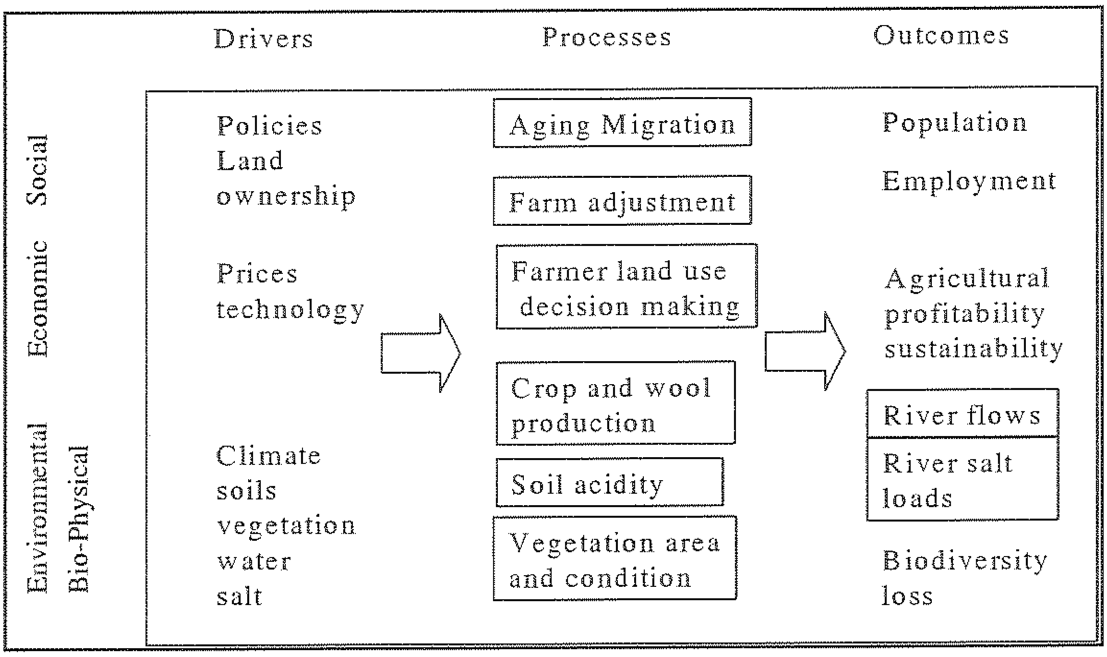

Figure 2. An overview of the INSIGHT model structure. Boxes indicate sub-models.

These are graphed over time, the Vensim software permitting rapid exploration of the causes of trends using causal trees and graphical and tabular presentations of the trends in these variables. In addition, the model structure is presented in a series of (ideally self-explanatory) flow diagrams. This interface is designed to focus on learning about the system rather than on presentation of precise quantitative results.

4. MODEL APPLICATION

The fundamental issues that an integrated modelling approach can address are:

- what rural economic and ecological developments are likely if significant changes in policies and technology do or do not occur?;
- what relationships exist between components of the system (e.g. water balance, agricultural production, rural employment), and which interconnections, if any, are quantitatively important enough to require consideration in issue-specific policy development?;
- how controllable is the system?; that is, can the existing policy levers have a sufficiently large impact on the issues they are aimed at, and can they be targeted and coordinated well enough not to have adverse effects on other assets?

5. SUMMARY

The paper has described the process and issues involved in attempting to define a new approach to the modelling of natural resource systems to support policy making. The prototype model is also described.

6. ACKNOWLEDGEMENTS

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