Which on-ground projects will give me the best environmental return?

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Key Points

- A major limitation to effective NRM resource allocation are simple and robust tools to guide the allocation process.
- Tools to support NRM investment should be fit for purpose and designed for the end user.
- A modelling approach to the prioritisation of NRM investment provides a consistent and defensible method of resource allocation.

Abstract

The collective Australian investment in Natural Resource Management (NRM) activity across federal, state and private funding sources is of the order of $3.5B/annum (RMCG 2017, ABS 2007). The investment is significant, however it is spread across large, multifaceted environmental and social problems. How do the administrators of this investment (mostly NRM regional groups and state based programs) assess the most worthwhile projects? A 2015 review of Australia's 2010-2030 Biodiversity Conservation Strategy found that this approach has failed to "effectively guide the efforts of governments, other organisations or individuals" (DOE 2016). That is, for a given investment there are limited tools to help answer the question "what should I do and where should I do it?"

In this paper we present a web based tool which allows the administrators of NRM investment to quantify the relative water quality benefits of prospective projects in agricultural areas of the Great Barrier Reef region. The tool is underpinned by a collection of paddock scale models developed by the Queensland Government over the last 10 years which provides a repeatable scientific basis for the tools' computations. The interface between the quantitative modelling process and prospective NRM projects is achieved by representing the water quality changes from farm management practice change projects. The management practice change described by a project is transformed to a predicted change in the generation of sediment, nutrients and pesticides that is specific for the farm based on its soil, climate and regionally specific farm management practices.

Keywords

decision support, modelling, sugar cane, banana, grain, prioritisation, software

Introduction

The Great Barrier Reef (GBR) is the largest living thing on earth. It is one of the seven natural wonders of the world, comprising a 2,300km-long ecosystem with thousands of reefs made of over 600 types of hard and soft coral. Poor water quality has been identified as a major threat to the GBR (Brodie et al. 2013). The GBR receives discharge from 35 river basins covering 424,000km^2. That is a drainage area nearly twice the size of

Victoria, Australia. The Queensland and Federal governments have set targets through Reef Plan to address the threat to the GBR from poor water quality (and other threats) (Reefplan 2013). As a result of the commitment to Reef Plan targets there is an ongoing major investment of the order of $25M/yr spent on agricultural practice improvement through the region.

The investment in agricultural practice improvement projects is from a range of funding sources, but is dominated by the Queensland and Federal Government, and industry bodies. The selection and administration of the projects is conducted by regional NRM bodies with support from industry groups. Hence the project development and implementation process is handled by locals. Whilst the project administrators have excellent local and industry knowledge they have inconsistent capacity to assess the likely water quality benefits of any given project (Figure 1).

The Queensland Government has an ongoing modelling program which captures the collective on-ground management practice change projects to produce annual predictions of how those projects may be improving water quality (Carroll et al. 2011) (final box in Figure 1). The agricultural practice improvement project administrators see the regionally reported results of the projects that they administer. However they have no consistent a-priori method of assessing individual or collective prospective projects. Hence it is possible that a significant proportion of the projects funded are providing less benefit to the water outcomes than anticipated by the project administrators.

To provide a-priori guidance to project administrators, we have developed a web based software tool –the Paddock to Reef Project Assessor – 'P2R Projector' to fill this need. The P2R Projector builds upon the underlying modelling capacity used by the state government for predicting water quality outcomes.

Figure 1: Basic funding workflow (P2R Projector addresses the blue box)

In this way the underlying predictions of the P2R Projector are a sophisticated application of the best available science (Carroll et al. 2011). The key challenge in developing the P2R Projector was not one of technical functionality (because the modelling approach is well established), but one of operational functionality. To be useful, the tool has to fit within the existing operational structures of project administering groups and match the skills of staff in those organisations.

The following sections step through the process of developing the P2RProjector to create a fit for purpose tool.

