Valuing the Impact of Selected Invasive Species in the Polynesia-Micronesia Hotspot

Final Report

Landcare Research
Manaaki Whenua

Valuing the Impact of Selected Invasive Species in the Polynesia-Micronesia Hotspot

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Executive Summary

Invasive species pose an enormous threat in the Pacific: not only do they strongly affect biodiversity, but they also potentially affect the economic, social, and cultural wellbeing of Pacific peoples. Invasive species can potentially be managed and that their impacts can potentially be avoided, eliminated, or reduced. However, neither the costs nor the numerous benefits of management are well understood in the Pacific.

Thus, the goals of this project were: A) to account for both the costs and benefits of managing invasive species; B) to prepare empirically grounded advocacy materials to help increase investment in the management of invasive species; C) to help governments prioritise investment in managing these species; and D) to build capability for undertaking economic assessments in the future.

To accomplish these goals, we undertook cost-benefit analyses (CBAs) of managing five species that are well established on Viti Levu, Fiji: *spathodea campanulata* (African tulip tree), *herpestus javanicus* (small Asian mongoose), *papuana uninodis* (taro beetle), *pycnonotus cafer* (red-vented bulbul), and *merremia peltata* (merremia vine). Next, we conducted a comprehensive training programme on the CBA for invasive species management for professionals from the Pacific. Third, we collaborated with Pacific organisations to develop a uniform guide to conducting CBAs with numerous examples from the region. We also designed a flexible Microsoft Excel-based tool for conducting CBAs, enabling professionals who did not attend the training course to nevertheless undertake rigorous CBAs on invasive spsecies management. Finally, we developed advocacy material and publicised findings from this project to promote investment in invasive species management.

This report details these activities in turn. It also includes numerous appendices that include the tools, guidance documents, and advocacy materials developed under this project.

1 Introduction

Natural resources are of crucial importance in the Polynesia-Micronesia Biodiversity Hotspot. At a regional level, the Pacific is among the most productive fishing grounds in the world (Seidel & Lal 2010). At the national level, primary industries such as agriculture, fishing, and forestry constitute as much as 25% of GDP in Kiribati and 33% of GDP in the Solomon Islands (www.spc.int/prism). Natural resources also contribute to economic development across the region through secondary and tertiary industries, i.e., manufacturing and processing.

Additionally, natural resources are fundamental to social development in the Pacific, supporting national identity and culture. It therefore comes as little surprise that the word for "land" in New Zealand Māori (*whenua*) is the same as that for "placenta" or that the word for "land" in both Tuvaluan (*fenua*) and Fijian (*vanua*) also refers to the community located on the land and encompasses their customs, beliefs, and values.

Invasive species pose an enormous threat to biodiversity throughout the Pacific. By impacting crops, livestock, fisheries, and forests, invasive species also potentially affect the economic, social, and cultural wellbeing of Pacific peoples. Moreover, because invasive species management strategies are often informal, highly localised, or poorly grounded in science – even for those appearing on IUCN's list of the 100 world's worst invasive species – the presence of (and hence problems associated with) invasive species has grown over time.

Evidence demonstrates that invasive species can be managed and that their impacts can be avoided (through prevention), eliminated (through eradication), or reduced (through control) (Veitch et al. 2011). Management may entail significant costs from eradicating or controlling invasive species that are already established and preventing others from becoming established. However, because invasive species management is in its infancy in the Pacific, its true costs are poorly understood.

Likewise, our understanding of the ecological, economic, social, and cultural impacts of invasive species in the Pacific islands region is largely based on anecdotal evidence and/or benefits transfer data collected elsewhere. As such, the benefits of controlling many invasive species in the Pacific islands region have not been well established.

Understanding the costs and benefits of invasive species management could help make more informed decisions at all levels regarding whether it is economically feasible to manage invasive species and, if so, the appropriate levels of resources to invest in prevention, eradication or control.

Building on a successful first phase (Landcare Research 2011) in which species that represent significant threats to the economies and socio-cultural fabric of Polynesia were identified, the overall goals of the second phase of this project were: A) to account for both the costs and benefits of managing invasive species; B) to prepare empirically grounded advocacy materials to help increase investment in the management of invasive species; C) to help governments prioritise investment in managing these species; and D) to build capability for undertaking economic assessments in the future. These goals are in line with the Secretariat of the Pacific Regional Environment Programme (SPREP) and the Secretariat of the Pacific Community (SPC) Guidelines for Invasive Species Management in the Pacific (2009), which recognise the need to understand and demonstrate the economic costs of invasive species in order to set management priorities (Box 1).

Box1 Economic cost objectives in the Guidelines for Invasive Species Management in the Pacific

Objective A1.2: Ensure national support by mainstreaming invasive species issues with national and regional decision-makers.

Specific objectives:

A1.2.a: Demonstrate the potential economic costs of specific potentially invasive species in the region and the necessity of adequately financing effective biosecurity and rapid-response plans.

A1.2.b: Demonstrate the economic costs of existing invasive species problems in the regional and the economic benefits of financing action to manage them.

A1.2.c: Publicise successes in invasive species prevention and management, including cost/benefit analyses.

Source: SPREP/SPC (2009).

To accomplish these goals, we undertook cost-benefit analyses (CBAs) of managing five species that are well established on Viti Levu, Fiji: *spathodea campanulata* (African tulip tree), *herpestus javanicus* (small Asian mongoose), *papuana uninodis* (taro beetle), *pycnonotus cafer* (red-vented bulbul), and *merremia peltata* (merremia vine). These CBAs were informed by primary-source data collected via matched household and community surveys, and the resulting recommendations were subjected to rigorous peer review from regional experts to ensure both accuracy of underlying assumptions and feasibility of implementation.

Next, we developed and conducted a comprehensive training course to teach project managers and professionals working in the area of invasive species management methods to develop, conduct, and present economic analyses of invasive species eradication or control. Some 17 professionals (drawn from an applicant pool exceeding 50) representing government agencies, research institutions, and non-governmental advocacy groups from seven Pacific island countries and Australia attended a 3-day workshop on conducting CBAs to evaluate management options for 13 invasive species. The training was specifically designed to follow and augment the Global Invasive Species Programme (GISP)'s Economic Analysis Toolkit. Attendees representing civil society met with the trainers monthly via skype as they developed CBAs for managing focal species and were invited back to the University of the South Pacific to present their research findings 4 months after the initial training.

Third, we collaborated with SPREP, SPC, the Pacific Island Forum Secretariat (PIFS), the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) to develop a step-by-step guide for conducting CBAs in the Pacific. This guide supplements existing guides and manuals by illustrating the steps of cost benefit analysis using case studies from the Pacific. Not only will it serve as a future reference for the application of CBA to natural resource management, but it will also support future training and capacity development in the region. Importantly, the guide provides a standardised approach to conducting CBAs from key players in the region.

In addition, we developed a highly customizable tool for evaluating the costs and benefits of invasive species management. User-entered data pertaining to individual species are utilised to aggregate costs and benefits automatically and to calculate net present values of each management option, and simple manipulations such as changing the program duration (i.e., years of organised control) or discount rate facilitate sensitivity analyses to help user evaluates the robustness of policy/management options. The tool was designed in Microsoft Excel to increase accessibility to non-specialist audiences.

Finally, we developed advocacy material and publicised findings from this project to promote investment in invasive species management. For example, a series of factsheets on CBAs for the five key invasives done under this project have been developed and will be distributed at the CEPF end-of-program conference in Suva in April 2013, at the 12th Pacific Science Inter-Congress in July 2013, and at the Ninth Pacific Islands Conference on Nature Conservation and Protected Areas in November 2013. Research findings were also presented in the Pacific Resource and Environmental Economics Network newsletter and at the annual conference of the Australian Agricultural and Resource Economics Society in February 2013. They were also featured in a seven-minute interview on Radio Australia (broadcast to 12 Pacific countries) in February 2013. All the outputs from the project will be made available on PII's website.

2 Quantifying the Costs and Benefits of Managing Invasive Species

Given the magnitude of the potential problems caused or exacerbated by invasive species in the Polynesia Micronesia Biodiversity Hotspot, the scarcity of data pertaining to their biological charactersitics, the damages that they cause, and the effectiveness of management options is notable. For example, despite the fact that the small Asian mongoose is considered to be among the 100 world's worst invasives by IUCN, we found few credible, published sources documenting its population growth rate or carrying capacity. Similarly, while the merremia is widely considered to be a scourge in the Pacific, many villages we visited in Fiji reported practical uses for the plant, including bundling twine, animal fodder, and medicinal qualities. Finally, while it is common practice in Fijian villages to manage the African tulip tree through mechanical extraction, application of herbicides, and targeted burning, neighbouring villages often take radically different approaches, underscoring the lack of publicly available information about the effectiveness of each management option.

We undertook the following concrete steps to address these knowledge gaps:

- Consulted with experts in the region on the design of the project
- Conducted quantitative surveys on socio-economic wellbeing in individual households as well as qualitative surveys on invasive species impacts and management options among community leaders in Viti Levu, Fiji
- Identified the costs and benefits of managing five key species already established in Fiji based on A, and B and developed specific management recommendations
- Produced detailed reports on management options and recommendations for each of the five species; prepared and distributed concise advocacy materials using non-technical language for general audiences

2.1 Expert Consultation in Project Design

Our extensive consultation with experts in the region increased the relevance and usefulness. The list of five target species in Fiji was drafted by the partners on this project and in consultation with Biosecurity Fiji, Birdlife International, and Nature Fiji, during the first phase of this project. The School of Geography, Earth Science, and Environment at USP, the South Pacific Regional Herbarium, and the Fijian Department of Lands and Surveys provided technical guidance and inputs on the presence of invasive species in Viti Levu to assist in site selection for our detailed fieldwork. Finally, the Excel-based CBA tool was developed after conferring with staff at SPREP, SPC, and GIZ.

2.2 Survey Research

Methods and Instruments

We surveyed 360 households in 30 villages in eastern Viti Levu, Fiji to investigate the socio-economic impacts of invasive species. These villages were stratified by geography and randomly drawn; one village that was inaccessible by road due to construction was replaced with another remote village. The distribution of villages is shown in Figure 1.

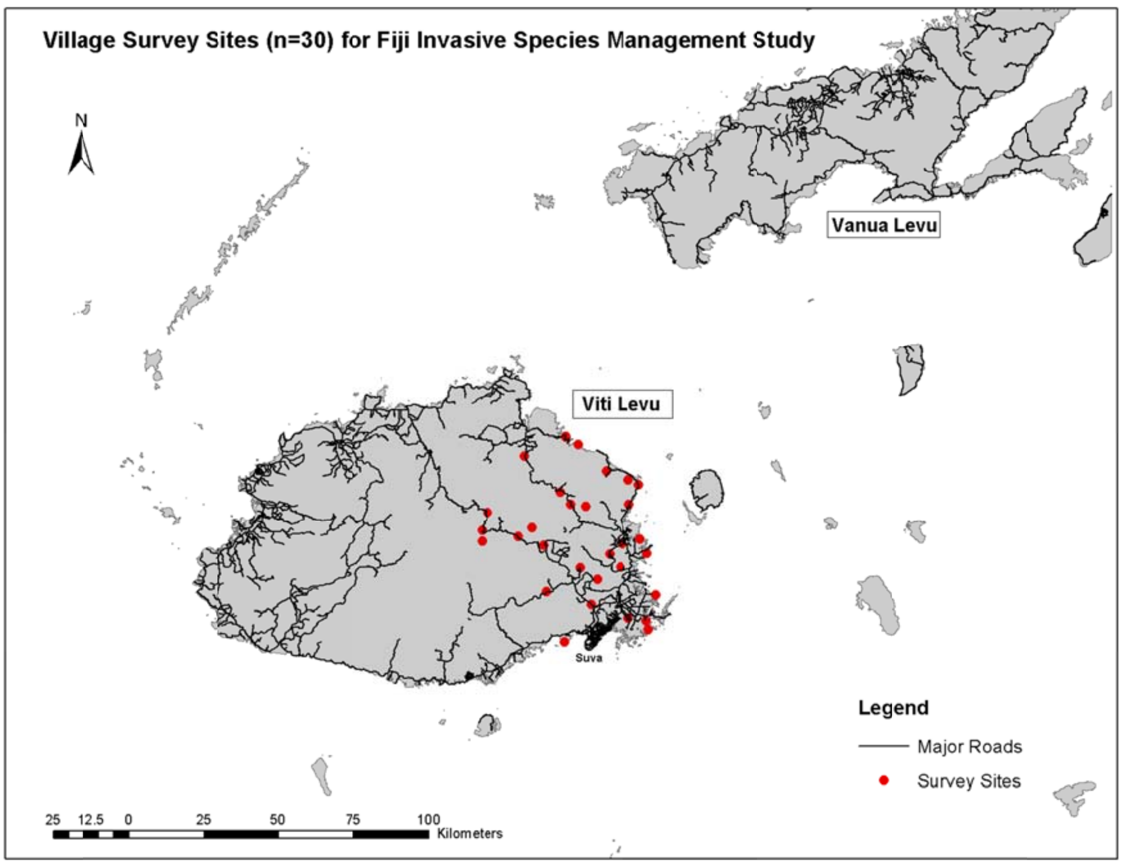

Figure 1 Villages surveyed (n=30).

Within each of the 30 villages, households were sampled at random from village rosters. Each survey was conducted directly with the head of household, and topics covered demographics; farming, fishing, wage work, and other income-generating activities; wealth and durables; education; health; agricultural extension activities; and damages/losses due to invasive species. The survey also included several novel elements pertaining to the social and economic impacts of invasive species, as described below.

First, respondents were asked to assume the role of Fiji's budget minister and to identify spending priorities by allocating budgetary shares to a broad range of categories, including education, healthcare, public order, trade, infrastructure development, and environmental protection. Respondents who allocated money to environmental protection were further asked to prioritise controlling specific invasive species relative to other environmental spending.

Second, a series of questions was asked to elicit willingness to contribute personally to controlling invasive species via volunteer labour. In most developed countries, willingness to pay is identified via questions pertaining to tax increases; however, few rural Fijian households pay taxes while virtually all of them contribute labour to maintaining the village, demonstrating the cultural relevance of this approach. Opening values of initial hours willing to volunteer were randomly assigned for each respondent via dice rolls to eliminate concerns about starting point bias.

Third, respondents were asked to state the extent to which they agreed with a series of 20 statements pertaining to the value of controlling invasive species (e.g., “It is bad that the taro beetle is found in this village.”) via a 5-point Likert scale. To eliminate concerns of yea-saying (i.e., the tendency to consistently give the same answer in survey questions), some statements read in the negative (e.g., “It is good that the mongoose is found in this village.”).

A second, complementary survey was conducted with a focus group of prominent individuals in each of the thirty sampled villages. This village-level questionnaire consisted of open-ended questions regarding the presence and state of each species and, where applicable, the consequences of its presence and community practices for encouraging or limiting its spread. Notably, respondents were asked to reflect on both the negative and positive (if any) impacts of each invasive species.

The survey was undertaken by a team of staff and students at USP. An intensive 3-day training on survey design and enumeration was held in a Fijian village before the start of the fieldwork. The survey content was carefully vetted in both the classroom and the village setting, and the enumerators gained the confidence needed to work independently while conducting multiple mock surveys with the project leaders. Including experienced staff in each surveying team provided further opportunities for mentoring for first-time enumerators.

The surveys were conducted over a four-week period during July 2012. The survey instruments are included in Appendices 4–6.

Key Results – African Tulip Tree

Respondents to the community survey (n=30) identified a number of costs associated with the African tulip tree, including the following:

- 76% of villages stated that the African tulip tree reduces agricultural output

- 36% stated that it reduces the quantity of land available for grazing
- 48% of villages stated that it competes with other, more desirable trees that are used for medicinal purposes and/or firewood

However, 52% of villages reported using the tree for building materials and 27% used the tree as firewood for cooking, despite its high moisture content. About 9% of the villages stated that the African tulip tree attracts birds and wild animals. Nevertheless, about 30% of the villages reported that the invasive tree provides no benefit to their community.

To control the spread of the African tulip tree, 73% of villages report that they prefer to cut the tree down, with 42% of villages further burning the stump after removing the trunk. Some 36% of villages surveyed reported that some farmers had stopped growing crops altogether in severely impacted fields because they could not keep up with the African tulip tree's aggressive spreading.

Respondents to the household survey (n=360) were asked a series of questions pertaining to their personal views of the species. Over 92% of survey respondents viewed the African tulip tree unfavourably, with 78% of survey respondents viewing the African tulip extremely negatively. Fewer than 3% of survey respondents had a favourable view of the invasive tree, on balance, and none held an extremely positive view.

Most respondents stated that the African tulip tree had some negative impact on their livelihoods, and some were spending considerable effort to address the problem. On average, surveyed households spent 3.7 hours/week (about 24 days/year) clearing the African tulip tree from their land. To put this figure in perspective, the average household surveyed spends about 35 hours a week managing their crops, of which about 10% of that time is used specifically to control this invasive species. Despite putting some effort into managing the African tulip tree, more than 95% of villages surveyed indicated that the population of the tree was increasing (Figure 2).

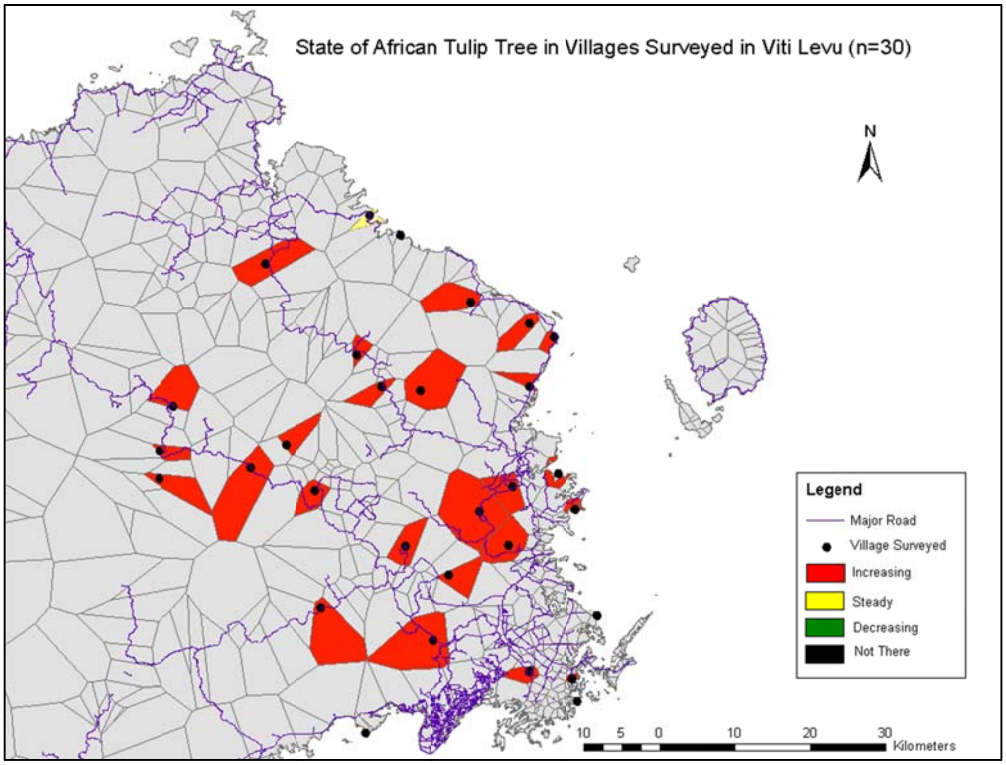

Figure 2 State of African tulip tree in villages surveyed (n=30).

Asked to reallocate Fiji's national budget according to their own spending priorities, respondents indicated that they would allocate approximately 7% of the national budget for invasive species management. They would further allocate 33% of that budget to control the African tulip tree. Furthermore, the median household among those who view the African tulip tree extremely negatively, offered to volunteer 10 additional hours/ household/week if their efforts would significantly reduce the density of the African tulip tree. The average household currently spends 6 hours/week on volunteer work, underscoring the perceived magnitude of the problem among Fiji's farmers. It also emphasizes their high willingness to work to alleviate the problem, provided the availability of effective control methods.

Key Results – Small Asian Mongoose

Respondents to the community survey (n=30) identified a number of costs associated with the mongoose, including:

- 83% of villages reported that mongooses had attacked livestock, primarily chickens
- 17% of villages reported that mongooses have reduced bird or animal populations
- 13% of villages have reported that mongooses have reduced agricultural output

Villagers also reported perceived benefits of the mongoose, however, including:

- 73% of villages reported that mongooses were eaten by villagers

- 27% of villages noted that the mongoose was useful for snake control

In addition, 17% of surveyed villages reported that mongooses brought no benefits to the local area.

Villagers in 87% of the surveyed villages actively trap mongooses and villagers in 47% of surveyed villages hunt it. These interventions are undertaken both for protecting crops live (e.g., bananas and plantains) and livestock and for food provision. Despite putting some effort into managing this, 90% of villages surveyed indicated that the population of the mongoose was increasing (Figure 3).

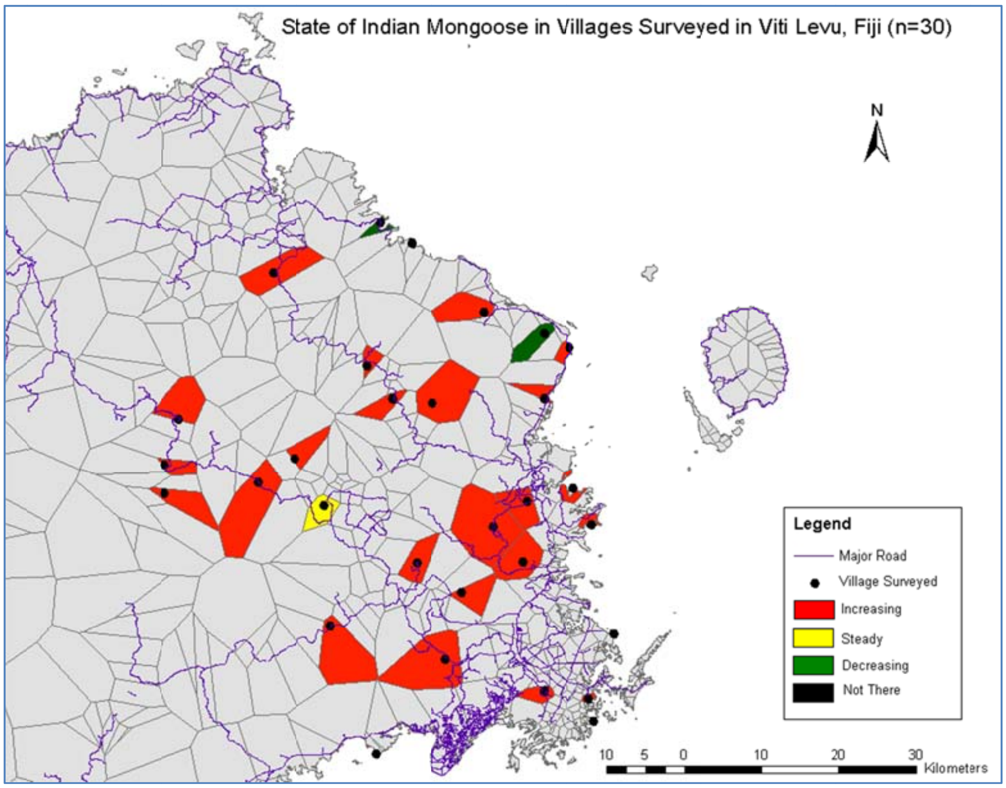

Figure 3 State of Small Indian Mongoose in villages surveyed (n=30).

Respondents to the household survey (n=360) were asked four questions on negative and positive attributes of the mongoose to elicit their personal views of the invasive. Only about 7% of survey respondents viewed the presence of the mongoose favourably, while 77% viewed the mongoose unfavourably. Of that, 56% of households answered all four attribute questions for the mongoose with an extremely negative response.

Despite the fact that respondents overwhelmingly held negative views of the small Asian mongoose and that most villages reported minor economic losses from the species, few respondents spent significant effort to address the presence of mongooses at the household level. On average, households in the surveyed areas spend just three minutes per week controlling mongooses through hunting and trapping activities. The maximum amount of time spent controlling mongooses was 8 hours/ week.

Asked to reallocate Fiji's national budget according to their own spending priorities, respondents would allocate approximately 7% of the national budget for invasive species management. They would further allocate 12% of that budget to control the small Indian mongoose. No respondents stated that the small Indian mongoose was the worst invasive species in their village.

Key Results – Taro Beetle

The taro beetle was found to be present in 83% of the villages surveyed. Respondents to the community survey identified two primary impacts associated with the beetle, including:

- 92% of villages observed that the taro beetle reduces agricultural output by burrowing into plant corms
- 42% of villages reported that the taro beetle caused plants to be more susceptible to disease

None of the villages surveyed stated that the beetle provided any biophysical or socio-economic benefits.

Some 44% of the villages used pesticides and other chemicals to reduce the incidence of the taro beetle, while 20% said that they dug and burned the affected crop. Approximately 36% of villages reported that farmers had stopped growing crops in severely impacted areas, and 32% noted that the taro beetle had prompted them to switch out of taro in favour of other crops such as cassava.

On average, surveyed households spent 0.7 hours/ week (about 4.5 person days/year) managing the beetle. To put this in perspective, the average household surveyed spends about 35 hours/ week managing their crops, of which about 2% of that time is used specifically to control this invasive species. Despite putting some effort into managing the beetle, 53% of the villages surveyed stated that the beetle has been spreading in recent years (Figure 4). Farmers in a few of the villages recently switched back to taro after many years because the beetle population had finally been reduced significantly, suggesting that the problem pest can be managed under certain conditions.

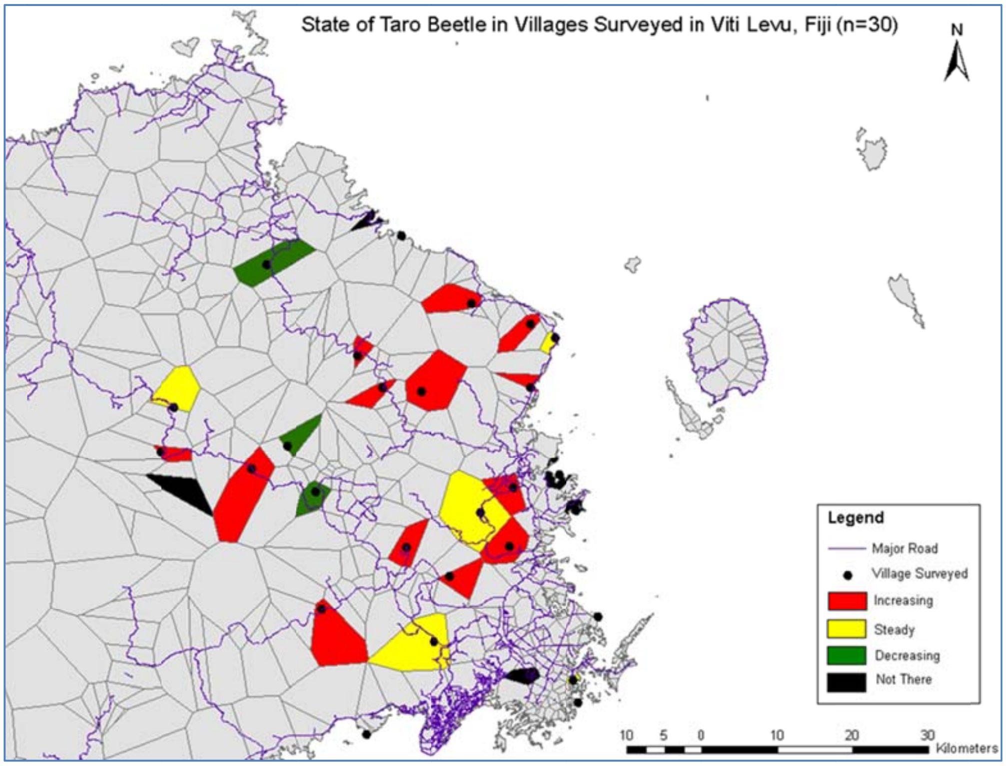

Figure 4 State of taro beetle in villages surveyed (n=30).

Respondents to the household survey (n=360) were asked a series of questions pertaining to their personal views of the species. Over 97% of respondents held negative views of the taro beetle, with 88% of respondents viewing the species extremely negatively. No respondent held a favourable view of this invasive pest.

Over 60% of respondents in areas in which the taro beetle is present experienced losses of taro crops due to the presence of pests in the year preceding the survey; the taro beetle was identified as the primary culprit in 89% of these households, reducing total output by an average of 8%.

Asked to reallocate Fiji's national budget according to their own spending priorities, survey respondents would allocate approximately 7% of the national budget for invasive species management. They would further allocate 38% of that budget to control the taro beetle. Furthermore, the median household among those who view the beetle extremely negatively, offered to volunteer 11 hours/ adult household member/week if their efforts would eradicate the taro beetle from their villages, underscoring the perceived magnitude of the problem among Fiji's farmers. It also emphasizes their high willingness to work to alleviate the problem, provided the availability of cost-effective control methods.

Key Results – Red-Vented Bulbul

The red-vented bulbul was present in 29 of 30 villages surveyed in Viti Levu. In the areas where this bird was present, 83% of villages noted that the bulbul reduces agricultural output, particularly for fruits. One village also noted that the bulbul has the potential to damage infrastructure by nesting inside the houses. The remaining villages stated that there were no socio-economic or biophysical impacts from this species.

About 47% of the village focus groups reported that the bulbul was good for their community. Key benefits identified include:

- 18% of villages responded that the bulbul is effective at insect control
- 12% of villages noted that the bulbul gives warning when a mongoose is about to attack chickens
- 12% stated the bulbul is occasionally eaten by villagers.

In terms of control, only 6% of the villages attempted to control the bulbul via hunting while 94% of the villages did nothing to control the species. As a result, 80% of villages surveyed indicated that the population of the bulbul was increasing or steady (Figure 5).

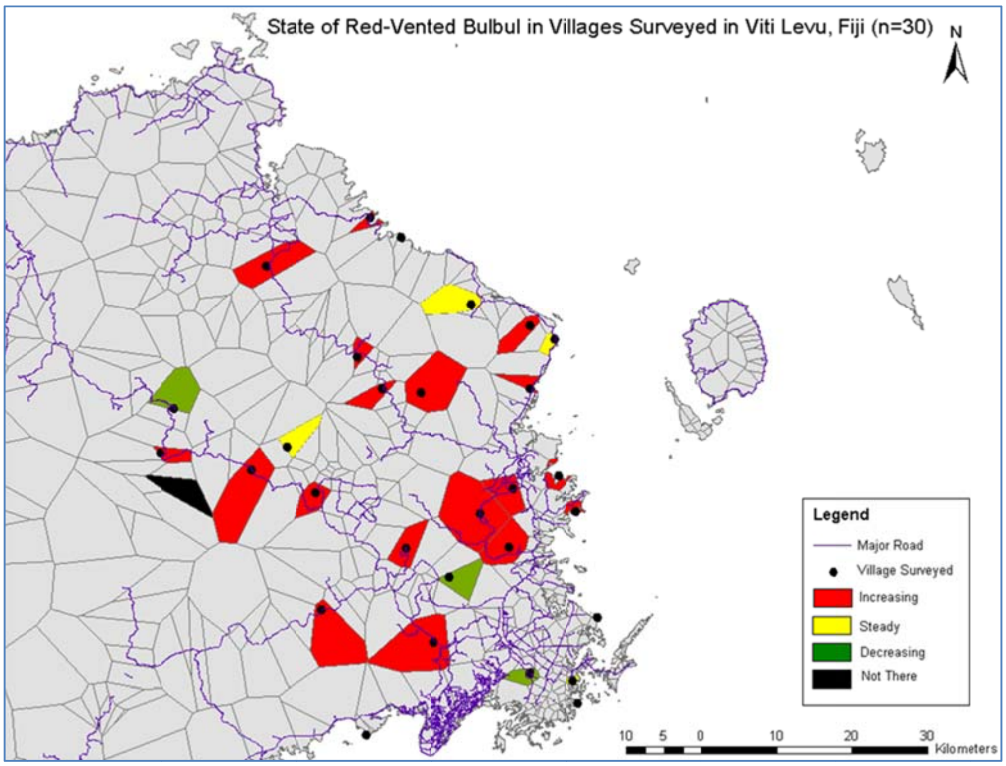

Figure 5 State of red-vented bulbul in villages surveyed (n=30).

