

Communicate environmental science and management with user-centred interactive design to empower data-driven decision-making

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Key Points

- There is a proliferation of natural resource management data and little of it gets published.
- Data that is published is often not in a format that is suitable for decision-makers.
- Creating interactive, data-driven web applications and employing a user-centred design approach ensures that decision-makers get the data they need in an appropriate format.
- We provide examples of dashboards created with the user-centred approach that empower data-driven decision-making.

Abstract

We are drowning in data. Much of the data we collect never sees the light of day or is delivered in forms that are hard to access and interpret for decision-makers. The data we use to inform decision-making and reporting is often held close by scientists and data curators, and only delivered to decision-makers in highly curated formats. These formats fail to engage decision-makers because they don't allow for data to be explored in the context of the information required to make their decisions.

We take data that is ordinarily hidden in detailed reports, or languishing in files on data portals, and make it accessible to a wider audience by creating interactive data visualisations and dashboards that communicate environmental science and management outputs and outcomes. Taking a user-centred design approach, that engages decision-makers throughout the design process allows us to fully understand what information is most important to various audiences and design accordingly.

We have found that by liberating obfuscated data and delivering it through interactive web applications designed and developed with the user at front of mind, decision-makers are empowered to explore data and engage in effective adaptive management.

Too much great work in environmental management goes unseen by decision-makers, thus limiting their capacity to continue to be advocates for the science and management actions that drive our sector. Communicating data through user-centred interactive design makes it more accessible and empowers environmental managers to make more informed decisions.

Keywords

Data-driven decision-making, Interactive data visualisations, User-centred design

Introduction

Natural resources management (NRM) is science and data driven. We strive to have the best available data to support science and inform management actions. We want data to assess ecosystem condition and establish baselines, data to model future condition, data to track NRM outputs from management actions, and data to demonstrate the outcomes of those actions on the things we value, the list goes on. Valuable data collection programs have been established, including an explosion of remotely sensed data products that are useful for environmental reporting such as vegetation observations, and indices of condition and use. Further, we have

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seemingly unlimited space to store all this data, that is proliferating exponentially (Bishop, 2000; Taylor, 2023). We are drowning in data. Yet very little of it is published and transformed into products that are useful for decision-makers.

Data-driven decision-making helps environmental managers make more informed, evidence-based decisions that are defensible, rather than those that are based on intuition. However, getting the right data, in the right format, into the hands of decision-makers can be challenging. Decision-makers are often time poor, may lack the technical knowledge to understand the information, and may, figuratively, speak a different language to data custodians, like scientists and data curators (Likens, 2010), whose job it generally is to interpret the data and generate information products.

Much of the data that is published, is often done so in formats, such as print documents with embedded images of charts (Grainger et al, 2016), that are static, highly curated, rapidly become out of date, and communicate what the data custodians themselves want to hear (de Bruin et al, 2013). Along with being potentially unsuitable for decision-makers to comprehend, these formats provide limited ability for reuse and exploration (McInerny et al, 2014). Allowing decision-makers to explore data independently helps understanding and reduces the bias of highly curated visualisations (Grainger et al, 2016). However, independent data exploration is only useful if there is an understanding of who the decision-makers are and what they need to know to make their decisions. It is not uncommon to see data products, such as reports and dashboards, serving up content because data is available, not because it is useful for decision-making. To create data products that are effective in informing decision-makers, product creators should focus on the users, engage them in the design process, and design products to meet their specific needs.

User-centred design approach

We have created many visualisation-rich web applications (e.g. interactive dashboards, report cards and modelling applications) for informing data-driven decision-making to support NRM. Each of these applications has a specific purpose and often multiple audiences with different levels of technical expertise. We employ a user-centred design approach to tailor the way data is presented to ensure that each audience has the high quality, actionable information they need to make decisions that aid adaptive management.

User-centred design is a software development concept that requires engaging users and considering their needs throughout the entire design and development process (Grainger et al, 2016). This approach of end user engagement not only ensures that users will end up with a product that is useful to them, it will also improve the chances of them adopting, and advocating for, the product by giving them a sense of ownership.

Our user-centred design approach to creating data-driven web applications starts with identifying the users and engaging them in the design process through a set of initial interviews. The interviews help us establish a picture of the user (a design persona), their technical capabilities, their goals for using the information, and what specific questions they need answered to inform their decisions. These design personas are then used to inform an iterative design process.