Designing the tool

We applied an agile approach to the creation of the P2R Projector. The agile approach for both the backend computational design and front end user experience design was based on regular meetings and multiple iterations to arrive at the end product. The overall approach for specifying the functionality and the interface development was to firstly understand the operating environment of the project administrators (the users).
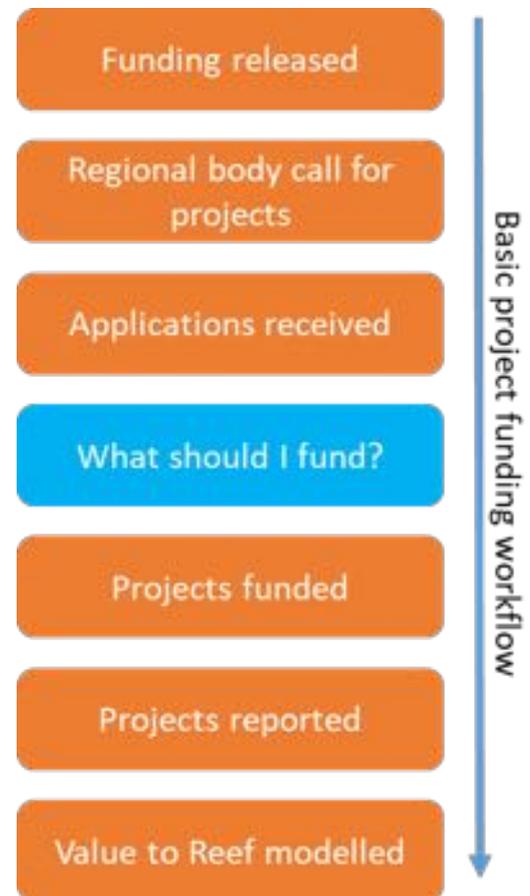
Review Regional Body workflow

The first task was to compile a complete workflow of the project funding and approval process for each of six NRM regional bodies in the Great Barrier Reef. Each region conducts this process differently and uses different review and assessment procedures. However through the review of each region we could identify the parts of the workflow that were common and where the P2R Projector could support that workflow. A straight forward example is where several of the groups required a simplified summary of proposed projects to present as a business case to an approval committee. The P2R Projector has an 'export summary' option to match this workflow step.

What other tools are in play?

Several NRM regions have developed their own systems for compiling project information and there are state wide tools that are used for collating project information. A critical element for the P2R Projector is to seamlessly fit with as many of these existing tools as possible. A consequence of this assessment is the format by which the project details are stored and transferred. The P2R Projector stores projects as spatial files (geojson which are inter-changeable to .shp files) because this is the basis for common project file sharing. Hence projects defined in the P2R Projector can be combined with projects defined in other systems.

Terminology matters

Our workplaces are defined by the jargon that we create to define what we do. We paid particular attention to the words used to describe different aspects of the project funding workflow. We also used A/B testing of alternatives where we found conflicting terms between user groups for the same thing. For example should we refer to the spatially separate areas over which a project is conducted as blocks, paddocks, or holdings?

> A / B testing is where alternative designs are tested with different groups to determine the most intuitive interface.

NRM is intrinsically spatial

Where a project is conducted is critical for predicting its water quality impacts because of the local soil and climate properties. Rather than use a survey based system to determine the soil and climate properties we tested and implemented a map based system. This approaches requires the user to simply know where in the landscape the project is to be undertaken. The users draw the project on a map and the P2R Projector retrieves the soil and climate properties from underlying spatial layer layers. The 'draw your project on a map' based approach makes the underlying computation more automated and consistent and it also makes the user experience more comfortable, as not all project administrators where confident in defining the soil types. Additionally, farm activities are intrinsically spatial and being able to explicitly specify where in the landscape a project is being conducted provides a visual catalogue of prospective projects for the user. As a layer of projects is built up the gaps in the landscape can also be seen.

User management and data sharing matter

Prospective projects potentially contain commercial in confidence information, hence the sharing of project based information must be well managed. Through a series of interviews we finalized the basic user group whereby all members of the group would be willing to share data with other members. This basic group structure is defined by a specific agricultural industry in a specific region. Hence there are a number of user groups currently using the tool with security of information kept within each user group.