Respondents to the household survey (n=360) were asked a series of questions pertaining to their personal views of the species. 55% of respondents viewed the red-vented bulbul unfavourably, with 31% of respondents viewing the invasive bird extremely negatively. Only 12% of respondents held favourable views of the bulbul.

Some respondents stated that the red-vented bulbul had some negative impact on their livelihoods, but none of the surveyed households reported taking any concerted effort to control them. Key crops impacted were pawpaw, plantain, and banana. Household surveys estimated that:

- Bulbuls affect 39% of surveyed households' pawpaw crops, reducing total output by 13%
- Bulbuls affect 16% of surveyed households' banana crops, reducing total output by 2%
- Bulbuls affect 14% of surveyed households' plantains crops, reducing total output by 12%

Tomato, vudi, chili, and guava were also reported to be affected in the study area. On average, a household affected by red-vented bulbul experienced $150 loss in the value of agricultural production in the preceding year.

Asked to reallocate Fiji's national budget according to their own spending priorities, survey respondents would allocate approximately 7% of the national budget for invasive species management. They would further allocate about 7% of that budget to control the red-vented bulbul, prioritising control of other invasive species over controlling the red-vented bulbul.

Key Results – Merremia vine

The merremia vine was present in 28 of 30 villages surveyed in Viti Levu (93%). Respondents to the community survey identified three primary costs associated with the vine:

- 42% of villages reported that merremia reduces agricultural output
- 37% of villages reported that merremia competes with medicinal trees and plants
- 26% of villages reported that merremia competes with trees used for building materials

Approximately 46% of the villages surveyed stated that there were no socio-economic or biophysical impacts.

More than 85% of the village focus groups reported that merremia was good for their community. Key benefits identified include:

- 53% of villages reported that merremia has important medicinal properties, including the ability to cure colds, stomach aches, and urinary tract infections.
- 50% of villages reported using merremia for bundling twine
- 25% of villages stated that it improved soil fertility
- 18% of villages reported that the merremia was used for witchcraft

Most villages nevertheless actively manage the vine to control its spread. Specifically:

- 76% of the villages regularly cut or pull merremia
- 16% of villages regularly burn merremia patches
- 11% of villages use herbicides to control the spread of merremia

Despite putting some effort into managing the invasive, 70% of the villages surveyed stated that the merremia population was still increasing (Figure 6).

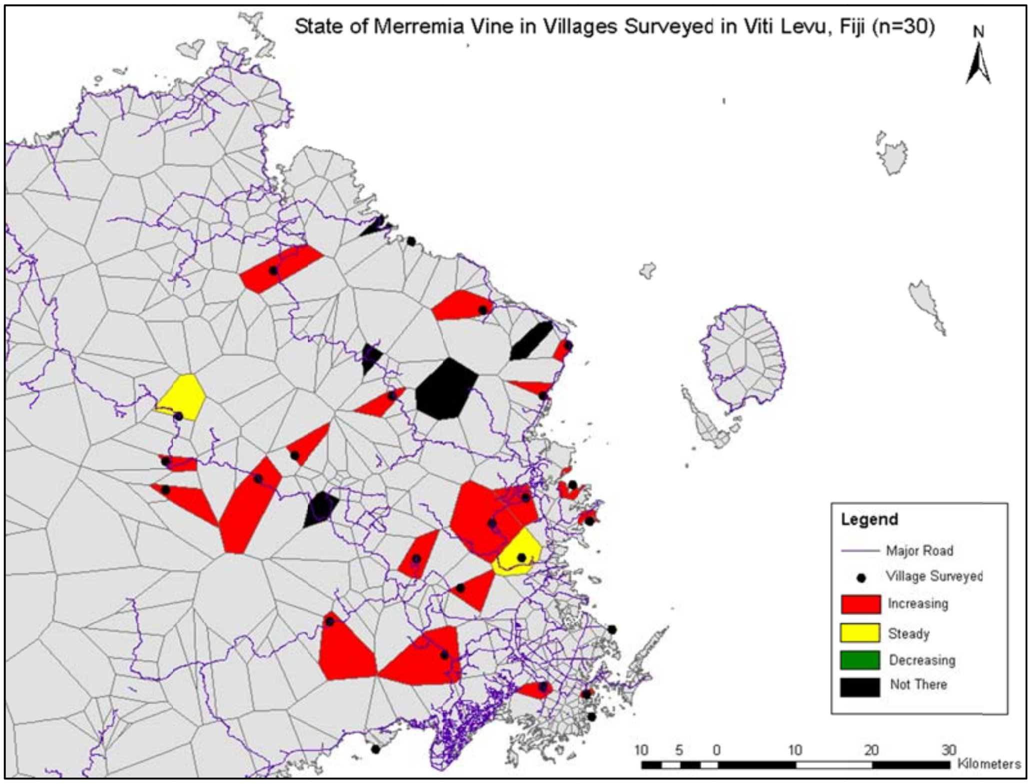

Figure 6 State of merremia vine in villages surveyed (n=30).

Respondents to a household survey (n=360) were asked a series of questions pertaining to their personal views of the species. Approximately 44% of the sampled households viewed the presence of merremia favourably, 34% viewed the presence of merremia negatively, and 22% was indifferent to its presence. Only a handful of respondents held an extremely negative view of the merremia vine, and none was entirely positive about its presence.

Some respondents to the household survey stated that the merremia had some negative impact on their livelihood, primarily by invading cassava and taro fields, but relatively few were taking any effort to reduce the problem. One-third of surveyed households spend time cutting and clearing merremia in a typical week, allocating on average about 1.8 hours/ week (about 13 person days/year) to the task. To put this in perspective, the average household spends about 35 hours/ week managing their crops, of which about 5% of that time is used specifically to control the invasive vine. The remaining two-thirds of surveyed households do not clear merremia from their land.

Asked to reallocate Fiji's national budget according to their own spending priorities, survey respondents would allocate approximately 7% of the national budget for invasive species management. They would further allocate 6% of that budget to controlling merremia, prioritising control of other species such as the African tulip tree and taro beetle over the merremia vine.

2.3 Cost-Benefit Analysis

Methods

In undertaking cost-benefit analyses of invasive species management, we follow an approach similar to that presented in the Global Invasive Species Programme (GISP) toolkit (Emerton and Howard 2008). The approach to CBA presented in this report is based on the CBA Manual and Toolkit for Invasive Species Management in the Pacific developed under this project and discussed in Section 4.

Specifically, the surveys described above informed our analysis by providing detailed data on damages resulting from each invasive species, common management practices, and their associated costs. These data were augmented by scientific evidence on the biophysical growth of each species and the relative effectiveness of each management option obtained from the published literature and specialists in the region.

In our analyses, all costs other than capital costs are assumed to occur at the end of each period for the duration of the management intervention. Capital costs, by contrast, only occur during the initial period.

Information about the number of physical units of inputs under each management option (e.g., litres of pesticide to control taro beetle and traps needed to control small Asian mongoose) is derived from the scientific literature, survey responses, and expert knowledge. The total monetised costs are estimated by multiplying the unit costs incurred in each year by the number of physical units.

Because costs accrue over the duration of a project, we calculate the present value of current and future costs by discounting future costs at the real rate of interest, i.e., the opportunity cost of money. For this study, we assume a project length of 50 years and a discount rate of 8%, which is the median discount rate used for long-term environmental management projects in the Pacific (Lal & Holland 2010). Results were also calculated with 4% and 12% discount rate to better understand the robustness of our calculations.

Prices, units, and the present value of benefits were calculated in a similar way.

Next, we calculate the net present value of each management option by subtracting the present value of costs from the present value of benefits. We also calculate the benefit-cost ratio, i.e., the ratio of the present value of benefits to the present value of costs. The benefit-cost ratio describes the relative efficiency of each management option.

Finally, estimates for individuals were scaled up to the village level. Specifically, a typical village in eastern Viti Levu comprises 45 households that each maintain 0.6 ha of productive land. Scaling up results does not change the overall ranking of management options because we assume constant economies of scale.

Key Results – African tulip tree

Different management options have differential impacts on the growth and spread of the African tulip tree. Management options considered in this analysis include doing nothing, maintaining the current management approach by the community, and adopting a more integrated management approach informed by expert opinion. See Appendix 13 for the full CBA.

Do Nothing

This option represents typical progression of growth and spread across the landscape with little-to-no management. Under this scenario, the African tulip tree eventually occupies all ecologically suited environments when it reaches carrying capacity 40 years after being introduced to a given area. All other options are measured relative to the costs and benefits estimated under this option. Obviously, there are no management costs associated with this option, but it does result in damages to land-based production that could be avoided if the spread of the tree was controlled.

Current management approach

Based on survey findings, treatment methods include a mix of cutting, stacking and drying plant material, and later burning this material. Regrowth from the cut stumps, roots, and any plant material left in contact with the ground is pervasive.

Tractors and diggers have been used to pull smaller trees from the ground but this disturbance often leads to increased germination of seeds in the seed bank. Herbicides are sometimes used but incorrect herbicide application often result poor levels of control.

Most villages surveyed reported an increase in the number of trees in their community despite some management. Based on expert opinion, we assume that the long-run population of the African tulip tree is reduced by 50% relative to the “do nothing” scenario.

Integrated management approach

This approach targets trees of different sizes and ages. The “hack-and-squirt” control treatment method is used for all trees greater than 10 cm diameter breast height (DBH). Some of the larger trees are ring-barked while, “cut-stump” treatment is used on saplings and small trees. Smaller seedlings are hand-pulled. If possible, these treatments are followed by mechanical clearing using a bulldozer followed by replanting with crops or pasture. Subsequent to this, herbicides and/or hand-pulling are used to remove all emerging seedlings including, those of other invasive plant species.

Based on expert opinion, we assume that the long-run population of the African tulip tree is reduced to 10% of that under the “do nothing” scenario.

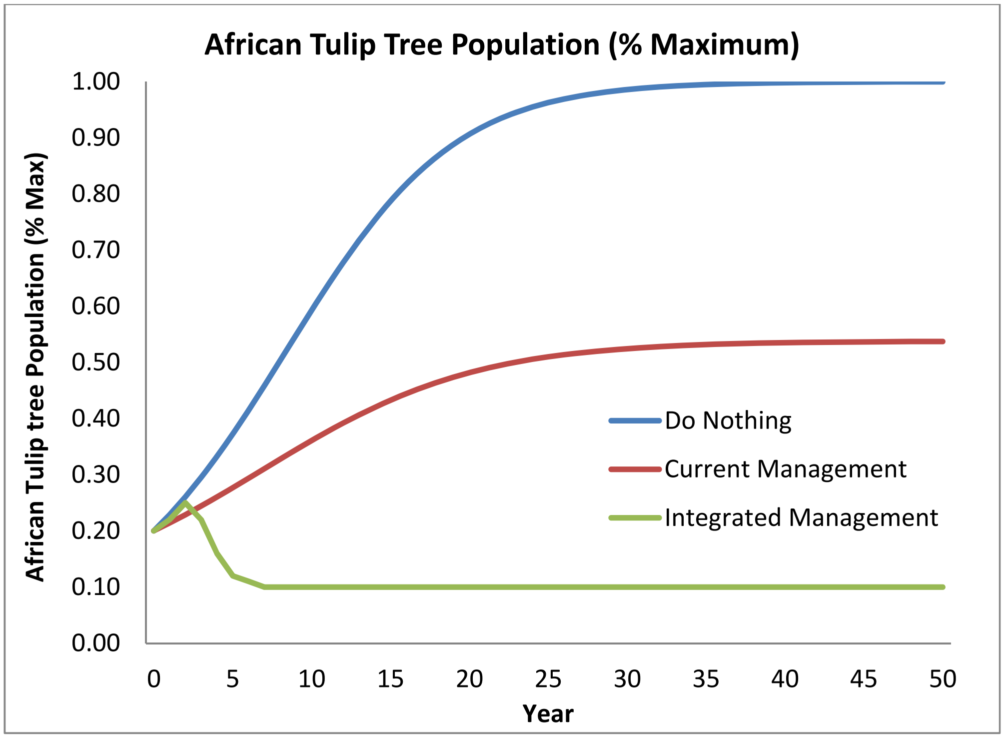

Figure 7 Change in African tulip tree population (as % carrying capacity) over time and management option

Benefits and Costs of Management

The focus of this analysis is on the direct economic impacts of the African tulip tree, namely the benefits of avoided damages to livestock, crop, and forestry yield. It is likely that other benefits such as biodiversity protection will also be positive as landowners are less likely to clear more natural forests for cultivation if the African tulip tree is controlled. We estimate that crop, livestock, and forestry production diminishes by 20% in the presence of African tulip trees due to competition under which scenario. Typical costs of controlling the African tulip tree include labour, herbicides, bulldozer or digger rental, and capital costs (e.g., chainsaws and herbicide sprayers).

Cost-Benefit Analysis

Estimated damages under the three management options are shown in Figure 78.

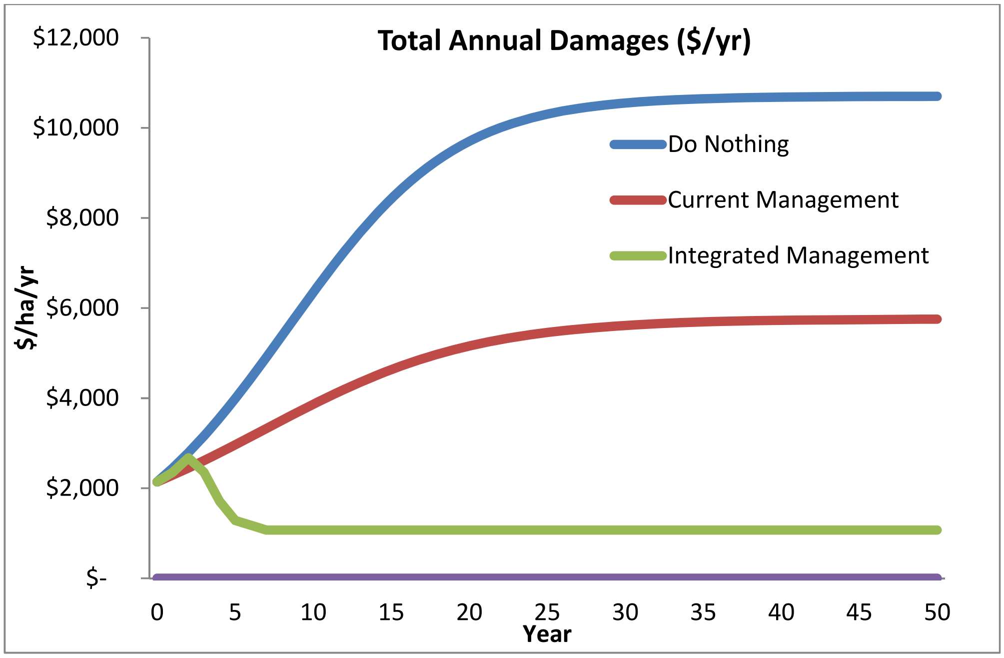

Figure 8 Total value of annual damages ($/ha) from for African Tulip tree under the three management options

Using pricing data from survey and government sources, we find that the integrated approach yields the highest net present value (Table 1) and is therefore the most efficient management option from an economic perspective, provided that people have the additional funding and knowledge to implement it. Nevertheless, the current management option also yields a positive NPV, indicating that it is preferred over undertaking no management at all.

Table 1 Summary of benefit-cost analysis (r = 8%, T= 50 years, study area = 1 ha)

Option	PV Costs	PV Benefits	Total NPV	Benefit-Cost Ratio	Rank
Do Nothing	$0	$0	$0	1.0	3
Current Management	–$11,201	$30,305	$19,104	2.7	2
Integrated Management	–$16,255	$60,351	$44,097	3.7	1

Key Results – small Asian mongoose

Different management options have differential impacts on the population of the small Asian mongoose. Management options considered in this analysis include doing nothing, live trapping, kill trapping, and hunting. See Appendix 14 for the full CBA.

Do Nothing

This option represents typical progression of growth and spread across the landscape with little-to-no management. Under this scenario, the small Indian Mongoose continues to occupy all ecologically suited environments at its carrying capacity. All other options are measured relative to the costs and benefits estimated under this option. Obviously, there are no management costs associated with the do nothing option, but it does result in damages that could be avoided if the spread of the mongoose was controlled.

Live Trapping

Trapping is a relatively inexpensive approach that is often successful at removing animals in the short term. However, traps must be regularly maintained as mongooses can rapidly re-colonise trapped areas. Mongooses can follow scents up to 500 m, so relatively inexpensive live traps (e.g., Haguruma) are set on a grid every 200 m (or about 1 trap/ha) to ensure appropriate coverage for the entire village boundary (William Pitt, USDA, pers. comm.). Because mongooses appear not be selective and consume most bait types (Creekmore et al. 1994), trapping is likely to be highly effective. This method requires skilled and intensive labour as traps must be checked daily. Mongooses captured in live traps can be consumed as food.

Kill Trapping

Similar to live trapping, kill traps are set on a grid every 200 m (or about 1 trap/ha) for the entire village boundary (William Pitt, pers. comm.). Non-toxic bait should be used and mongoose captured in kill traps could be consumed as food if the kills are fresh. Traps must be checked daily initially (to refill stations) but longer term programs require less frequent checks. Key considerations include bait type, baiting density, non-target species, and timing (Barun et al. 2011). We assumed that this option can potentially reduce the mongoose population to less than 20% of carrying capacity over the project period, although it could vary by site and number of traps per hectare.

Hunting

This approach requires significant labour as well as capital for hunting (e.g. guns and ammunition). This approach could be effective when the population is high but could require a high level of effort per kill (e.g., search costs) for lower populations. Some experts have stated that hunting is not known to be employed or expected to be effective (Barun et al. 2011), althought our study found that it is currently being done in nearly 50% of the villages surveyed. Therefore, we assume this option is less effective than trapping at controlling mongoose population, reducing it to about 50% below carrying capacity.

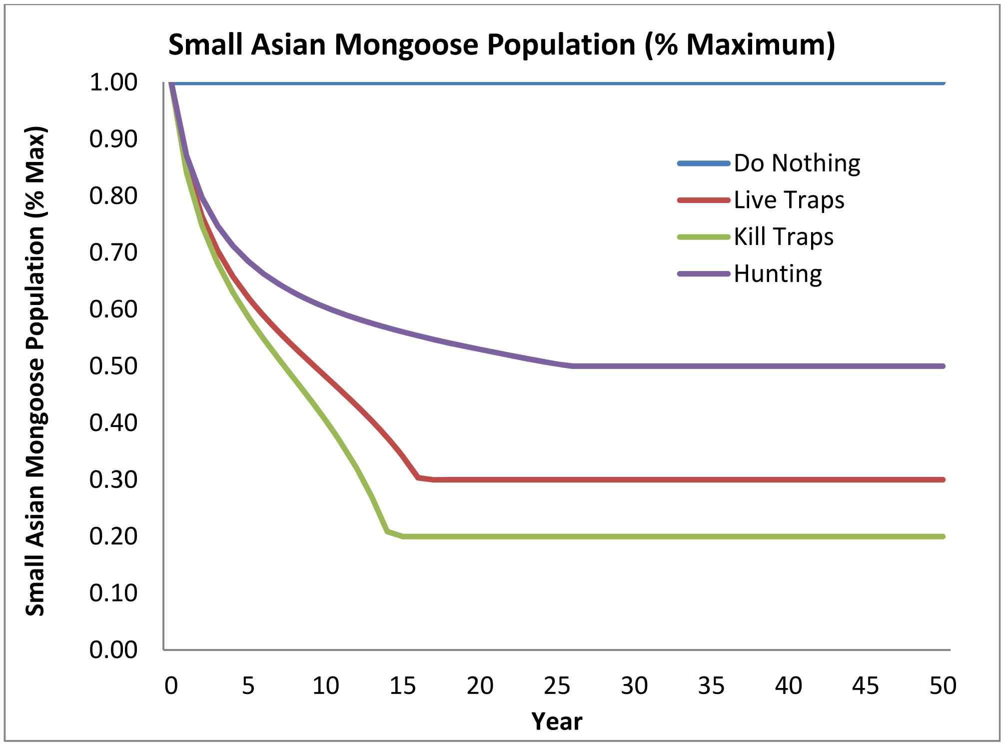

Figure 9 Change in small Asian mongoose population (as % carrying capacity) over time and management option.

Benefits and Costs of Management

The focus of this analysis is on the direct economic impacts of the mongoose, namely the benefits of avoided damages in livestock and crop yields (e.g., bananas and plantains). It is likely that other benefits such as biodiversity protection will also be positive if the small Asian mongoose is controlled. Typical costs of controlling the mongoose include labour, non-toxic bait/lure, ammunition, maintenance and initial capital costs (e.g., guns and traps).

Cost-Benefit Analysis

Estimated damages under the three management options are shown in Figure 10.

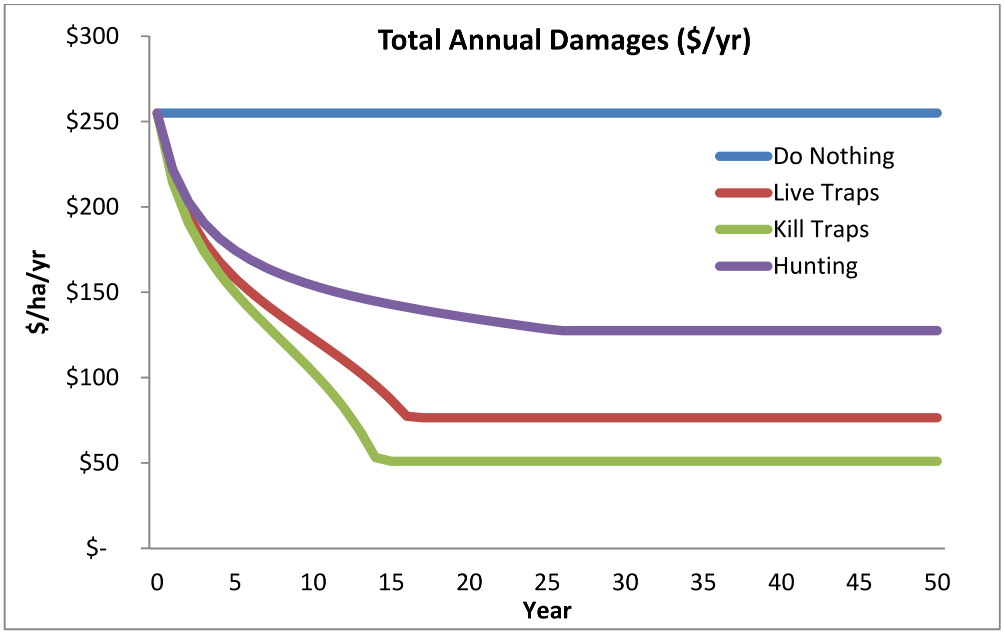

Figure 10 Total value of annual damages ($/ha) for small Asian mongoose under the three management options.

Using pricing data from survey and government sources, we find that hunting yields the highest benefit-cost ratio (Table 2) and is therefore the most efficient management option from an economic perspective. Nevertheless, all three management options yield positive NPVs, indicating that they are preferred over undertaking no management at all.

Table 2 Summary of benefit-cost analysis (r = 8%, T= 50 years, study area = 1 ha)

Option	PV Costs	PV Benefits	Total NPV	Benefit-Cost Ratio	Rank
Do Nothing	$0	$0	$0	1.0	4
Live Traps	–$1,151	$1,533	$382	1.3	3
Kill Traps	–$1,201	$1,747	$546	1.5	2
Hunting	–$617	$1,140	$523	1.8	1

Key Results – Taro beetle

Different management options have differential impacts on the growth and spread of taro beetle. Management options considered in this analysis include doing nothing, switching out of taro into other crops, cultural control, and applying pesticides. See Appendix 15 for the full CBA.

Do Nothing

Households currently spend close to zero time actively managing the taro beetle, thus allowing this invasive species to reach the estimated carrying capacity within about 10 years. At that time, taro yield will fall by approximately 30% (Lal et al 2008).

Switch cropping

If farmers in affected villages replant their taro fields with cassava, both the population of taro beetle and the total production of taro will fall to zero. While it is feasible that taro could be replanted after the beetle is eradicated, we assume that cassava is planted instead for the entire project period of 50 years.

Cultural control

Farmers are assumed to continue planting taro but also to implement more effective crop management practices, including more frequent crop rotation, using clean planting material, flooding, trap cropping, and destroying breeding sites. Additional costs will largely comprise labour required to closely monitor and manage the taro crop. In this scenario, the population of the beetle will be maintained at the same level as the initial period for the duration of the project.

Chemical control

Confidor applied at a rate of 5 g per plant could raise the yield of marketable taro corms to as much as 97% of the expected production with no beetle-related impacts (Lal et al 2008). As a result, we assume that annual spraying will eradicate the pest within 10 years.

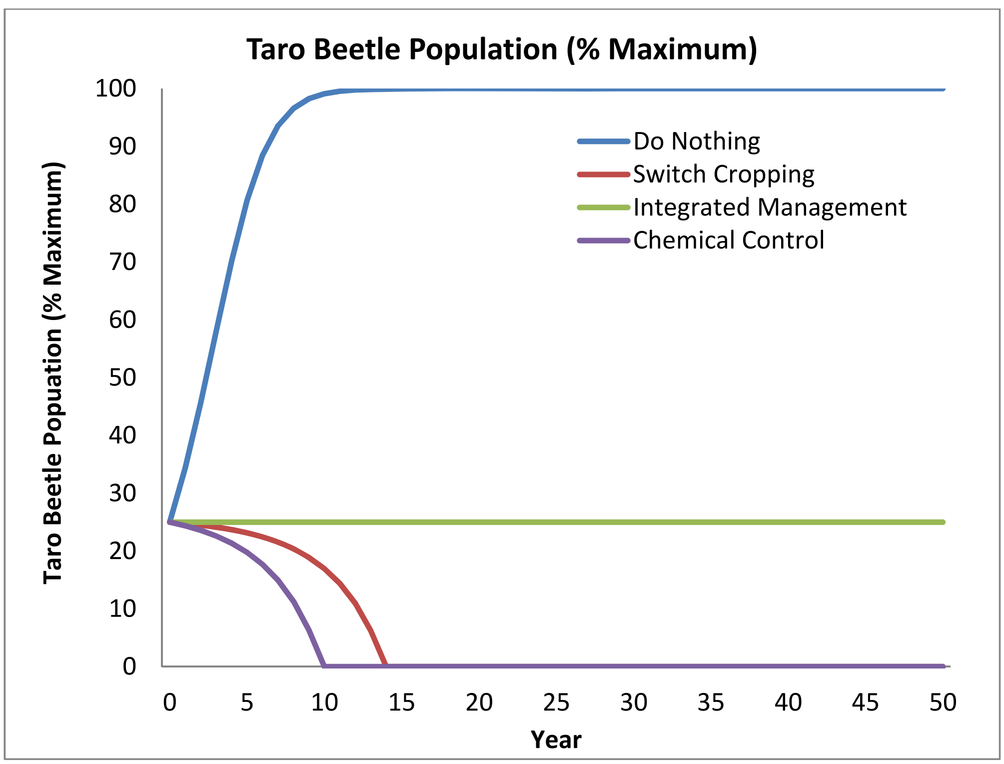

Figure 11 Change in taro beetle population (as % carrying capacity) over time and management option.

A fourth option, biological control, was also considered. Trials of the ability for the fungus Metarhizium to reduce the impacts from taro beetles have been undertaken, but as yet there is no recommendation for farmers. Additionally, a virus has been developed, but it has not yet demonstrated success in reducing beetle population (ISSG Database). Given that the effectiveness of these options is not yet known, they were not included in the assessment.

Benefits and Costs of Management

The focus of this analysis is on the direct economic impacts the taro beetle, namely the benefits of avoided damages in crop yields. However, we also account for the cultural value of taro in rural Fiji by attributing an extra 10% of the market value of the crop.

Cost-Benefit Analysis

Estimated damages under the three management options are shown in Figure 712.

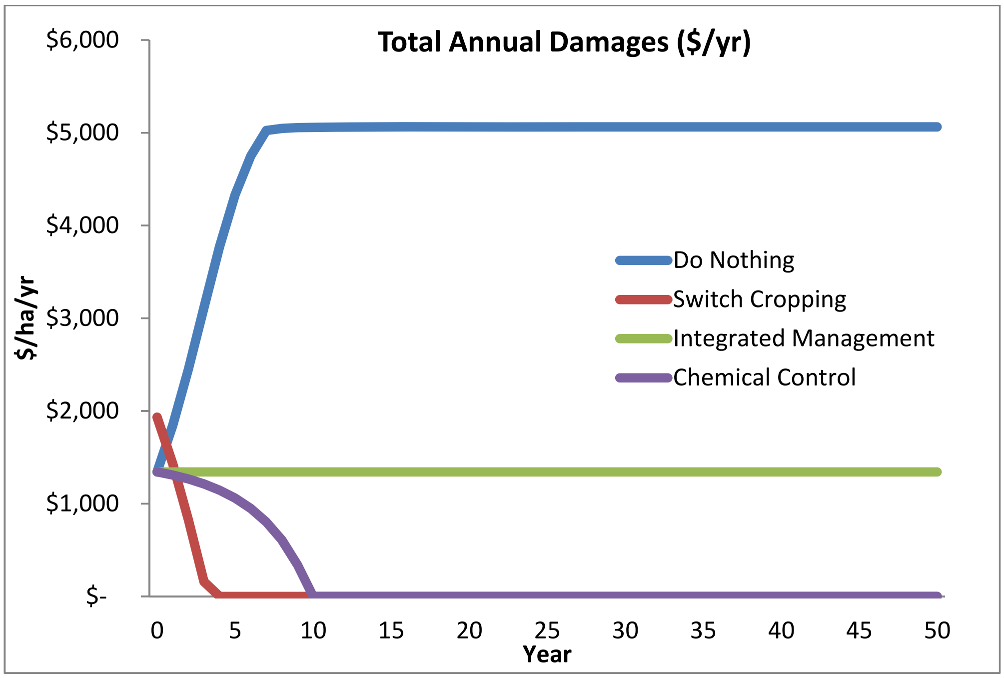

Figure 12 Total value of annual damages ($/ha) from for taro beetle under the four management options.

Using pricing data from survey and government sources, we find that chemical control yields the highest benefit-cost ratio (Table 3) and is therefore the most efficient management option from an economic perspective. Nevertheless, all three management options yield positive NPVs, indicating that they are preferred over undertaking no management at all. This result holds even when accounting for the potential loss in cultural values from not growing taro, as in the case of the crop switching option.

Table 3 Summary of benefit-cost analysis (r = 8%, T= 50 years, study area = 1 ha)

Option	PV Costs	PV Benefits	Total NPV	Benefit-Cost Ratio	Rank
Do Nothing	$0	$0	$0	1.0	4
Switch Cropping	–$2,000	$11,293	$9,293	5.6	3
Cultural Control	–$11,377	$37,071	$25,693	3.3	2
Chemical Control	–$6,706	$47,100	$40,394	7.0	1

Key Results – Red-Vented Bulbul

Different management options have differential impacts on the population of the red-vented bulbul. Management options considered in this analysis include doing nothing and two interventions to limit damage to crops. We do not consider options such as trapping as there is limited knowledge of whether trapping is a viable management option in the Pacific. See Appendix 16 for the full CBA.

Do Nothing

This option assumes that communities maintain the status quo of putting no noticeable effort into controlling the red-vented bulbul or into protecting crops. This approach results in the bird having a steady impact on agriculture.

Crop Management

The bulbul is attracted by edible weeds, so frequent weeding or applying herbicides reduces damage. Staking crops to raise them above ground may also increase yields. Hence, crop management entails investing more time and effort into weed control, applying herbicides, and staking crops. Some fruits and vegetables are also harvested earlier in the season and ripened under cover to avoid them being consumed by the bulbul when they are ripening. Such management interventions may reduce yield losses by half.

Crop Protection

Placing nets over vulnerable crops reduces damages caused by the red-vented bulbul. In this case, we assume that farmers place netting over all crops. Crops that cannot be covered with nets are harvested and stored under cover before they ripen, where possible. As with crop management, impacts from the bulbul are reduced by about one-half under this management option.

Benefits and Costs of Management

The focus of this analysis is on the direct economic impacts of the bulbul, namely the benefits of avoided damages in crop yields. Note that it is likely that the non-quantified benefits of control such as reduction in seed dispersal of invasive weeds will also have positive economic value, and thus the figures listed here are likely to be an underestimate of the total benefits from managing bulbuls.

