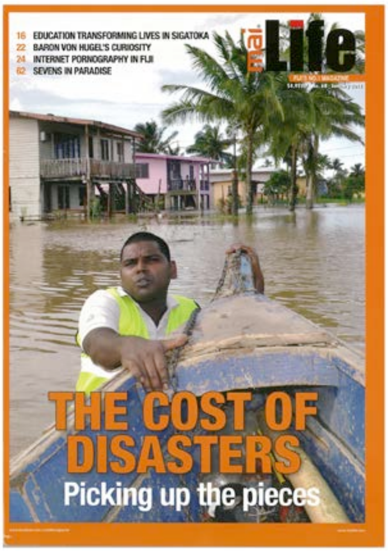
EVALUATING ECOSYSTEM-BASED ADAPTATION FOR DISASTER RISK REDUCTION IN FIJI

Executive summary

Overview

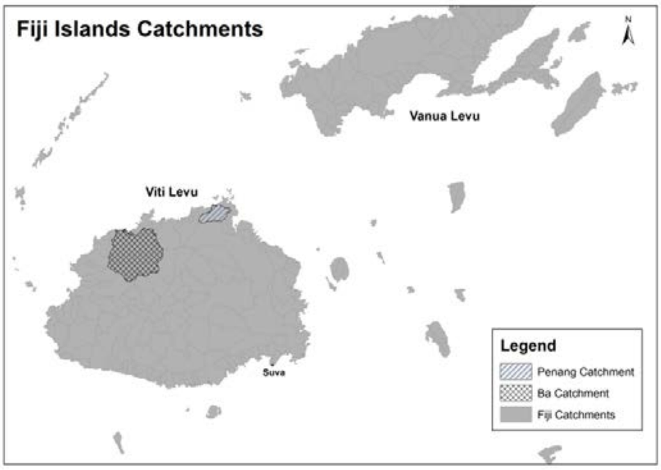
Natural disasters such as hurricanes, cyclones, and tropical depressions cause average annual direct losses of US$284 million in the Pacific. With a combined population of fewer than 10 million people, annual losses are the highest in the world on a per-capita basis. Extreme weather events such as heavy rainfall are closely linked to climate change, suggesting that Pacific Island nations face increasing risk of disasters such as flooding and landslides. Proactive management through infrastructure development, social solutions, and/or ecosystem-based adaptation can mitigate these risks. However, there are a paucity of data pertaining to the costs, effectiveness, and feasibility of most management options.



In the wake of two major flood events and a cyclone occurring between January and December 2012, we conducted a state-of-the-science assessment of disaster risk reduction for flooding in the Ba and Penang River catchments in Viti Levu, Fiji to identify the most cost-effective management options for communities and households. The analysis accounted for the biophysical and socioeconomic impacts of flooding, the costs, benefits, and feasibility of management, and the potential impacts of climate change.

Study Approach

The foundation of this study is an extensive socioeconomic survey that quantifies the direct and indirect impacts of flooding in the Ba River and Penang River catchments. We then develop hydrological models of the two river catchments to forecast future flood damages and to evaluate the effect of infrastructure development and ecosystem-based adaptation on future flood damage. Next, we employ secondary data and GIS to incorporate likely impacts from climate change. Finally, we conduct a comprehensive cost-benefit analysis to systematically assess adaptation options.

