



Jul 1st, 12:00 AM

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N. F. Herron

T. W. Barrett

S. M. Cuddy

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Herron, N. F.; Barrett, T. W.; and Cuddy, S. M., "Linking Catchment Environmental Planning to On-Ground Investment: the SCaRPA DSS" (2008). *International Congress on Environmental Modelling and Software*. 178.  
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# Linking Catchment Environmental Planning to On-Ground Investment: the SCArPA DSS

**N.F. Herron<sup>a</sup>, T.W. Barrett<sup>b</sup> and S.M. Cuddy<sup>a,c</sup>**

<sup>a</sup> *Integrated Catchment Assessment and Management Centre, The Fenner School of Environment and Society, The Australian National University, Canberra ACT 0200, Australia ([natasha.herron@anu.edu.au](mailto:natasha.herron@anu.edu.au))*

<sup>b</sup> *NSW Department of Environment and Climate Change, Armidale, Australia ([tom.barrett@environment.nsw.gov.au](mailto:tom.barrett@environment.nsw.gov.au))*

<sup>c</sup> *CSIRO Land and Water, Black Mountain Laboratories, Clunies-Ross St, Canberra ACT 2600 Australia ([susan.cuddy@csiro.au](mailto:susan.cuddy@csiro.au))*

**Abstract:** The Site and Catchment Resource Planning and Assessment (SCArPA) decision support system (DSS) has been developed for use by Catchment Management Authorities (CMA) in New South Wales, Australia to assist with catchment planning and environmental investment decision-making. The catchment planning module can be used to set targets for environmental outcomes and broad priorities for investment, using multi-criteria assessment and prioritisation tools, scenario building functions and environmental assessment models. Outputs from catchment planning can then be used to set the criteria for environmental incentives funding programs in the site-scale module, and the targeting of investment to key areas. Site-scale models are run to evaluate landholder proposals to undertake environmental works, and the results ranked by benefit-cost ratio to maximise environmental return on investment. When coupled with a well-planned monitoring and evaluation program, the SCArPA DSS can contribute significantly to an adaptive management framework, in which site-scale investment decisions are informed by a catchment plan, which in turn is informed by progress towards management outcomes and resource condition targets through time via investment in environmental works. This paper describes the SCArPA DSS and its intended use.

**Keywords:** catchment planning; environmental investment, integrated assessment; decision support tool (DSS);

## 1. INTRODUCTION

As population pressures, climate change impacts and competing demands on our natural resources base have increased, there has been a significant shift in the way nations manage their natural resources – i.e. from the relatively unconstrained exploitation of ‘unlimited’ resources to the establishment of management frameworks, underpinned by guiding principles, for the integrated management and sustainable development of finite resources for future generations. In recognition of the complexity of natural resource management (NRM), due to factors such as institutional arrangements, trans-boundary issues and the inter-connectedness of natural systems, inter- and intra- national initiatives continue to be established around the world to undertake NRM based on principles of ecologically sustainable development (ESD), integrated catchment management (ICM) and adaptive management. In Australia, Commonwealth and State governments have agreed to a national framework for regional delivery of NRM [NNRMTF, 1999] which has seen the establishment of 56 regionally-based catchment management bodies across the country, responsible for the preparation and implementation of catchment management plans and investment strategies that adhere to the aforementioned principles of ESD, ICM and

adaptive management The catchment plans provide the over-arching frameworks for regional investment, and include statements of broad environmental objectives (longer term aspirational goals), accompanied by shorter-term resource condition and management targets, which contribute to realising the longer term objectives of the plans.

To support the implementation of their catchment plans, the catchment management bodies must prepare investment strategies, which provide detail on the activities, timeframes and costs for achieving targets. The effective implementation of a plan, via actual investment in on-ground works, requires the management body to address various issues, including:

- where to invest?
- how to calculate the environmental benefit?
- how much to invest?
- how to engage the community?
- how to ensure an equitable process?
- how to measure the benefit?
- how to link site-based measures back to catchment targets?

Ultimately, each catchment management body aims to achieve its environmental targets in the most efficient way, where efficiency takes into account not just the cost of change, but social considerations, such as the engagement, support and education of the community. Their challenge is to find the right balance between the potentially competing interests of livelihood, cultural values and environmental values.