Cost-Benefit Analysis

Estimated damages under the three management options are shown in Figure 713.

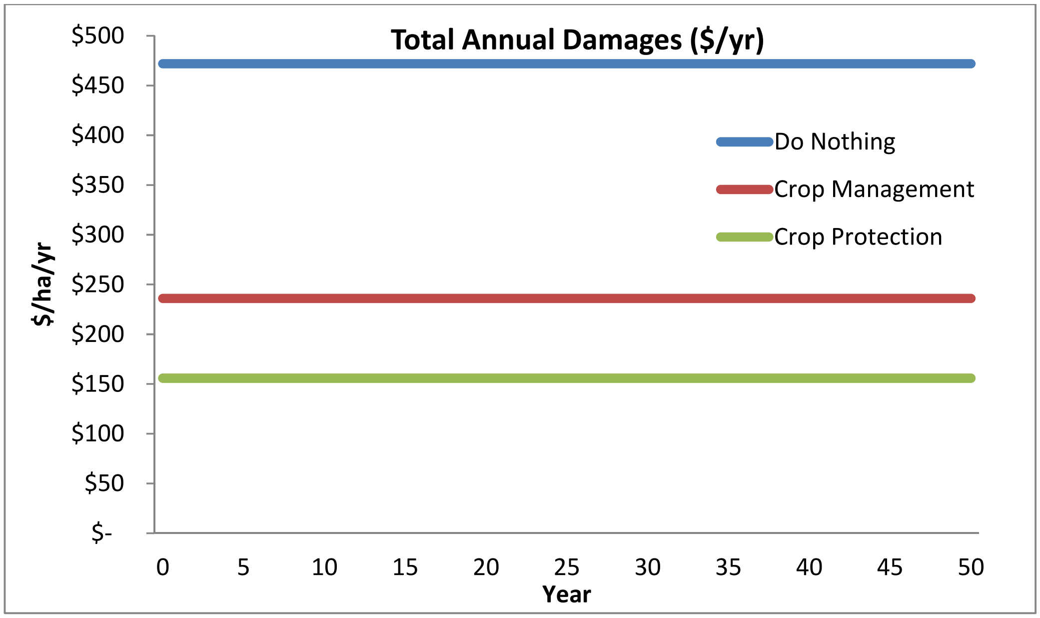

Figure 13 Total value of annual damages ($/ha) from for red-vented bulbul under various management options.

Using pricing data from survey and government sources, we find that the present value of costs of implementing either management option outweighs the present value of benefits accrued over the same period compared to the status quo (Table 4). We thus recommend taking no action against the bulbul until such time as other benefits and or means of control have been field tested. Regardless, this result is in line with nearly all respondents to the surveys indicating that they spend little to no effort to mitigate the impacts of the red-vented bulbul on their agricultural yields.

Table 4 Summary of benefit-cost analysis (r = 8%, T= 50 years, study area = 1 ha)

Option	PV Costs	PV Benefits	Total NPV	Benefit-Cost Ratio	Rank
Do Nothing	$0	$0	$0	1.0	1
Crop Management	–$19,574	$3,122	–$16,451	0.16	3
Crop Protection	–$12,466	$4,184	–$8,282	0.34	2

Key Results – Merremia Vine

Different management options can have differential impacts on the growth and spread of the merremia vine. Management options considered in this analysis include the current community management approach, increased application of herbicides, and a more integrated management approach informed by expert opinion. See Appendix 17 for the full CBA.

Do nothing

This option represents typical progression of growth and spread across the landscape with no management. Under this scenario, the merremia vine eventually occupies all ecologically suited environments when it reaches carrying capacity about 15 years after being introduced to the study site. All other options are measured relative to the costs and benefits estimated under this option. Obviously, there are no management costs associated with the do-nothing option, but it does result in damages to land-based production and native trees that could be avoided if the spread of the vine was controlled.

Current management approach

Based on survey findings, households spend the survey average of 13 person days/year clearing merremia. Treatment methods include a mix of cutting the vine, burning merremia patches, and using a small amount of herbicides. This approach can mitigate the potential damage caused by the invasive vine, but only to a certain degree. Most villages surveyed reported an increase in merremia in their community despite some management, and therefore we assume that the long-run population of the merremia vine is reduced by about 50% relative to the do-nothing scenario.

Chemical application

This option assumes that chemical herbicides are the primary way to control merremia. We assume that control work is undertaken on all disturbed land in the village as that is the area most sensitive to merremia infestation. Spot treatment is also done on significantly affected areas adjacent to the primary treatment sites. All rooting stems and tubers are treated with suitable herbicide, but the exact treatment method used depends on the site and number of established vines. Effort is also made to only apply herbicides to the target plant (i.e. treatment methods must avoid any off-target damage to native plant species). As a result, we assume that annually spraying herbicides at the recommended rate will keep the population of merremia steady at about 20% of carrying capacity.

Integrated management approach

This approach builds on the methods used in the other two management options but with a more integrated and rigorous manner. First, a machete can be used to slash merremia stems out of host trees, where vines are cut as close as practical to ground level. Second, all rooting stems and tubers are then treated with suitable herbicide in the same manner as the chemical application option. Third, emerging merremia plants are dug out or treated with suitable herbicide, and any seedlings germinating from seed can be hand-pulled. Fourth, trees are planted to promote shade and minimise spread of the vine to native vegetation areas.

Cost-Benefit Analysis

Estimated damages under the four management options are shown in Figure .

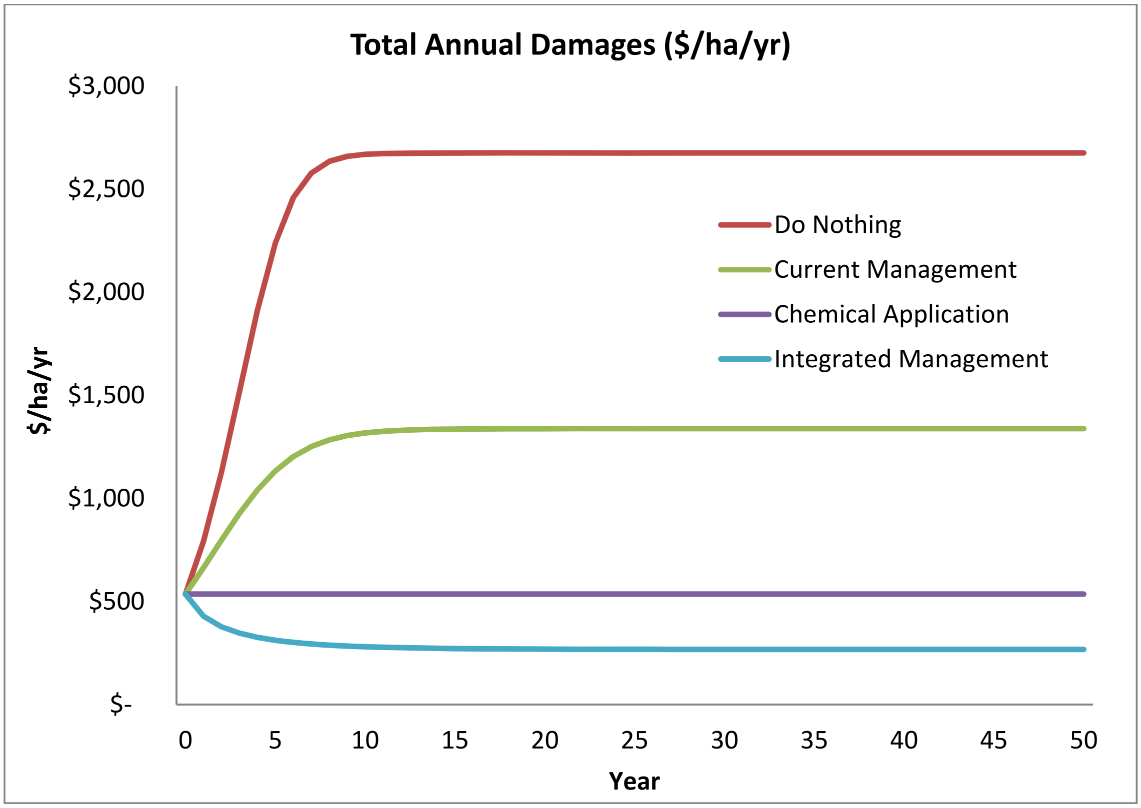

Figure 14 Total value of annual damages ($/ha) from for Merremia Vine under thefour management options

Using pricing data from survey and government sources, we find that the current management approach of using a mix of limited-levels of labour and herbicides to control the vine yields the highest net present value (Table 5). It is therefore the most efficient management option from an economic perspective, provided that people have the additional funding and knowledge to implement it. Nevertheless, the more intensive integrated management option also yields a positive NPV, indicating that it is preferred over undertaking no management at all.

Table 5 Summary of benefit-cost analysis (r = 8%, T= 50 years, study area = 1 ha)

Option	PV costs	PV benefits	Total *NPV*	Benefit–Cost Ratio	Rank
Do nothing	$0	$0	$0	1.0	3
Current management	-$6,044	$13,261	$7,216	2.2	1
Chemical application	-$21,669	$21,102	-$567	1.0	4
Integrated management	-$19,232	$23,920	$4,688	1.2	2

Research dissemination

A report detailing the incidence of each invasive species, management options, and the costs and benefits of control is included in the Appendices 13–17. Each CBA report has been reviewed by external experts to ensure the validity of data and the feasibility of implementation.

Shorter advocacy notes targeted toward more general audiences are also included in the Appendices 8–12. More details on these notes and other outreach for findings from this project are discussed in Section 5.

2.4 Lessons Learned

A number of lessons emerged through this work.

First, collecting survey data at both community and household level proved to be crucial. The former provided a clear understanding of current management practices, while the latter provided much greater insight on attitudes toward invasive species and costs expended to control them.

Second, the capacity for survey research in Fiji is generally quite low. Our 3-day training facilitated collection of high-quality data, yet enumerators and/or data entry personnel nevertheless recorded numerous outliers. Based on this experience, subsequent survey work in the Pacific will use tablet computers, allowing quality checks to be programmed into the survey itself.

Third, the scarcity of biological data on the five key invasive species made CBA extraordinarily challenging. We have undertaken an extensive literature review and have consulted with many regional and international experts through direct contact and internet list-serves. Nevertheless, we have had to make assumptions about rate of population growth and effectiveness of management options in some cases.

3 Cost-Benefit Analysis Training

Training project managers and professionals working in the area of invasive species management methods to develop, conduct, and present economic analyses of invasive species management represents another key aspect of the project. Using a mix of facilitated classroom learning sessions and hands-on practical experience, the training was specifically designed to follow and augment GISP's Economic Analysis Toolkit.

3.1 Course Development

The training course was developed and conducted by environmental economists Adam Daigneault and Pike Brown of Landcare Research. It was delivered through the University of the South Pacific (USP) in Suva, Fiji.

The training consisted of three main components:

1. Workshop (14–16 May 2012): Initial 3-day, intensive classroom course at USP. The training outlined the necessary tools to conduct an economic analysis of invasive species management. The course emphasised defining the problem, quantifying economic, environmental, and social benefits of reducing local impacts from invasive species, estimating costs of eradication or control, collecting data, and presenting findings. Case studies from the Pacific were used to illustrate the methodology. The agenda of the intial 3-day classroom training course is listed in Appendix 3.

2. Mentorship (May–September 2012): Course participants who elected to undertake detailed CBAs for managing specific species were invited to meet with the course leaders via regularly scheduled skype meetings. Feedback and guidance presented in these sessions proved to be instrumental in shaping participants' CBAs.

3. Follow-up Workshop (19–20 September 2012): Individual case studies were presented, evaluated, and discussed by workshop participants at a follow-up meeting held at USP.

3.2 Course Participantion

Project managers and professionals from a wide variety of organisations in the Pacific were encouraged to apply for the course via list serves, direct contact, and posting on regional websites. A copy of the advertisement calling for applicants is listed in Appendix 1.

While previous training in economics was not a pre-requisite for participation, knowledge of Microsoft Excel was required. In addition to those experienced in Excel, applicants who were already working on specific eradication or control projects were given priority.

Seventeen professionals evaluating management options for 13 invasive species were drawn from an applicant pool exceeding 50 people representing government agencies, research institutions, and non-governmental advocacy groups from seven Pacific countries and Australia. Participants and their invasive species case studies are included in Appendix 2.

3.3 Future Training Opportunities

The success of this training program resulted in the trainers being contracted to conduct a similar course in the Caribbean in March 2013. The course will be hosted by CABI with funding from the Global Environment Facility.

3.4 Lessons Learned

Firstr, classroom exercises were key to ensuring that participants grasped key economic terms (e.g., discounting and net present value) and case studies from the Pacific proved to be invaluable for facilitating experiential learning. Excel represented a familiar platform through which participants could undertake their analytical analyses.

Second, participants were eager to learn more about techniques that can be used to estimate non-market values such as species protection and clean water. Some methods such as stated and revealed preference survey questionnaires were touched on during the classroom session, but a longer course period would be required to train participants adequately on non-market valuation techniques.

Finally, participants who had specific projects to manage found particular value in the hands-on training and follow-on mentoring. However, even the most enthusiastic participants found it difficult to undertake comprehensive CBAs in the 4-month timeframe, largely due to limitations in existing biophysical and social data.

Based on these lessons, the initial workshop in the Caribbean will last 4 days, including a full day devoted to ecosystem services. In addition, participants will have 12 months to complete their CBAs, with opportunities to follow up and ask questions through monthly video-conferences with the instructors.

4 Cost-Benefit Analysis Tool and Handbook

Wanting our work to have an impact beyond those directly involved in the training, we collaborated with economists from SPC, SOPAC, and SPREP to develop a manual for conducting CBAs in the Pacific. The resulting guide (Appendix 7) not only serves as a reference for the application of CBA to natural resource and invasive species management, but also supports future training and capacity development in the region. Importantly, the guide provides a standardised approach to conducting CBAs from key players in the region.

In addition, we developed a highly customizable tool for evaluating the costs and benefits of invasive species management. User-entered data pertaining to individual species are utilised to automatically aggregate costs and benefits and to calculate net present values of each management option, and simple manipulations such as changing the program duration (i.e., years of organised control) or discount rate facilitate sensitivity analyses to help users evaluate the robustness of preferred management options. The tool was designed in Microsoft Excel to increase accessibility to non-specialist audiences.

4.1 Cost-Benefit Anlaysis Manual

The purpose of the CBA Manual is to support economic analysis in the Pacific (government and non-government organisations) by:

- illustrating the various steps in cost benefit analysis using Pacific-only examples that are familiar in context, content and challenge to the region
- providing practical tools to support local analysis, and
- rromoting a consistent approach to CBA.

The document is intended as an introductory guidance note only. Users are therefore encouraged to refer to the many CBA and economic textbooks (e.g., Boardman 2006; Tietenberg 2006; Hanley et al. 1993; Wills 1997; Mishan 1988; European Commission undated, 1997; HM Treasury 2003; UNECE 2007; OECD 2006; USEPA 2010) available for more information on these areas.

The CBA process follows a logical and systematic sequence of analysis. For a basic CBA, this can be summarised as six key steps, as illustrated in 5.

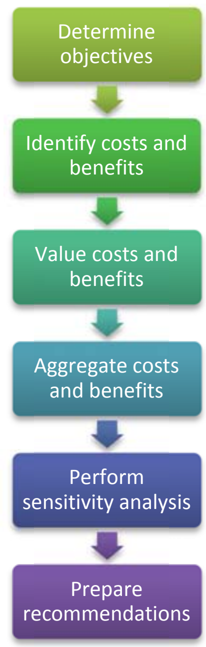

Figure 15 Key steps of the CBA process

The general details of each step are as follows:

1. **Determine the objective(s) of the CBA.** The primary objective(s) of the CBA is to determine whether the benefits of a project option outweigh its cost and by how much relative to other alternatives. The purpose of this is to (i) determine whether the proposed project is (or was) a sound investment (justification/feasibility), and/or (ii) compare between alternative project options (rank and prioritise).

2. **Identify all of the costs and benefits relating to each of the project options.** To do this, the analyst should define what is expected to happen if no project options are implemented to address the identified problem, i.e., the 'without-project' scenario. This provides the 'baseline' from which costs and benefits of the (with) project can be identified and measured. The intent of "with and without analysis" is to identify only those changes that are clearly associated with the project options, and not include changes that would have occurred anyway.

3. **Value costs and benefit items identified for each option**. As far as possible, this should be done in monetary term as this enables direct comparison of different cost and benefit items. Building on the qualitative with and without analysis outlined in the previous chapter, the initial step to valuing costs and benefits is to determine the physical amounts of inputs required outputs created over time (i.e. for every year of the proposed project) from implementing a given activity. The (physical) amount of costs and benefits attributable to a project are only those that result from the project activities. That is, costs and benefits for an option must be additional/incremental to what would happen under business as usual (i.e., without).

4. **Aggregate costs and benefits**. Aggregation refers to the bringing together of all the different costs and benefits over the life of the project, and presenting it as one number (value or ratio). The purpose of this step is to convert available data into manageable information to facilitate the comparison and decision of all options considered. Aggregating costs and benefits is undertaken in two parts: (1) discounting costs and benefits to account for values that accrue at different points in time, and (2) summing these discounted values into a single metric called 'net present value' that can be used to compare the relative benefit of all options considered. Both of these parts are described in detail below as well as alternative ways to measure and compare the relative effectiveness of different options.

5. **Conduct sensitivity analysis.** This is done to account for uncertainty about the values of future costs and benefits. It is generally done by changing the values of key variables in the analysis, such as the discount rate and significant costs and benefits, and the re-estimating the the net present value. Conducting a sensitivity analysis to properly account for uncertainty around the initial results will reduce the risk that the option as a result of the CBA is indeed sub-optimal.

6. **Prepare recommendations.** After comparisons are made, reasons for a particular recommendation should be clearly set out. In many cases, it is important to revisit the key assumptions used in forecasting the costs and benefits of the proposal or programme. The report should be clear, concise, written to the level of the intended audience, and include sufficient evidence for why a given option was selected.

4.2 Invasive Species Cost-Benefit Anlaysis Toolkit

A supplementary toolkit was developed to complement the guide. Using Microsoft Excel, all key calculations (e.g., net present value and cost-effectiveness) are pre-programmed, meaning that users need only focus on key inputs, including program duration, discount rates, benefits categories, cost categories, and invasive species growth trajectories.

A screenshot of the explanatory screen of the toolkit is shown in Figure16.

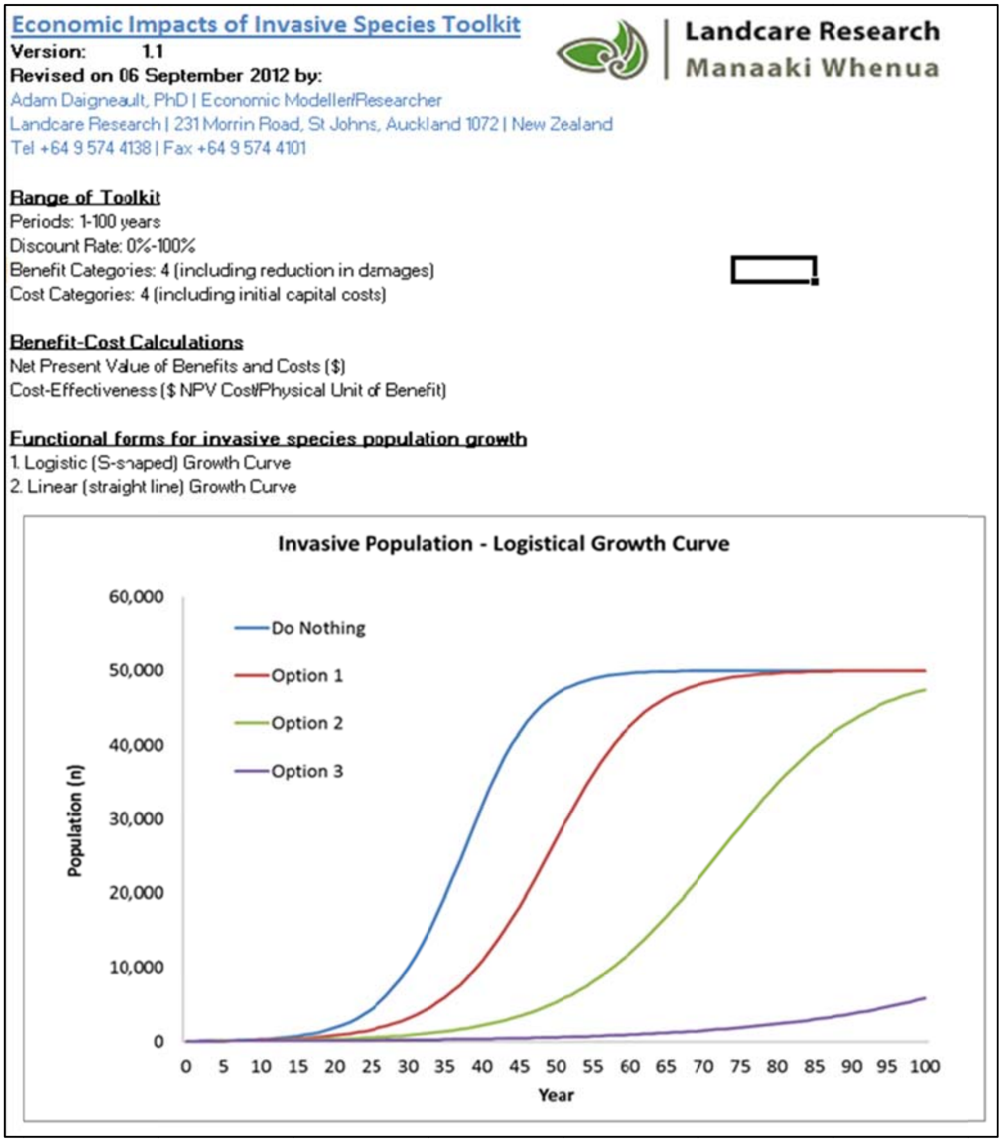

Figure 16 Screenshot of explanatory tab of Invasive Species Toolkit.

A screenshot of the worksheet for the invasive species management economic analysis is shown in Figure17.

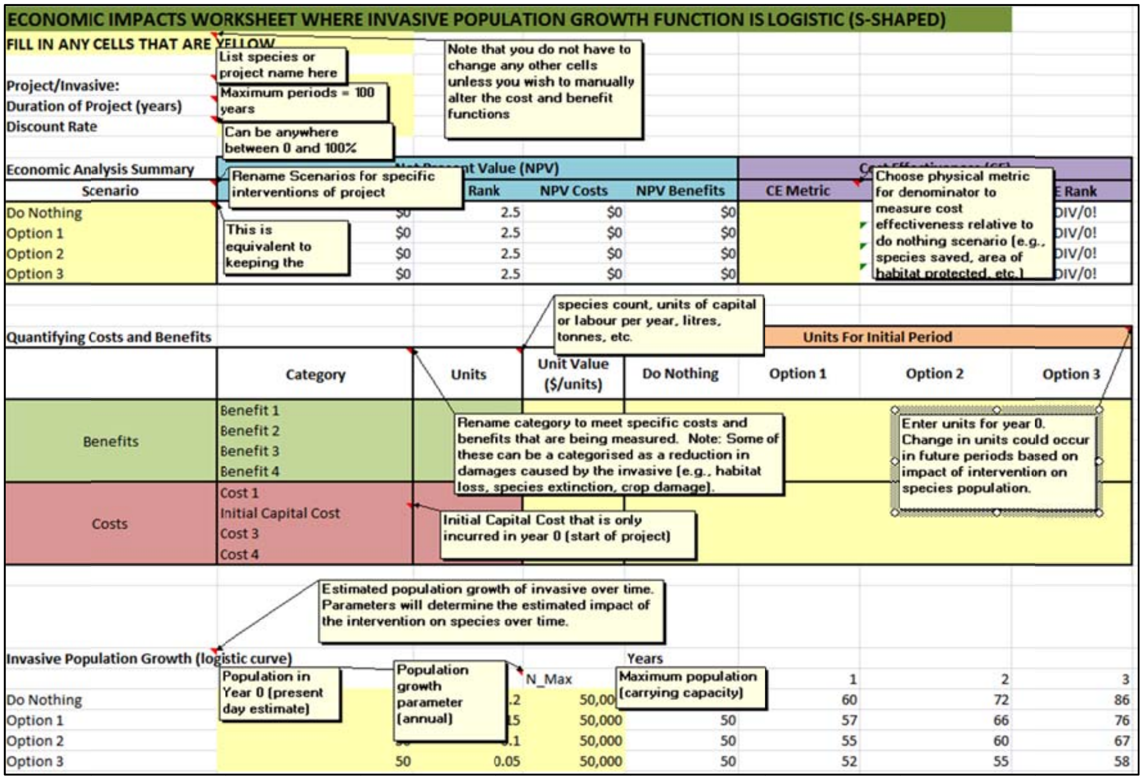

Figure17 Screenshot of worksheet for Invasive Species Economic Anlaysis Toolkit.

The CBA manual and toolkit will be published on the Landcare Research website.

4.3 Lessons Learned

There is a strong demand for CBA training in the Pacific, especially regarding environmental management. Over the last year, trainings have been conducted by Landcare Research, SOPAC, SPC, SPREP, and others. Our Excel-based toolkit was well-received at the training course and most participants could complete the case study examples using the excel spreadsheet.

Despite this, the tool requires accompanying documentation. Because most of the concepts were new to practitioners, we deliberately chose to keep the manual concise. We found that adding specific examples from the Pacific Islands region was a key component of improving understanding.

5 Outreach

The final component for this project was to develop advocacy material and publicise findings of the CBAs for the five target invasive species. The purpose was to contribute to enhancing support from PICTs and donors for invasive species management.

Factsheets summarising the findings of the surveys and CBAs have been developed for each of the 5 target invasives species. These will be distributed at the CEPF End of Term

Evaluation Workshop in Suva in April 2013, at the 12th Pacific Science Inter-Congress in Suva in July 2013, and at the Ninth Pacific Islands Conference on Nature Conservation and Protected Areas in November 2013. They will also be widely distributed through PII's network.These factsheets are included in Appendices 8–12.

Research findings were also presented in the Pacific Resource and Environmental Economics Network newsletter and at the annual conference of the Australian Agricultural and Resource Economics Society in February 2013. They were also featured in a 7-minute interview on Radio Australia (broadcast to 12 Pacific countries) in February 2013.

The authors of the CBAs plan on making these available to the scientific community by publishing the results of the project, including CBA recommendations, in relevant scientific journals. The authors also plan on publicising the findings in *Islands Business* magazine. This magazine is widely read in the region and a good means of reaching politicians and other decision-makers in the Pacific.

Finally, all the outputs from the project will be made available on Pacific Invasives Initiative website.

6 Summary

Invasive species pose an enormous threat in the Pacific: not only do they strongly affect biodiversity, but they also potentially affect the economic, social, and cultural well-being of Pacific peoples. Invasive species can be managed and their impacts can be avoided, eliminated, or reduced. However, neither the costs nor the numerous benefits of management are well understood in the Pacific.

In this project, we undertook cost-benefit analyses of managing five species in Viti Levu, Fiji: *spathodea campanulata* (African tulip tree), *herpestus javanicus* (small Asian mongoose), *papuana uninodis* (Taro beetle), *pycnonotus cafer* (red-vented bulbul), and *merremia peltata* (merremia vine). These CBAs were informed by first-of-its-kind primary-source data collected via matched household and community surveys, which hold major scientific significance in and of themselves. For example, the surveys document the economic costs of living with invasive species, both direct (e.g., the values of crops lost to invasive pests such as the taro beetle) and indirect (e.g., the time that individuals spend pulling merremia vine). They also document novel management practices (e.g., some villages kill African tulip tree stumps by burning tyres around them) and, importantly, personal attitudes toward each invasive species. Specifically, when asked to reallocate Fiji's national budget according to their own spending priorities, survey respondents would allocate approximately 7% of the national budget for invasive species management.

Cost-benefit analysis revealed that an integrated approach (which includes cutting, stacking and drying, and burning) is more cost effective than current management practices for controlling the spread of African tulip tree. Kill traps are more cost effective than live traps and hunting for controlling small Asian mongoose. Given the importance of taro in Fijian culture, increased pesticide use is more efficient for controlling taro beetle than integrated approaches or switching out of taro in favour of cassava. The current approach (i.e., weeding and cutting) to managing merremia vine is more cost effective than either pesticides or integrated management. Finally, managing or protecting crops to alleviate damaged caused by the red-vented bulbul was not estimated to produce net economic benefits. These findings are reported in a series of short technical reports and factsheets, each covering a different target species.

In addition, we conducted a comprehensive training programme on cost-benefit analysis of managing invasive species. Some 17 professionals representing government agencies, research institutions, and non-governmental advocacy groups from seven Pacific countries and Australia attended this training. Several participants met with the trainers over the following four months to undertake CBAs of their own. This training will be replicated for a similar audience of professionals based in the Caribbean in March 2013.

This training made extensive use of two other novel components of this research. First, we collaborated with Pacific organisations to develop a guide to conducting CBAs in the Pacific, including numerous examples from the region. This guide was supplemented by a flexible Microsoft Excel-based tool for conducting CBAs, enabling professionals who did not attend the training course to nevertheless undertake rigorous CBAs on invasive species management.

Through the activities listed above, we have rigorously assessed both the costs and benefits of managing key invasive species in the Polynesia-Melanesia Biodiversity Hotspot, have undertaken CBA to prioritise investment in managing these invasive species, have developed capability for undertaking economic assessments of invasive species in the future, and have prepared empirically grounded advocacy materials to encourage investment in the management of invasive species.

Through our approach of including primary data collection, conducting professional trainings, and developing new tools and guidelines specifically for practitioners in the Pacific, we have dramatically enhanced capability for undertaking CBA for managing invasive species in the Pacific region. In the process, we he have trained a new generation of enumerators who can design and conduct surveys and analysts who can use such data to conduct robust policy analyses. We recommend that similar, integrated approaches be used in other projects to increase knowledge development in the region and to improve the robustness of information used for making management decisions for invasive species.

7 Acknowledgements

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Appendix 1: Training Course Call for Applications

Call for Applications

Training Course on Economic Analyses of Invasive Species in the Pacific

The training course will be conducted by Landcare Research NZ, with assistance from the Pacific Invasives Initiative (PII) and the University Of South Pacific Institute of Applied Science. The course is funded by the Critical Ecosystem Partnership Fund.

ABOUT THE COURSE

This course will teach project managers and professionals working in the area of invasive species management, methods to develop, conduct, and present economic analyses of invasive species eradication or control. The training will provide the methodology and tools for participants to conduct their own benefit-cost analyses in the field. It will include a mix of facilitated classroom learning sessions and hands-on practical experience. Emphasis will be placed on how to estimate economic and environmental benefits of managing invasives at the project level. Participants will leave the course with the experience of completing an economic analysis on an invasive species of their choosing. The three parts of the course include:

1. Initial 3-day intensive classroom course outlining the necessary tools to conduct an economic analysis of invasive species eradication or control. The course will emphasise defining the problem, quantifying economic, environmental, and social benefits of reducing local impacts from invasive species, estimating costs of eradication or control, collecting data, and presenting findings. Case studies from the Pacific Region will be used to illustrate the methodology.
2. Participants develop and conduct their own cost-benefit analysis for a problem of their choosing over a four-month period. Guidance and assistance for the case study part of the course will be provided electronically by the instructors.
3. Individual case studies will be presented, evaluated, and discussed over a 2-day period in September 2012 (date to be determined).

The course will be led by Dr. Adam Daigneault, Environmental and Natural Resource Economist, Landcare Research NZ. The training is limited to 12 participants.

3 PART COURSE

1. Classroom Training: May 14–16, 2012
   University of South Pacific Suva, Fiji Campus
2. Case Work Development: May–September 2012
   At participants' home organisations
3. Evaluation and Presentation of Case Studies: 2 days in September 2012 (date TBD)
   University of South Pacific Suva, Fiji Campus

COST

There is no fee for attending the training program, but participants will be responsible for their own travel and accommodation. Lunch will be provided during the classroom training sessions.

PREREQUISITES

We encourage project managers and professionals from a variety of backgrounds and organisations working with issues surrounding invasive species in the Pacific Islands Region to apply. The training will be in the English language. Previous training in economics is not necessary, but knowledge of Microsoft Excel is essential. Students are asked to provide their own laptops for classroom exercises, if possible.