We design the user interface specifically to answer the questions that the decision-makers require answers to and to meet their technical capabilities. To cater for audiences with different needs and technical capabilities in a single application, we regularly utilise an interactive design pattern called 'progressive disclosure'. This pattern allows for a tiered approach that serves up the right information to the right users by initially showing a high-level view of information and allowing them to drilldown to more detail, should they require it (Grice et al, 2021).

During the iterative design process, we explore potential data sources. However, we focus this exploration on what data may be required to answer the decision-makers' questions first and consider data availability later. This avoids a data first approach where we are tempted to answer questions that nobody is asking, because we can, not because we should.

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Once a draft design is complete, we reengage the users for feedback and amend the design accordingly. There are typically multiple iterations of this phase and only once the users are content that the design meets their needs do we collate real data and embark on application development.

Once development of the draft product is complete, we reengage with users, giving them access, either through usability or user acceptance testing, or both. We then start a second iterative process, this time of gathering feedback and making amendments. Only once the users are satisfied that the application meets their needs, do we consider the product complete.

By following this user-centred design approach, we are able provide decision-makers with the information they require, at the push of a button. We can unlock unseen, or incomprehensible data, and empower decision-makers to make timely, well-informed decisions, which support them to engage in effective adaptive management of natural resources.

Examples

The following examples feature a selection of visualization-rich interactive dashboards that were developed using our user-centred design approach. Each example empowers decision-makers by answering the questions that support their decisions, using the data they require, in a form that is suitable for them to understand and communicate.

Reef Investor

Reef Investor is an interactive dashboard created for investors in on-ground water quality improvement actions reported to the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program. Investors are primarily from State and Federal Government departments, or funding bodies. They are mostly program managers who make decisions about how to invest money in on-ground actions to improve water quality.

Reef Investor draws on project information (location, estimated water quality improvement) captured in [P2R Projector](#) and funding information (programs, budgets) captured within the dashboard to communicate to investors about the outputs and outcomes of their investments. Investors can login to the dashboard any time they please and explore outputs and outcomes by location, year, program type (targeting fine sediment or dissolved inorganic nitrogen) and project status (draft, proposed, in progress, submitted), as well as access individual program reports.

Reef Investor answers the following questions defined by users in our interviews with them:

- How much money have we invested?
- What are the water quality outcomes of my program?
- What outcomes were funded by which funding body?
- What types of on-ground actions are most effective?
- Which programs are getting the best return on investment?

Prior to the development of Reef Investor, investors had to go through the time-consuming process of contacting multiple data custodians, who in turn had to perform *ad hoc* analyses, to answer those questions. Reef Investor places the answers to those questions squarely at investors' fingertips and empowers them to make decisions in a timely fashion, whenever they choose, to get the best return on their investment.

Reef Investor also supports other parts of the Reef reporting universe, by supplying aggregated data about program activities at an appropriate scale for reporting 'What's being done' to help the Reef in the [Reef Water Quality Report Card](#).

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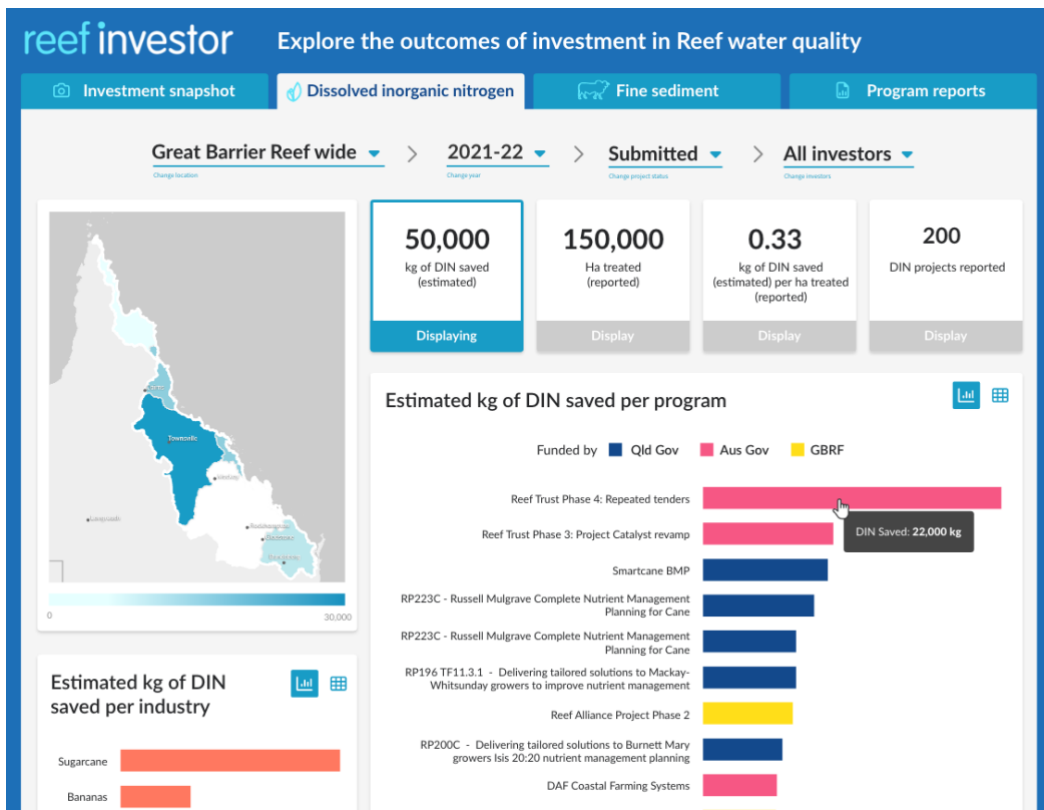