A decision support system (DSS) can assist in managing the implementation process, and many of the catchment management bodies have developed DSSs to support their investment processes. The result is a plethora of different systems for informing NRM investment, which vary in their sophistication, the issues considered, their data requirements and their prioritization and assessment methods, thus complicating state-wide and nation-wide analysis and reporting. A federally-funded project was commenced in 2005 to develop decision support tools to assist Catchment Management Authorities (CMAs) in New South Wales with their catchment planning and investment processes. The system developed, the Site and Catchment Resource Planning and Assessment (SCaRPA) DSS, links catchment planning and implementation processes into a single GIS-based framework, and includes functionality for scenario modeling, managing data and models, visualizing results, generating reporting and multi-criteria assessments.

This paper looks at how the SCaRPA DSS can assist NSW CMAs to put in place an adaptive management framework which facilitates the cycle from catchment planning to effective implementation and round again.

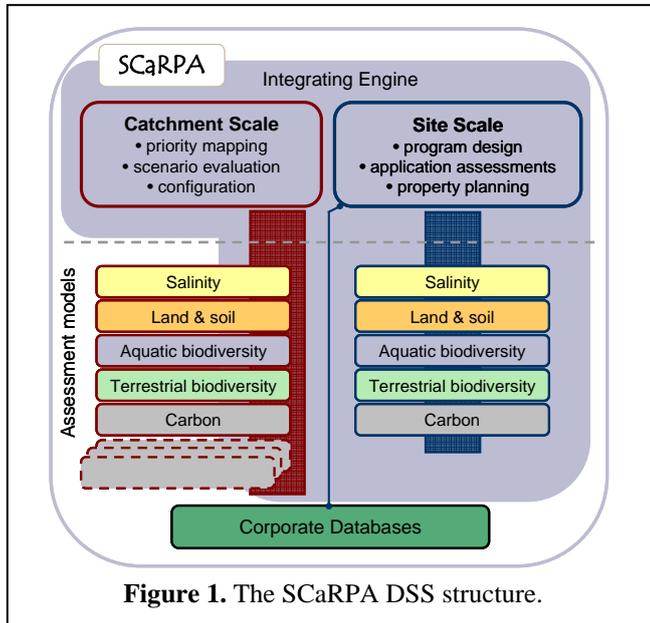
## **2. NATURAL RESOURCE MANAGEMENT IN NSW**

In 2003, 13 Catchment Management Authorities (CMAs) were established by an Act of the State Parliament to manage natural resources in NSW. The CMAs have been delegated responsibility for investing \$436M (AUD) in on-ground works that improve environmental outcomes. To inform the investment process, each CMA has prepared a Catchment Action Plan (CAP), which contains the environmental and community objectives for its region for the life of the plan, including resource condition and management targets for water, land and biodiversity assets, and community outcomes. These CAPs embrace the principles of sustainable development and integrated catchment management, and are subject to periodic review and updating, consistent with an adaptive management framework.

CAPs are accompanied by 3-year investment strategies and annual implementation plans, which outline activities, timeframes and costs for achieving targets at different stages of a CAP's life. To support implementation, most CMAs have developed methods for making investment decisions, which vary in sophistication from paper-based questionnaires to GIS-based assessments to simulation modelling to custom-built decision support systems (DSS). While there is considerable overlap in the issues and methodologies between CMAs, the

lack of a consistent framework for undertaking catchment- and site-scale assessments makes comparisons between regions and statewide reporting significantly more challenging.

### 3. THE SCaRPA DSS



The SCaRPA DSS was designed to support current CMA business processes, specifically the process of developing catchment action plans and identifying priority areas for NRM investment, and at the implementation scale, evaluating competing proposals for incentives funding in terms of their cost-benefit ratio. Figure 1 illustrates the broad DSS structure, including the 2 modules – catchment-scale planning and site-scale incentives assessment – and the various environmental impact assessment models housed within each module.

The system also includes a configuration tool, which allows each CMA to tailor the system to individual needs, including populating the database with region-specific resource condition and management targets, biodiversity benchmark data and other reference data.