APPLICATIONS

Application forms may be obtained by emailing the Pacific Invasives Initiative (PII) at: pii@auckland.ac.nz. Preference will be given to applicants currently working on specific eradication or control projects. Applicants are asked to submit a brief overview of a proposed study project that provides information on the invasive species of interest, the location of the study, and proposed option of eradication or control.

Applications due: Tuesday 10 April 2012

USP THE UNIVERSITY OF THE SOUTH PACIFIC | Landcare Research Manaaki Whenua | Pacific Invasives Initiative | CRITICAL ECOSYSTEM PARTNERSHIP FUND

Appendix 2: Training Course Participants

Surname	Given Name	Country	Organisation	Species
Tuamoto	Tuverea	Fiji	NatureFiji-MareqetiViti	mongoose
Thomas	Nunia	Fiji	NatureFiji-MareqetiViti	American Iguana
Saurara	Lesio Soko	Fiji	Secretariat of the Pacific Community	Termite
Macanawai	Apaitia	Fiji	Department of Agriculture	African tulip
Duval	Thomas	New Caledonia	Société Calédonienne d'Ornithologie	Feral Pigs
Devynck	David	Wallis et Futuna	Forests department of Wallis and Futuna's State services	Falcata moluccana
Kailola	Patricia	Fiji	USP-IAS	Invasive plants
Korovulavula	Isoa	Fiji (visiting from QLD, AUS)	USP-IAS	Mahogany
Teuea	Turang	Kiribati	Environment and Conservation Division, Tarawa	Rattus Rattus
Lomavatu	Mereia	Fiji	Fiji Dept of Agriculture, Koronivia Research Station	Colletochrium (fungal disease)
Powell	Lennard	Fiji	Fiji Dept of Agriculture, Koronivia Research Station	Fruit Flies
Timote	Visone	Fiji	Biosecurity Authority of Fiji	Moko Disease (invasive pathogen)
Radford	Lee	French Polynesia	Société d'Ornithologie de Polynésie - Manu, BirdLife Partner	Pacific Rats
Tron	Francois	New Caledonia	Conservation International	Deer and Pig control
Floret	Arthur	Australia	Independent Consultant	Deer and Pig control
Naivalu	Inise	Fiji	Fiji Ministry of Primary Industries/ Department of Agriculture	Weed Species
Tenakanai	David	Papua New Guinea	National Agriculture Quarantine Inspection Authority (NAQIA)	Little fire ants

Appendix 3: Classroom Training Course Agenda

Training Course on Economic Analyses of Invasive Species in the Pacific
14–16 May 2012
University of the South Pacific, Laucala, Lower Campus
Warbler House

DAY 1 Monday 14 May	Activity
9:00 – 9:30	Registration
9:30 – 10:30	Introduction and course overview
10:30 – 11:00	Morning tea break
11:00 – 12:30	Economic Analysis: The Basics
12:30 – 1:30	Lunch Break
1:30-2:30	Economic Analysis of Invasive Species – Step by step #1
2:30 – 3:30	Afternoon tea break and class exercise #1 – Economic analysis in excel
3:30-5:00	Economic Analysis of Invasive Species – Step by step #2

Homework Assignment #1: Economic analysis: sensitivity and policy choice

Day 2 Tuesday 15 May	Activity
9:00 – 9:30	Go over homework assignment #1
9:30-10:30	Policy Analysis: Choosing the 'Right' Option
10:30 – 11:00	Morning tea break
11:00 – 12:00	Invasive Case Study #1: Brown Tree Snake in Hawaii
12:00 – 1:00	Lunch Break
1:00-2:30	Experimental design
2:30 – 3:30	Afternoon tea break and class exercise #2
3:30-4:30	Data: Primary and secondary sources
4:30-5:00	Summary

Homework Assignment #2: Develop community survey

DAY 3 Wednesday 16 May	Activity
9:00 – 9:45	Go over homework assignment #2
9:45 – 11:00	Empirical analyses: Resolving real world issues of data and resource constraints
10:30 – 11:00	Morning tea break
11:00 – 12:30	Invasive Case Study #2:
12:30 – 1:30	Lunch Break
1:30-3:00	Participants present their case study proposals (about 10 minutes each)
3:00 - 3:30	Summary and wrap up
3:30 - 5:00	Instructors available to discuss case studies with participants (not compusory)

Appendix 4: Survey Form – Community

Village name: ____________________________

Name of survey leader: ____________________________

Mobile phone number of survey leader: ____________________________

Other researchers in attendance: ____________________________

Date: ____________________________

Time started: __________ AM/PM Time ended: __________ AM/PM

Name of village headman or most senior person in attendance:

____

Name of contact person in village: ____

Mobile phone number of contact person in village: ____________________________

Number of people in attendance
by gender and approximate age

	Men	Women
Age 0-14		
Age 15-25		
Age 25-40		
Age 40-60		
Age 60+		

African tulip tree – *Spathodea campanulata*

1. Is this species here?	□ Yes □ No [go to next page]	
2. What do you call it?	______________________	
3. When did it first arrive?	□ __________ (year) □ It has been here for as long as we can remember	
4. Has the population been…?	□ Increasing □ Decreasing □ Steady ______________	
5. In what ways is this species **good** for people in this community? Does it…? If so, provide details	□ Directly provide food for people	______________
	□ Directly provide food for domestic animals	______________
	□ Provide medicine (detail medicinal uses)	______________
	□ Provide building materials	______________
	□ Provide firewood for cooking	______________
	□ Attract birds or wild animals (note any sold/eaten/medicinal)	______________
	□ None	
6. Do people buy and sell all or part of it **for the village**?	□ Yes, people sell fruit/flowers □ Yes, people sell wood □ No [next question]	Total time/month: __________ person days / Average monthly sales: $ __________
7. Do people buy and sell all or part of it **for themselves**?	□ Yes, people sell fruit/flowers □ Yes, people sell wood □ No	
8. Do people do anything to attract more of this tree?	□ Yes, they plant it	
	□ Yes, they do something else	______________
	□ No	
9. In what ways is this species **bad** for people in this community? Does it…? If so, how do people in the village manage?	□ Reduce agricultural output	______________
	□ Reduce grazing land	______________
	□ Damage infrastructure	______________
	□ Compete with medicinal trees/plants (list species and medicinal uses)	______________
	□ Compete with building material trees	______________
	□ Compete with firewood trees	______________
	□ Reduce bird or animal populations (note any sold/eaten/medicinal)	______________
	□ Reduce tourism	______________
	□ None	
10. Do people do anything to get rid of this tree **for the village**?	□ Yes, they cut/dig it □ Yes, they burn it □ Yes, they use herbicides □ No [next question]	Total time/month: __________ person days / Average monthly costs: $ __________
11. Do people do anything to get rid of this tree **for themselves**?	□ Yes, they cut/dig it □ Yes, they burn it □ Yes, they use herbicides □ No	
12. Has this tree caused people to change their work or to move away?	□ Yes, people plant different crops	______________
	□ Yes, people have stopped planting	______________
	□ Yes, they stopped raising animals	______________
	□ Yes, people have left the village	______________
	□ No	______________

Notes (including process for clearance/control, if applicable):

Pond Apple – *Annona glabra*

1. Is this species here?	□ Yes □ No [go to next page]
2. What do you call it?	________________
3. When did it first arrive?	□ __________ (year) □ It has been here for as long as we can remember
4. Has the population been…?	□ Increasing □ Decreasing □ Steady ________________
5. In what ways is this species **good** for people in this community? Does it…? If so, provide details	□ Directly provide food for people ________ □ Directly provide food for domestic animals ________ □ Provide medicine (detail medicinal uses) ________ □ Provide building materials ________ □ Provide firewood for cooking ________ □ Attract birds or wild animals (note any sold/eaten/medicinal) ________ □ None
6. Do people buy and sell all or part of it **for the village**?	□ Yes, people sell fruit/flowers □ Yes, people sell wood □ No [next question] Total time/month: __________ person days Average monthly sales: $ __________
7. Do people buy and sell all or part of it **for themselves**?	□ Yes, people sell fruit/flowers □ Yes, people sell wood □ No
8. Do people do anything to attract more of this tree?	□ Yes, they plant it □ Yes, they do something else ________ □ No
9. In what ways is this species **bad** for people in this community? Does it…? If so, how do people in the village manage?	□ Reduce agricultural output ________ □ Reduce grazing land ________ □ Damage infrastructure ________ □ Compete with medicinal trees/plants (list species and medicinal uses) ________ □ Compete with building material trees ________ □ Compete with firewood trees ________ □ Reduce bird or animal populations (note any sold/eaten/medicinal) ________ □ None
10. Do people do anything to get rid of this tree **for the village**?	□ Yes, they cut/dig it □ Yes, they burn it □ Yes, they use herbicides □ No [next question] Total time/month: __________ person days Average monthly costs: $ __________
11. Do people do anything to get rid of this tree **for themselves**?	□ Yes, they cut/dig it □ Yes, they burn it □ Yes, they use herbicides □ No
12. Has this tree caused people to change their work or to move away?	□ Yes, people plant different crops ________ □ Yes, people have stopped planting ________ □ Yes, they stopped raising animals ________ □ Yes, people have left the village ________ □ No

Notes (including process for clearance/control, if applicable):

Octopus Tree – *Schefflera actinophylla*

1. Is this species here? □ Yes □ No [go to next page]

2. What do you call it? ______________________________

3. When did it first arrive?
   - □ __________ (year)
   - □ It has been here for as long as we can remember

4. Has the population been…?
   □ Increasing □ Decreasing □ Steady

5. In what ways is this species **good** for people in this community? Does it…? If so, provide details
   - □ Directly provide food for people ______________________
   - □ Directly provide food for domestic animals ______________________
   - □ Provide medicine (detail medicinal uses) ______________________
   - □ Provide building materials ______________________
   - □ Provide firewood for cooking ______________________
   - □ Attract birds or wild animals (note any sold/eaten/medicinal) ______________________
   - □ None

6. Do people buy and sell all or part of it **for the village**?
   - □ Yes, people sell fruit/flowers
   - □ Yes, people sell wood
   - □ No [next question]

Total time/month:	Average monthly sales:
__________ person days	$ __________

7. Do people buy and sell all or part of it **for themselves**?
   - □ Yes, people sell fruit/flowers
   - □ Yes, people sell wood
   - □ No

8. Do people do anything to attract more of this tree?
   - □ Yes, they plant it
   - □ Yes, they do something else ______________________
   - □ No

9. In what ways is this species **bad** for people in this community? Does it…? If so, how do people in the village manage?
   - □ Reduce agricultural output ______________________
   - □ Reduce grazing land ______________________
   - □ Damage infrastructure ______________________
   - □ Compete with medicinal trees/plants (list species and medicinal uses) ______________________
   - □ Compete with building material trees ______________________
   - □ Compete with firewood trees ______________________
   - □ Reduce bird or animal populations (note any sold/eaten/medicinal) ______________________
   - □ None

10. Do people do anything to get rid of this tree **for the village**?
    - □ Yes, they cut/dig it
    - □ Yes, they burn it
    - □ Yes, they use herbicides
    - □ No [next question]

Total time/month:	Average monthly costs:
__________ person days	$ __________

11. Do people do anything to get rid of this tree **for themselves**?
    - □ Yes, they cut/dig it
    - □ Yes, they burn it
    - □ Yes, they use herbicides
    - □ No

12. Has this tree caused people to change their work or to move away?
    - □ Yes, people plant different crops ______________________
    - □ Yes, people have stopped planting ______________________
    - □ Yes, they stopped raising animals ______________________
    - □ Yes, people have left the village ______________________
    - □ No

Notes (including process for clearance/control, if applicable):

Merremia Vine – *Merremia peltata*

1.Is this species here? □ Yes □ No [go to next page]

2.What do you call it? ______________________________

3.When did it first arrive?
□ __________ (year)
□ It has been here for as long as we can remember

4.Has the population been…?
□ Increasing □ Decreasing □ Steady

5.In what ways is this species **good** for people in this community? Does it…? If so, provide details
- □ Directly provide food for people ______________________
- □ Directly provide food for domestic animals ______________________
- □ Provide medicine (detail medicinal uses) ______________________
- □ Provide building materials ______________________
- □ Provide material for cooking ______________________
- □ Attract birds or wild animals (note any sold/eaten/medicinal) ______________________
- □ None

6.Do people buy and sell all or part of it **for the village**?
- □ Yes, people sell leaves/flowers
- □ No [next question]

Total time/month: __________ person days	Average monthly sales: $ __________

7.Do people buy and sell all or part of it **for themselves**?
- □ Yes, people sell leaves/flowers
- □ No

8.Do people do anything to attract more of this vine?
- □ Yes, they plant it
- □ Yes, they do something else ______________________
- □ No

9.In what ways is this species **bad** for people in this community? Does it…? If so, how do people in the village manage?
- □ Reduce agricultural output ______________________
- □ Reduce grazing land ______________________
- □ Damage infrastructure ______________________
- □ Compete with medicinal trees/plants (list species and medicinal uses) ______________________
- □ Compete with building material trees ______________________
- □ Compete with firewood trees ______________________
- □ Reduce bird or animal populations (note any sold/eaten/medicinal) ______________________
- □ Reduce tourism ______________________
- □ None

10.Do people do anything to get rid of this vine **for the village**?
- □ Yes, they cut/dig it
- □ Yes, they burn it
- □ Yes, they use herbicides
- □ No [next question]

Total time/month: __________ person days	Average monthly costs: $ __________

11.Do people do anything to get rid of this vine **for themselves**?
- □ Yes, they cut/dig it
- □ Yes, they burn it
- □ Yes, they use herbicides
- □ No

12.Has this vine caused people to change their work or to move away?
- □ Yes, people plant different crops ______________________
- □ Yes, people have stopped planting ______________________
- □ Yes, they stopped raising animals ______________________
- □ Yes, people have left the village ______________________
- □ No

Notes (including process for clearance/control, if applicable):

Creeping daisy/wedleia –*Sphagnetifolialia trilobata*

1.Is this species here?	□ Yes □ No [go to next page]	
2.What do you call it?	______________________	
3.When did it first arrive?	□ __________ (year) □ It has been here for as long as we can remember	
4.Has the population been…?	□ Increasing □ Decreasing □ Steady	
5.In what ways is this species **good** for people in this community? Does it…? If so, provide details	□ Directly provide food for people □ Directly provide food for domestic animals □ Provide medicine (detail medicinal uses) □ Provide building materials □ Provide material for cooking □ Attract birds or wild animals (note any sold/eaten/medicinal) □ None	______________________
6.Do people buy and sell all or part of it **for the village**?	□ Yes, people sell leaves/flowers □ No [next question]	Total time/month: __________ person days | Average monthly sales: $ __________
7.Do people buy and sell all or part of it **for themselves**?	□ Yes, people sell leaves/flowers □ No	
8.Do people do anything to attract more of this plant?	□ Yes, they plant it □ Yes, they do something else □ No	______________________
9.In what ways is this species **bad** for people in this community? Does it…? If so, how do people in the village manage?	□ Reduce agricultural output □ Reduce grazing land □ Damage infrastructure □ Compete with medicinal trees/plants (list species and medicinal uses) □ Compete with building material trees □ Compete with firewood trees □ Reduce bird or animal populations (note any sold/eaten/medicinal) □ Reduce tourism □ None	______________________
10.Do people do anything to get rid of this plant **for the village**?	□ Yes, they cut/dig it □ Yes, they burn it □ Yes, they use herbicides □ No [next question]	Total time/month: __________ person days | Average monthly costs: $ __________
11.Do people do anything to get rid of this plant **for themselves**?	□ Yes, they cut/dig it □ Yes, they burn it □ Yes, they use herbicides □ No	
12.Has it caused people to change their work or to move away?	□ Yes, people plant different crops □ Yes, people have stopped planting □ Yes, they stopped raising animals □ Yes, people have left the village □ No	______________________

Notes (including process for clearance/control, if applicable):

African Giant Snail – *Achatina fulica*

1.Is this species here? □ Yes □ No [go to next species]

Notes:

taro beetle – *Papuana uninodis*

1.Is this species here? □ Yes □ No [go to next page]

2.What do you call it? ____________________

3.When did it first arrive?
□ __________ (year)
□ It has been here for as long as we can remember

4.Has the population been…?
□ Increasing □ Decreasing □ Steady

5.In what ways is this species **good** for people in this community? Does it…? If so, provide details
□ Directly provide food for people ____________________
□ Directly provide food for domestic animals ____________________
□ Provide medicine (detail medicinal uses) ____________________
□ Attract birds or wild animals (note any sold/eaten/medicinal) ____________________
□ None

6.In what ways is this species **bad** for people in this community? Does it…? If so, how do people in the village manage?
□ Reduce agricultural output ____________________
□ Damage infrastructure ____________________
□ Destroy medicinal trees/plants (list species and medicinal uses) ____________________
□ Destroy building material trees ____________________
□ Destroy trees used for firewood ____________________
□ Reduce bird or animal populations (note any sold/eaten/medicinal) ____________________
□ Spread disease to people ____________________
□ Spread disease to plants/animals ____________________
□ Reduce tourism ____________________
□ None

7. Do people do anything to get rid of this insect **for the village**?
□ Yes, they dig/burn affected taro
□ Yes, they use poisons on affected taro
□ No [next question]

Total time/month: __________ person days	Average monthly costs: $ __________

8. Do people do anything to get rid of this insect **for themselves**?
□ Yes, they dig/burn affected taro
□ Yes, they use poisons on affected taro
□ Yes, they let land go fallow
□ No

9. Has it caused people to change their work or to move away?
□ Yes, people plant different crops ____________________
□ Yes, people have stopped planting ____________________
□ Yes, they stopped raising animals ____________________
□ Yes, people have left the village ____________________
□ No

Notes (including process for clearance/control, if applicable):

small Asian mongoose – *Herpestes javanicus*

1. Is this species here?	□ Yes □ No [go to next page]	
2. What do you call it?	________________	
3. When did it first arrive?	□ __________ (year) □ It has been here for as long as we can remember	
4. Has the population been…?	□ Increasing □ Decreasing □ Steady	
5. In what ways is this species **good** for people in this community? Does it…? If so, provide details	□ Directly provide food for people □ Directly provide food for domestic animals □ Provide medicine (detail medicinal uses) □ Attract other birds/wild animals (note any sold/eaten/medicinal) □ Bring tourism opportunities □ None	________________
6. Do people buy and sell all or part of it **for the village**?	□ Yes, people sell the meat □ Yes, people sell the fur □ No [next question]	Total time/month: __________ person days | Average monthly sales: $ __________
7. Do people buy and sell all or part of it **for themselves**?	□ Yes, people sell the meat □ Yes, people sell the fur □ No	
8. Do people do anything to attract more of them?	□ Yes, they lure them with chickens □ Yes, they do something else □ No	________________
9. In what ways is this species **bad** for people in this community? Does it…? If so, how do people in the village manage?	□ Reduce agricultural output □ Damage infrastructure □ Destroy medicinal trees/plants (list species and medicinal uses) □ Destroy building material trees □ Destroy trees used for firewood □ Attack people □ Attack livestock □ Reduce bird or animal populations (note any sold/eaten/medicinal) □ Spread disease to people □ Spread disease to plants/animals □ None	________________
10. Do people do anything to get rid of this animal **for the village**?	□ Yes, they hunt it □ Yes, they trap it □ Yes, they poison it □ No [next question]	Total time/month: __________ person days | Average monthly costs: $ __________
11. Do people do anything to get rid of this animal **for themselves**?	□ Yes, they hunt it □ Yes, they trap it □ Yes, they poison it □ No	
12. Has it caused people to change their work or to move away?	□ Yes, people raise them □ Yes, people have left the village □ No	________________

Notes (including process for clearance/control, if applicable):

Wild Boar/Roaming pigs – *Sus scrofa*

1. Is this species here? □ Yes □ No [go to next page]

2. What do you call it? ________________________________

3. When did it first arrive?
   - □ __________ (year)
   - □ It has been here for as long as we can remember

4. Has the population been…? □ Increasing □ Decreasing □ Steady

5. In what ways is this species **good** for people in this community? Does it…? If so, provide details
   - □ Directly provide food for people ____________________
   - □ Directly provide food for domestic animals ____________________
   - □ Provide medicine (detail medicinal uses) ____________________
   - □ Attract other birds/wild animals (note any sold/eaten/medicinal) ____________________
   - □ Bring tourism opportunities ____________________
   - □ None

6. Do people buy and sell all or part of it **for the village**?
   - □ Yes, people sell the meat
   - □ Yes, people sell the fur
   - □ No [next question]

Total time/month:	Average monthly sales:
__________ person days	$ __________

7. Do people buy and sell all or part of it **for themselves**?
   - □ Yes, people sell the meat
   - □ Yes, people sell the fur
   - □ No

8. Do people do anything to attract more of them?
   - □ Yes, they plant crops to bring them ____________________
   - □ Yes, they do something else ____________________
   - □ No

9. In what ways is this species **bad** for people in this community? Does it…? If so, how do people in the village manage?
   - □ Reduce agricultural output ____________________
   - □ Damage infrastructure ____________________
   - □ Destroy medicinal trees/plants (list species and medicinal uses) ____________________
   - □ Destroy building material trees ____________________
   - □ Destroy trees used for cooking ____________________
   - □ Attack people ____________________
   - □ Attack livestock ____________________
   - □ Reduce bird or animal populations (note any sold/eaten/medicinal) ____________________
   - □ Spread disease to people ____________________
   - □ Spread disease to plants/animals ____________________
   - □ None

10. Do people do anything to get rid of this animal **for the village**?
    - □ Yes, they hunt it
    - □ Yes, they trap and kill it
    - □ Yes, they poison it
    - □ No [next question]

Total time/month:	Average monthly costs:
__________ person days	$ __________

11. Do people do anything to get rid of this animal **for themselves**?
    - □ Yes, they hunt it
    - □ Yes, they trap and kill it
    - □ Yes, they poison it
    - □ No

12. Has it caused people to change their work or to move away?
    - □ Yes, people raise them ____________________
    - □ Yes, people have left the village ____________________
    - □ No

Notes (including process for clearance/control, if applicable):

Red-Vented Bulbul – *Pycnonotus cafer*

1.Is this species here?	□ Yes □ No [go to next page]	
2.What do you call it?	______________________________	
3.When did it first arrive?	□ __________ (year) □ It has been here for as long as we can remember	
4.Has the population been…?	□ Increasing □ Decreasing □ Steady	
5.In what ways is this species **good** for people in this community? Does it…? If so, provide details	□ Directly provide food for people □ Directly provide food for domestic animals □ Provide medicine (detail medicinal uses) □ Attract other birds/wild animals (note any sold/eaten/medicinal) □ Bring tourism opportunities □ None	______________________________
6.Do people buy and sell all or part of it **for the village**?	□ Yes, people sell them □ No [next question]	Total time/month: __________ person days | Average monthly sales: $ __________
7.Do people buy and sell all or part of it **for themselves**?	□ Yes, people sell them □ No	
8.Do people do anything to attract more of them?	□ Yes, they plant crops to bring them □ Yes, they do something else □ No	______________________________
9.In what ways is this species **bad** for people in this community? Does it…? If so, how do people in the village manage?	□ Reduce agricultural output □ Damage infrastructure □ Destroy medicinal trees/plants (list species and medicinal uses) □ Destroy building material trees □ Destroy trees used for firewood □ Reduce bird or animal populations (note any sold/eaten/medicinal) □ Spread disease to people □ Spread disease to plants/animals □ None	______________________________
10.Do people do anything to get rid of this bird **for the village**?	□ Yes, they hunt it □ Yes, they trap and kill it □ Yes, they poison it □ No [next question]	Total time/month: __________ person days | Average monthly costs: $ __________
11.Do people do anything to get rid of this bird **for themselves**?	□ Yes, they hunt it □ Yes, they trap and kill it □ Yes, they poison it □ No	
12.Has it caused people to change their work or to move away?	□ Yes, people raise them □ Yes, people have left the village □ No	______________________________

Notes (including process for clearance/control, if applicable):

Tilapia – *Oreochromis niloticus or Oreochromis mossambicus*

1.Is this species here?	□ Yes □ No [go to next page]	
2.What do you call it?	________________	
3.When did it first arrive?	□ __________ (year) □ It has been here for as long as we can remember	
4.Has the population been…?	□ Increasing □ Decreasing □ Steady	
5.In what ways is this species **good** for people in this community? Does it…? If so, provide details	□ Directly provide food for people □ Directly provide food for domestic animals □ Provide medicine (detail medicinal uses) □ Attract other birds/wild animals (note any sold/eaten/medicinal) □ Remove weeds from waterways □ Bring tourism opportunities □ None	________________
6.Do people buy and sell all or part of it **for the village**?	□ Yes, people sell them □ No [next question]	Total time/month: __________ person days — Average monthly sales: $ __________
7.Do people buy and sell all or part of it **for themselves**?	□ Yes, people sell them □ No	
8.Do people do anything to have more of them?	□ Yes, they dig ponds/ditches □ Yes, they do something else □ No	________________
9.In what ways is this species **bad** for people in this community? Does it…? If so, how do people in the village manage?	□ Damage infrastructure □ Destroy medicinal plants (list species and medicinal uses) □ Attack other farmed fish □ Reduce wild fish, prawn, or other freshwater animal populations (note any sold/eaten/medicinal) □ Spread disease to people □ Spread disease to plants/animals □ Reduce water quality □ None	________________
10.Do people do anything to get rid of this fish **for the village**?	□ Yes, they poison water □ Yes, they catch and kill them □ No [next question]	Total time/month: __________ person days — Average monthly costs: $ __________
11.Do people do anything to get rid of this fish **for themselves**?	□ Yes, they poison water □ Yes, they catch and kill them □ No	
12.Has it caused people to change their work or to move away?	□ Yes, people raise them □ Yes, people have left the village □ No	________________

Notes (including process for clearance/control, if applicable):

Grass Carp – *Ctenopharyngodon idella*

1.Is this species here?	□ Yes □ No [go to next page]	
2.What do you call it?	______________________	
3.When did it first arrive?	□ __________ (year) □ It has been here for as long as we can remember	
4.Has the population been…?	□ Increasing □ Decreasing □ Steady	
5.In what ways is this species **good** for people in this community? Does it…? If so, provide details	□ Directly provide food for people □ Directly provide food for domestic animals □ Provide medicine (detail medicinal uses) □ Attract other birds/wild animals (note any sold/eaten/medicinal) □ Remove weeds from waterways □ Bring tourism opportunities □ None	______________________
6.Do people buy and sell all or part of it **for the village**?	□ Yes, people sell them □ No [next question]	Total time/month: __________ person days Average monthly sales: $ __________
7.Do people buy and sell all or part of it **for themselves**?	□ Yes, people sell them □ No	
8.Do people do anything to have more of them?	□ Yes, they dig ponds/ditches □ Yes, they do something else □ No	______________________
9.In what ways is this species **bad** for people in this community? Does it…? If so, how do people in the village manage?	□ Damage infrastructure □ Destroy medicinal plants (list species and medicinal uses) □ Attack other farmed fish □ Reduce wild fish, prawn, or other freshwater animal populations (note any sold/eaten/medicinal) □ Spread disease to people □ Spread disease to plants/animals □ Reduce water quality □ None	______________________
10.Do people do anything to get rid of this fish **for the village**?	□ Yes, they poison water □ Yes, they catch and kill them □ No [next question]	Total time/month: __________ person days Average monthly costs: $ __________
11.Do people do anything to get rid of this fish **for themselves**?	□ Yes, they poison water □ Yes, they catch and kill them □ No	
12.Has it caused people to change their work or to move away?	□ Yes, people raise them □ Yes, people have left the village □ No	______________________

Notes (including process for clearance/control, if applicable):

Other species

Are there other species of… that have had serious negative consequences for agriculture, fisheries, native plants and animals, health and/or the local economy (even if they have also brought benefits)? [If yes, list species and explain impact. Where appropriate, use some of the above questions to elaborate the impacts, time of introduction, spread and attempted control methods, etc.

1.Trees	□ Yes □ No [next]	______
2.Shrubs	□ Yes □ No [next]	______
3.Vines	□ Yes □ No [next]	______
4.Reeds and grasses	□ Yes □ No [next]	______
5.Herbs and other soft plants	□ Yes □ No [next]	______
6.Seaweeds or aquatics plants	□ Yes □ No [next]	______
7.Snails	□ Yes □ No [next]	______
8.Ants	□ Yes □ No [next]	______
9.Wasps and bees	□ Yes □ No [next]	______
10.Moths	□ Yes □ No [next]	______
11.Other insects	□ Yes □ No [next]	______
12.Snakes and lizards	□ Yes □ No [next]	______
13.Frogs and toads	□ Yes □ No	______

	[next]	______________________
14. Birds	□ Yes □ No [next]	______________________
15. Mammals	□ Yes □ No [next]	______________________
16. Freshwater fish	□ Yes □ No [next]	______________________
17. Saltwater fish	□ Yes □ No [next]	______________________
18. Clams and molluscs	□ Yes □ No [next]	______________________
19. Agricultural pests and diseases	□ Yes □ No [next]	______________________

Appendix 5: Survey Form – Household/Individual (English)

888 Do not know
999 Refused to answer

Village name: ____________________________

Household # _____________________________

Hello. My name is [NAME] and I am a student/lecturer/researcher at the University of the South Pacific. Together with Landcare Research in New Zealand, we are conducting a study of village economics.

In total, we will interview 360 households from 30 different villages in eastern Viti Levu. The survey will also be conducted on Taveuni.

Because this is an economics survey, we will ask some personal information about your income in addition to many questions about your crops, your livestock, your children, and several other topics. We will use these answers to conduct research, but our study will not show the names or other identifying characteristics of the people who answer our survey. We also promise not to share any personal data with *anyone*, including other people in the village.

The survey will take 1 to 1.5 hours to complete covering 15 topics, and we will make a donation to the village fund for each survey that we complete.

Do you agree to participate in the survey?

I understand what I have been told and I agree to participate.

_________________________	_________________________	_________________________
NAME	SIGNATURE	PHONE NUMBER

Name of survey enumerator: ____________________________

Mobile phone number of survey enumerator: ____________________________

Other researchers in attendance: ______________________________

Date: ______________________________

Time started: __________ AM/PM Time ended: __________ AM/PM

FORM 1. HOUSEHOLD ROSTER

If the household has **1 generation**, then the male of that generation is the head. If the household has **2 generations**, then the male of the older generation is the head. If the household has **3 generations**, then the male of the middle generation is the head.

1 WRITE THE NAMES OF ALL INDIVIDUALS IN THE HOUSEHOLD AND ANSWER QUESTIONS 2 AND 3 FOR EACH. THEN ASK QUESTIONS 4-6. THEN ASK QUESTIONS 7-14.	I D C O D E	2 SEX MALE .... 1 FEMALE 2	3 How many years old is [NAME] now?	4 RELATION TO THE HEAD OF THE HOUSEHOLD HEAD ....1 SPOUSE............2 SON/DAUGHTER ....3 SON-IN-LAW/ DAUGHTER-IN-LAW .....4 HEAD'S PARENT ....5 SPOUSE'S PARENT ....6 HEAD'S BROTHER/ SISTER ....7 SPOUSE'S BROTHER/ SISTER ....8 GRANDCHILD...........9 GRANDPARENT ....10 OTHER RELATIVE ....11 NON-RELATIVE.........12	5 What is the relationship status of [NAME]? MARRIED ....1 NOT MARRIED, BUT LIVING TOGETHER ....2 DIVORCED/WIDOWED ..3 ➢Q7 LIVING APART BUT NOT DIVORCED..........4 ➢Q7 NEVER MARRIED ....5 ➢Q7	6 If [NAME]'s spouse is a household member, what is his/her name? IF THE SPOUSE NOT IN HOUSE-HOLD, WRITE ZERO	7 For how many months was [NAME] present here during the last 12 months? IF ANSWER IS MORE THAN 6 ➢NEXT PERSON	8 Why was [NAME] away during the last year? WORK ....1 STUDYING ...2 ➢Q 11 MILITARY ....3 HOSPITAL OR PRISON..........4 ➢Q 11 MARRIED INTO HH IN LAST YEAR ..5 ➢Q 11 BORN IN LAST YEAR............6 ➢NEXT PERSON OTHER 7	9 Does [NAME] support the family financially? YES .... 1 NO .... 2 ➢Q 11	10 Approx. how much money did [NAME] send to this household in the last 12 months?	11 Where did [NAME] spend most of his or her away from the household? THIS VILLAGE .... 1 ➢NEXT PERSON THIS DISTRICT DIF. VILLAGE ..... 2 THIS PROVINCE, DIF. DISTRICT..... 3 THIS ISLAND, DIF. PROVINCE .... 4 OTHER ISLAND IN FIJI .... 5 ➢Q 13 OTHER COUNTRY6 ➢Q 14	12 The place where [NAME] lives is SUVA..............1 BA...............2 KOROVU ....3 LAMI ....4 LAUTOKA ....5 NADI ....6 NASINU ....7 NAUSORI.........8 SIGATOKA ......9 TAVUA...........10 OTHER ....11 ➢NEXT PERSON	13 The place where [NAME] lives is VANUA LEVU .... 1 TAVEUNI .. 2 KADAVU ... 3 MAMANUCA GROUP ...... 4 YASAWA GROUP ...... 5 LOMAVITI GROUP ...... 6 LAU GROUP7 OTHER....... 8 ➢NEXT PERSON	14 The place where [NAME] lives is AUSTRALIA1 NEW ZEALAND..2 UK ....3 USA ....4 OTHER PACIFIC COUNTRY .5 OTHER N. AMERICA /EUROPE....6 OTHER 7
FULL NAME			#			ID CODE	#			$				
	1													
	2													
	3													
	4													
	5													
	6													
	7													
	8													
	9													
	10													
	11													
	12													

FORM 2. EDUCATION

QUESTIONS ARE TO BE ASKED OF ALL HOUSEHOLD MEMBERS AGED 7 YEARS OR OLDER
Household members are defined as all the people that lived in the household for 6 or more months in the last year.