Figure 1. Reef Investor user interface communicating the outputs and outcomes of investments targeting dissolved inorganic nitrogen (Note: Data is fabricated for design purposes)

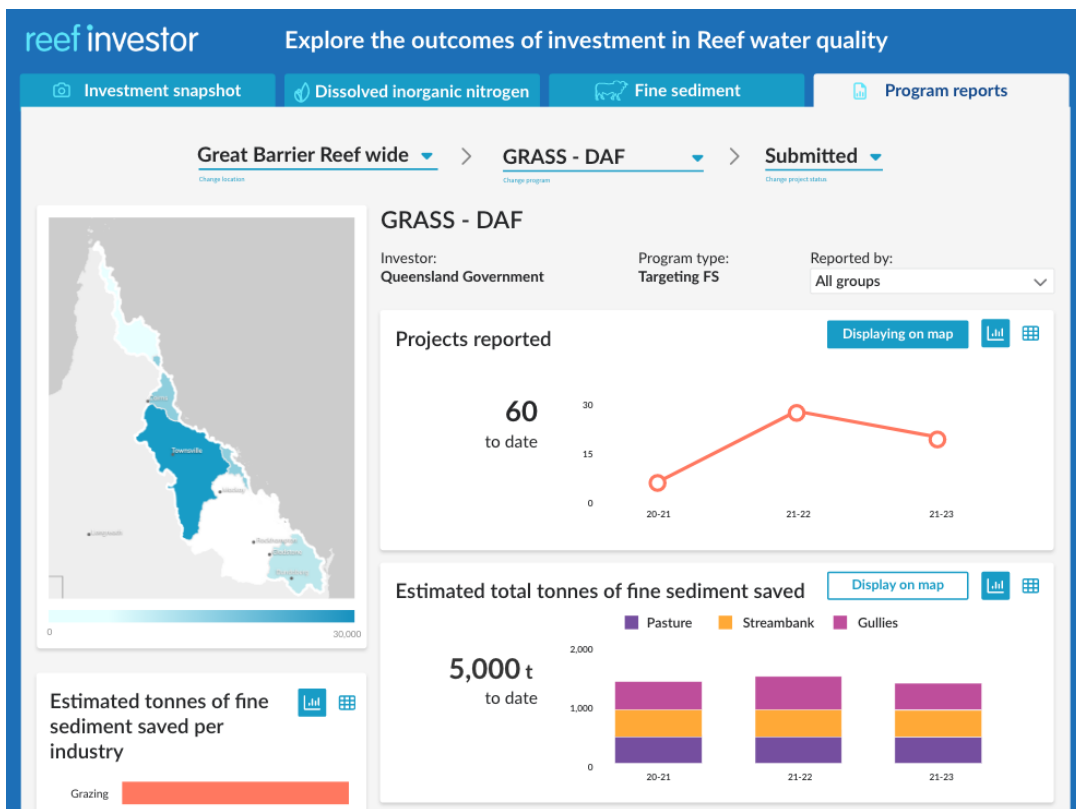


Figure 2. Reef Investor user interface communicating the outputs and outcomes of an individual program (Note: Data is fabricated for design purposes)

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Healthy Waterways Strategy Performance Dashboard

The Healthy Waterways Strategy Performance Dashboard is an internal facing interactive dashboard designed for delivery groups within Melbourne Water. The delivery groups are those responsible for implementing on-ground actions, such as riparian vegetation management, as part of Melbourne Water's commitment to waterway improvement. The groups include Waterway and Land Officers (WLOs) who implement the on-ground activities and make decisions day-to-day on where to them carry out, Program Leads who manage and allocate resources to the WLOs and report up to management, and Managers who make decisions related to the strategic planning of activities across the Port Phillip and Westernport region.