The catchment planning module, SCaRPA-cp, has been designed so that, provided certain protocols are met, a CMA can ‘plug in’ catchment-scale assessment models of their choice. It contains tools for registering catchment models and data layers, generating priority maps, visualising multiple priority layers, building scenarios and evaluating the environmental impacts of land cover/management changes using the registered catchment models.

The incentives assessment module, SCaRPA-ia, permits CMAs to design funding programs, evaluate the environmental benefit of landholder proposals against criteria specified in a funding program and rank or rate proposals by their cost-benefit ratio, leading to a determination to fund or not fund.

The SCaRPA system supports the full planning process from identifying priority areas for NRM investment and the exploration of scenarios to assist in setting targets, to the evaluation of investment proposals for environmental outcomes via a competitive, credible, transparent assessment process. Links between catchment planning outputs and site-scale assessments are not automated in version 1, but will be a feature of future versions.

Under current deployment arrangements, SCaRPA will be delivered to CMAs as a stand-alone desktop application, with plans to connect it to the corporate network at a later date.

### 4. THE ROLE OF SCaRPA IN ENVIRONMENTAL INVESTMENT DECISION MAKING

While there is no prescribed process for using SCaRPA, we have assumed that any on-ground implementation program will be informed by some level of catchment planning. Together SCaRPA-cp and SCaRPA-ia assist CMAs to:

1. formulate and refine resource condition targets in terms of evaluation measures provided by the catchment scale tools, and set management targets accordingly;
2. identify spatially explicit priorities for each management target to guide investment at whole of catchment and subcatchment scales;
3. set minimum environmental thresholds for funding and determine the dollar value of environmental services;
4. predict the impacts of alternative planning/investment scenarios on resource condition targets, such as regional biodiversity status and other natural resource targets (e.g. soil, water);
5. respond to the results of monitoring and evaluation (M&E) by updating reference data and models, and reformulating catchment priorities in light of achievements;
6. communicate investment frameworks and assessment criteria to landholders; and
7. follow due process, by providing a transparent, equitable, repeatable, defensible framework for investing public funds.