ID CODE	1 How well are you able to read in Fijian? NOT AT ALL .... 1 SOME .... 2 FLUENTLY....... 3	2 How well are you able to read in English? NOT AT ALL .... 1 SOME .... 2 FLUENTLY 3	3 How well are you able to read in Fiji Hindi? NOT AT ALL.....1 SOME.................2 FLUENTLY 3	4 Do you know how to do arithmetic? YES................1 NO 2	5 Did you ever attend school? YES........... 1 NO .... 2 ➢NEXT PERSON	6 How many years of schooling did you complete?? #	7 Do you currently attend school? YES .... 1 NO .... 2 ➢NEXT PERSON	8 How much did the household spend during the past 12 months on [NAME'S] education for... IF NOTHING WAS SPENT, WRITE ZERO					
								A tuition and fees? $	B books and supplies? $	C uniforms? $	D transport to school? $	E room and board? $	F other (clubs, sports)? $
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													

FORM 3. HEALTH

QUESTIONS ARE TO BE ASKED OF ALL HOUSEHOLD MEMBERS

Household members are defined as all the people that lived in the household for 6 or more months in the last year.

I D C O D E	1 Do you suffer from a chronic illness or disability that has lasted more than 6 months? YES .... 1 NO .... 2 ➢Q 3	2 Which part of your body is most affected by this chronic illness or disability? HEART/CIRCULATORY SYSTEM .... 1 LUNGS/RESPIRATORY SYSTEM2 STOMACH/DIGESTIVE SYSTEM3 HEAD .... 4 ARMS OR LEGS.......................... 5 BACK/SPINE .... 6 OTHER INTERNAL ORGANS .... 7 OTHER... 8	3 Have you had any illness or injury during the past 4 weeks? YES .... 1 NO .... 2 ➢Q 6	4 What type of illness or injury did you have? COLD/FLU ....1 STOMACH PAIN ......2 DIARRHEA ....3 HEADACHE..............4 HEART ....5 LUNG ....6 BROKEN BONE........7 OTHER 8	5 How many days during the last month were you unable to carry on your usual activities because of illness, disability, or injury? # OF DAYS	6 In general would you say that your health is... Excellent? .... 1 ➢NEXT PERSON Good? .... 2 Fair? .... 3 Poor? 4	7 Does your health limit you a lot, a little or not at all when you perform the following activities? LIMITS A LOT .... 1 LIMITS A LITTLE .... 2 DOES NOT LIMIT AT ALL............ 3			
							A Vigorous activities such as running, lifting heavy objects, and doing hard labour? IF 3 ➢NEXT PERSON	B Moderate activities such as moving a table, climbing stairs, carrying groceries?	C Walking 100 meters?	D Eating, dressing and bathing?
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										

FORM 4. TIME ALLOCATION (MUST BE READ ACROSS PAGE)

Turn Page

QUESTIONS ARE TO BE ASKED OF ALL HOUSEHOLD MEMBERS AGED 7 YEARS OR OLDER. COMPLETE BOTH PAGES OF THE FORM FOR EACH PERSON BEFORE CONTINUING TO THE NEXT PERSON.

Household members are defined as all the people that lived in the household for 6 or more months in the last year.

ID CODE	1 In the past 7 days, did you attend school? YES .... 1 NO .... 2 ➢Q 4	2 How many of the last 7 days did you do this activity? DAYS	3 On days you did this activity, what was the average # of hours spent on it? HOURS	4 In the past 7 days, did you work for wages or work for any business? YES............ 1 NO .... 2 ➢Q 7	5 How many of the last 7 days did you do this activity? DAYS	6 On days you did this activity, what was the average # of hours spent on it? HOURS	7 In the past 7 days, did you travel more than 10 minutes away for school, work for wages, or work for any business? YES ....1 NO...............2 ➢Q 10	8 How many of the last 7 days did you do this activity? DAYS	9 On days you did this activity, what was the average # of hours spent on it? HOURS	10 In the past 7 days, did you work on your own farm in agriculture or raising animals? YES .... 1 NO .... 2 ➢Q 17	11 How many of the last 7 days did you do this activity? DAYS	12 On days you did this activity, what was the average # of hours spent on it? HOURS	TOTAL TIME IN AGRICULTURE Q11xQ12	13 Of those hours, how many did you spend clearing or cutting African tulip trees? HOURS	14 Of those hours, how many did you spend clearing or cutting other trees? HOURS	15 Of those hours, how many did you spend clearing or cutting Merremia vine? HOURS	16 Of those hours, how many did you spend clearing or cutting other vines and weeds? HOURS
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	

ID CODE	17 In the past 7 days, did you go fishing or hunting? YES .... 1 NO .... 2 ➢Q 22	18 How many of the last 7 days did you do this activity? DAYS	19 On days you did this activity, what was the average # of hours spent on it? HOURS	TOTAL TIME IN HUNTING AND FISHING Q18xQ19	20 Of those hours, how many did you spend hunting or trapping wild boar and roaming pigs? HOURS	21 Of those hours, how many did you spend hunting or trapping mongoose? HOURS	22 In the past 7 days, did you attend to village business or do work for the village? YES .... 1 NO............. 2 ➢Q 25	23 How many of the last 7 days did you do this activity? DAYS	24 On days you did this activity, what was the average # of hours spent on it? HOURS	25 In the past 7 days, did you do household chores, including cooking, cleaning, and caring for children or old people? YES............ 1 NO .... 2 ➢Q 28	26 How many of the last 7 days did you do this activity? DAYS	27 On days you did this activity, what was the average # of hours spent on it? HOURS	28 In the past 7 days, did you do leisure activities such as watching TV, talking with friends, sports and drinking kava (not including sleep)? YES............ 1 NO .... 2 ➢NEXT PERSON	29 How many of the last 7 days did you do this activity? DAYS	30 On days you did this activity, what was the average # of hours spent on it? HOURS
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
11															
12															

FORM 5. AGRICULTURE (MUST BE READ ACROSS PAGE)

This form should be asked of the household head or the household member who knows most about agriculture.

1. Has any member of this household raised any crops in the past 12 months?

YES 1 [ ]
NO 2 ➢NEXT FORM

CROP CODE	ASK QUESTION 2 FOR EACH CROP AND THEN ASK QUESTIONS 3-17 FOR THE APPLICABLE CROPS	2 Have the members of your household grown [CROP] during the past 12 months? YES......... 1 NO .... 2 ➢NEXT CROP	3 What is the total size of the plot or plots used to grow [CROP] during the past 12 months? GARDEN .. 1 <¼ AC .... 2 ¼-½ AC ..... 3 ½-1 AC ...... 4 1-3 AC .... 5 3-5 AC .... 6 >5 AC 7	4 If there were no pests, disease, droughts, or flood, how many KGs of [CROP] could you harvest from this land over the last 12 months?	5 Were any [CROP] lost to disease, droughts, or flood? YES...... 1 NO .... 2 ➢Q 7	6 How many KGs of [CROP] were lost to disease, drought, or floods?	7 Were any [CROPS] lost to pests such as wild boars, insects, or birds? YES ..... 1 NO .... 2 ➢Q 11	8 What was the main pest that affected [CROP]? BOAR/PIGS…...1 OTHER ANIMALS………2 SNAILS………...3 TARO BEETLE..4 ANTS/ TERMITES........5 OTHER INSECTS……...6 BULBULS……..7 OTHER BIRDS…………8		9 How many KGs of [CROP] were lost to all pests in the last 12 months?	11 How many KGs of [CROP] were sold in the last 12 months?	12 What was the average selling price of [CROP] per KG?	13 How much [CROP] has been consumed by household members in the last 12 months?	14 How many KGs of [CROP] were processed into other goods by household members in the last 12 months?	15 How many KGs of this year's [CROP] does your household have in storage?	16 Did you grow other crops in the same field at the same time as [CROP]? YES............ 1 NO .... 2 ➢NEXT CROP	17 Which crops? LIST THE 2 MOST IMPORTANT CROP CODES	
	CROP			KGS		KGS				KGS	KGS	$ PER KG	KGS	KGS	KGS		#1	#2
1	Dalo																	
2	Cassava																	
3	Dalo Ni Tana																	
4	Ginger																	
5	Kumala																	
6	Yaqana																	
7	Yams																	
8	Duruka																	
9	Other Root Crops																	
10	Rice																	
11	Pulses/Beans																	
12	Fresh Vegetables																	
13	Maize																	
14	Banana																	
15	Plantains																	
16	Coconut																	
17	Pineapple																	
18	Pawpaw																	
19	Melon, Watermelon																	
20	Citrus Fruit																	
21	Other Fruits																	
22	Sugarcane																	
23	Cut Flowers																	
24	Nuts																	

18. Did any member of this household have a business processing food products, for example by making jam, oil, dried fruit, kava, beer, or any other product from crops grown by your household?
YES ....1 [ ]
NO ....2 ➢Q25

OUTPUT CODE	ASK QUESTION 19 FOR EACH FOOD PRODUCT AND THEN ASK QUESTIONS 20-24 FOR THE APPLICABLE FOOD PRODUCTS	19 During the past 12 months, has any member of your household made [FOOD PRODUCT] from crops grown by the household? YES............ NO .... ➢NEXT FOOD PRODUCT	20 How much [FOOD PRODUCT] did you produce in the past 12 months?		21 How much [FOOD PRODUCT] was sold in the past 12 months?		22 What was the average selling price of [FOOD PRODUCT]?		23 How much [FOOD PRODUCT] has been consumed by household members in the last 12 months?		24 How many KGs of [FOOD PRODUCT] produced in the last 12 months does your household have in storage?	
	FOOD PRODUCT		AMT	UNITS	AMT	UNITS	$	UNITS	AMT	UNITS	AMT	UNITS
1	Coconut oil											
2	Jam, compote											
3	Kava											
4	Other #1											
5	Other #2											
6	Other #3											

1 KG	3 ml
2 litre	

INPUT CODE	ASK QUESTION 25 FOR EACH INPUT AND THEN ASK QUESTIONS 26-28 FOR THE APPLICABLE INPUTS	25 Have the members of your household purchased [INPUT] during the past 12 months? YES.................... 1 NO 2	26 How much [INPUT] did you purchase during the past 12 months?		27 What was the average price paid per unit of [UNPUT] purchased during the past 12 months?	28 What was the total amount paid for [INPUT] during the last 12 months?
	INPUT		QTY	UNITS	$	$
1	NPK					
2	Urea					
3	Other Fertilizer					
4	Chicken Manure					
5	Cow Manure					
6	Compost Manure					
7	Orthene					
8	Other Pesticide #1					
9	Other Pesticide #2					
10	Gramaxzone					
11	Paraquat					
12	Rambo					
13	Round-up					
14	Glysophate					
15	Other herbicide					
16	Sunsis					
17	Other fungicide #1					
18	Other fungicide #2					
19	Labour for clearing land					
20	Labour for planting					
21	Labour for harvesting					
22	Other agricultural labour					
23	Animal rental					
24	Equipment rental					
25	Equipment maintenance					
26	Land taxes					
27	Other agricultural inputs					

FORM 6. LIVESTOCK

This form should be asked of the household head or the household member who knows most about livestock.

1. Has any member of this household raised large livestock such as cattle, horses, pigs, and goats in the past 12 months?
   YES 1 [ ]
   NO 2 ➢Q 14

STOCK CODE	ASK QUESTION 2 FOR EACH TYPE OF STOCK AND THEN ASK QUESTIONS 3-9 FOR THE APPLICABLE STOCK STOCK	2 Did any member of your household raise [STOCK] in the last 12 months? YES.........1 NO 2	3 How many [STOCK] do members of your household currently own? \#	4 How many [STOCK] did members of your household own at this time last year? \#	5 How many [STOCK] were purchased during the last 12 months? \#	6 How many [STOCK] were sold during the last 12 months? \#	7 How many [STOCK] were consumed by the household during the last 12 months? \#	8 How many [STOCK] died of disease, accident, drought, old age, or other natural causes? \#	9 What is the average price of [STOCK] if one was bought or sold today? $
1	Beef cattle								
2	Dairy cows								
3	Horses								
4	Pigs								
5	Sheep								
6	Goats								

PROD CODE	ASK QUESTION 10 FOR EACH PRODUCT AND THEN ASK QUESTIONS 11-13 FOR THE APPLICABLE PRODUCT BYPRODUCT	10 Did any livestock produce [BYPRODUCT] in the last 12 months? YES .... NO	11 Approximately how much [BYPRODUCT] was produced? AMT	 UNIT	12 Approximately how much [BYPRODUCT] was sold? AMT	 UNIT	13 What is the average price of [BYPRODUCT] if it is bought or sold today? $	 UNIT
1	Milk			litres		litres		litres
2	Fresh meat			kg		kg		kg
3	Cheese/yogurt/butter			kg		kg		kg
4	Tanned skins			skins		skins		skins
5	Wool			kg		kg		kg
6	Manure			35 kg sack		35 kg sack		35 kg sack
7	Other							

14. Has any member of this household raised chickens, ducks, geese, pond fish, or bees in the past 12 months?
    YES ....1 [ ]
    NO..2 IF Q1=2 & Q14=2 ➢NEXT FORM; OTHERWISE ➢Q 26

STOCK CODE	ASK QUESTION 15 FOR EACH TYPE OF STOCK AND THEN ASK QUESTIONS 16-21 FOR THE APPLICABLE STOCK STOCK	15 Did any member of your household raise [STOCK] in the last 12 months? YES.........1 NO 2	16 Approximately how many [STOCK] do members of your household currently own? \#	17 What is the average price of [STOCK] if bought or sold today? $	 UNIT	18 Have any of the [STOCK] been attacked by mongoose in the last 12 months? YES ....1 NO...........2 ➢Q 20	19 Approx. how many have been killed, injured, or damaged by mongoose in the last 12 months? \#	20 Have any of the [STOCK] been attacked by wild boars or roaming pigs in the last 12 months? YES ....1 NO...........2 ➢NEXT STOCK	21 Approx. how many have been killed, injured, or damaged by wild boars or roaming pigs in the last 12 months? \#
1	Chickens				each				
2	Chicks				each				
3	Ducks/geese				each				
4	Ducklings/goslings				each				
5	Pond fish				kg				
6	Bee hives				hive				

PROD CODE	ASK QUESTION 22 FOR EACH PRODUCT AND THEN ASK QUESTIONS 23-25 FOR THE APPLICABLE PRODUCT BYPRODUCT	22 Did any livestock produce [BYPRODUCT] in the last 12 months? YES .... NO	23 Approximately how much [BYPRODUCT] was produced in the last 12 months? AMT	 UNIT	24 Approximately how much [BYPRODUCT] was sold in the last 12 months? AMT	 UNIT	25 What is the average price of [BYPRODUCT] if it is bought or sold today? $	 UNIT
1	Eggs			dozen		dozen		dozen
2	Honey			litres		litres		litres
3	Other							

1 KG	2 LITRES

INPUT CODE	ASK QUESTION 26 FOR EACH INPUT AND THEN ASK QUESTIONS 27 FOR THE APPLICABLE INPUTS INPUT	26 Have the members of your household purchased [INPUT] during the past 12 months? YES .... 1 NO 2	27 How much in total was spent on [INPUT] during the past 12 months? $
1	Feed for animals		
2	Veterinary services		
3	Transportation for animals		
4	Commissions on sales		
5	Packaging for animal products		
6	Sheep shearing		
7	Wool washing		
8	Paid labour for herding		
9	Other expenses		

FORM 7. OTHER AGRICULTURAL INCOME

This form should be asked of the household head or the household member who knows most about agriculture.

1. Did any member of this household rent land out to the Native Land Trust Board? [ ]
   YES 1
   NO .... 2 ➢Q 4

2. In total, how much land was rented out to the National Land Trust Board in the last 12 months? [ ]

1 garden	3 ¼-½ AC	5 1-3 AC	7 >5 AC
2 <¼ AC	4 ½-1 AC	6 3-5 AC	

3. What was the total amount of income from renting land to the National Land Trust Board In the last 12 months?

   AMOUNT IN $ [ ]

4. Did any member of this household do compensated agricultural work for other people in the last 12 months? [ ]
   YES 1
   NO .... 2 ➢NEXT FORM

5. What was the total amount of income from agricultural work on other peoples' farms In the last 12 months?

   AMOUNT IN $ [ ]

TIME UNITS	DAY 3	MONTH 5	HALF YEAR 7
	WEEK 4	QUARTER 6	YEAR 8

FORM 8. EXTENSION SERVICES

This form should be asked of the household head or the household member who knows most about agriculture and livestock.

1. Has any member of this household met with an extension officer to discuss raising crops in the last 12 months?
   YES ....1 [ ]
   NO ....2 ➢Q 4

2. What crops were discussed? [ ] [ ] [ ]
[REFER TO FORM 5. IF MORE THAN 3, LIST 3 MOST IMPORTANT]

3. What kind of information or assistance was provided? [ ] [ ] [ ]
[IF MORE THAN 3, LIST 3 MOST IMPORTANT]

1 use of fertilizer/pesticides	6 marketing advice	11 other weed/vine control
2 irrigation	7 credit advice	12 boar/pig control
3 new seed varieties	8 African tulip tree control	13 taro beetle control
4 soil problems	9 other tree control	14 ant/termite/snail control
5 weather problems	10 merremia control	15 bird control

4. Has any member of this household met with an extension officer to discuss raising livestock in the last 12 months?
   YES ....1 [ ]
   NO ....2 ➢Q 7

5. What livestock was discussed? [ ] [ ] [ ]

[REFER TO FORM 6. IF MORE THAN 3, LIST 3 MOST IMPORTANT]

6. What kind of information or assistance was provided? [ ] [ ] [ ]
[IF MORE THAN 3, LIST 3 MOST IMPORTANT]

1 vaccinations	4 insemination services	7 mongoose control
2 animal nutrition	5 marketing advice	8 boar/pig control
3 animal disease	6 credit advice	

7. Did anyone else visit this household to discuss species that may be harmful in the last 12 months?
   YES ....1 [ ]
   NO ....2 ➢NEXT FORM

8. Which species were discussed in detail? [ ] [ ] [ ]
[IF MORE THAN 3, LIST 3 MOST IMPORTANT]

1 African tulip tree	4 other vines or weeds	7 wild boar/roaming pigs
2 Pond Apple/other tree	5 taro beetle	8 birds
3 Merremia vine	6 mongoose	9 fish
		10 other

FORM 9. FISHING

This form should be asked of the household head or the household member who knows most about fishing.

1. Has any member of this household regularly caught wild fish, prawns, oysters, mussels, lobsters, crabs, eels, or other seawater life for consumption?

YES ....1 [ ]
NO ....2 ➢NEXT FORM

FISH CODE	ASK QUESTION 2 FOR EACH TYPE OF FISH AND THEN ASK QUESTIONS 3-9 FOR THE APPLICABLE FISH. . FISH	2 Have the members of your household gone fishing for [FISH] during the past 12 months? YES .... 1 NO .... 2 ➢NEXT FISH	3 How many KGs of [FISH] did you harvest in the last 12 months? KGS	4 Is this amount more or less than your household caught 1 year ago? MUCH MORE………...1 MORE…………………2 ABOUT THE SAME….3 LESS.........................4 MUCH LESS………….5 NOT SURE……………9	5 Is this amount more or less than your household caught 10 years ago? MUCH MORE…………..1 MORE…………………….2 ABOUT THE SAME.......3 LESS……………………..4 MUCH LESS…………….5 NOT SURE………………9	6 How many KGs of [FISH] were sold during the last 12 months? KGS	7 What was the average selling price of [FISH] per KG? $	8 How much [FISH] has been consumed by household members? KGS	9 How many KGs of [FISH] does your household have in storage? KGS
1	Siganidae (Rabbitfish)								
2	Acanthuridae (surgeonfish)								
3	Mullidae (goatfish)								
4	Serranidae (groupers)								
5	Lethrinidae (emperors)								
6	Scombridae (tunas)								
7	Carangidae (trevallies/jacks)								
8	Lutjanidae (snappers)								
9	Sphyraenidae (barracudas)								
10	Scaridae (parrotfishes)								
11	Tetrapontidae (grunters)								
12	Oysters/clams/molluscs								
13	Sea cucumbers								
14	Seaweeds								
15	Prawns								
16	Lobster								
17	Octopus								
18	Other saltwater species #1								
19	Other saltwater species #2								
20	Other saltwater species #3								

FORM 9. FISHING CONTINUED

This form should be asked of the household head or the household member who knows most about fishing.

10. Has any member of this household regularly caught wild fish, crabs, eels, or other freshwater life for consumption?

YES 1 [ ]
NO 2 ➢NEXT FORM

FISH CODE	ASK QUESTION 10 FOR EACH TYPE OF FISH AND THEN ASK QUESTIONS 12-18 FOR THE APPLICABLE FISH. FISH	11 Have the members of your household gone fishing for [FISH] during the past 12 months? YES.1 NO ..2 ➢NEXT FISH	12 How many KGs of [FISH] did you harvest in the last 12 months? KGS	13 Is this amount more or less than your household caught 1 year ago? MUCH MORE .... MORE…………………2 ABOUT THE SAME….3 LESS.........................4 MUCH LESS…………5 NOT SURE……………9	14 Is this amount more or less than your household caught 10 years ago? MUCH MORE .... MORE……………………2 ABOUT THE SAME.......3 LESS……………………..4 MUCH LESS…………….5 NOT SURE………………9	15 How many KGs of [FISH] were sold during the last 12 months? KGS	16 What was the average selling price of [FISH] per KG? $	17 How much [FISH] has been consumed by household members? KGS	18 How many KGs of [FISH] does your household have in storage? KGS
1	Freshwater clams								
2	Freshwater eels								
3	Freshwater crabs								
4	Freshwater prawns								
5	Tilapia								
6	Carp								
7	Other freshwater species #1								
8	Other freshwater species #2								
9	Other freshwater species #3								

CODE	ASK QUESTION 10 FOR EACH INPUT AND THEN ASK QUESTION 11 FOR THE APPLICABLE INPUTS INPUT	19 Have the members of your household purchased or hired [INPUT] during the past 12 months? YES.................................. 1 NO 2	20 What was the total price paid for [INPUT] in the last 12 months? $
1	Boats and boat repair		
2	Bait and tackle		
3	Traps		
4	Fishing gear		
5	Hired labour		
6	Fuel		
7	Other fishing costs		

IF NO FISH IS CAUGHT (Q1=2 AND Q10=2), DO NOT ASK Q19 AND Q20

FORM 10. LABOUR FOR WAGES OR SALARY (MUST BE READ ACROSS)

QUESTIONS ARE TO BE ASKED OF ALL **HOUSEHOLD MEMBERS** AGED 7 YEARS OR OLDER

Household members are defined as all the people that lived in the household for 6 or more months in the last year.

I D C O D E	1	2	3	4	5	6	7	8	9	10	11		12	13	14	15	16	
	During the past 12 months, did you spend 1 month or more working for wages or salary? YES .... 1 ➢Q 3 NO 2	What is the main reason that you did not work for wages or salary? WORK ON OWN FARM OR FAMILY BUSINESS......1 SCHOOL, TOO YOUNG ....2 RETIRED, TOO OLD ....3 HOMEMAKER, CHILD CARE.4 SICKNESS......5 PRISON ....6 OTHER 7	In what field was your main wage/salary job in the last 12 months? AGRICULTURE, FISHING .... 1 VILLAGE ADMIN .... 2 CHURCH WORK............. 3 SHOP.............. 4 CONSTRUCTION...................... 5 OTHER BUSINESS ...... 6 GOVERNMENT, SAFETY .... 7 OTHER............ 8	Where was this job located? THIS VILLAGE. 1 ➢Q 8 THIS DISTRICT, DIF. VILLAGE .. 2 ➢Q 8 THIS PROVINCE, DIF. DISTRICT..........3 THIS ISLAND, DIF. PROVINCE ....4 OTHER ISLAND IN FIJI................5 ➢Q 6 OTHER COUNTRY ....6 ➢Q 7	What is the name of this place? SUVA .... 1 BA .... 2 KOROVU ...... 3 LAMI............. 4 LAUTOKA.... 5 NADI .... 6 NASINU .... 7 NAUSORI ..... 8 SIGATOKA... 9 TAVUA ....10 OTHER.........11 ➢Q 8	What is the name of this place? VANUA LEVU1 TAVEUNI...... 2 KADAVU ...... 3 MAMANUCA GROUP.......... 4 YASAWA GROUP.......... 5 LOMAVITI GROUP.......... 6 LAU GROUP . 7 OTHER .... 8 ➢Q 8	The place where [NAME] lives is AUSTRALIA .1 NEW ZEALAND .....2 UK..................3 USA................4 OTHER PACIFIC COUNTRY.....5 OTHER N. AMERICA / EUROPE ....6 OTHER...........7	Out of the last 12 months, how many months did you work in your main wage/salary job?	In the typical month that you worked this job, how many days did you work?	On a typical day, how many hours did you work at this job?	How much was your wage from this job? HOUR .... 1 DAY............... 2 WEEK........... 3 FORTNIGHT . 4 MONTH......... 5 YEAR 6		During the past 12 months, did you spend 1 month or more working a second job for wages or salary? YES ....1 NO...............2 ➢NEXT FORM	Out of the last 12 months, how many months did you work in your second wage/salary job?	In the typical month that you worked this job, how many days did you work?	On a typical day, how many hours did you work at this job?	How much was your wage from this job? HOUR .... 1 DAY............... 2 WEEK........... 3 FORTNIGHT . 4 MONTH......... 5 YEAR 6	
		➢NEXT PERSON						MONTHS	DAYS	HOURS	$	UNIT		MONTHS	DAYS	HOURS	$	UNIT
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		

FORM 11. OTHER INCOME

This form should be asked of the household head or another senior household member.

1. In the last 12 months, did any member of your household receive rent for housing, equipment, or anything other than renting land to the National Land Trust Board?
   YES ....1 [ ]
   NO ....2 ➢Q 5

CODE	ASK QUESTION 2 FOR EACH RENTAL ITEM AND THEN ASK QUESTIONS 3-4 FOR THE APPLICABLE RENTAL ITEMS RENTAL ITEM	2 Did you receive rent for [RENTAL ITEM] during the past 12 months? YES .... 1 NO .... 2 ➢Q 5	3 How many months in the last 12 did you receive this rent? # OF MONTHS	4 What was the average amount of rent each month it was received? $/MONTH
1	Housing other than this home			
2	Cars, trucks, tractors			
3	Boats			
4	Farm animals			

5. In the last 12 months, did any member of your household receive government assistance such as the Family Assistance Program or benefits such as a private pension?
   YES ....1 [ ]
   NO ....2 ➢NEXT FORM

CODE	ASK QUESTION 6 FOR EACH BENEFIT AND THEN ASK QUESTIONS 7-8 FOR THE APPLICABLE BENEFITS BENEFITS	6 Did you receive [BENEFITS] during the past 12 months? YES.............................. 1 NO .... 2 ➢NEXT FORM	7 How many months in the last 12 did you receive this benefit? #	8 What was the average amount of the benefit each month it was received? $
1	Government Pension (civil servant, military)			
2	Family Assistance Program			
3	Disability benefits			
4	Old age pension (>60 yrs)			
5	Other government support			
6	Private pension			
7	Other private support			

FORM 12. DURABLE GOODS

This form should be asked of the household head or another senior household member.

CODE	ASK QUESTION 1 FOR EACH DURABLE AND THEN ASK QUESTIONS 2-6 FOR THE APPLICABLE DURABLES DURABLE	1 Do the members of your household own any [DURABLE]? YES ....1 NO.......................................2 ➢NEXT ITEM	2 How many [DURABLE] do you own? #	3 What is the total value of [DURABLE] if you sold all that you own today? $
1	Cell phone			
2	Personal computer			
3	Television			
4	DVD Player			
5	Stereo, radio, or tape recorder			
6	Camera or video camera			
7	Air conditioner			
8	Electric fan			
9	Gas or electric stove			
10	Refrigerator			
11	Other kitchen appliances			
12	Automatic washing machine			
13	Sewing or knitting machine			
14	Generator			
15	Bicycle			
16	Motorcycle or moped			
17	Passenger automobile or van			
18	Motorized boat			
19	Non-motorized boat			
20	Tractor			
21	Brushcutter			
22	Chainsaws			
23	Other farming tools (e.g. plough)			
24	Carpentry tools			
25	Watches and jewellery			
26	Other durable asset			

4. Do you have a chequing account, a bank account, or any financial investments?
   YES 1 [ ]
   NO 2 ➢NEXT FORM
5. What is the approximate value of all bank accounts and financial investments combined?
   AMOUNT IN $ [ ]

FORM 13. DWELLING

This form should be asked of the household head or another senior household member.

1. How long has your household been living in this dwelling?

YEARS [ ]

2. What is the space of your dwelling?

SQUARE METERS [ ]

3. In approximately what year was this dwelling built?

ASK THE RESPONDENT TO PROVIDE AN ESTIMATE IF UNSURE OF THE EXACT YEAR

YEAR BUILT [ ]

4. WHAT IS THE MAJOR CONSTRUCTION MATERIAL OF THE EXTERNAL WALLS?

CORRUGATED IRON/METAL SHEETS.....1 [ ]
CYNDER BLOCKS/CONCRETE.....2
BRICKS.....3
WOOD/WOVEN BAMBOO/REEDS.....4
OTHER (SPECIFY______________________).....5

5. WHAT IS THE MAJOR MATERIAL OF THE ROOF?

CORRUGATED IRON/METAL SHEETS.....1 [ ]
THATCH.....2
TILES.....3
WOOD.....4
PADANAS/PALM LEAVES.....5
OTHER (SPECIFY ___________________).....6

6. Do you own this dwelling?
YES.....1 [ ]
NO.....2 ➢Q 14

TIME UNITS	DAY.....3	MONTH.....5	HALF YEAR.....7
	WEEK.....4	QUARTER.....6	YEAR.....8

7. If you sold this dwelling today, how much would you receive for it?

AMOUNT IN $ [ ]

8. Estimate the amount of money you could receive as rent if you moved away and let this entire dwelling out.
AMOUNT IN $ [ ]

TIME UNIT [ ]

9. Does anyone pay the household head rent to live in this dwelling?

YES.....1 [ ]
NO.....2 ➢NEXT FORM

10. Is any of the rent paid in money?

YES.....1 [ ]
NO.....2 ➢Q 12

11. How much money is paid in rent?
AMOUNT IN $ [ ]

TIME UNIT [ ]

12. Is any of the rent paid in goods or services?

YES.....1 [ ]
NO.....2 ➢NEXT FORM

13. What is the approximate value of the goods and services paid to your household?
AMOUNT IN $ [ ]

TIME UNIT [ ]
➢NEXT FORM

14. Does your household pay rent in money to live in this dwelling?

YES.....1 [ ]
NO.....2 ➢NEXT FORM

15. How much does your household pay in money to rent this dwelling?
AMOUNT IN $ [ ]

TIME UNIT [ ]

16. Does your household pay rent with goods or services?

YES.....1 [ ]
NO.....2 ➢NEXT FORM

17. What is the approximate value of the goods and services paid by your household?
AMOUNT IN $ [ ]

TIME UNIT [ ]

FORM 14. INVASIVE SPECIES

This form should be asked of the household head or another senior household member.