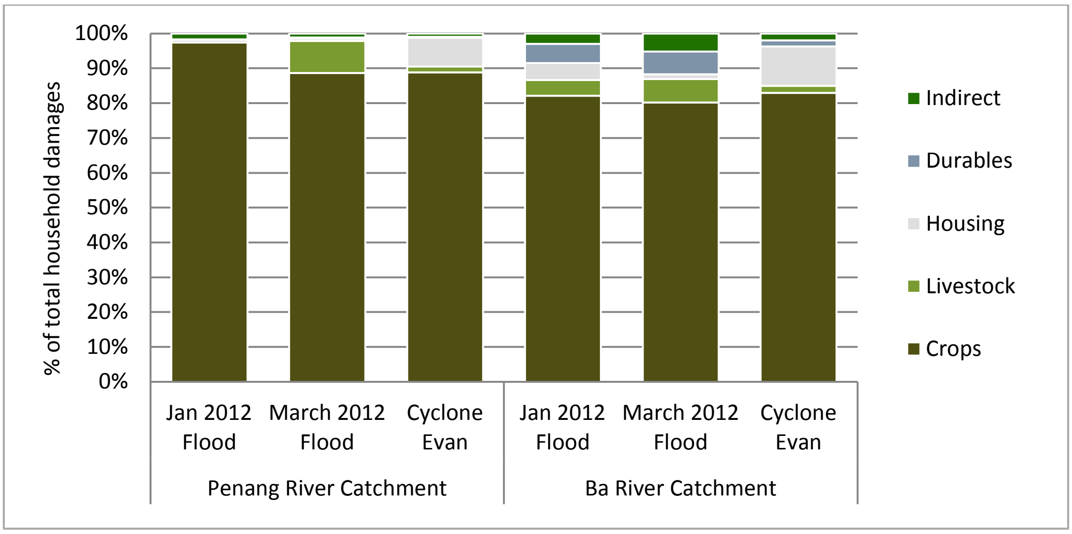


Impacts

Fiji's single worst natural disaster occurred in 1931, when a hurricane led to the highest recorded flood in the Ba River catchment. History nearly repeated itself in 2009, when a severe monsoonal trough caused significant damage, loss of life, and widespread flooding, particularly in Ba town. In January 2012, however, a flood of similar magnitude followed a tropical rain depression, leading to widespread flooding of both the Ba River and the Penang River. In March of that same year, severe rains cause additional flooding throughout the two catchments. Cyclone Evan struck the same areas in December 2012, causing additional damage and exacerbating the challenges of recovery.

Based on a survey of 369 households in 36 communities spread across the two catchments, we combine hydrological modelling of the Ba and Penang rivers with GIS to estimate that the January 2012 flood caused FJ$36.4 and FJ$12.2 in damages for the Ba River and Penang River catchments, respectively, while the March 2012 flood caused FJ$24.1 and FJ$8.4 in damages for the Ba River and Penang River catchments, respectively.

Estimated household damages



Crop damages were especially pronounced, accounting for well over 80% of the total damages recorded for both floods as well as for Cyclone Evan. Direct damage to housing and durables – although by no means negligible – was modest in comparison. Losses to livestock were also modest in comparison to crop losses.

Climate Change and Disaster Risk

Climate change projections for Fiji suggest that extreme rainfall will increase in frequency, particularly in the area comprising the Ba and Penang River catchments. Hence, we use the range of projected shifts in heavy rainfall return periods to construct 'moderate' and 'severe' climate-change scenarios in order to estimate future damages from flooding relative to 'current' climate.
Flooding events can be expressed in return periods. For the moderate scenario, we assume that each event shifts one return interval; analogously, for the severe scenario, we assume a shift of two return intervals. That is, the January flood that was considered a 1-in-50 year event under the current climate scenario is assumed to become a 1-in-20 year event under the moderate scenario and a 1-in-10 year event under the severe scenario. Similarly, the March 2012 flood is estimated to shift from a 1-in-20 year flood under the current climate scenario to become a 1-in-10 year flood and a 1-in-5 year flood under the moderate and severe climate-change scenarios, respectively. Annual losses from flooding will increase accordingly. A summary of the estimated impacts of climate change on various flood return periods is listed in the following table. We estimate that annual losses will increase by about 90% with moderate climate change and by nearly 275% with severe climate change.

Estimated damages to Ba and Penang River catchments from flooding (million FJD)

Climate	1-in-5	1-in-10	1-in-20	1-in-50	1-in-100	Expected Annual
Ba River Catchment						
Current	$5.6	$11.2	$22.3	$38.3	$76.5	$4.9
Moderate	$11.2	$22.3	$38.3	$76.5	$153.0	$9.4
Severe	$22.3	$38.3	$76.5	$153.0	$306.0	$18.2
Penang River Catchment						
Current	$2.1	$4.2	$8.5	$13.1	$26.2	$1.8
Moderate	$4.2	$8.5	$13.1	$26.2	$52.4	$3.4
Severe	$8.5	$13.1	$26.2	$52.4	$104.7	$6.4