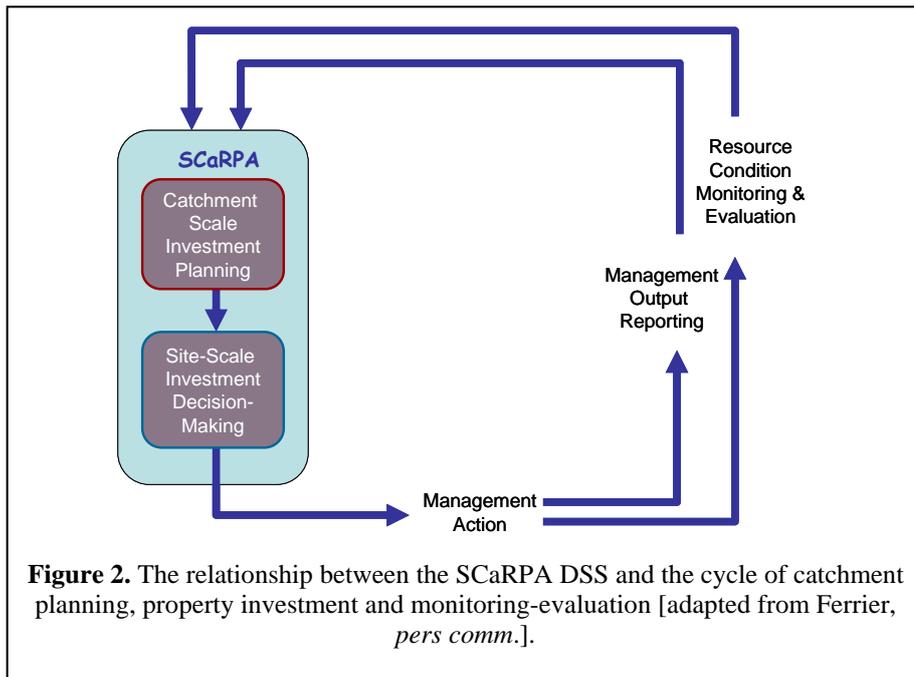
#### 4.1 Guide Target Setting

Two types of targets are contained within CAPs: *resource condition* targets express the intention to achieve an improvement in the condition of a natural resource by a specified time; and *management* targets set implementation objectives for meeting resource condition targets. Government has given little guidance on how resource condition targets should be set, though it has stated that they should provide a broad indication of catchment health. Management targets are to be more specific and measurable. As a result, resource condition targets tend to be poorly defined, qualitative statements and management targets are more quantitative. Table 1 lists a few examples of catchment and management targets from current CMA catchment plans.

**Table 1.** Examples of resource condition and associated management targets

Resource condition target	Associated management target/s
By 2016, improve the condition of native terrestrial and aquatic ecosystems	By 2016, 2200 ha of corridor habitat restored to provide connectivity (630 ha by 2009) [NR CMA, 2005]
By 2015 increase by at least 50,000 ha the area of the catchment that is managed to produce a net improvement in soil condition	<ul style="list-style-type: none"> <li>• By 2015 an additional 15,000 hectares of land will be sustainably managed using industry agreed best management practices in accordance with the Land and Soil Capability system</li> <li>• By 2015 1,500 farmers will have developed property plans and at least 500 of these will have implemented improved farm management measures [BR-G CMA, 2007]</li> </ul>

SCArPA-cp includes priority mapping and scenario evaluation tools, which can be used to set more quantitative resource condition targets. Through an exploration of alternative management scenarios, informed by single and multi-criteria priority layers, the cp module can be used to align resource condition and management targets more closely. With quantitative targets, and a set of models to predict resource condition, progress towards targets from on-ground investment can be evaluated. In the SCArPA, this necessary involves a comparison of modelled outcomes against a modelled target value, which is useful, although certainly not ideal. Independent monitoring programs are needed that measure the same condition indicators/metrics as those that inform the catchment-scale models within the DSS. Figure 2 illustrates an adaptive management framework in which the SCArPA is used to assist catchment planning and site-scale investment decision-making steps, leading to the implementation of management actions, and subsequent reporting of progress towards targets via monitoring and evaluation. Ideally, results from the M&E process feed back into the catchment planning and investment decision-making process via iterative updating of model assumptions and reference data in the SCArPA system.



#### 4.2 Guide Investment Location

Decisions about where to invest occur at both catchment and site scales. SCaRPA-cp helps set the broad-scale investment strategy, and is informed by regional, state-wide and/or national data layers, which do not provide sufficient spatial differentiation to pinpoint areas for investment. The site-scale models in SCaRPA-ia are informed by data collected at the sites where management changes are proposed. Thus SCaRPA-ia does not identify the ‘best’ areas in the CMA management area, but rather the ‘best’ proposals from a sample population of potential proposals from the CMA management area. Good planning at the catchment-scale can ensure that the sample population of investment proposals is from the ‘best’ end of the environmental outcomes continuum.

For each management target, spatially explicit priorities indicate where investment in different types of management intervention will maximise resource condition across a range of environmental values. The MCAS-S [BRS, 2007] software, which has been incorporated into SCaRPA-cp, is a spatial multi-criterion assessment tool for combining multiple priority layers into a composite priority surface. With a user-friendly drag-and-drop approach, and the ability to specify different weights for different layers, CMAs can quickly and easily identify areas for investment. If economic data is available spatially, the resultant priority layer can express priority in terms of an environmental cost-benefit ratio.

This information can then be used to establish an investment framework, including directing CMA efforts to engaging landholders in priority areas and/or setting different environmental cost-benefit thresholds for funding in different parts of the CMA area. Where there are competing demands for incentives funding, the priority maps provide a framework for negotiation and communicating the investment strategy. Investment decisions might still be driven by CMA values/policies and socio-economic pressures, but guided by target-driven priorities.