READ THE FOLLOWING STATEMENT TO THE RESPONDENT. SHOW SLIDES TO ENSURE THAT THE RESPONDENT IS FAMILIAR WITH ALL 5 SPECIES.

I am now going to read some statements about 5 different plants and animals that may be here in the community. Those species are: African tulip tree, Merremia vine, taro beetle, Asian mongoose, and Red-Vented Bulbul. For each statement, please state whether you agree, disagree, or are neutral.

	Disagree	Neutral	Agree
1. It is bad that the mongoose is found in this village.			
2. People in this village are happy when they see the merremia vine.			
3. I would like to have more taro beetle in this village.			
4. There are more good things about the bulbul than bad things.			
5. People in this village are happy when they see the taro beetle.			
6. It is bad that the tulip tree is found in this village.			
7. I would like to have more bulbul in this village.			
8. There are more bad things about the taro beetle than good things.			
9. It is bad that the merremia vine is found in this village.			
10. There are more bad things about the mongoose than good things.			
11. People in this village are unhappy when they see the tulip tree.			
12. I would like to have less merremia vine in this village.			
13. It is bad that the bulbul is found in this village.			
14. There are more good things about the merremia vine than bad things.			
15. I would like to have less tulip tree in this village.			
16. People in this village are happy when they see the mongoose.			
17. There are more good things about the tulip tree than bad things.			
18. It is good that the taro beetle is found in this village.			
19. I would like to have more mongoose in this village.			
20. People in this village are unhappy when they see the bulbul.			

FORM 15. CONTINGENT VALUATION

GIVE THE RESPONDENT 70 BEANS. READ THE FOLLOWING STATEMENT TO THE RESPONDENT:

In 2008, the government spent about $700 million on defence; public order and safety; economic affairs such as construction, mining, transportation, and labour; environmental protection such as water pollution and soil erosion and control of harmful species such as [LIST TWO MOST HARMFUL SPECIES FROM FORM 14]; housing and community amenities; health, recreation, culture, and religion; education; and social protection such as the Family Assistance Program.

Imagine that this pile of beans represents all the money that the government can spend on all of these things. If you were the budget minister, how much would you allocate to each of these categories? Please place the beans on the appropriate rectangles.

COUNT THE NUMBER OF BEANS ON EACH RECTANGLE. LIST THE NUMBERS BELOW.

1. DEFENCE [ ]
2. PUBLIC ORDER AND SAFETY [ ]
3. ECONOMIC AFFAIRS [ ]
4. ENVIRONMENTAL PROTECTION AND CONTROL OF HARMFUL SPECIES [ ]
5. HOUSING AND COMMUNITY AMENITIES [ ]
6. HEALTH [ ]
7. RECREATION, CULTURE, AND RELIGION [ ]
8. EDUCATION [ ]
9. SOCIAL PROTECTION [ ]

COLLECT ALL BEANS EXCEPT THOSE ALLOCATED TO ENVIRONMENTAL PROTECTION AND CONTROL OF HARMFUL SPECIES.

READ THE FOLLOWING STATEMENT TO THE RESPONDENT.

You allocated [NUMBER OF BEANS] to environmental protection and control of harmful species. Of that, how much would you allocate to environmental protection (such as controlling erosion and preventing water pollution) and how much would you allocate to controlling harmful species such as [LIST TWO MOST HARMFUL SPECIES FROM FORM 14]?

COUNT THE NUMBER OF BEANS ON EACH RECTANGLE. LIST THE NUMBERS BELOW.

10. ENVIRONMENTAL PROTECTION [ ]
11. CONTROL OF HARMFUL SPECIES [ ]

COLLECT ALL BEANS EXCEPT THOSE ALLOCATED TO CONTROL OF HARMFUL SPECIES.

READ THE FOLLOWING STATEMENT TO THE RESPONDENT:

You allocated [NUMBER OF BEANS] to control of harmful species. Of that, how much would you allocate to controlling each of the 5 species we discussed already and how much to other species??

COUNT THE NUMBER OF BEANS ON EACH RECTANGLE. LIST THE NUMBERS BELOW.

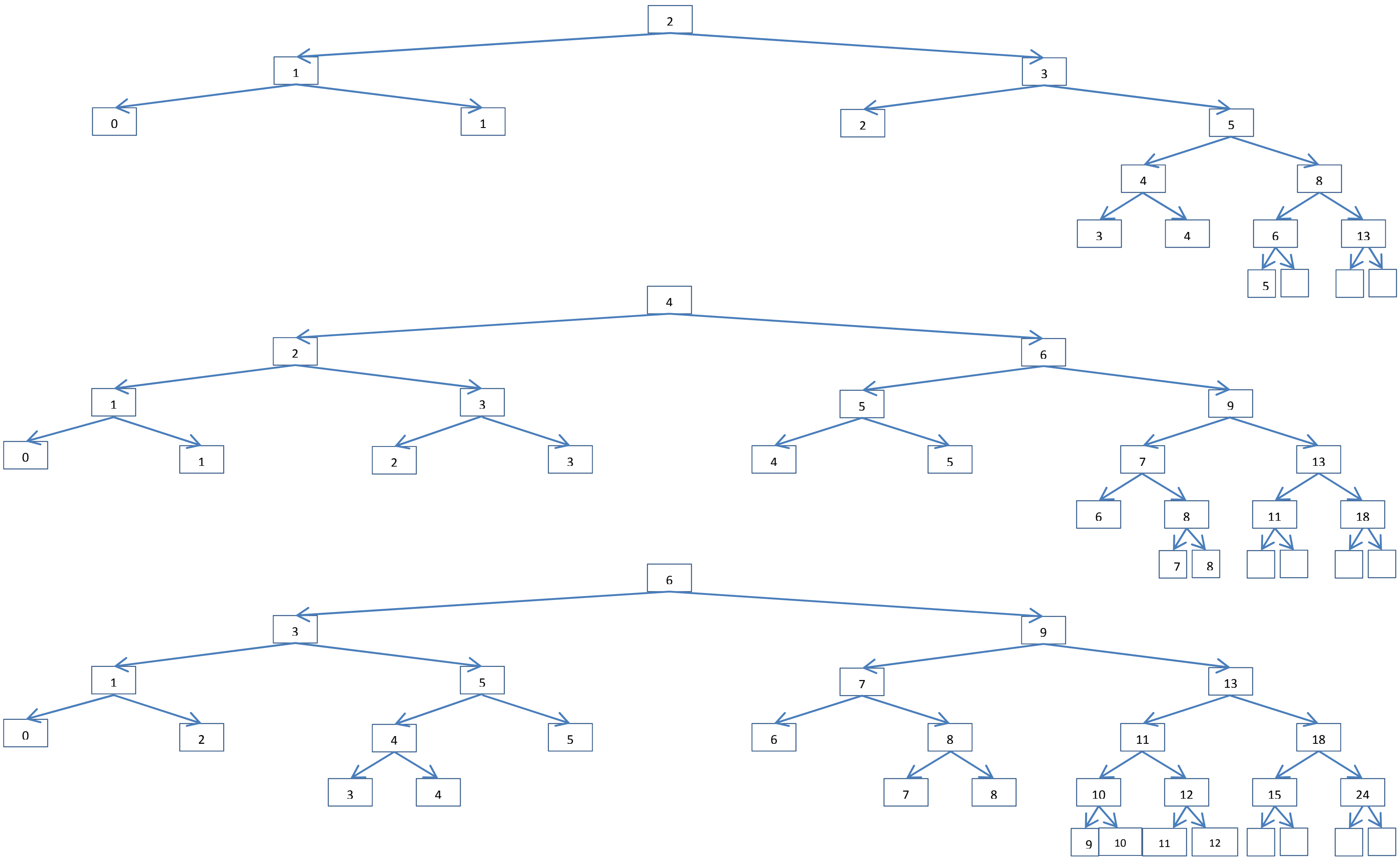
12. AFRICAN TULIP TREE [ ]
13. INDIAN MONGOOSE [ ]
14. BULBUL [ ]
15. MERREMIA VINE [ ]
16. TARO BEETLE [ ]
17. OTHER SPECIES [ ]

ROLL 1 DICE. MULTIPLY THE NUMBER SHOWN ON THE DICE BY 2. THIS INDICATES WHERE TO START ON THE TREE.

AT AN EMPTY BOX, ASK "WHAT IS THE MOST YOU ARE WILLING TO WORK?" CIRCLE THE FINAL ANSWER

READ THE FOLLOWING STATEMENT TO THE RESPONDENT.

Imagine that the researchers at the University of the South Pacific developed a new way to completely control the [MOST HARMFUL SPECIES IDENTIFIED BY THE RESPONDENT] in this village. Unfortunately, for this project to work, it would require every adult in the village to volunteer some of his or her time in addition to any time already given to the village. Would all adult members of your household be willing to volunteer [DICE] hours per week? If someone in the household couldn't volunteer that amount of time, another person in the household could substitute for him or her.


2
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15
24
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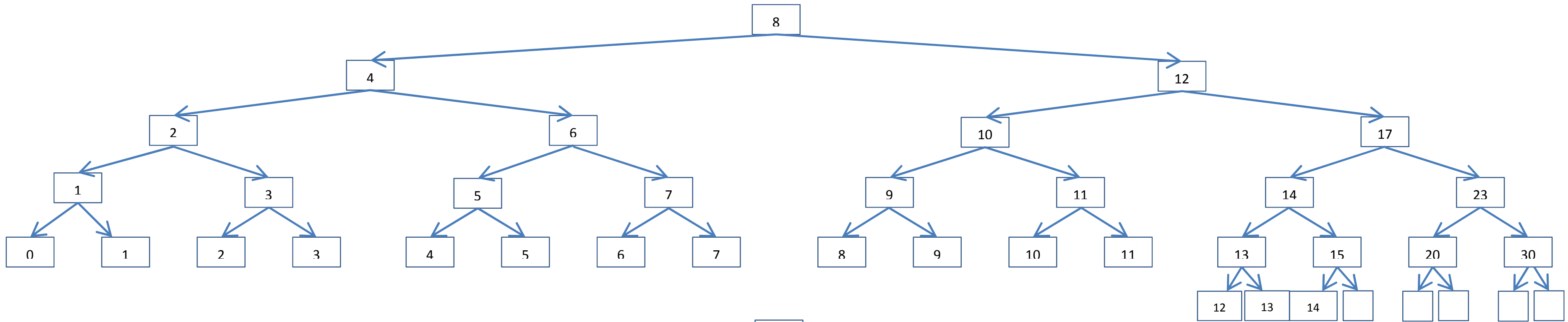
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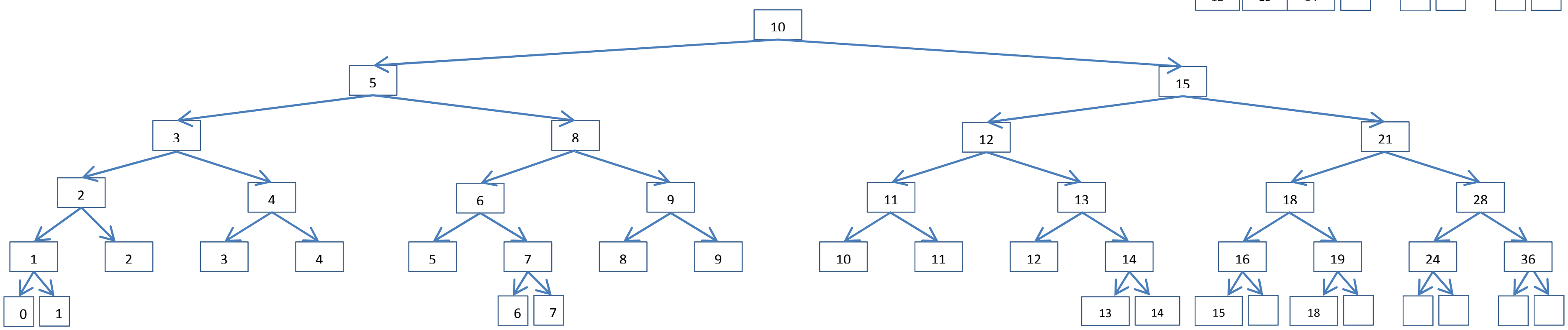
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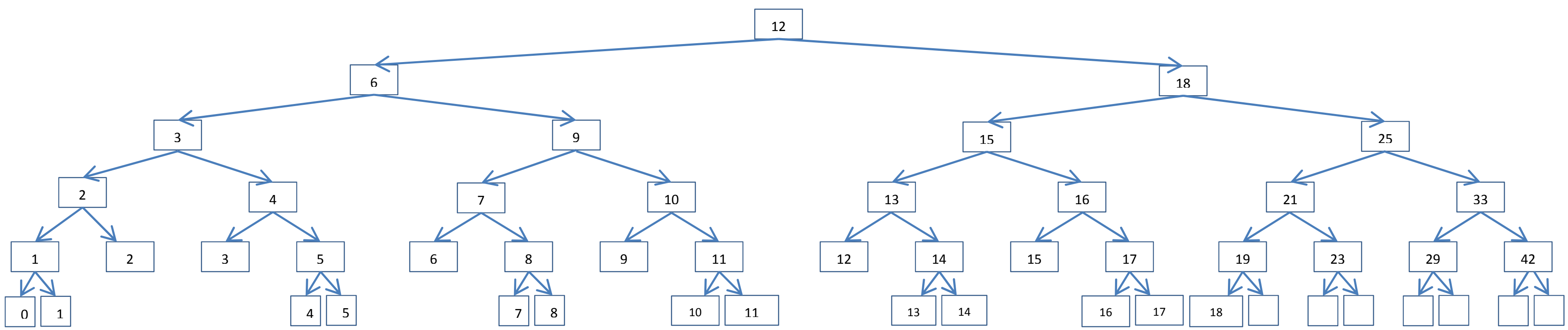
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Appendix 6: Survey Form – Household/Individual (Fijian)

888	Do not know
999	Refuse to answer

Yaca ni koro: ____________________________

Naba ni Vuvale _____________________________

Ni sa bula. Na yacaqu ko (YACA), au gonevuli/cakacaka/qasenivuli tiko ena Univesiti ni Ceva ni Pasivika. Keitou qarava tiko edua na vakadidike ni bula vakailavo ena veikorokoro vata kei na dua na tabana mai Niusiladi, na Landcare Research in New Zealand.

Keitou na vakasokomuna tiko e rauta ni 360 na vuvale ena loma ni 30 na koro ena tokalau kei Viti Levu. Na vakadidike talega qo ena qaravi talega e Taveuni.

Na vakadidike oqo e baleta tiko na bula vakailavo, keitou na kerea tiko eso na i tukutuku bibi ni nomuni rawaka vakailavo e na loma ni vuvale ka kena i kuri na taro me baleta na teitei, susu manumanu, na lewe ni vuvale kei nai ulutaga tale eso. E na vakayagataki nai sau ni taro, ia ena sega ni vakaraitaki na yacamuni se yaca ni vuvale. Keitou yalataka talega ni keitou na sega ni wasea nai tukutuku kei dua na lewe ni vuvale se lewe ni koro.

Na vakatataro oqo e na kovuta tiko e tinikava nai ulutaga ka rauta vakacaca na 1 kina 1.5 na aua. Ena soli tale tikoga ena koro e dua na ka ni vakavinavinaka ena vuku ni nomuni saumi taro.

Ko sa duavata mo vakaitavi ena vakatataro oqo?

Au sa ciqoma na veika sa vakaraitaki ka'u sa duavata meu vakaitavi.

_________________________	_________________________	_________________________
YACA	SAINI	NABA NI TALEVONI

Yaca ni dau tauri tukutuku: ____________________________

Mobile nei dau tauri tukutuku: ______________________________

So tale na dauvakadidike e tiko rawa: ______________________________

Tiki ni siga: ______________________________

Gauna e tekivu kina: __________ AM/PM Gauna e cava kina: __________ AM/PM

FORM 1. TUKTUKU NI VUVALE

Kevaka e lewena na vuvale e dua ga na i taba tamata(**1 generation)**, na turaga qase taudua e i liuliu.Kevaka e 2 na i taba tamata, koya na turaga enai matai ni taba tamata e i liuliu ni vuvale. Kevaka e tiko kina e tolu nai taba tamata, koya na turaga ena i taba e loma donu e liuliu ni matavuvale.

1 Vakalewena na yacadra yadua na lewe ni vuvale ka qai sauma na Taro 2 & 3 yadua mai na lewe ni vuvale. Oti, qai toso kina taro 4-6. Qai toso sara kina taro 7-14. YACA TAUCOKO	ID CODE	2 SEX Tagane..1 Yalewa..2	3 Ena gauna qo, sa na yabaki vica beka ko (YACANA)? #	4 VEIWEKANI VUA NAI LIULIU NI VUVALE LIULIU…………………1 WATI LIULIU…………2 LUVEI LIULIU ……….3 WATI LUVEI LIULIU...4 TUBUTUBU NEI LIULIU…………………5 TUBUTUBU NEI WATI LIULIU ………………..6 TACINA SE GANEI LIULIU…………………7 TACINA SE GANEI WATI LIULIU…………8 MAKUBUI LIULIU…...9 TUTU SE BUBU NEI LIULIU……………….10 VEIWEKANI TALE E SO……………………11 SEGA NI WEKA……12	5 TUTU NI BULA NEI (YACANA)? VAKAWATI…...1 SEGA NI VAKAWATI IA BULA VATA TIKO…………..2 VEIBIU SE SA MATE NA WATINA………3 ➢Q7 DUI TUTU IA SEGA NI VEIBIU.…………………4 ➢Q7 SE BERA NI A VAKAWATI…..5 ➢Q7	6 Kevaka e lewe ni vuvale na wati (YACANA),, ko cei na yacana? KEVAKA NA WATI (YACA) E SEGA NI TIKO ENA LOMA NI VUVALE, VOLA NA SAIVA ID CODE	7 E vica beka na vula e tiko kina ENA LOMA NI VUVALE ko (YACANA) ena loma ni 12 na vula sa oti? KEVAKA NAI SAU NI TARO E CAKE E SIVIA NA 6 ➢TAMATA TARAVA #	8 E cava na vuna e tiko tani kina ko (YACANA) ena yabaki sa oti? CAKACAKA…….1 VULI……………..2 ➢Q 11 MATAIVALU…….3 VALENIBULA SE VALENIVEIVES..4 ➢Q 11 VAKAWATI MAI LOMA NI VUVALE ENA YABAKI SA OTI……………….5 ➢Q 11 SUCU ENA YABAKI SA OTI..6 ➢TAMATA TARAVA SO TALE NA VUNA…………….7	9 Bau dau veivuke tu mai vakailavo ko (YACANA)? Io………1 Sega….2 ➢Q 11	10 Vakacaca, e vica sara mada na levu ni lavo e vakauta tiko ko (YACANA) kina vuvale ena 12 na vula sa oti? $	11 E vei na vanua e tiko vakalevu kina ko (YACANA) ka vuni nona yawa TU mai kina vuvale? KORO OQO…………...1 ➢TAMATA TARAVA TIKINA OQO IA DUATANI NA KORO…2 YASANA OQO IA DUATANI NA TIKINA..3 YANUYANU QO IA DUATANI NA YASANA………………4 VEIRANUYANU TALE E VITI……………………..5 ➢Q 13 DUA TALE NA MATANITU…………….6 ➢Q 14	12 Na vanua e tiko mai kina ko (YACANA) SUVA................1 BA.....................2 KOROVU ....3 LAMI ....4 LAUTOKA ....5 NADI ....6 NASINU ....7 NAUSORI.........8 SIGATOKA ......9 TAVUA...........10 OTHER ....11 ➢NEXT PERSON	13 Na vanua e tiko mai kina ko (YACANA) VANUA LEVU .... 1 TAVEUNI .. 2 KADAVU... 3 MAMANUCA GROUP ...... 4 YASAWA GROUP ...... 5 LOMAVITI GROUP ...... 6 LAU GROUP7 OTHER....... 8 ➢NEXT PERSON	14 Na vanua e tiko mai kina ko (YACANA) AUSTRALIA1 NEW ZEALAND..2 UK ....3 USA ....4 OTHER PACIFIC COUNTRY .5 OTHER N. AMERICA /EUROPE....6 OTHER 7
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FORM 2. VULI

NA TARO OQO MERA KECE KINA NA LEWE NI VUVALE ME TEKIVU MAI VEI IRA NA **YABAKI 7 KA LAKO CAKE**
Na lewe ni vuvale e kena i balebale ko ira na tiko kina ena loma ni vula 6 se sivia.

I D C O D E	1 E vacava nai vakatagedegede ni nomu rawa ni wili vola vaka-Viti? SEGA SARAGA..........1 VAKALAILAI .. 2 TALADRODRO.3	2 E vacava nai vakatagedegede ni nomu rawa ni wili vola vaka-vavalagi? SEGA SARAGA..........1 VAKALAILAI ... 2 TALADRODRO.3	3 E vacava nai vakatagedegede ni nomu rawa ni wili vola vaka-Idia? SEGA SARAGA..........1 VAKALAILAI ...2 TALADRODRO.3	4 E vakacava na nomu kila na FIKA? IO...................1 SEGA.............2	5 Ko a bau vuli? IO.............. 1 SEGA........ 2 ➢LEW NI VUVALLE KA TARAVA	6 E vica kece na i wiliwli ni yabaki ni nomu a vuli tu?? #	7 O vuli tiko ena gauna qo? IO.............. 1 SEGA .... 2 ➢ LEWE NI VUVALLE KA TARAVA	8 E VICA KECE NAI LAVO E VAKAYAGATAKA NA VUVALE ENA LOMA NI 12 NA VULA SA OTI E NA VULE NEI (YACA).................. KE SEGA NAI LAVO A VAKAYAGATAKI, VOLA NA SAIVA (0)					
								A Curucuru ni vuli? $	B Vola kei nai yaya ni vuli (peni, kato etc.)? $	C Sulu ni vuli? $	D Vodovodo ki koronivuli? $	E Curucuru ni bured? $	F So tale na ka (qito, veika tale a lavaki)? $
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FORM 3. NA TIKO BULABULA

NA TARO KECE ME TAROGI VEI IRA KECE **NA LEWENIVUVALE**
Na lewe ni vuvale e kena i balebale ko ira na tiko kina ena loma ni vula 6 se sivia.

ID CODE	1 Bau tauvi iko tiko eso na mate SEGA NI DEWA IA VAKAVU GA MAI NA I VAKARAU NI NODA BULA (KAKANA BEKA) SE E VAKALEQAI E DUA NA TIKI NI YAGOMU ENA LOMA NI 6 na vula sa oti? Io .... 1 Sega .... 2 ➢Q 3	2 Na tiki ni yagomu cava e tauva kina na mate qo (chronic illness or disability)? UTO.......... 1 YATE VUSO/OCA SE CEGUCEGU LEKA .... 2 KETE KEI NA GACAGACA DAU QAQIA NA KAKANA.......... 3 ULU.......... 4 LIGA SE YAVA.......... 5 DAKU .... 6 SO TALE NA GACAGACA E LOMA .... 7 SO TALE.......... 8	3 Bau tauvi iko dua na mate se mavoa ena loma ni 4 na macawa sa oti? Io .... 1 Sega .... 2 ➢Q 6	4 Na mataqali mate se mavoa vakacava e yaco vei iko? BATABATA KEI NA MATE TAKA .... 1 MOSI NI KETE .... 2 COKA .... 3 MOSI NI ULU .... 4 UTO .... 5 YATE VUSO .... 6 RAMUSU.......... 7 SO TALE 8	5 E vica na siga e loma ni vula sa oti ko a sega ni qarava vinaka kina nomu itavi/cakacaka ena vuku ni tauvimate/mavoa a yaco vei iko? # OF DAYS	6 Vakarabailevu, bau rawa ni kaya ni nomu bula e..... Taucoko? .... 1 ➢NEXT PERSON Vinaka? .... 2 Vinaka vakarauta? .... 3 Ca? 4	7 Bau dau tarovi iko na nomu tuvaki ni bula ena levu na gauna, vakalailai ga se sega sara ga ena gauna ko qarava kina na veicakacaka qo? VAKATATAO VAKALEVU .... 1 VAKATATAO VAKALALAI .... 2 SEGA NI VAKATATAO SARAGA.......... 3			
							A Yavavala se cakacaka bibi vaka na cici, lave ka bi, se cakacaka ena i teitei se qoli? IF 3 ➢NEXT PERSON	B Cakacaka vakarauta me vaka na toso teveli, kaba ena baba, tube kato ni kakana dina?	C Taubaletaka e 100 na mita?	D Kana, vakaisulu se sisili?
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FORM 4. GAUNA E VAKAYAGATAKI (MUST BE READ ACROSS)

Na veitaro qo me ra saumi taro kina na veivuvale yadua (yabaki 7 lako cake).

Lewe ni vuvale – e rawa ni vakatokai tiko me koya e tiko ena loma ni vuvale rauta ni 6 na vula se sivia ena yabaki sa oti.

TURN PAGE

I D C O D E	1	2	3	4	5	6	7	8	9	10	11	12		13	14	15	16
	Bau vuli tu ena loma ni vitu na siga sa oti? Io...............1 Sega.........2 ➢Q 4	Ena loma ni vitu na siga sa oti, e vica na siga ko vuli kina? WILIWILI NI SIGA	Ena gauna ko vuli kina, e vica na auwa e taura ena dua na siga? WILIWILI NI AUWA	Ko bau vakayacora tu dua na cakacaka saumi ena vitu na siga sa oti? Io...............1 Sega..........2 ➢Q 7	Ena loma ni vitu na siga sa oti, e vica na siga ko cakacaka saumi kina? WILIWILI NI SIGA	Ena gauna ko cakacaka saumi kina, e vica na auwa e taura? WILIWILI NI AUWA	Ena vitu na siga sa oti, bau veitosoyaki tu rauta e tini na miniti se sivia ena nomu vuli se cakacaka saumi? Io.............1 Sega.........2 ➢Q 10	Ena lomani vica na siga sa oti ko veitosoyaki kina mo laki vuli se cakacaka, WILIWILI NI SIGA	Ena siga ko veitosoyaki kina oqo, mo laki cakacaka se vuli, e vica na auwa e taura? WILIWILI NI AUWA	Bau vakayacora tu dua na cakacaka ni vakayagataki qele (teitei, susu manumanu) ena vitu na siga sa oti? Io...............1 Sega.........2 ➢Q 17	Ena loma ni vitu na siga sa oti, e vica na siga ko vakaitavi kina ena cakacaka ni vakayagataki qele qo? WILIWILI NI SIGA	Ena gauna ko cakava kina na cakacaka ni vakayagataki qele, e vica na auwa e taura? WILIWILI NI AUWA	Levu ni auwa e taura mo cakacaka kina ena i teitei. LEVU TAUCOKO NI GAUNA NI CAKACAKA VAKADAUT EITEI Q11 X Q12	Ena levu ni auwa e tauri ena cakacaka ena i teitei, e vica na auwa e taura na nomu musuka tiko veivunikau me vaka na pisipisi? WILIWILI NI AUWA	Ena levu ni auwa e tauri ena cakacaka ana i teitei, e vica na auwa e taura na nomu musuka na vo ni mataqali kau WILIWILI NI AUWA	Ena levu ni auwa e tauri ena cakacaka ana i teitei, e vica na auwa e taura na nomu musuka wadamu (Merremia vine). WILIWILI NI AUWA	Ena levu ni auwa e tauri ena cakacaka ana i teitei, e vica na auwa e taura na nomu musuka wasalasala? WILIWILI NI AUWA
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ID CODE	17 Bau siwa se vakasasa vuaka tu ena loma ni vitu na siga sa oti? Io..............1 Sega.........2 ➢Q 22	18 Ena loma ni vitu na siga sa oti, e vica na siga ko gole kina ki siwa se vakasasa vuaka kina? WILIWILI NI SIGA	19 Ena gauna ko siwa se vakasasa vuaka kina, e vica na auwa e taura? WILIWILI NI AUWA	Levu ni auwa e taura mo siwa se vakasasa vuaka kina. Levu ni gauna ena vakasasa Q18XQ19	20 Ena levu ni auwa e tauri, e vica e vakayagataki ena vakasasa vuaka? WILIWILI NI AUWA	21 Ena levu ni auwa e tauri, e vica e vakayagataki ena vakasasa manipusi? WILIWILI NI AUWA	22 Ko bau vakayacora tu dua na cakacaka vakabisinisi se vakoro ena vitu na siga sa oti? Io..............1 Sega.........2 ➢Q 25	23 Ena loma ni vitu na siga sa oti, e vica na siga ko cakacaka vakabisinisi se vakoro kina? WILIWILI NI SIGA	24 Ena gauna ko cakacaka vakabisinisi se vakoro kina, e vica na auwa e taura? WILIWILI NI AUWA	25 Ena loma ni vitu na siga sa oti, bau vakayacora tu dua na cakacaka vakavuvale (vakasaqa, meimei)? Io..............1 Sega.........2 ➢Q 28	26 Ena loma ni vitu na siga sa oti, e vica na siga ko qarava kina na cakacaka vakavuvale qori? WILIWILI NI SIGA	27 Ena gauna ko qarava kina na cakacaka vakavuvale qori, e vica na auwa e taura? WILIWILI NI AUWA	28 Ena loma ni vitu na siga sa oti, bau vakayacora tu dua na cakacaka me vaka na sara yaloyalo,qito gunu yaqona (sega ni wili kina na moce)? Io..............1 Sega.........2 ➢NEXT PERSON	29 Ena loma ni vitu na siga sa oti, e vica na siga ko qarava kina na cakacaka qori? WILIWILI NI SIGA	30 Ena gauna ko qarava kina na veicakacaka qori, e vica na auwa e taura? WILIWILI NI AUWA
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FORM 5. VAKAYAGATAKI QELE (MUST BE READ ACROSS)

Na vakaleweni ni fomu qo dodonu me vakaitavi kina na liuliu ni vuvale se dua ga ena loma ni vuvale koya ka kila vinaka tu na cakacaka ni vakayagataki qele vakabibi na teitei.

1. Bau dua na lewe ni vuvale e vakayacora tu ena teivaki ni kakana dina ena loma ni vula 12 sa oti?

IO. ....1 SEGA...........................2 ➢NEXT FORM

C R O P C O D E	Taroga na taro 2 ena vuku ni kakana taucoko koya e volai koto qori, ka qai taroga ga na taro 3-17 ena so ga na kakana ka veiganiti dina me tarogi.	2 Bau vakayacora tu na vuvale eso na teitei ena 12 na vula sa oti? Io…....1 Sega,,2 ➢NEXT CROP	3 E vakacava sara mada na levu (raba, balavu) ni bulibuli qele e vakayagataki ena teitei ena 12 na vula sa oti? TEITEI....... 1 <¼ AC……2 ¼-½ AC ..... 3 ½-1 AC ...... 4 1-3 AC .... 5 3-5 AC .... 6 >5 AC 7	4 Kevaka a sega na manumanu meca, tauvimate, dravuisiga, e vica beka na bibi (KGs) ni vuaniqele e rawa ni rawati mai na qele qo ena 12 na vula sa oti?	5 E bau so na vua ni qele (kakana dina) e vakaleqai ena vuku ni tauvimate, dravuisiga se ualuvu? Io.......... 1 Sega ..... 2 ➢Q 7	6 E vica beka na bibi (KGs) ni vuaniqele (kakana dina) e vakaleqai ena vuku ni tauvimate, dravuisiga se ualuvu?	7 E bau so na kakana dina e vakaleqai ena vuku ni manumanu meca, vuaka ni veikau? Io………1 Sega….2 ➢Q 11	8 Na manumanu meca cava sara mada e vakaleqa tiko na kakana dina? Vuaka ni veikau.......1 Sici ni vanua...........2 Manumanu tale eso.3 Manumanu ni dalo...4 Kadi vuka................5 Manumanu vuka tale eso.........................6 Bulbul.....................7 OTHER PESTS		9 E vica beka na bibi (KGs) ni vuaniqele (kakana dina) e vakaleqai ena vuku ni manumanu meca ena loma ni 12 na vula sa oti?	11 E vica beka na bibi ni kakana dina ko volitaka ena 12 na vula sa oti?	12 E vica sara mada na kena isau tudei ni voli na kakana dina?	13 E vica sara mada na levu ni kakana dina e vakayagataka na vuvale ena loma ni 12 na vula sa oti?	14 E vica sara mada na bibi (KGs) ni kakana dina e vakayagataka na vuvale me qaqi ena loma ni 12 na vula sa oti?	15 E vica sara mada na bibi (KGs) ni kakana dina e maroroya tu na vuvale ena loma ni yabaki qo?	16 Bau teivaka tale eso na mataqali kakana dina ena nomu vanua vata ga ni teitei ya? Io………1 Sega….2 ➢NEXT CROP	17 Na kakana dina cava sara mada? Vola mai e rua na kakana dina bibi taudua? CROP CODES	
	CROP			KGS		KGS		#1	#2	KGS	KGS	$ PER KG	KGS	KGS	KGS		#1	#2
1	Dalo																	
2	Tavioka																	
3	Dal Ni Tana																	
4	Ginger																	
5	Kumala																	
6	Yaqona																	
7	Yams																	
8	Duruka																	
9	Kakana dina tale e so																	
10	Raisi																	
11	Pulses/Beans																	
12	Kakana draudrau																	
13	Sila																	
14	Jaina																	
15	Vudi																	
16	Niu																	
17	Painapiu																	
18	Weleti																	
19	Meleni																	
20	Moli																	
21	So tale na vuata																	
22	Dovu																	
23	Cut Flowers																	
24	Nuts (pinati,tavola,vutu)																	

18. Bau dua na lewe ni vuvale e bisinisitaka tiko na kakana qaqi se saqa se sigani me vaka na jamu, waiwai, kava, vuata, se dua tale na mataqali kakana e teivaka tiko na vuvale?

