Getting the picture: using data visualization to make complex models more accessible to policy-makers

Introduction

History abounds with examples of water management decisions made without the involvement or consent of the parties most affected by the impacts. SEI endorses a more inclusive planning approach by inviting watershed stakeholders to the table to articulate the challenges they face and work with scientists to evaluate their options for the future.

Building on the RAND Corporation's work on robust decision-making, SEI has developed the Robust Decision Support (RDS) approach, which combines sophisticated water systems modelling, data visualization and participatory techniques. The goal is to work with stakeholders to identify strategies that demonstrate satisfactory outcomes over a broad range of possible futures, or scenarios.

This fact sheet focuses on the role of data visualizations in that process, and the value of succinctly presenting the results of hundreds of model runs within a single chart to inform planning discussions.

The RDS process alternates between stakeholder engagement and technical/scientific analysis. It begins by soliciting input from key actors groups – scientists, resource managers, policy-makers, and citizens who rely on the water resources in question – to define the scope of the analysis. Key aspects include future uncertainties, potential strategies to address them, and the metrics that will be used to evaluate whether a particular strategy contributes to successful outcomes.

The stakeholders' insights reveal the demands on the system, opportunities and constraints, while the scientists provide the tools to evaluate the possible outcomes of implementing the policy strategies under consideration. In the process, all the actors have the opportunity to participate in framing the analysis and setting priorities.

As the project progresses, the different actors are able to see how their contributions are reflected in the scientific model.

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The Tableau graphs are presented to stakeholders in Piura, Peru.

For example, water managers may have noted a growing need for irrigation water that could become difficult to supply in a changing climate. The model would then explore irrigation water availability under scenarios that included climate change and possible basin management strategies.

The stakeholders work with the scientists to evaluate the model results and, as needed, to refine the different components. In this way, RDS helps ensure that the models reflect the different voices within scientific, stakeholder and policy-making communities and that the solutions identified through the process are appropriate to the context and well aligned with local development priorities.

Making complex analyses accessible to policy-makers

SEI's water management models are typically built with the Water Evaluation and Planning (WEAP) system, a water resources planning tool that combines supply- and demand-side perspectives in a comprehensive, flexible analytical framework.

Watersheds span large areas and embody many complex processes, and WEAP models that explore a wide range of uncertainties can produce enormous amounts of data that risk obscuring the underlying insights and findings they generate. Thus, a key challenge is to distil the entire range of uncertainties and strategies under consideration to provide sufficient clarity for stakeholders to have confidence in the conclusions they draw based on the analyses carried out.

As part of the RDS approach, SEI uses the software Tableau to produce interactive data visualizations that fill this crucial communication gap and enable stakeholders, decision-makers and scientists to analyse model results together.

Figure 1 shows a Tableau dashboard that illustrates results for the Peruvian Chira-Piura watershed and its vulnerability in the current situation, with no adaptation strategy considered. Each column shows one of 13 system performance metrics identified by stakeholders, and each row shows a combination of external factors about which there is uncertainty, to encompass a range of possible futures. All the metrics and uncertainties are defined by policy-makers and stakeholders.

This is an example of *multi-field graphics* that incorporate several dimensions; in this case, the rows incorporate all the possible combinations of the four designated uncertainties. The figure's colours denote the level of vulnerability as a percentage of times the system underperforms. The red indicates above 50% and the green indicates below 50% vulnerable.

The tool on the top right corner is used to filter the data to show the effects of implementing any one of 11 strategies. As more strategies are added, the graphic updates the data to demonstrate the effects of another strategy in relation to the

Figure 1: Map of vulnerability of the current management system in percentage terms for key performance metrics. Green denotes below 50% and red above 50% vulnerability for four of the uncertainties evaluated.