At the site-scale, a decision to invest in on-ground management relies on more detailed site information, which can include an assessment of current condition, local and upstream threats, and details of the current and proposed land uses and management. The site-level models are not automatically linked to priority area information from the catchment planning module, but this information can be entered manually into the data entry window for relevant environmental assessment models or used to frame the investment program within which proposals are evaluated. A funding program design tool is included in the site

module, which CMAs use to specify all the details and assessment criteria pertaining to a new funding program. Priority areas identified through the catchment prioritisation process can be explicitly targeted for investment by calling for applications from those areas.

### 4.3 Guide Investment Amount

Putting a dollar value on environmental services is a challenging issue, and this project has not attempted to provide a definitive answer to this question. Instead, we have assumed that the value of an environmental service will be determined by the funds available for investment and the market. The funding model options in SCArPA-ia include tender-based and threshold-based approaches. In the absence of threshold information, a CMA might choose to run a closed tender program and fund the most competitive proposals. The cost-benefit score of the last proposal to be funded can then be used to set a minimum threshold for subsequent funding programs. Over time, as investment information is collected and collated, each CMA will develop a feel for what level of environmental benefit can be achieved per dollar spent. The threshold value for culling proposals from a funding program can be expected to vary over time and with varying assessment criteria – e.g. the threshold value for funding proposals based on providing salinity and biodiversity benefits could differ from that set for proposals that are being assessed for water quality and aquatic habitat benefits, even if the model scores have been standardised to a common range.

If a minimum benefit threshold has been defined, then the threshold-based funding model can be adopted instead of the ranked approach, or the threshold can be used in the ranked approach to cull unacceptable proposals prior to ranking. Figure 3 shows the funding model screen from which the CMA can select their preferred funding model for a program.

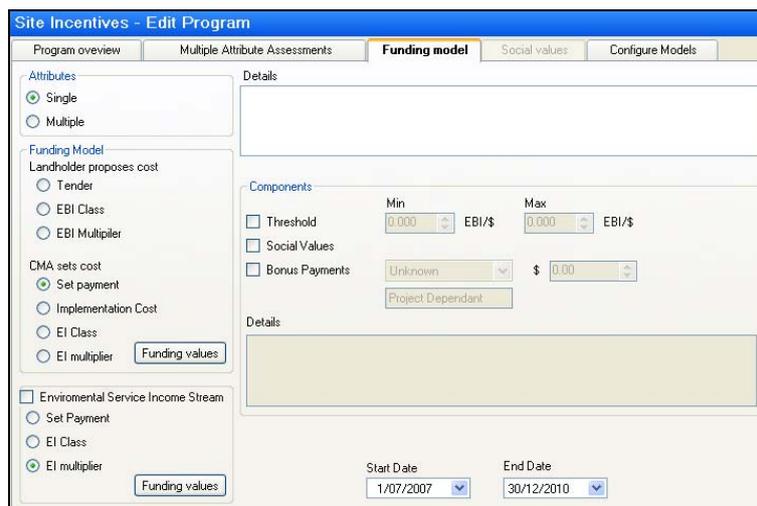


Figure 3. Example of funding models available within SCArPA-ia

### 4.4 Determine Environmental Benefit

The environmental outcomes from changing land cover or management can be evaluated at both scales in the SCArPA, but using different models. At the catchment-scale, models tend to be spatial, utilising existing grid and vector data, to evaluate environmental outcomes. SCArPA-ia models, which evaluate salinity, terrestrial biodiversity, aquatic biodiversity, land and soil capability and carbon sequestration impacts, are not spatial, although the information captured during site assessments and the model predictions are attributed to spatial units and managed in a GIS. Outputs from these models can be re-expressed as a cost-benefit score, by standardising the environmental benefit score by the proposal cost, and then ranked by cost effectiveness. This ranking process also informs the where to invest question at the scale of implementation.

The metrics/indicators used by the different models, at both scales, do not translate easily into quantitative resource condition targets. However, while resource condition targets are largely qualitative, this is not a big problem. The use of indicators, rather than actual measures of the desired environmental outcome, is commonplace and is a consequence of the many difficulties in quantifying environmental benefits. This paper is not the place to discuss the issue, except to acknowledge that what some of the SCaRPA models predict as the environmental impact might be difficult to express in terms of contributions to resource condition targets. At the site-scale, we have adopted the position that the aim of the incentives assessment module is to assist with ranking competing proposals and that indicators of environmental benefit will suffice for this purpose. To evaluate progress towards targets, the proposals that are implemented can be fed back into the catchment models as a single scenario and evaluated in terms of their catchment-wide environmental impacts.