Io.. ....1 [ ]
Sega...2 ➢Q 25

OUTPUT CODE	Taroga na taro 19 ena vuku ni kakana taucoko koya e volai koto qori, ka qai taroga ga na taro 20-24 ena so ga na kakana ka veiganiti dina me tarogi. KAKANA ESO	19 Bau vakayacora tu na vuvale eso na cakacakatak i ni kena qaqi na kakana koya e tea tu na vuvale? Io................ Sega............ ➢NEXT FOOD PRODUCT	20 E vica beka na levu ni kakana e dau vakayagataki ena kena qaqi ena loma ni dua na vula? KENA LEVU	VAKA RAU	21 Na vei kakana qaqi qori, bau volitaki ena loma ni 12 na vula sa oti? KENA LEVU	VAKA RAU	22 E vica beka na kena levu ni sau e vakarautaki ena kena volitaki na veikakana qaqi/saqa/sigan i qori? $	VAKA RAU	23 Mai na veikakana qaqi qori, e vica beka koya e vakayagataka se kania na vuvale ena loma ni 12 na vula sa oti? KENA LEVU	VAKA RAU	24 E vica beka na kena bibi (KGs) na kakana qaqi qori koya e rawata ka maroroya rawa na vuvale ena loma ni 12 na vula sa oti? KENA LEVU	VAKA RAU
1	Waiwai niu											
2	Jam											
3	Yaqona											
4	So tale #1											
5	So tale #2											
6	So tale #3											

1 KG	3 ML
2 LITRES	

UT CODE	Taroga na taro 25 ena vuku ni INPUT taucoko koya e volai koto qori, ka qai taroga ga na taro 26-28 ena so ga na INPUT ka veiganiti dina me tarogi. ASK QUESTION 25 FOR EACH INPUT AND THEN ASK QUESTIONS 26-28 FOR THE APPLICABLE INPUTS INPUT	25 Bau so na lewe ni vuvale era volia (INPUT) na veiyaya oqori ena loma ni 12 na vula sa oti? Lo…................1 Sega.................2	26 E vica na levu taucoko ni sau e vakayagataki ena (INPUT) ena loma ni 12 na vula sa oti? KENA LEVU	VAKA RAU	27 E vica taucoko nai sau vakarautaki me baleta na kena saumi ni voli e dua na (INPUT) qori ena loma ni 12 na vula sa oti? $	28 E vica taucoko na levu ni sau e saumi kina na (INPUT) qori ena loma ni 12 na vula sa oti? $
1	NPK					
2	Urea					
3	So tale na (fertilizer)					
4	De ni toa					
5	De ni bulumakau					
6	Civicivi ni kakana					
7	Othene					
8	So tale (Pesticide #1)					
9	So tale (Pesticide #2)					
10	Gramaxzone					
11	Paraquat					
12	Rambo					
13	Round-up					
14	Glyphosate					
15	So tale (herbicide)					
16	Sunsis					
17	So tale (fungicide #1)					
18	So tale (fungicide #2)					
19	Tamata cakacaka saumi ena werewere					
20	Tāmata cakacaka saumi ena kena teivaki					
21	Tāmata cakacaka saumi ena tatamusuki					
22	So tale na tāmata saumi					
23	Manumanu tale eso e sega ni nomu ia ko sauma ni oti nomu vakayagataka					
24	Yaya ni cakacaka eso e sega ni nomu ia ko sauma ni oti nomu vakayagataka					
25	Sau ni kena vakavinakataki na I yaya ni cakacaka					
26	Na I sau ni vakacavacava ni qele					
27	So tale na ka (agricultural inputs)					

FORM 6. SUSU MANUMANU

Na vakaleweni ni fomu qo dodonu me vakaitavi kina na liuliu ni vuvale se dua ga ena loma ni vuvale koya ka kila vinaka tu na cakacaka ni susu manumanu.

1. Bau dua na lewe ni vuvale e vakayacora tu na susu manumanu me vaka na bulumaka, vuaka kei na me ena loma ni 12 na vula sa oti?

Io.. ....1 [ ]
Sega...2 ➢Q 14

STOCK CODE	Taroga na taro 2 ena vuku ni manumanu susu taucoko koya e volai koto qori, ka qai taroga ga na taro 3-9 ena so ga na manumanu susu ka veiganiti dina me tarogi. STOCK	2 Bau dua na lewe ni vuvale e susu manumanu tu ena loma ni 12 na vula? Io ....1 Sega.........2	3 E vica beka na levu taucoko ni manumanu e susuga ka taukena tiko na vuvale? #	4 E vica beka na levu taucoko ni manumanu e susuga ka taukena tiko na vuvale ena loma ni gauna vata va qo ena yabaki sa oti? #	5 E vica na manumanu susu e voli mai ena loma ni 12 na vula sa oti? #	6 E vica na manumanu susu e volitaki ena ena loma ni 12 na vula sa oti? #	7 E vica na manumanu susu e vakayagata ka ka kania na vuvale ena loma ni 12 na vula sa oti? #	8 E vica na manumanu susu era mate ena vuku ni tauvimate, leqa vakacalaka, dravuisiga, qaseqase. #	9 E vica beka na kena levu ni sau e vakarautak i ena kena volitaki se voli ni kua? $
1	Bulumakau (beef)								
2	Bulumakau loba								
3	Ose								
4	Vuaka								
5	Sipi								
6	Me								

PRODUCT CODE	Taroga na taro 10 ena vuku ni (BYPRODUCT) taucoko koya e volai koto qori, ka qai taroga ga na taro 11-13 ena so ga na (BYPRODUCT) ka veiganiti dina me tarogi. BYPRODUCT	10 Bau so na manumanu susu e vakayagataki (BYPRODUCT) ena loma ni 12 na vula sa oti? Io....................... Sega	11 Vakacaca, e vica na levu ni BYPRODUCT e rawati mai kina ena loma ni 12 na vula sa oti? AMT	 UNIT	12 Vakacaca, e vica na levu ni BYPRODUCT e volitaki ena loma ni 12 na vula sa oti? AMT	 UNIT	13 E vica na levu ni sau ni (BYPRODUCT) vakarautaki kevaka e volitaki se voli ni kua? $	 UNIT
1	Sucu			LITRES		LITRES		LITRES
2	Lewe ni manumanu			KG		KG		KG
3	Cheese/yogurt/bata			KG		KG		KG
4	Kuli ni manumanu			SKINS		SKINS		SKINS
5	Vuti ni manumanu			KG		KG		KG
6	Vakabulabula ni qele			35KG BAG		35KG BAG		35KG BAG
7	So tale							

14. Bau dua na leweni vuvale e susu toa, ga, ika, oni ena loma ni 12 na vula sa oti?

Io . ... 1 [ ]
Sega .... 2 IF Q1=2 & Q14=2 ➢NEXT FORM; OTHERWISE ➢Q 26

STOCK CODE	Taroga na taro 15 ena vuku ni mataqali susu manumanu taucoko koya e volai koto qori, ka qai taroga ga na taro 16-21 ena so ga na mataqali susu manumanu ka veiganiti dina me tarogi. STOCK	15 Bau dua na lewe ni vuvale e susuga koto na veimanumanu (toa,ga) qori ena loma ni 12 na vula? Io .... 1 Sega 2	16 Vakacaca sara mada e vica na levu ni manumanu susu qori e taukena na vuvale? #	17 E vica beka nai sau vakarautaki kevaka e volitaki se voli na veimanumanu susu (toa, ga) qori ni kua? $	 VAKARAU	18 Bau so vei ira na manumanu susu qori e ra vakamatei ena vuku ni manipusi ena loma ni 12 na vula sa oti? Io.............1 Sega.........2 ➢Q 20	19 Vakacaca, e vica sara mada era mate, vakamavo ataki se vakacacan i mai ena manipusi ena loma ni 12 na vula sa oti? #	20 Bau so na manumanu susu qori era vakasasataki mai ena vuaka ni veikau ena loma ni 12 na vula sa oti? Io............. 1 Sega ....2 ➢NEXT STOCK	21 Vakacaca, e vica sara mada era mate, vakamavoat aki se vakacacani mai ena vuaka ni v eikau ena loma ni 12 na vula sa oti? #
1	Toa				NI DUA				
2	Luveni toa				NI DUA				
3	Ga				NI DUA				
4	Luveni ga				NI DUA				
5	Susu ika				KG				
6	Susu oni				HIVE				

PROD CODE	Taroga na taro 22 ena vuku ni BYPRODUCT taucoko koya e volai koto qori, ka qai taroga ga na taro 23-25 ena so ga na BYPRODUCT ka veiganiti dina me tarogi. BYPRODUCT	22 Bau so na manumanu susu e vakavurea eso na (BYPRODUCT) ena loma ni 12 na vula sa oti? Io...................... 1 Sega.................. 2	23 Vakacaca, e vica na levu ni BYPRODUCT e rawati mai kina ena loma ni 12 na vula sa oti? AMT	 VAKARAU	24 Vakacaca, e vica na levu ni BYPRODUCT e volitaki ena loma ni 12 na vula sa oti? AMT	 VAKARAU	25 E vica na levu ni sau ni (BYPRODUCT) e vakarautaki kevaka e volitaki se voli ni kua? $	 VAKARAU
1	Yaloka			DASENI		DASENI		DASENI
2	Honey			LITRES		LITRES		LITRES
3	So tale							

1 KG	2 LITRES

INPUT CODE	Taroga na taro 26 ena vuku ni INPUT taucoko koya e volai koto qori, ka qai taroga ga na taro 27 ena so ga na INPUT ka veiganiti dina me tarogi. INPUT	26 Bau so na lewe ni vuvale era volia (INPUT) na veiyaya oqori ena loma ni 12 na vula sa oti? Io... 1 Sega	27 E vica na levu taucoko ni sau e vakayagataki ena (INPUT) ena loma ni 12 na vula mai qo? $
1	Kedra kakana na manumanu		
2	Sau ni laurai vakavuniwai na manumanu		
3	Veikauyaki ni manumanu		
4	I lavo rawati ka I vakavinavinaka ni veivoli		
5	I sau ni veika me tawa kina nai voli (e.g. plastic,bottle,tray)		
6	Toro laivi ni vutini manumanu		
7	Vakasavasavataki ni vuti ni manumanu		
8	Saumi na tāmata me qarava na manumanu		
9	So tale na veika e saumi		

FORM 7. VUREVURE NI LAVO TALE MAI NA QELE

Na vakaleweni ni fomu qo dodonu me vakaitavi kina na liuliu ni vuvale se dua ga ena loma ni vuvale koya ka kila vinaka tu na cakacaka ni vakayagataki qele.

1. Bau dua na lewe ni vuvale e sauma tiko na rede ni qele (Land rent) vei ratou na Native Land Trust Board ena loma ni 12 na vula?
   Io...1 [ ]
   Sega .... 2 ➢Q 4

2. E vica taucoko na levu ni qele e lisitaki tu mai vei ratou na Nativi Land Trust Board ena loma ni 12 na vula? [ ]

1 garden	3 ¼-½ AC	5 1-3 AC	7 >5 AC
2 <¼ AC	4 ½-1 AC	6 3-5 AC	

3. E vica taucoko na levu ni lavo rawati ka vakayagataki tiko ena saumi qele rede (land rent) vei ratou na Native Land Trust Board ena loma ni 12 na vula sa oti?
   AMOUNT IN $ [ ]

4. Bau so na lewe ni vuvale e musumusu tiko ena sausaumi ni cakacaka ni vakayagataki qele vei ira eso tale ena loma ni 12 na vula sa oti?
   Io.. .... 1 [ ]
   Sega .... 2 ➢NEXT FORM

5. E vica taucoko na levu ni lavo rawati ena kena vakayacori tiko na cakacaka ni vakayagataki qele ki vei ira tale na so ena loma ni 12 na vula sa oti?
   AMOUNT IN $ [ ]
   TIME UNIT [ ]

TIME UNITS	DAY......................... 3	MONTH 5	HALF YEAR 7
	WEEK...................... 4	QUARTER 6	YEAR.......................8

FORM 8.TABANA NI VEIQARAVI SUSU MANUMANU/VAKAYAGATAKI QELE [EXTENSION SERVICES]

Na fomu me vakaleweni maivei ira na vei liuliu ni vuvale ka ra kila vinaka na veika me baleta na vakayagataki qele kei na susu manumanu.

1. Sa bau dua na lewe ni vuvale oqo e sa veitalanoa oti kei na dua na vakailesilesi mai na tabana ni veiqaravi me baleta na kena teivaki na kakana ena loma ni 12 na vula sa oti?

IO ....1 [ ]
SEGA ....2 ➢Q 4

2.Na teivaki ni kakana cava e a veitalanoataki? [ ] [ ] [ ]
[**RAI KINA I KA 5 NI FOMU**. KE SIVIA NA 3, VOLA GA MAI E 3 KA YAGA SARA VAKALEVU.]

3. Na I vakamacala cava kei nai tukutuku cava e a vakarautaki? [ ] [ ] [ ]
[KE SIVIA NA 3, VOLA GA MAI E 3 KA YAGA SARA VAKALEVU.]

1 vakayagatki ni vakabulabula ni qele/wanimate ni manumanu	6 nai vakasala maivei ira na dauniveivoli	11 na veico ca tale eso/tarovi ni tubu ni vaini
2 salisali ni wai buli	7 vakasala ni tauri lavo vakadinau	12 vuaka ni veikau/vuaka ni vale
3 veimataqali I tei	8 na kena tarovi na tubu ni kau na Pasi.	13 tarovi ni manumanu ni dalo
4 leqa ni qele	9 na tarovi ni veikau tale eso	14 qasikalolol/kadivuka/snail control
5 leqa ni draki	10 na tarovi ni bula ni wa damu	15 tarovi ni manumanu vuka

4. Sa bau dua na lewe ni vuvale e veitalanoa oti kei na dua nai vakalesilesi me baleta na susu manumanu ena lomani 12 na vula sa oti?

IO ....1 [ ]
SEGA ....2 ➢Q 7

5. Na mataqali susu manumanu cava e a veitalanoataki? [ ] [ ] [ ]

[**RAI KINA I KA 6 NI FOMU**. KE SIVIA NA 3, VOLA GA MAI E 3 KA YAGA SARA VAKALEVU.]

6. Na I vakamacala cava kei nai tukutuku cava e a vakarautaki? [ ] [ ] [ ]
[KE SIVIA NA 3, VOLA GA MAI E 3 KA YAGA SARA VAKALEVU.]

1 vaccinations	4 insemination services	7 na kena tarovi na I wiliwili ni manivusi
2 qaravi ni kakana kedra na manumanu	5 vakasala main a tabana ni veivoli	8 tarovi ni vuaka ni veikau/vuaka ni vale
3 tauvimate ni manumanu	6 vakasala ni tauri lavo dinau	

7. E a bau duatale e gole mai kina loma ni vuvale qo me mai veitalanoataka eso tale na veika bula ka vakavu leqa ena loma ni 12 na vula sa oti?

IO ....1 [ ]
SEGA ....2 ➢LAVELAVE NI FOMU KA TARAVA

8. Na mataqali kau/manumanu cava e a veitalanoataki sara vakamatailalai? [ ] [ ] [ ]
[KE SIVIA NA 3, VOLA GA MAI E 3 KA YAGA SARA VAKALEVU]

1 vunikau na Pasi/pisipisi	4 vunivaini tale eso kei na coca	7 vuaka ni veikau/vuaka kila
2 uto ni bulumakau/vunikau tale eso	5 manumanu ni dalo	8 manumanu vuka
3 wa damu	6 manivusi	9 ika 10 manumanu/kau tale eso

FORM 9.TABANA NI QOLI

Na fomu oqo me ra vakalewena na I liuliu ni vuvale se lewe ni vuvale ka ra kena dau se kila vinaka na veika me baleta na qoli.

1. E bau dua na lewe ni vuvale e dau rawata vakawasoma na ika, ura,civa,kai, urau,qari,duna se eso tale na sasalu ni waitui me laukana?

IO ....1 [ ]

SEGA...2 ➢Q 10

FISH CODE	Na I ka 2 ni taro me baleta na veimataqali ika,ka 3-9 ni taro me baleta na kena vakayagataki IKA	2 Ena loma ni 12 na vula sa oti, era sab au laki qoli [ika] tiko na lewe ni nomudou vuvale? IO.................. 1 SEGA............ 2 ➢IKA KA TARAVA	3 E vica nai vakarau ni bibi ni ika e rawati ena 12 na vula sa oti? KG	4 Nai vakarau oqoroi e levu se lailai ni vakatautauvatani kei na veika e rawa ena 1 na yabaki sa oti? LEVU VAKALAILAI….1 LEVU…………………..2 VIA TAUTAUVATA…..3 LAILAI…………………4 LAILAI VAKALAILAI...5 SEGA NI MACALA…..888	5 Na kenai vakarau oqo e levu se lailai mai na veika e rawati ena 10 na yabaki sa oti? LEVU VAKALAILAI….1 LEVU…………………..2 VIA TAUTAUVATA…..3 LAILAI………………...4 LAILAI VAKALAILAI…5 SEGA NI MACALA…..888	6 E vica na I vakarau ni bibi ni ika e a volitaki rawa ena loma ni 12 na vula sa oti? KG	7 Na cava nai sau tautauvata ni volitaki e dua na kilo na ika? $	8 Sa bau vica mada na ika e sab au vakayagataki se laukana ena loma ni vuvale? KG	9 E vica sara mada na bibi (KGs) ni ika e maroroya tu na vuvale ena gauna oqo? KG
1	Nuqa, ragaraga, nuqanuqa [Siganidae: Rabbitfish]								
2	Balagi, ta, dridri, jila, meto, ika loa [Acanthuridae: Surgeon fish]								
3	Cucu, Se, Ki, Ose, Mataroko [Mullidae: Goatfish]								
4	Kawakawa, donu, kasala, motosa, senikawakawa, senigaraga [Serranidae: Groupers]								
5	Kabatia, kawago, kacika, sabutu [Lethrinidae: Emperors]								
6	Tuna, yellow fin, big eye [Scombridae: Tuna]								
7	Saqa, saqaleka, saqaloa, vilu, saqa ni tobu, kaikai [Carangidae: Jacks/Trevallies]								
8	Damu, dam uni veidogo, kake, tavula, bo, rosi ni bogi [Lutjanidae: Snapper]								
9	Ogo, Silasila [Sphyraenidae: Barracuda]								
10	Ulavi, kakarawa, karakarawa, Bune [Scaridae: Parrotfish]								
11	Qitawa, ovisa ni baravi, qiawa [Tetrapontidae: Grunters]								
12	civa,dio,vasua,sici,yaga etc. [Oysters/clams/molluscs]								
13	dri [Sea cucumbers]								
14	lumi [Seaweeds]								
15	ura [Prawns]								
16	urau [Lobster]								
17	kuita [Octopus]								
18	vei sasalu ni waitui tale eso #1								
19	vei sasalu ni waitui tale eso #2								
20	vei sasalu ni waitui tale eso #3								

FORM 9.TABANA NI QOLI (CONTINUED)

Na fomu oqo me ra vakalewena na I liuliu ni vuvale se lewe ni vuvale ka ra kena dau se kila vinaka na veika me baleta na qoli.

10. E bau dua na lewe ni vuvale e dau rawata vakawasoma na ika,qari, ura, duna se eso tale na sasalu ni waidrano me laukana?

IO ....1 [ ]

SEGA...2 ➢Q19

FISH CODE	Na I ka11 ni taro me baleta na veimataqali ika,ka 12-18 ni taro me baleta na kena vakayagataki IKA	11 Ena loma ni 12 na vula sa oti, era sab au laki qoli [ika] tiko na lewe ni nomudou vuvale? IO.................. 1 SEGA............ 2 ➢IKA KA TARAVA	12 E vica nai vakarau ni bibi ni ika e rawati ena 12 na vula sa oti? KILO	13 Nai vakarau oqoroi e levu se lailai ni vakatautauvatani kei na veika e rawa ena 1 na yabaki sa oti? LEVU VAKALAILAI….1 LEVU…………………..2 VIA TAUTAUVATA…..3 LAILAI…………………4 LAILAI VAKALAILAI...5 SEGA NI MACALA…..888	14 Na kenai vakarau oqo e levu se lailai mai na veika e rawati ena 10 na yabaki sa oti? LEVU VAKALAILAI….1 LEVU…………………..2 VIA TAUTAUVATA…..3 LAILAI………………...4 LAILAI VAKALAILAI…5 SEGA NI MACALA…..888	15 E vica na I vakarau ni bibi ni ika e a volitaki rawa ena loma ni 12 na vula sa oti? KILO	16 Na cava nai sau tautauvata ni volitaki e dua na kilo na ika? $	17 Sa bau vica mada na ika e sab au vakayagataki se laukana ena loma ni vuvale? KILO	18 E vica sara mada na bibi (KGs) ni ika e maroroya tu na vuvale ena gauna oqo? KILO
1	vasua ni waidroka [Freshwater clams]								
2	duna ni waidroka [Freshwater eels]								
3	qari ni waidroka [Freshwater crabs]								
4	ura ni waidroka [Freshwater prawns]								
5	Tilapia								
6	Carp								
7	sasalu ni waidroka #1								
8	sasalu ni waidroka #2								
9	sasalu ni waidroka #3								

CODE	TAROGI NA KA 19 NI TARO ENA VEIYAYA ESO ECURU MAI, TARO 20 ME BALETA NA VAKAYAGATAKI NI VEIYAYA YA. NAI YAYA CURU MAI	19 Ena loma ni 12 na vula e sa bau dua ena loma ni vuvale e volia se taura vakarede e dua na I yaya me veivuke ena qoli? IO.......................................1 SEGA.................................2	20 Na cava na kena levu kece sau ni yaya e taurivaki ena 12 na vula sa oti? $
1	waqa kei na kena vakavinakataki na waqa [Boats and boat repair]		
2	baca ni siwa [Bait and tackle]		
3	dai ni ika [Traps]		
4	yaya ni qoli [Fishing gear]		
5	tamata cakacaka [Hired labour]		
6	waiwai [Fuel]		
7	sau tale ni qoli eso [Other fishing costs]		

IF NO FISH IS CAUGHT (Q1=2 AND Q10=2), DO NOT ASK Q19 AND Q20

FORM 10.TAMATA CAKACAKA SAUMI VAKA ILAVO [LABOUR FOR WAGES OR SALARY] TARO ME TAROGI VEI IRA NA LEWE NI VUVALE YABAKI 7 SE SIVIA.

O ira na lewe ni vuvale era okati kina o ira na tiko ena vuvale oya ni rauta e 6 se siva na 6 na vula.

ID CODE	1 Ni a bau cakacaka saumi ena 1 na vula se sivia na 1 na vula ena loma ni 12 na vula sa oti? IO…….1 ➢Q 3 SEGA..2	2 Na cava na vuna o ni sega kina ni cakacaka saumi? CAKACAKA ENA ITEITEI/ BISINISI NI VUVALE..........1 SE VULI, SE GONE2 VAKACEGU NA CAKACAKA,SA QASE.....................3 CAKACAKA TU GA IVALE, DUMEIMEI...........4 TAUVIMATE........5 CURU VALENIVEIVESU ....6 SO TALE...............7 ➢NEXT PERSON	3 Na tabana ni cakacaka saumi cava ni tiko kina ena 12 na vula sa oti? TABANA NI TEITEI,QOLI…1 MATABOSE NI KORO………...2 CAKACAKA VAKALOTU….3 DAUNIVEIVOLI ………………...4 MATAI NI BULI YAYA…………5 EIBISINISI TALE ESO…...6 MATANITU, TATAQOMAKI ………………...7 SO TALE……..8	4 E vei na vanua e vakavalenivolavol ataki kina cakacaka qo? NA KORO QO…1 ➢Q 8 TIKINA QO, DUATANI NA KORO, ...2 ➢Q 8 YASANA OQO, DUATANI NA TIKINA..............3 YANUYANU QO, DUATANI NA YASANA ....4 SO TALE NA VEIYANUYANU E VITI...............5 ➢Q 6 VEIVANUA TALE ESO.........6 ➢Q 7	5 O cei na yaca ni vanua oqo? SUVA ....1 BA ....2 KOROVU ...3 LAMI..........4 LAUTOKA.5 NADI ....6 NASINU .....7 NAUSORI ..8 SIGATOKA ....9 TAVUA ....10 SO TALE..11 ➢Q 8	6 O cei na yaca ni vanua oqo? VANUA LEVU1 TAVEUNI...... 2 KADAVU ...... 3 MAMANUCA GROUP .... 4 YASAWA GROUP .... 5 LOMAVITI GROUP .... 6 LAU GROUP . 7 SO TALE .... 8 ➢Q 8	7 E vakaitikotiko o [YACA] e: AUSTRALIA .1 NEW ZEALAND .....2 UK..................3 USA................4 OTHER PACIFIC COUNTRY.....5 OTHER N. AMERICA / EUROPE ....6 OTHER...........7	8 E na loma ni 12 na vula e vica na vula o ni a cakacaka saumi kina?	9 E na loma ni vica na vula ni cakacaka saumi kina qo, e vica na siga ni a gole kina ki cakacaka?	10 Ena dua na siga ni cakacaka e vica na aua ko ni cakacaka kina?	11 E a vica beka na kemuni i sau ena cakacaka qo? AUA.................. 1 SIGA .... 2 MACAWA......... 3 MACAWA RUA 4 VULA .... 5 YABAKI............ 6		12 Ena 12 na vula sa oti o ni a vakayagataka e 1 na vula se sivia ena nomui karua ni cakacaka saumi? IO ....1 SEGA ....2 ➢LAVELAVE NI FOMU KA TARAVA	13 .Ena loma ni 12 na vula e vica na vula o ni cakacaka kina ena nomuni karua ni cakacaka saumi?	14 E vica na siga ena loma ni vula o ni a cakacaka kina ena cakacaka oqri?	15 Ena dua na siga ni cakacaka e vica na aua o ni cakacaka kina?	16 E a vica beka na kemuni ni sau ena cakacaka oqo? AUA.................. 1 SIGA .... 2 MACAWA......... 3 MACAWA RUA4 VULA .... 5 YABAKI............ 6	
								VULA	SIGA	AUA	$	UNIT		VULA	SIGA	AUA	$	UNIT
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		

FORM 11. VUREVURE NI LAVO TALE ESO

Nai lavelave ni fomu oqo me tarogi vua na I liuliu ni vuvale se e dua e tiko ka matua cake.

1. Ena na 12 na vula sa oti sa bau dua mada ena loma ni vuvale e ciqoma e dua nai sau ni rede ni vale, I yaya se dua tale na ka me kua ni wili kina na rede kina Tabacakacaka ni Qele Maroroi?

IO ....1 [ ]
SEGA ....2 ➢Q 5

C O D E	TAROGI NA TARO 2 ME BALETA NA VEIYAYA REDETAKI YADUDUA, TARO 3-4 ENA KENA VAKAYAGATAKI NA I YAYA REDETAKI YAYA REDETAKI	2 Ni a bau ciqoma e dua nai yaya redetaki ena loma ni 12 na vula sa oti? IO .... 1 SEGA .... 2 ➢Q 5	3 E vica na vula ena 12 na vula ni a ciqoma kina na i yaya redetaki WILIWILI NI VULA	4 E vica na levu ni wiliwili tautauvata ni rede e ciqoma ena veivula? $/VULA
1	Housing other than this home			
2	motoka, lori lelevu, terekita			
3	Waqa			
4	Manumanu susu			

5. Ena 12 na vula sa oti, sa bau dua na lewe ni vuvale e ciqoma se vukei mai na veivuke ni Family Assistance Program se na veivuke ni peniseni?

IO ....1 [ ]
SEGA ....2 ➢LAVELAVE NI FOMU KA TARAVA

C O D E	TAROGI NA I KA 6 NITARO ME BALETA NA VEIKA VINAKA E RAWA KEI NA KA 7-8 NI TARO ENA KENA YAGA NA KENA YAGA	6 Ni sa bau ciqoma oti na veivuke ena loma ni 12 na vula sa oti? IO.................................. 1 SEGA........................... 2 ➢LAVELAVE NI FOMU KA TARAVA	7 E vica na vula ena loma ni 12 na vula o ni ciqoma kina na veivuke qo? #	8 E vica beka nai wiliwili tautauvata ni veivuke o ni vukei kina ena veivula yadua? $
1	Lavo vakacegu ni cakacaka(retire civil servant/military)			
2	Family assistance program			
3	Lavo veivuke vei ira na vakaleqai(disability)			
4	lavo veivuke ni malumalumu(>60yrs)			
5	So tale na veivuke vakamatanitu			
6	Peniseni ni kabani			
7	So tale na veivuke yaduadua			

FORM 12. DURABLE GOODS

Na taro ena I lavelave oqo me tarogi vei ira na vei liuliu ni vuvale se e dua e matua cake ena loma ni vuvale.

C O D E	TAROGI NA 1 NI TARO ME BALETA NA VEIYAYA MAREQETI KA DAU VEIKAUYAKI, KA 2-6 NI TARO ENA KENA VAKAYAGATAKI YAYA MAREQETI VEIKAUYAKI	1 E dua vei kemudou e taukena eso nai yaya mareqeti veikauyaki? IO…………………..1 SEGA……………..2 ➢YAYA KA TARAVA	2 E vica taucoko nai yaya vakaoqo o ni taukena? #	3 E na via vica taucoko na levu ni lavo ena rawa mai ke o ni volitaka na veiyaya vakaoqo o ni taukena tiko? $
1	talevoni veikauyaki [Cell phone]			
2	komupiuta [Personal computer]			
3	reitio yaloyalo [Television]			
4	DVD Player			
5	Stereo, radio, or tape recorder			
6	I taba [Camera or video camera]			
7	Air conditioner			
8	Wiri ni cagi livaliva			
9	sitovu kasi se livaliva [Gas or electric stove]			
10	kato ni wai liliwa [Refrigerator]			
11	So tale nai yaya vakalivaliva ni valenikuro			
12	Misini ni savasava livaliva			
13	misini ni culacula [Sewing or knitting machine]			
14	dini ni cina [Generator]			
15	basikeli [Bicycle]			
16	Motopai			
17	Lori vakaitaukei			
18	waqa vakaidini [Motorized boat]			
19	waqa sega ni vakaidini [Non-motorized boat]			
20	Katavila ni teitei (tractor)			
21	Koti ni co			
22	Chainsaw			
23	So tale na I yaya ni cakacaka			
24	Yaya vakamatai			
25	kaloko kei na yaya ni sasauni [Watches/jewellery]			
26	kei na so tale			

4. Ni vakacuru I lavo vakacava, na jeke, I vola ni lavo se duatale na gaunisala ni vakatubu I lavo?

IO ....1 [
SEGA ....2 ➢LAVELAVE NI FOMU KA TARAVA

5. Ena via vica beka na levu ni lavo ke soqoni vata na ka sa tu ena I vola ni lavo kei na veigaunisala ni vakatubu I lavo tale eso?

KENA LEVU NI $ [ ]

FORM 13. I TIKOTIKO/VALE [DWELLING]

Na taro ena I lavelave oqo me tarogi vei ira na I liuliu ni vuvale se e dua e matua cake.