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User testing is critical?

Through the development of the P2R Projector we went through five rounds of user testing. These tests where focused on testing the user experience with the interface. The testing consisted of observing the user conducting a series tasks. We achieved large decreases in the time taken to complete tasks between the rounds of testing by making small changes to the interface. For example, adding a subtle outline to any area that we expected text to be entered made the tool immediately more intuitive for new users.

How does it work?

The P2R Projector is actually 18 tools specific for industries and regions. Each tool is created to apply to one of six NRM regions and applies to one of three industries (sugar cane, grain and banana). For example there is tool specifically for sugarcane in the Burdekin region. The reason for these regional subtleties is that the each industry is run slightly differently in each region and subsequently, the types of management practice for each industry varies between the regions.

Users are assigned a group (industry and region combination). When they log into the P2R Projector they are provided with water quality project information that applies for their specific region and industry.

Create a project

A project within the P2R Projector is comprised of an agricultural practice change survey and a spatial layer which defines the area/s over which the project will be conducted.

Agricultural practice change survey

The agricultural practice change survey for a project captures the pre and post project agricultural practice (Figure 2). The survey questions are industry specific and region specific. The practice change questions have been developed and refined over several years as part of the Queensland Government's paddock to reef modelling program.

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Figure 2: Example of agricultural practice change questions

The practice change questions are used to create a code to represent the pre and post agricultural practices. The code represents the soil management practices, nutrient management practices, irrigation practices and pesticide management practices.

Draw the project

Once the survey is complete, the project administrator draws the project areas on a map (Figure 3). A project can be composed of multiple areas. This is particularly relevant for the sugarcane industry where a farmer has acquired several non-adjacent blocks that they are planning to apply the same practice change to.

Figure 3: Draw the project areas on a map

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Once the project has been drawn on a map, the project areas are overlayed with a soil layer to determine the area of each soil type within the project. The project is also overlayed with a climate layer to determine the relevant rainfall region for the project.

The P2R Projector creates an intersection between soil, climate and management to define a number of unique pre and post project water quality codes. These codes are used to retrieve constituent generation rates for sediment, nutrients and pesticides for both the pre and post agricultural practices. The constituent generation rate is multiplied by the sub-area of the project, and the sub areas are combined to produce a load. The pre and post loads are compared to produce a percentage change, absolute change and load reduction per dollar ($/kg) (Figure 4).
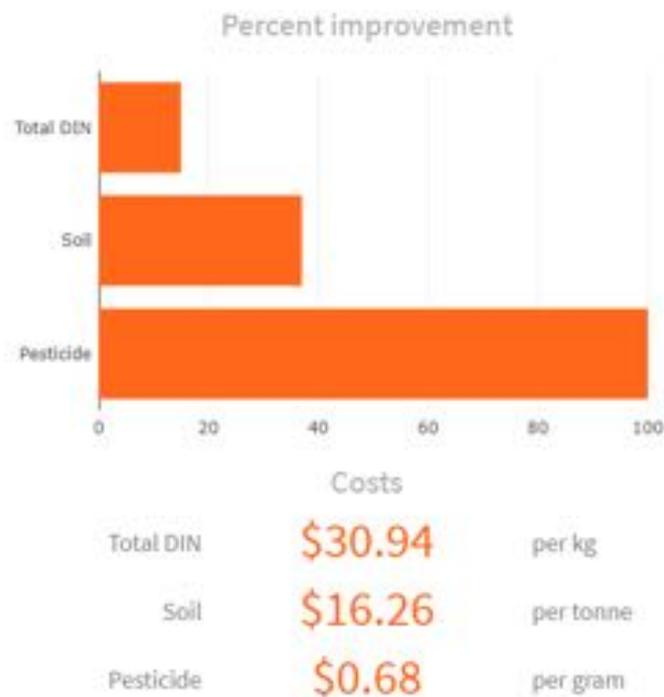

Figure 4: Headline figures for selected project.