#### **4.5 Monitoring and Evaluation**

The SCaRPA system is not specifically a monitoring and evaluation tool, but progress towards achieving management targets and resource condition targets can be evaluated. The former assessment is relatively easy, since the management targets are expressed in terms of areas or lengths of change (e.g. area re-vegetated; length of stream rehabilitated) and this information is captured spatially via the SCaRPA-ia. The evaluation of progress towards resource conditions targets is more complicated. While the targets continue to be expressed qualitatively, progress towards targets cannot be reported in any meaningful way. Leaving aside the very real issue that any observed improvements might not be caused by the management activity, data collected from an M&E program could only be used to support an assertion that condition had or had not improved. The question of how much improvement or deterioration has occurred can only be determined using models. Thus one role of SCaRPA-cp is, firstly, to set resource condition targets, expressed in terms of the metrics of each of the assessment models and, secondly, to evaluate the environmental impacts of any implemented activities using the SCaRPA-cp models.

As management interventions are implemented, investment priorities will change. By updating the SCaRPA-cp model layers with the management outcomes and resource condition changes identified during monitoring, subsequent rounds of prioritisation and target setting can reflect the changing status through time, consistent with a truly adaptive management framework (Figure 2).

#### **4.6 Engage the Community**

The SCaRPA system provides a vehicle for engaging landholders and land managers in property-planning. A CMA officer can sit with a landholder and explore different management scenarios and see how they contribute, or not, to better environmental outcomes. With the aid of air photos or other imagery, maps and site information, a property plan can be developed or an incentives proposal prepared that is consistent with the catchments environmental objectives. The use of a DSS in this way can also contribute to meeting community targets within the CAPs.

#### **4.7 Ensure an Equitable Process**

Community engagement will also be facilitated through having a transparent, equitable, repeatable, defensible, scientifically-based framework for managing the assessment process. A CMA must be able to defend their decision to fund or not fund a proposal for incentives dollars, as they are accountable to the Commonwealth and NSW government for the investment of public funds.

SCaRPA-ia includes a program design tool (or template builder), which is where the objectives, details and assessment criteria of a funding program are laid down, prior to

advertising the program and processing applications. The assessment criteria nominated in the program design stage are coded into the system, such that when an application is assessed under that program, an automatically generated set of assessment questions (which might include a selection of social, cultural and risk criteria) and data requirements appear in the application entry windows, and the application is assessed against the rules (e.g. the type of funding model; the minimum benefit threshold, etc.) specified in the program template. If, for example, only salinity and biodiversity models were selected as part of an assessment process, only questions and data inputs needed to inform these assessments would appear in the application pro forma.

If the CMA wants to vary an assessment, we provide a text entry window in the DSS in which the justification for varying the decision from that generated via the assessment process can be recorded.

## 5. CONCLUDING REMARKS

The integration of catchment planning and on-ground implementation decision support tools into a single framework is a key feature of the SCaRPA DSS design. While version 1 does not fully realise the goal of automated links between priority maps generated in the catchment planning module and the site-scale assessment tools, it goes a considerable way to integrating catchment NRM planning and implementation decisions. Close consultation with the CMA clients has resulted in a customisable framework, which supports their business processes. Used in conjunction with a well planned monitoring and evaluation program, an adaptive management framework for improving natural resource condition can be realised, in which site-scale investment decisions are informed by a catchment plan, which in turn is informed by progress towards management outcomes and resource condition targets through the implementation of on-ground investment in environmental works.

## ACKNOWLEDGEMENTS

SCaRPA is a product of the TOOLS2 project, a collaborative R&D project with the NSW Departments of Environment and Climate Change, and Primary Industries, and CSIRO (Land and Water). The authors would like to acknowledge the contributions of their colleagues towards the development of the assessment models and the implementation of the framework. The project operates under an Activity Agreement for use in the devolution of NAP/NHT funds under a Commonwealth and State Bilateral Agreement.

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