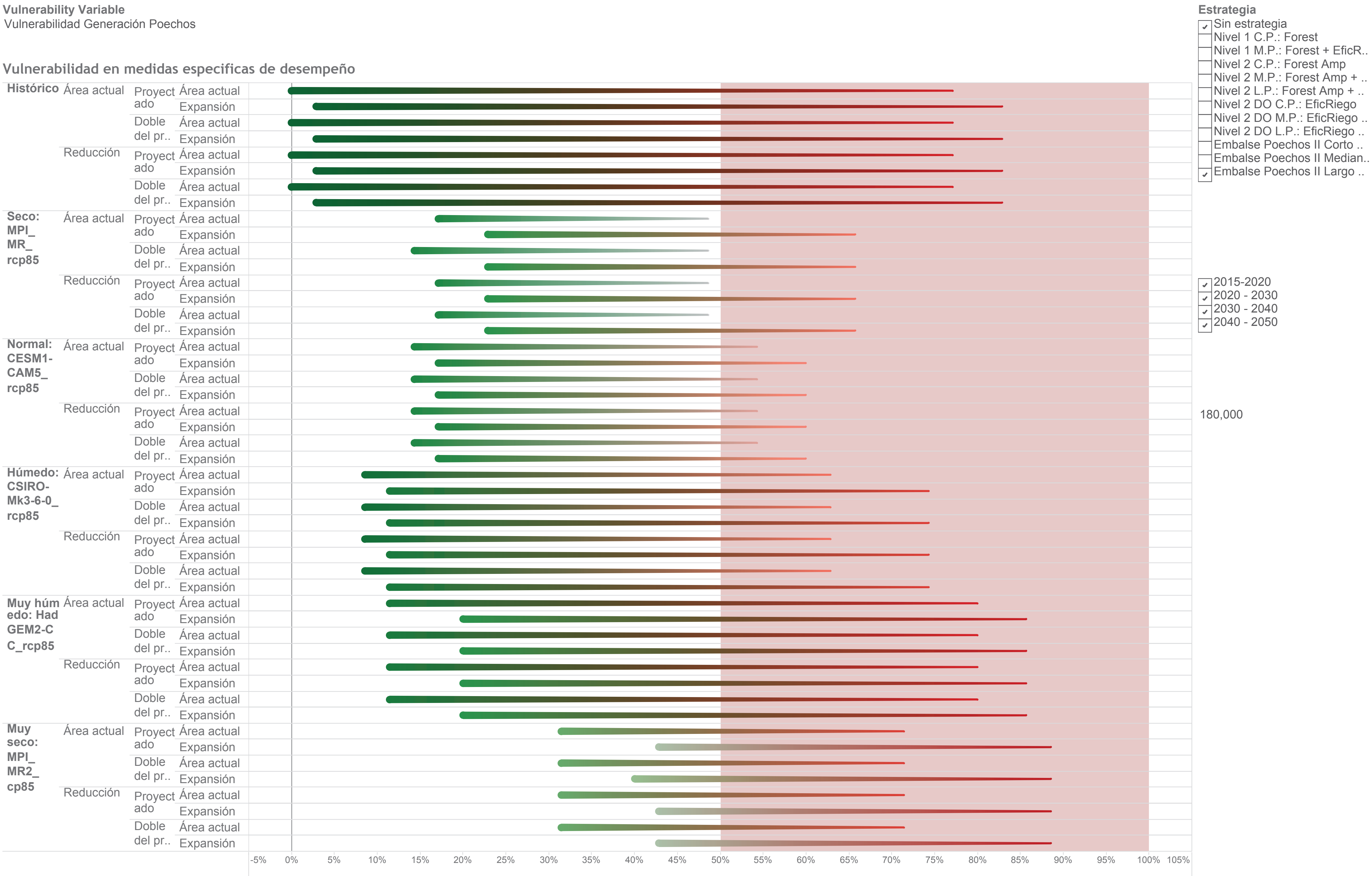

Figure 2: Changes in long-term vulnerability of hydropower production due to the construction of a new dam.

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The project team reviews the ensemble results to define vulnerability thresholds.

current basin dynamics. In addition, the data can be segmented in terms of different time horizons (in this case, decades) to capture the effects in the short, medium and long term.

Finally, the options on the far right represent the quantified values for the thresholds for each performance metric used to assess the vulnerability of the system. The thresholds of performance determine the number of times that the system underperforms in terms of the stakeholder's metrics. The occurrences of underperformance under the specified time horizon become percentages that represent the system's vulnerability.

All these interactive thresholds and filters allow users to interact with the visualizations and understand changing system outcomes. In this case, the graphic shows that while building a dam would improve the system's performance on some metrics across a wide range of possible future conditions, it would also imperil performance on metrics related to other sectors or objectives. Any decision to implement this strategy would need to weigh the trade-offs of favouring one part of the system over another.

The visualization in Figure 2 examines the changes in vulnerability for each metric under the range of futures considered. In this case, hydropower generation greatly benefits from the construction of a dam, making the system largely less vulnerable to failing to meet the hydropower generation standards dictated by the threshold. The same analysis can demonstrate the dam's impacts with respect to flooding.

The visualizations presented here show the results of hundreds of model runs, and others cover thousands.s. When evaluating this many model runs, it is the comparison between the various runs that provides the most information. An abundance of red under a strategy suggests it may not meet the desired performance standards in many scenarios, while an abundance of green suggests that a strategy is robust across many scenarios.

Examining Tableau visualizations can spur new ideas for analysis, such as combining different development strategies to consider integrated strategies, different numerical definitions of those strategies, or changes in characterizations of the simulated futures under which the strategies would be expected to operate. Following these changes, the visualizations can be reproduced and updated with new data for further consideration.

Ultimately the process suggests which strategies are likely to be most advantageous in the future by providing examples of their performance within the structure of scientific analysis. The process aims to build confidence around a strategy and generate the public commitment needed to pursue development options that acknowledge an uncertain future.

Current applications and next steps

Advances in computer technology will facilitate the analysis of increasingly large data pools. From a policy perspective, this is immensely valuable, as it allows scientists to model a much broader range of future possibilities – instead of just a handful of scenarios, as has been typically done in the past. The analysis will provide much richer and more comprehensive analyses to support decision-making. However, as models become ever more complex, effective communication of the results will be crucial.

The utility of any information depends upon human ability to process it. Scientific data must be generated and organized to enable conclusions to be drawn and decisions to be made. Data visualizations, such as the Tableau designs created as part of the RDS process, reconcile the scale of the data with the underlying message. Clear visualizations allow stakeholders and policy-makers to access and apply the complex scientific findings generated by tools otherwise unavailable to non-scientists.

It is important to note that as powerful and useful as SEI has found Tableau, visualization software is not, in itself, a solution to the communication challenge. It is a tool that must be used thoughtfully, balancing the need to present the spectrum of nuances with the need to be clear and not overwhelm decision-makers.

Close interaction with all key actors is also essential to explain the visualizations and to use the resulting discussions to further improve the model as needed. Thus, the challenge for the scientists is twofold: to make sure the right people are at the table, and to keep improving how they present the findings to ensure that they are accessible and actionable to these individuals.

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