Through the Healthy Waterways Strategy partnership and through its own Waterways and Drainage Investment Plan, Melbourne Water has set targets for vegetation management. The dashboard uses near real-time data related to on-ground actions planned and performed, to assess progress towards these vegetation management targets. Targets reported against in the dashboard, relate to establishing new vegetation, maintaining existing vegetation, and maintaining existing high quality vegetation (a proportion of the overall vegetation maintenance target) along waterways.

Our user-centred design approach led us to develop multiple user interfaces specific to different audiences. There are three primary sections to these interfaces:

1. **Regions interfaces** – these allow for high level reporting to Managers, so they can strategically decide which programs they need to leverage funding for.
2. **Catchment and sub-catchments interfaces** – these allow Program Leads to report up to the Healthy Waterways Strategy and Waterways and Drainage Investment Plan and inform decisions on where resource allocations may need to change to meet the catchment and sub-catchment scale targets.
3. **Waterway and Land Officer patches interfaces** – these allow Waterway and Land Officers to assess their own performance in achieving targets on their patch, and decide where they should focus their time day-to-day, and for Program Leads to decide which WLOs require more or fewer resources to meet their targets.

The Healthy Waterways Strategy Performance Dashboard answers the following questions defined by users from our interviews:

- Where are the targets?
- How are we progressing towards our targets across the region?
- Where are we falling behind on the targets?
- Do we have enough planned projects in the pipeline to meet the targets in the future?
- Where do I need to do more?
- Which areas do the Waterway and Land Officers need to focus on?
- What are the different types of projects being implemented?
- In this area, should we focus on establishing or maintaining vegetation?

Prior to the development of the dashboard, the process for answering these questions was the responsibility of a single data analyst, who was tasked with compiling all the data from the various sources into a simple dashboard and responding to data requests. The compiling was undertaken once per year, meaning data was only up-to-date and for a short time and not inadequate for adaptive management.

The Healthy Waterways Strategy Performance Dashboard allows Melbourne Water staff to check their progress towards vegetation management targets at any time and at multiple spatial scales, so they can adaptively manage their on-ground delivery programs.

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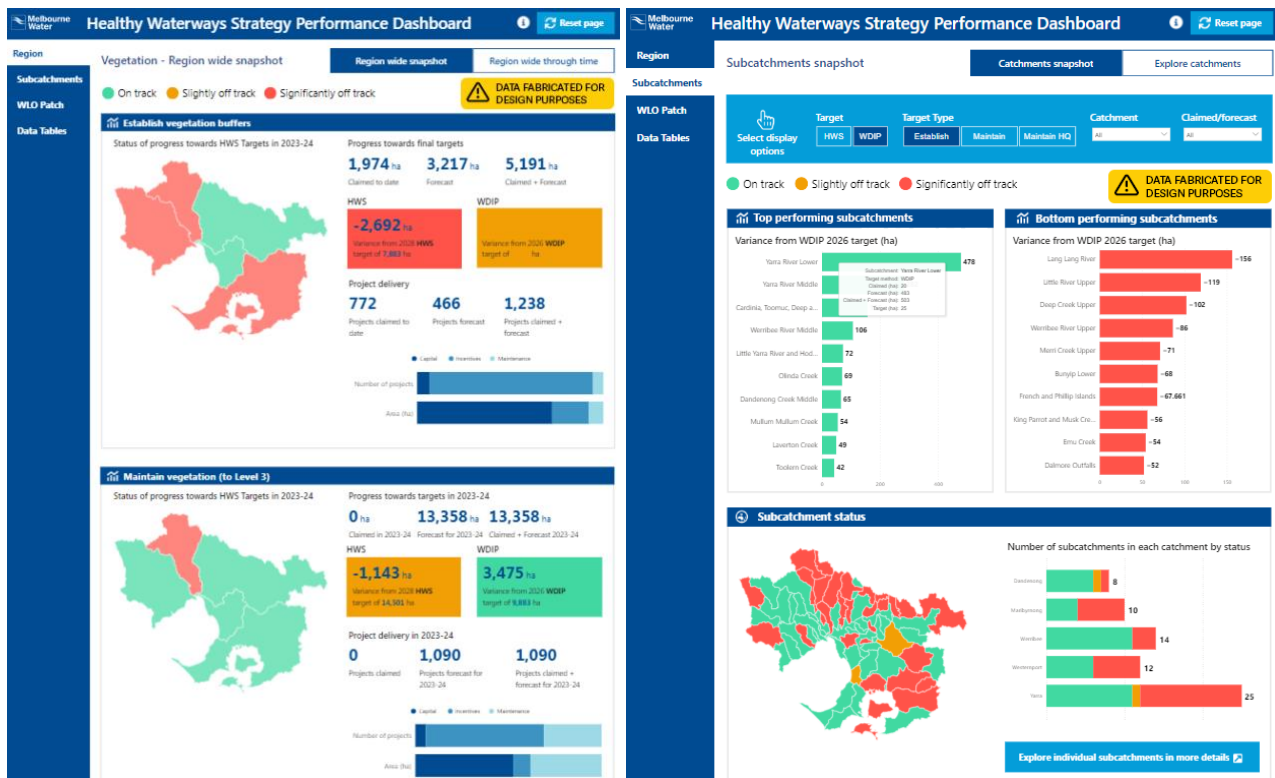