Adaptation

Adaptation to climate change may include 'hard approaches', 'soft approaches', and 'ecosystem-based adaptation', or EbA. Hard approaches employ infrastructure or technology in an effort to limit the damages caused by natural disasters. Examples include physical structures such as sea walls and embankments as well as activities such as channel dredging. Soft approaches are behavioural, focusing on limiting exposure through early warning systems, education, and effective planning. In contrast, EbA relies on natural or biological systems to mitigate natural disaster risks and to safeguard essential ecosystem services.

Box 1: Overview of EbA

Definition: Adaptation that integrates ecosystem services and biodiversity into a strategy to limit the adverse impacts of climate change.

Examples: Afforestation, riparian planting, floodplain planting, alternative cropping systems, wetland restoration, integrated water resource management.

Co-Benefits: In addition to protection from climate change impacts, EbA provides benefits such as maintenance and enhancement of ecosystem services (e.g., habitat provision, erosion control) that are crucial for livelihoods and human well-being, such as clean water and food. EbA can also contribute to the mitigation of climate change by reducing emissions from ecosystem loss and degradation and by enhancing carbon sequestration. EbA approaches are typically more flexible approaches than hard infrastructure projects.

Economics: EbA approaches are often highly cost-effective. For example, Naumann et al. (2011, p. 3) compared EbA approaches with hard infrastructure approaches for the potential to reduce climate change impacts across Europe and conclude that 'the majority of projects using ecosystem-based approaches can be considered as beneficial from an economic point of view…[In addition,] ecosystem-based approaches are likely to be more cost-effective than traditional engineered approaches…' Similarly, Rao et al. (2012, p. 13) suggest that EbA strategies are often 'orders of magnitude cheaper than engineering options…'

Options for the Ba and Penang River Catchments

Evidence from our socioeconomic surveys shows that hard approaches and soft approaches are the most common methods of adaptation in communities living near the Ba and Penang rivers (Table E2). For example, 44% of respondents reported reinforcing buildings and 33% reported requesting government assistance to adapt to climate change. In contrast, just 3% had planted trees to mitigate the effects of climate change.

In our analysis, we focus on EbA that may reduce damages stemming from flooding in particular. For EbA, these mitigation options include planting riparian buffers, afforesting the upper catchment, and planting floodplain vegetation. For hard approaches, these mitigation options include reinforcing riverbanks, dredging rivers, and raising houses. We also evaluate an integrated approach to adaptation that includes both EbA and hard options to assess the robustness of our findings.

Current Adaptation Strategies in Communities Surveyed, Ba and Penang River Catchments, Fiji

Adaptation Option	% Communities
Reinforce buildings	44%
Request government assistance	33%
Designate evacuation centre	19%
Change cropping practices/varieties	17%
Dredge river	**14%**
Raise buildings	**11%**
Relocate buildings	8%
Store crops/food supply	8%
Save money for disaster response	8%
Plant mangroves	3%
Plant trees	**3%**
Construct diversion channel	3%
Plant riparian buffers along waterways	**0%**
Protect reef	0%
Create fire break, fire bans	0%
Change forestry practice/harvest ages	0%
Plant native vegetation in floodplains	**0%**
Improve village drainage system	0%
Construct sea wall	0%

Cost-benefit Analysis

Cost-benefit analysis (CBA) is a systematic process of identifying, valuing, and comparing costs and benefits of a project in order to make concrete recommendations. Specifically, CBA is used to determine the extent to which the benefits of a given project outweigh the costs and to compare the relative merits of alternative projects in order to identify a preferred approach.

We consider the costs and benefits of the adaptation approaches identified above under three climate change scenarios – current, moderate, and severe. The CBA assumes a project life of 100 years, and net present values (NPV) are calculated using a standard discount rate of 8%. Results are summarized in the table. In terms of NPV, the larger the value, the greater the net benefits the option provides. As for the benefit-cost ratio (BCR), the larger the ratio, the greater the amount of monetised benefit that are provided for each dollar spent on the intervention.