Review the project or collection

Users can select multiple projects to review the soil, nutrient and pesticide savings of each project. The lists of selected projects can be sorted and the projects can be expanded to see the relative contribution of each block within a project (Figure 5). An important feature of the tool is to allow the review a large number of projects simultaneously thereby allowing NRM groups to prioritise projects to be funded. This also makes funding allocation consistent with broader P2R modelling efforts and ensures that funding is targeted at projects which the latest modelling or science suggests will have the largest impact on improving GBR water quality.

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Selected project(s)

Click on a column header to sort by that result

	Project title ⬍	Description	Budget ⬍	Block id	Total DIN saved kgs ⬍	Soil saved tonnes ⬍
⊟	test project	This is for testing	$2,223.00		885.47	500.25
	test project	This is for testing		0	623.25	302.07
	test project	This is for testing		1	262.22	198.18
⊞	test project 2	demo project	$10,000.00		323.16	615.01
⊞	test project 3	demo project	$73,000.00		22.80	199.61
⊞	test project 4	demo project	$34,000.00		1,610.72	6.62
⊞	test project 5	demo project	$27,000.00		34.71	479.66

Figure 5: Sortable summary table showing selected projects.

How the constituent generation rates were modelled

A water quality risk framework was developed for each industry; grains, sugar cane and bananas. These describe the management practices that were known to influence water quality in runoff and deep drainage, with levels from high to low water quality risk for sediment, nutrients and pesticides. Detailed profiles of how these practices would be used in each industry and region were developed with regional technical working groups. These profiles included all of the details need for modelling, for example, planting dates for crops, tillage and traffic used, irrigation, fertilizer and pesticide rates and timing, and recycling pits operations.

The APSIM (**A**gricultural **P**roduction Systems **Sim**ulator) was used for modelling sugar cane, particularly for dissolved inorganic nitrogen in runoff and drainage (Keating et al. 2003). Howleaky? (Rattray et al. 2004, Shaw and Silburn 20016) with some enhancements was used to model pesticides and phosphorus in cane and for all constituents for cropping lands and bananas. Paddock models are one-dimensional, daily time-step models for soil water balance, runoff, erosion and constituent loads for an area that is acceptably uniform in soil, vegetation and climate (typically several to tens of hectares). Paddock models were used because they represent a level of processing detail compatible with, and their outputs respond to, the management practices. These models have a long history of use in these industries including testing and calibration against field water quality monitoring trials. Unique combinations of climate and soil type within each land-use are modelled for all of the management practice combinations in the water quality risk framework, for a 28 year climate period. Outputs include water balance components, sediment loads, particulate and dissolved nitrogen and phosphorous, and various pesticides. Each simulation is uniquely identified by its climate, soil and management practices. These unique simulations are represented as the codes used by the P2R Projector to determine load generation rates.

What have we learned

Through the process of developing the P2R Projector we have been encouraged by the enthusiasm of the intended end users to contribute to the development of the tool and proactively engage in the process. We

didn't find any reluctance to adopt new technology in the bush, but we did find a resistance to dumb ideas. The key message here is that a technical solution must be appropriate for the end user.

From previous experience we noticed that many regional practitioners have a visceral response to the mention of the word 'model'. They are immediately resistant to the concept that a model can adequately communicate their deep local understanding. We think that this is partly a response to previous inappropriate, overstated or poorly communicated modelling exercises and a basic difference in the paradigms of modellers versus practitioners. Modellers assume that the ability to, and the value of, abstraction to generalise a result has an obvious value, whilst local practitioners see that a deep and hyper-local understanding of what makes a particular site unique to be an equally obvious value. This conflict between the value of using the similarities between areas as a basis for modelling and the value of showing the uniqueness of different areas is an ongoing dichotomy. Our approach was to introduce a modelling based tool to *support* the existing practices, rather than to *replace* those practices with a model based alternative.

Acknowledgments

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