Figure 3. Healthy Waterways Strategy Performance Dashboard region and catchment user interfaces for Managers and Program Leads (Note: Data is fabricated for design purposes)

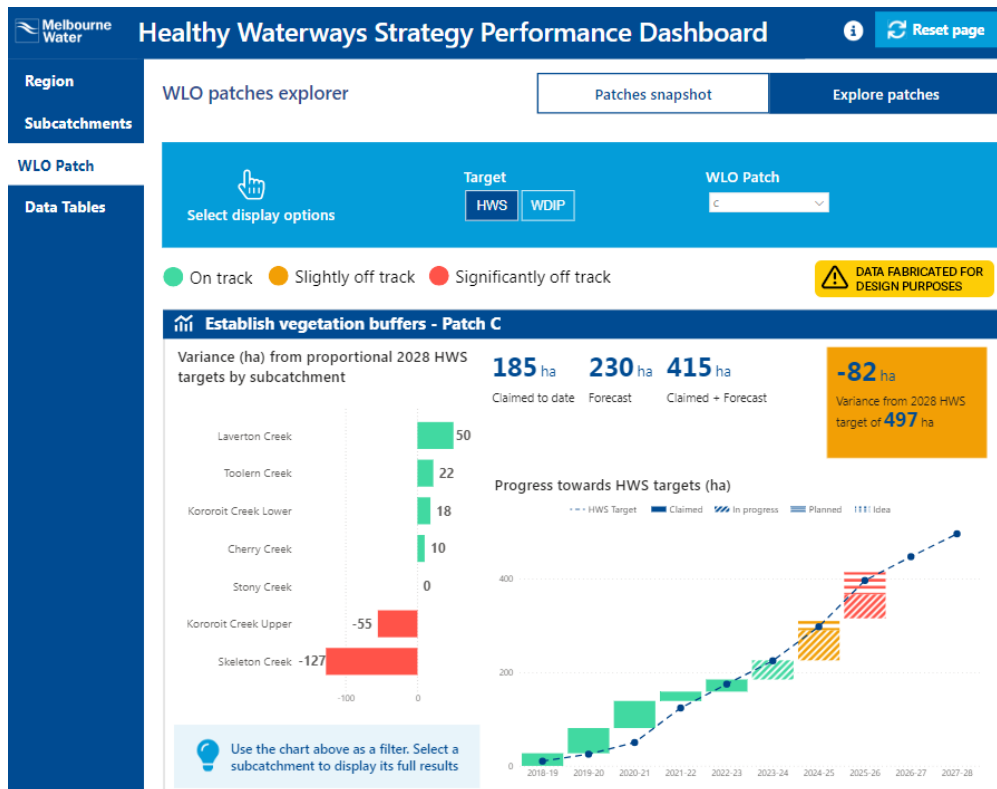


Figure 4. Healthy Waterways Strategy Performance Dashboard Waterway and Land Officer Patch user interface for assessing progress towards vegetation management targets (Note: Data is fabricated for design purposes)

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Conclusions

Increasing volumes of data in environmental science and management rarely get published or make it into the hands of decision-makers. Data that does make it to decision-makers is often in an inappropriate format to make informed decisions. To empower environmental managers to make better decisions they should be allowed to explore data in their own time, in a format they can comprehend that answers their questions and is presented without bias. We advocate the use of interactive, visualization-rich, data-driven web applications, created using a user-centred design approach that focuses on engagement with decision-makers throughout the iterative design and development processes. This approach ensures that decision-makers have the information they need to engage in effective adaptive management of natural resources, at their fingertips.

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