Cost-benefit Analysis of Adaptation to Flood Risk in Ba and Penang River Catchments

	Ba River Catchment		Penang River Catchment	
Option	**Total NPV** *(FJ$ million)*	**BCR**	**Total NPV** *(FJ$ million)*	**BCR**
Current Climate Change				
Riparian buffers	12.6	2.8	5.0	6.8
Upland afforestation	19.5	1.2	8.6	1.5
Floodplain vegetation	(4.8)	0.8	1.6	1.4
Riverbank reinforcement	(83.2)	0.3	(17.5)	0.4
Raising houses	(13.5)	0.0	(4.6)	0.0
Dredging the river	(22.3)	0.6	3.9	1.6
Mixed Intervention	(3.3)	1.0	6.1	1.4
Moderate Climate Change				
Riparian buffers	26.8	4.9	9.7	12.3
Upland afforestation	47.8	1.4	18.1	2.1
Floodplain vegetation	6.6	1.3	5.4	2.3
Riverbank reinforcement	(54.9)	0.5	(8.0)	0.7
Raising houses	(13.1)	0.1	(4.6)	0.0
Dredging the river	6.0	1.1	13.4	2.9
Mixed Intervention	39.1	1.5	20.3	2.4
Severe Climate Change				
Riparian buffers	53.8	8.7	18.5	22.5
Upland afforestation	101.8	1.8	35.7	3.1
Floodplain vegetation	28.2	2.3	12.4	4.1
Riverbank reinforcement	(0.8)	1.0	9.5	1.3
Raising houses	(12.3)	0.1	(4.6)	0.0
Dredging the river	60.1	2.1	31.0	5.5
Mixed Intervention	88.8	2.1	42.6	4.0

Notes: NPV is the 'Net Present Value', which reports the discounted stream of future benefits less the discounted stream of future costs over the life of the project (i.e., monetary benefits for every dollar spent). BCR is the 'Benefit-Cost Ratio', which indicates the efficiency of spending on a particular form of adaptation. In the full report, we further consider differing levels of effectiveness for each option.

Recommendations

Although planting along streams and riverbanks does not provide the highest level of protection from flooding, the low cost of implementation coupled with the ecosystem services such as carbon sequestration, non-timber forest products, and habitat provision means that riparian planting has the highest impact per dollar spent on mitigation, i.e., it is most efficient.

Upland afforestation provides the greatest benefits overall because trees not only reduce the damages from flooding but also produce large quantities of monetised ecosystem services such as fruits, firewood, and carbon sequestration. Afforestation can also provide benefits that were not monetised in this study, including habitat provision and erosion control. However, the cost of planting and monitoring large areas is relatively high, rendering upland afforestation less efficient than riparian planting.

The benefits of planting native vegetation exceed the costs when climate change is expected to be moderate or severe, and the opportunity costs to planting in areas previously used for agriculture are modest. However, planting native vegetation in floodplains is neither as efficient as riparian buffers nor as effective as upland afforestation, so should be considered only as part of a mixed adaptation strategy.

The benefits of river dredging exceed the costs under the moderate and extreme climate-change scenarios. However, the repeated cost of dredging the river at least once every ten years is high relative to the benefits, particularly in the Ba River catchment. In the Penang River catchment, river dredging is more efficient than afforestation and floodplain planting, although it trails behind riparian buffers in terms of efficiency. Importantly, dredging does not reduce the flood risk in communities in the upper catchment, i.e., the benefits of dredging accrue exclusively downstream, which may or may not be desirable.

Neither reinforcing riverbanks nor raising houses is economically viable. In fact, under most scenarios, the costs of these activities greatly exceed their benefits.

A mixed intervention that incorporates both hard approaches and EbA is effective under most scenarios, indicating that it may be preferable to many approaches. This would particularly be the case if this approach incorporated a number of 'single-focused' options with positive NPVs (e.g., riparian planting, afforestation, and dredging). Nevertheless, we note that the cost of hard approaches can be high, and hence the efficiency of mixed interventions is lower than that of some EbA by themselves.

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The full report is available from: www.landcareresearch.co.nz *(key word: Fiji disaster risk)*