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Contact:
J.beher@uq.edu.au

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Science for Environment Policy

How to choose the most cost-effective methods for improving water quality

Agricultural run-off can contain pesticides, sediment particles and nitrates, and is a major threat to the health of the sea. Although there are policy frameworks to reduce run-off water, they often don't clearly explain how to maximise benefits. A new study provides an economic framework that prioritises methods based on their cost-effectiveness, which could help policymakers to reduce the pollution of marine ecosystems.

When rainwater is unable to penetrate the surface of land (because the soil is too saturated to absorb it or it falls on impervious surfaces such as concrete, for example), it flows across the ground towards rivers, lakes, streams and ultimately the ocean. Sometimes this excess water can pick up pollutants and particles from soil, especially from agricultural land. This contaminated run-off is one of the biggest threats facing marine ecosystems. Pollutants in agricultural run-off include nutrients (linked to the overgrowth of algae and subsequent loss of oxygen), sediment (which can reduce light availability in water) and pesticides (which exacerbate coral bleaching and kill some aquatic plants and species that depend on them).

To tackle this problem, several water-quality improvement initiatives have been launched, including the European Water Framework Directive and the Reef Water Quality Protection Plan in Australia — designed to protect the Great Barrier Reef, the largest coral reef ecosystem in the world.

Initiatives usually include targets for improving water quality, but often do not provide detailed guidance on how to achieve them. This leaves decision makers with the difficult task of choosing the best activities to reduce run-off. Often, decision makers prioritise the cheapest or most financially economical projects, which can compromise cost-effectiveness.

As an alternative, planning based on conservation benefits as well as cost has been proposed, allowing decision makers to invest in the conservation projects that offer the highest returns on investment (which are not necessarily the cheapest). Several frameworks have been developed to help choose these projects, but they have various issues, including focusing on only one type of land use and being time-consuming to apply.

This paper describes a new framework, applied to a case-study from Australia, where the Queensland government has implemented a price-based approach to water quality, through which land managers bid for funding to implement water-quality improvement projects on their land. However, there is a lack of guidance on how to prioritise projects for investment. Decision makers in this region (and many others) are in need of a method of prioritisation that considers the costs, benefits and feasibility of different management actions in order to get the most out of their limited budget.

The researchers populated their framework with projects that have been funded to reduce run-off to the Great Barrier Reef. The method used existing information on these projects and has six steps: defining the conservation objective, listing the management projects, estimating the benefit of actions, calculating the cost of actions, estimating feasibility, and estimating cost-effectiveness.

The study focused on sediment run-off, which has various negative impacts on the coral reef ecosystem, including smothering coral reef organisms, reducing the clarity of water and limiting the growth of plants and animals that need light to survive. Sediment particles can also be attached to nutrients and chemicals such as pesticides. A range of 'conservation actions' to reduce sediment run-off were explored.

Continued on next page.

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Actions were prioritised based on their cost-effectiveness. This means they deliver the greatest outcome for a specific objective per monetary unit (in this case, the most annual sediment reduction per Australian dollar spent).

The researchers applied the framework to two catchments adjacent to the Great Barrier Reef (which receive funding from the Reef Plan program). In total, the researchers evaluated 296 different actions to reduce run-off. They followed the six-step process, including estimating benefit (the estimated annual reduction of sediment run-off), calculating cost using government data and estimating feasibility considering a range of operational, social and political factors. Finally, actions were ranked by their cost-effectiveness on a cost curve.

The cost of reducing a tonne of sediment ranged from $9 (most cost-effective) to $71 000 (least cost-effective), depending on the characteristics of the site/action. Cost-effectiveness was highly variable across land-uses, catchments and projects, and no single type of project came out as overall more cost-effective.

In order to compare the cost-effectiveness approach to other prioritisation approaches that focus on greatest benefit, maximum area covered or lowest cost, the researchers determined the 10 most cost-effective actions from their curve. Results using their framework were around four times more cost-effective than the alternatives.

This approach shows clear benefits over other possible approaches to achieving maximum sediment reduction for the least cost and, according to the researchers, reduces the likelihood of decision makers making 'common mistakes' in conservation prioritisation, such as failing to prioritise actions and making hidden value judgements[1]. The researchers say it integrates land and sea threats and could help to link the currently fragmented stages of investment prioritisation, modelled run-off and distribution at sea.

The researchers conclude that investment should be directed towards the conservation projects that are the most cost-effective. The approach presented here could help inform the economic analysis required by the Water Framework Directive, as it includes, for example, the ability to prioritise for multiple pollutants and differentiate their importance within the same prioritisation. This can improve efficiency, but is often not done due to its complexity. This new, simpler approach might help to overcome the current difficulties, as it is easy to apply and sufficiently flexible to account for multiple costs and multiple pollutants.

1. Game, E. T., Kareiva, P. & Possingham, H. P. (2013), Six Common Mistakes in Conservation Priority Setting. *Conservation Biology* 27: 480–485. DOI: 10.1111/cobi.12051