1. Sa vacava na kena dede na nomudou tiko vakavuvale ena vale oqo?

LEVU NI YABAKI [ ]

2. E vakacava na kena levu na nomudoui tikotiko?

VAKARIVIRIVI [ ]

3. Vakacaca sara na gauna cava beka e a tara kina na vale qo?

KEREA VUA E SAUMI TARO TIKO ME BIUTA MAI E DUA NA ESITIMETI KE SEGA NI MATATA NA YABAKI

YABAKI E TARA KINA [ ]

4. NA MATAQALI DAGODAGO CAVA O NI VAKAYAGATAKA ENA LALAGA E TAUDAKU?

CORRUGATED IRON/METAL SHEETS......................................1 [ ]
CYNDER BLOCKS/CONCRETE..2
BRICKS 3
WOOD/WOVEN BAMBOO/REEDS 4
OTHER (SPECIFY______________________)..............................5

5. NA DAGODAGO CAVA E VAKAYAGATAKI ENA DELAVUVU NI VALE?

CORRUGATED IRON/METAL SHEETS......................................1 [ ]
THATCH...2
TILES..3
WOOD 4
PADANAS/PALM LEAVES 5
OTHER (SPECIFY ___________________)..................................6

6. O ni taukena beka na vale qo?
IO ....1 [ ]
SEGA ....2 ➢Q 14

TIME UNITS	SIGA........................3	VULA.......................5	VEIMAMA
	MACAWA...............4	¼ NI YABAKI 6	NIYABAKI.............7
			YABAKI..................8

7. Kevaka e volitaki na vale oqo, ena via vica na kena I sau o na taura?

KENAI SAU $ [ ]

8. Vakacaca ena via vica na levu ni lavo e rawa ni o ni taura kevaka me redetaki na vale qo.

KKENA LEVU $ [ ]

GAUNA YADUA [ ]

9. E tiko e dua e sauma na I sau lavaki ni rede me trawa ni tiko ena vale oqo?

IO..1 [ ]
SEGA..2 ➢LAVELAVE KA TARAVA

10. E dua na rede qo e saumi enai lvo qaqa?

IO..1 [ ]
SEGA..2 ➢Q 12

11. Evica na levu ni lavo e saumi ena rede?

KENA LEVU $ [ ]

WASEWASE NI GAUNA [TIME UNIT] [ ]

12. Is any of the rent paid in goods or services? Na I sau ni rede e ra saumi vakaiyaya se vakacakacaka?

IO..1 [ ]
SEGA..2 ➢LAVELAVE NI FOMU KA TARAVA[NEXT FORM]

13. E via vica beka vakacaca nai sau ni yaya kei na cakacaka e saumi kina nomuni vuvale?

KENA LEVU $ [ ]

WASEWASE NI GAUNA [TIME UNIT] [ ]
➢LAVELAVE NI FOMU KATARAVA

14. Dou sauma tiko beka vakailavo na nomudou tiko ena vale qo?

IO..1 [ ]
SEGA..2 ➢LAVELAVE NI FOMU KA TARAVA

15. E vica beka na I sau ni nomuni redetaka tiko na vale qo?

KENA LEVU $ [ ]

WASEWASE NI GAUNA [TIME UNIT] [ ]

16. Dou sauma tiko vakailavo se vakacakacakaca na nomudpou rede?

IO..1 [ ]
SEGA..2 ➢LAVELAVE NI FOMU KA TARAVA

17. Na cava na kenai sau vakailavo na I yaya kei na cakacaka e saumi kina nomudou vuvale?

KENA LEVU $ [ ]

WASEWASE NI GAUNA [TIME UNIT] [ ]

FORM 14.KAU/MANUMANU DAU VAKAVU LEQA [INVASIVE SPECIES]

Na I lavelave ni taro oqo me tarogi kina vei liuliu ni vuvale se ki vua e dua e sa matua cake ena loma ni vuvale.

ME WILIKI NA I TUKUTUKU OQO KI VEI KOYA E SAUMI TARO TIKO. VAKARAITAKA NA I YALOYALO NI 5 NA MATAQALI MANUMANU/KAU.

Au sa na wilika yani oqo e 5 na veikau kei na manumanu ka rawa ni ra bula tu ena vanua oqo. Oqori me vaka na: vuni pasi/pisipisi[African tulip tree] wa damu [Merremia vine], manumanu ni dalo[taro beetle], Manivusi [Asian mongoose], kei na Red-Vented Bulbul. Ena veituktuku kece era, ni vakaraitaka ga se oni duavata kina,sega ni duavata, se sega ni rawa ni biuta e dua na digidigi.

	Disagree	Neutral	Agree
21. E ca ke laurai ena koro qo na manivusi?			
22. O ira na lewe ni koro e ra marau ni ra raica ni bula tiko eke na wa damu[merremia vine]			
23. Au na gadreva me so na manumanu ni dalo ena koro oqo.			
24. E levu na ka e vinaka me baleta na bulbul main a kena ca.			
25. O ira na lewe ni koro era marautaka ni ra raica na manumanu ni dalo			
26. E ka ca ni laurai ena koro oqo na vunikau na pasi/pisipisi[tulip tree]			
27. Au gadreva me levu tale na bulbul ena koro oqo.			
28. E levu sara na ca ni manumanu ni dalo mai na kena vinaka.			
29. E ca ni laurai I na koro oqo na wa damu [merremia vine]			
30. E levu cake na ca ni manivusi main a kena vinaka.			
31. E ra sega ni marautaka na lewe ni koro me ra raica na vunikau na pasi/ [tulip tree]			
32. Au vinakata me lailai na wa damu ena koro oqo.			
33. E ka ca ni kune ena loma ni koro oqo na bulbul			
34. E levu cake na vinaka ni wa damu mai na kena ca.			
35. Au vinakata me lailai na vunikau na pasi ena loma ni koro oqo.			
36. O ira na lewe ni koro era marautaka ni tiko na manivusi ena koro oqo.			
37. E levu na kena vinaka na vunikau na pasi [tulip tree] mai na kena ca.			
38. E ka vinaka beka ke tiko na manumanu ni dalo ena koro oqo?			
39. Au vinakata me levu na manivusi ena koro oqo.			
40. Era sega ni marautaka na lewe ni koro ni laurai eke na bulbul.			

FORM 15. CONTINGENT VALUATION

SOLIA VUA NA DAU NI SAUMI TARO E 70 NA 'BEANS'. WILIKA NAI TUKUTUKU ERA VEI IRA NA SAUMI TARO.GIVE THE RESPONDENT 70 BEANS. READ THE FOLLOWING STATEMENT TO THE RESPONDENT:

Ena yabaki 2008, e a vakayagataka kina na matanitu e rauta ni $700 na milioni ena tataqomaki; nodra qaravi na lewe ni vanua kei na nodra taqomaki;bula raraba me vaka na buli I yaya, keli koula,tabana ni veilakoyaki, kei na tamata cakacaka;taqomaki ni noda itikotiko me vaka na vakadukadukataki ni wai kei na sisi ni qele kei na kena tarovi na manumanu/kau dau vakavu leqa me vaka[VOLA E RUA NA KAU/MANUMANU DAU VAKAVU LEQA MAI NA I KA 14 NI FOMU[FORM 14]Itabana ni veivakavaletaki kei na bula vakaitikotiko, tabanani bula, tiko marau,bula vakavanua kei na lotu, vuli kei na maroroi ni noda bula veimaliwai me vaka na Family Assistance Programme. Vakaraitayaloyalotaka mada ni binibini 'BEANS' qori e vakaraitaka tiko nai lavo ka vakayagataka na matanitu ena veika sa volai koto e cake. Kevaka o ni a minisita ni veika vakailavo, ena vica sara mada nai lavo o ni na wasea ena vei tabana ka sa vakamacalataki toka e caka. Ni biuta na 'BEANS' ena vanua o ni nanuma me na biu kina ka sa vakarauatki toka ena drau ni veva.

COUNT THE NUMBER OF BEANS ON EACH RECTANGLE. LIST THE NUMBERS BELOW.

18. DEFENCE [ ]
19. PUBLIC ORDER AND SAFETY [ ]
20. ECONOMIC AFFAIRS [ ]
21. ENVIRONMENTAL PROTECTION AND CONTROL OF HARMFUL SPECIES [ ]
22. HOUSING AND COMMUNITY AMENITIES [ ]
23. HEALTH [ ]
24. RECREATION, CULTURE, AND RELIGION [ ]
25. EDUCATION [ ]
26. SOCIAL PROTECTION [ ]

KUMUNA NA 'BEANS' ME KUA NI WILI KINA O KOYA KA SA WASEA TU ME BALETA NA KENA TAQOMAKI NA NODA ITIKOTIKO KEI NA TAROVI NI KAU/MANUMANU DAU VAKAVU LEQA.COLLECT ALL BEANS EXCEPT THOSE ALLOCATED TO ENVIRONMENTAL PROTECTION AND CONTROL OF HARMFUL SPECIES.

WILIKI QO KI VUA NA DAU NI SAUMI TARO. READ THE FOLLOWING STATEMENT TO THE RESPONDENT.

Wasewasea nai wiliwili ni 'BEANS' kina kena taqomaki na noda i tikotiko kei na kena tarovi na kau/manumanu dau vakavu leqa. E vica o na wasea kina kena taqomaki na noda I tikotiko [tarovi ni sisi ni qele kei na tarovi ni vakadukadukataki ni wai] ka vica ko ni na wasea kina kena tarovi na kau/manumanu dau vakavu leqa[VOLA MAI E RUA NA KAU/MANUMANU MAI NA I KA 14 NI FOMU [FORM 14].You allocated [NUMBER OF BEANS] to environmental protection and control of harmful species. Of that, how much would you allocate to environmental protection (such as controlling erosion and preventing water pollution) and how much would you allocate to controlling harmful species such as [LIST TWO MOST HARMFUL SPECIES FROM FORM 14]?

WILIKA NAI WILIWILI NI' BEANS' ENA VANUA VAKARAUTAKI.VOLA NA KENAI TUVATUVA ERA.

27. MAROROI/TAQOMAKI NA I TIKOTIKO WAVOLITI KEDA [ENVIRONMENTAL PROTECTION]

[ ]

28. VALUTI NA KAU/MANUMANU DAU VAKAVU LEQA [ ]

KUMUNA NA 'BEANS' ME KUA NI WILI KINA O KOYA SA WILI TU ME VALUTA NA VUNIKAU/MANUMANU DAU VAKAVU LEQA.
WILIKA NAI TUKUTUKU KIVUA NA DAU NI SAUMI TARO:

Oni sa biuta nai wasewase [NUMBER OF BEANS]me valuta na vunikau/manumanu dau vakavu leqa. Mai nai wiliwili oya e vica o ni na wasea me valuti kina na 5 na vunikau/manumanu e sa veitalanoataki oti ka vica ena gole kina vei wasewase ni vunikau/manumanu tale eso?

WILIKA NAI WILIWILI NI ['BEANS'] ENA VEI VANUA E VAKARAUTAKI ['RECTANGLES']. VOLA NA KENAI I TUVATUVA ERA.[COUNT THE NUMBER OF BEANS ON EACH RECTANGLE. LIST THE NUMBERS BELOW]

29. VUNIKAU NA PASI [AFRICAN TULIP TREE] [ ]
30. MANIVUS [INDIAN MONGOOSE] [ ]
31. BULBUL [ ]
32. WA DAMU [MERREMIA VINE] [ ]
33. MANUMANU NI DALO [TARO BEETLE] [ ]
34. SO TALE [OTHER SPECIES] [ ]

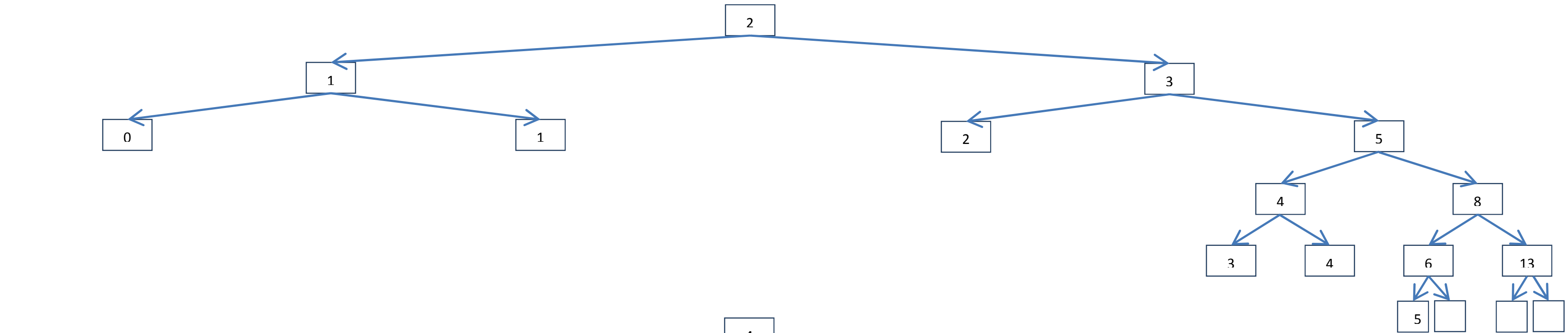
ROLL 1 DICE. MULTIPLY THE NUMBER SHOWING BY 2. THIS INDICATES THE TREE TO USE.

WLIKI NA I TUKUTUKU VEI IRA NA SAUMI TARO.

Raitayaloyalotaka mada, era sa bulia vou na dauni vakadidike ena Univesiti ni Ceva ni Paisifika e dua nai walewale vou ni kena tarovi na veimanumanu/kau vulagi [invasive species] ena loma ni koro. Ia na ka me ra cakava yadudua na tamata uabula kece ena loma ni koro me ra solia eso nodra gauna mei kuri ni gauna sa lavaki oti tu vakoro. E na rawa beka li ni ra na solia na gauna oya ko ira na qase ena loma ni vuvale me ra cakava na cakacaka oya ena loma ni macawa [DICE]? Kevaka e dua na qase ena loma ni vuvale e sega ni rawata nai wiliwili ni gauna oya, e rawa tale ni dua main a matavuvale vata ga oya e rawa ni veisosomitaki.

AT AN EMPTY BOX:

Vakacava sara mada na levu ni gauna e gadreva e dua na uabula me cakacaka kina?


2
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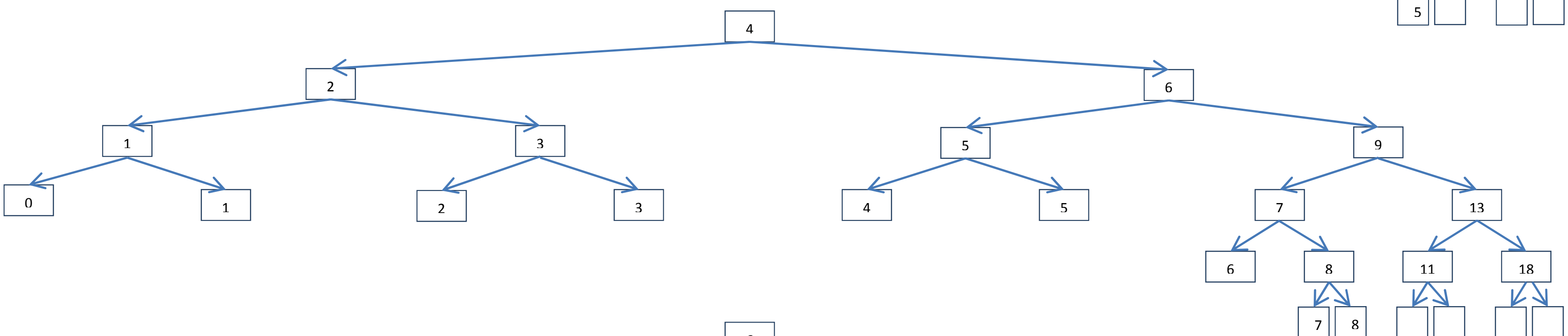
13
5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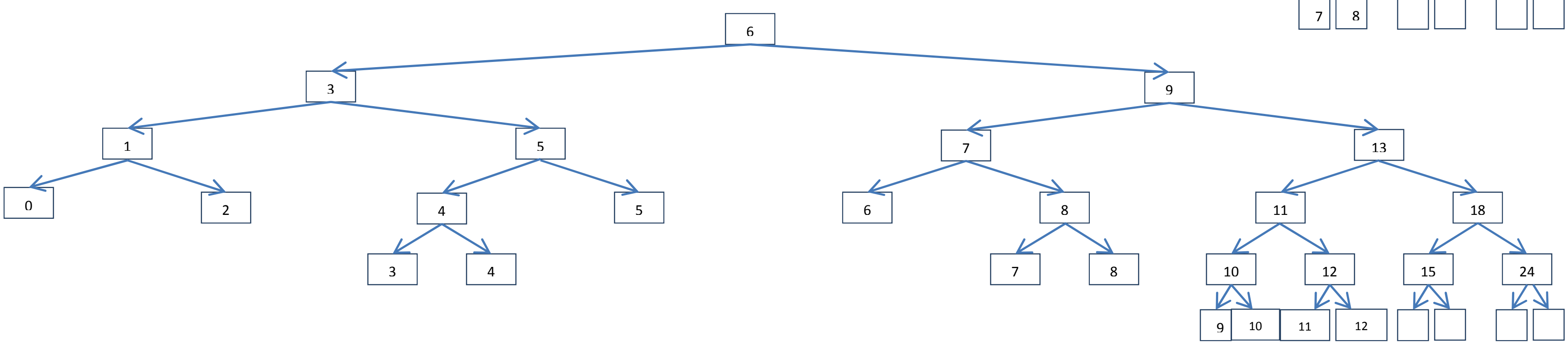
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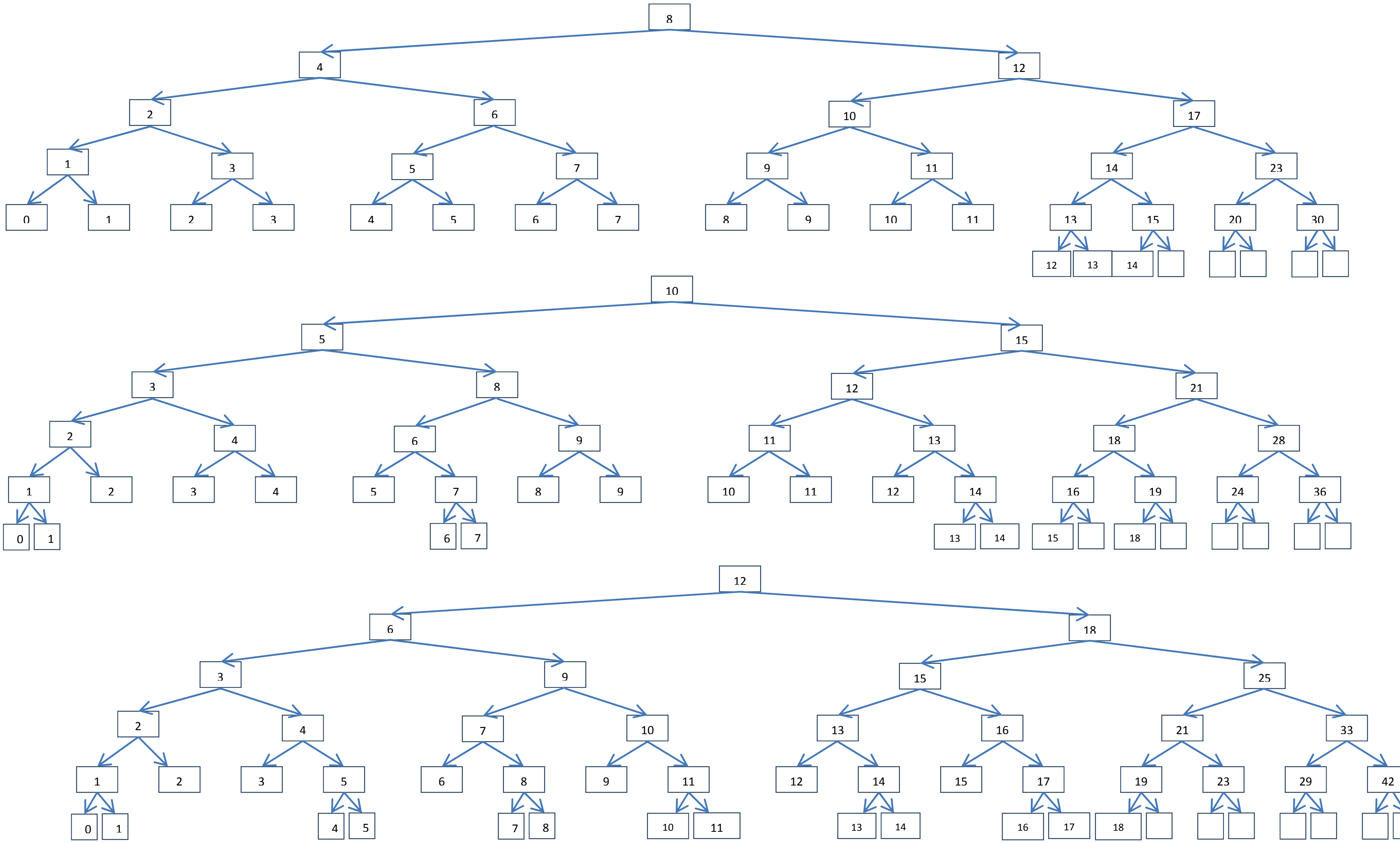
8
4 12
2 6 10 17
1 3 5 7 9 11 14 23
0 1 2 3 4 5 6 7 8 9 10 11 13 15 20 30
12 13 14
10
5 15
3 8 12 21
2 4 6 9 11 13 18 28
1 2 3 4 5 7 8 9 10 11 12 14 16 19 24 36
0 1 6 7 13 14 15 18
12
6 18
3 9 15 25
2 4 7 10 13 16 21 33
1 2 3 5 6 8 9 11 12 14 15 17 19 23 29 42
0 1 4 5 7 8 10 11 13 14 16 17 18

Appendix 7: Cost-Benefit Analysis in the Pacific Manual

PREFACE

There has been a substantial increase in the use of cost benefit analysis (CBA) in the natural resource sectors of the Pacific in recent years. Accompanying this growth has been an increased demand for expertise to conduct the analysis, including a surge of requests for training to increase national and sectoral staff skills. In the last 12 months, for example, regional training activities for cost benefit analysis have been delivered to support natural resource projects aimed at invasive species management, climate change adaptation, conservation, and food security.

Supporting such capacity building work is a wide variety of guides and manuals from across the globe that informs trainers and trainees how cost-benefit analysis could be conducted. On the other hand, no one document brings together the steps of cost-benefit analysis using purely regional examples to which Pacific islanders can relate to facilitate learning.

This document is intended to support Pacific island governments and non-government organisations that are designing or assessing activities using cost benefit analysis. To do this, it will supplement existing guides and manuals by illustrating the steps of cost benefit analysis using Pacific case studies from a wide variety of natural resource sectors. The document will serve not only as a reference for the application of cost benefit analysis for natural resources in the region, but will support future training and capacity development for Pacific natural resource related activities. In so doing, this document is intended to convey a standardised approach to cost benefit analysis from the agencies involved so that practitioners receive a consistent message in what to do.

GLOSSARY

Baseline: A measurement or description of a scenario used as a basis for comparison. In cost-benefit analysis, the baseline represents the best assessment of the world in the absence of the regulation or action proposed for assessment.This is sometimes referred to as the ‘without’ scenario.

Benefit: Monetary or non-monetary gain received because of an action taken or a decision made.

Benefit-Cost Ratio (BCR): The ratio of the present value of benefits from an activity, expressed in monetary terms, relative to the present value of its costs.

Business as Usual (BAU): The baseline (without) scenario against which other options may be compared

Cost-Benefit Analysis (CBA): A systematic process for calculating and comparing the advantages (benefits) and disadvantages (costs) of an activity from a social perspective.

Cost-Effectiveness Analysis (CEA): A systematic method to find the lowest cost of accomplishing an objective.

Costs: An amount that has to be paid or given up in order to get something. In markets, costs usually reflect monetary valuations of the inputs and opportunity forgone to produce and deliver a good or service. In practice, all expenses are costs, but not all costs (such as environmental damaged incurred during production) appear as expenses.

Costs of Production: Amounts paid for resources (land, labour, capital, and entrepreneurship) used to produce goods and services.

Discounting: A method used the value of future benefits and or costs are expressed as present day values.

Discount Rate (r): The rate at which future value of benefits and costs are adjusted to remove their time value and express them in present day values.

Externality: A positive or negative consequence of an economic activity that is experienced by an unrelated party.

Internal Rate of Return (IRR): The maximum discount rate that could be applied to all monetised costs and benefits for a project that would still allow for it to break even (i.e., have a NPV = 0).

Market: An institution in which goods and services are bought and sold.

Non-market Benefits and Costs: Benefits or costs arising from the production or consumption of goods/services that either have no monetary price or whose price does not reflect all the benefits and or costs.

Opportunity Cost: The cost of forgoing the nearest alternative to a course of action; in other words, the value of the next best option that much be surrendered when scarce resources are used for one purpose instead of another.

Willingness to Pay (WTP): The maximum amount a person would be willing to pay, sacrifice or exchange in order to receive a good or service or to avoid something undesired.

CHAPTER 1 – Environmental and resource projects in the Pacific

The Pacific region comprises thousands of small islands spread across a vast ocean area. Taking into account independent nations as well as the various territories and states of metropolitan countries (Australia, New Zealand, the EU, and the US), the area occupies around of the 38.5 million km^2 of the Earth's surface. Over 98% of this area over which Pacific nations have direct influence is ocean. Pacific communities therefore have traditionally relied on coastal resources – their bounty and services – for their development.

Oceanic resources have formed the basis of many island economies through, for example, access to commercial and or subsistence fishing, transport for trade and national security. At the same time, coastal land based resources provide major development opportunities, with some larger countries drawing on forestry and mineral/hydrocarbon-based resources to promote economic trade and development. With improved access to technology and new markets, new development opportunities are also now appearing in the region in the form of potential for deep-sea mining and tourism.

The importance of natural resources to the economy of the Pacific island region cannot be overstated. At a regional level, the Pacific represents the most important tuna fishing ground in the world, generating commercial fisheries including exports in 2007 worth an estimated US$166 million (Seidel & Lal 2010). At the national level, primary industries such as agriculture, forestry, fishing, and or minerals constitute as much as a quarter of the GDP in Kiribati and one third of the GDP for the Solomon Islands[1]. Natural resources also contribute to economic development through secondary and territory sectors (such as manufacturing and processing).

Additionally, the traditional reliance of Pacific island nations on natural resources is recognized as a critical component of social development, supporting national identity and culture. It is little surprise that the word for 'land' in New Zealand Māori (whenua) is also the same term as that for 'placenta', underscoring the strong connection between the Māori peoples and their land. Likewise, the same word in Tuvaluan (fenua) and Fijian (vanua) means both land and the community located there, including their customs, beliefs, and values.

While the connections of Pacific islanders to their natural environment persist to varying degrees across the region, most communities have nevertheless shifted in the last century from a largely subsistence-based economy to an increasingly market-oriented one. Access to better technology and increased trade with the outside world have, in many cases, resulted in higher income levels and generally improved health and life expectancy prospects. At the same time, the rapid or unconstrained development in many Pacific island countries has come at the cost of increased (often unsustainable) production and consumption, resulting in increasing resource scarcity and pollution problems on a scale never before witnessed in the Pacific (Lal & Holland 2010).

The result of these emerging environmental challenges is a surge in recent years in the number of development activities in the region that target the environment and or natural

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[1] Data available at www.spc.int/prism

resources. The success of these activities, however, has been chequered. One issue raised has been the need for economic analysis of projects before design and implementation to ensure the feasibility of projects (see, for example, Lal & Keen 2002). Accordingly, there have been a series of calls in the Pacific to include economic analysis of projects to ensure their efficiency and effectiveness (see for example SPREP (1999, 2001). In response, a significant increase in the cost benefit analyses of natural resource management projects has occurred in the last 5–10 years, addressing a variety of natural resource management sectors (see Appendix 7.1).

In principle, the application of the various cost benefit analyses undertaken in the Pacific region in recent years should be similar, not just to each other but also to other cost-benefit analyses undertaken elsewhere on the globe. This is because cost-benefit analysis generally follows a set series of steps. The steps are articulated in any number of academic texts (for example, Boardman 2006; Tietenberg 2006; Hanley et al. 1993; Wills 1997; Mishan 1988), as well as manuals and guidebooks generated by different organisations (for example, European Commission undated, 1997; HM Treasury 2003; UNECE 2007; OECD, 2006; USEPA 2010.)

While these resources are plentiful, few provide an opportunity to view locally executed case studies to which Pacific islanders can relate to promote learning. There have therefore been numerous requests to SPC, SPREP and other agencies in the region to produce a guide to help countries plan and deliver cost benefit analyses of development activities that target natural resources.

The purpose in this document is therefore to support economic analysis in Pacific island countries (government and non-government organisations) by:

- illustrating the various steps in cost benefit analysis using Pacific-only examples that are familiar in context, content and challenge to the region
- providing practical tools to support local analysis
- promoting a consistent approach to cost benefit analysis.

This document is intended only as an introductory guidance note. The focus of the document is on the practical application of the CBA procedure in the Pacific context. It does not explain the theoretical concepts underpinning CBA. Readers are encouraged to refer to the many CBA and economic textbooks available for more information on these theoretical areas.

The document is divided into several chapters. Chapter 2 provides an overview of the purpose of CBA, some of its key features, and describes where CBA can be used in project planning and evaluation. Chapter 3 presents CBA as a 6-step process starting from the determination of the objective of the CBA through to preparation of recommendations. The remaining chapters discuss each of the 6 steps in a bit more detail. These chapters also illustrate key points with the use of a case-study example for how to conduct a CBA for managing a key invasive in the Pacific, the African tulip tree. A series of appendices provide supporting material and tools for the main text.

CHAPTER 2 – Overview of Cost-Benefit Analysis

Cost-benefit analysis (CBA) is a systematic process for identifying, valuating, and comparing costs and benefits of a project(s)[2].

The primary objective(s) of this process is to determine whether the benefits of a project option outweigh its cost and by how much relative to other alternatives. The purpose of this is to:

1. determine whether the proposed project is (or was) a sound investment (justification/feasibility); and

2. compare alternative project options (rank and prioritise).

Ultimately, CBA aims to help inform decisions about whether to invest in a project or not, and/or choose which project option to implement. It is one of several tools that can be used to help this purpose.

The CBA process is based on the fundamental principles of welfare economics and public finance. CBA was initially developed in the 1800s in response to a need to assess and prioritise public policy and project alternatives that generate benefits or costs not priced in markets (Fuguitt & Wilcox 1999). Since then, CBA has been intensively developed and debated among economists and is now reasonably well settled, although refinements continue to be made.

The key features of CBA are:

- All related costs (losses) and benefits (gains) are considered, including potential impacts on human lives and the environment
- Costs and benefits are valued from a whole-of-society perspective[3], rather than just from one particular individual or interest group (i.e. private perspective)
- Costs and benefits are expressed as far as possible in money terms, and
- Costs and benefits that are realised in different time periods in the future are aggregated to a single time dimension (discounting).

These features make CBA very well suited to analysis of public-sector projects in particular.

Today, CBA is commonly used in most countries across the globe to assess a wide range of projects. In the Pacific, CBA has been applied to a variety of natural resource management sectors. Appendix 7.1 provides a listing of some of these CBAs undertaken.

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[2] The project or projects in question may be public projects – undertaken by the public sector – or private projects. CBA can also be used to analyse the effects of changes in public policies such as the tax/subsidy or regulatory regimes. However, a very broad range of issues can arise in this kind of analysis and, for ease of exposition, we adopt the narrower perspective of project analysis in this document.

[3] for this reason, some people refer to CBA as *social* cost-benefit analysis.

When is a CBA used?

For this document we describe the project development and implementation process using the Project Cycle concept. The Project Cycle is a standard process that project managers normally need to work through when developing and implementing evidence-based projects (Lal & Holland 2010).This process is not always strictly followed by Pacific governments but nonetheless represents what work broadly needs to be done in order to develop and implement high quality projects. It is consistent with the Logical Framework Approach that is also commonly used in the Pacific, particularly among donor projects.

The Project Cycle is illustrated in Figure 11. The figure shows the stages of the project cycle at which CBA can be applied. These are ex-ante (before project implementation), mid-term, and ex-post (after project implementation). At each stage, CBA serves a slightly different function as described below.

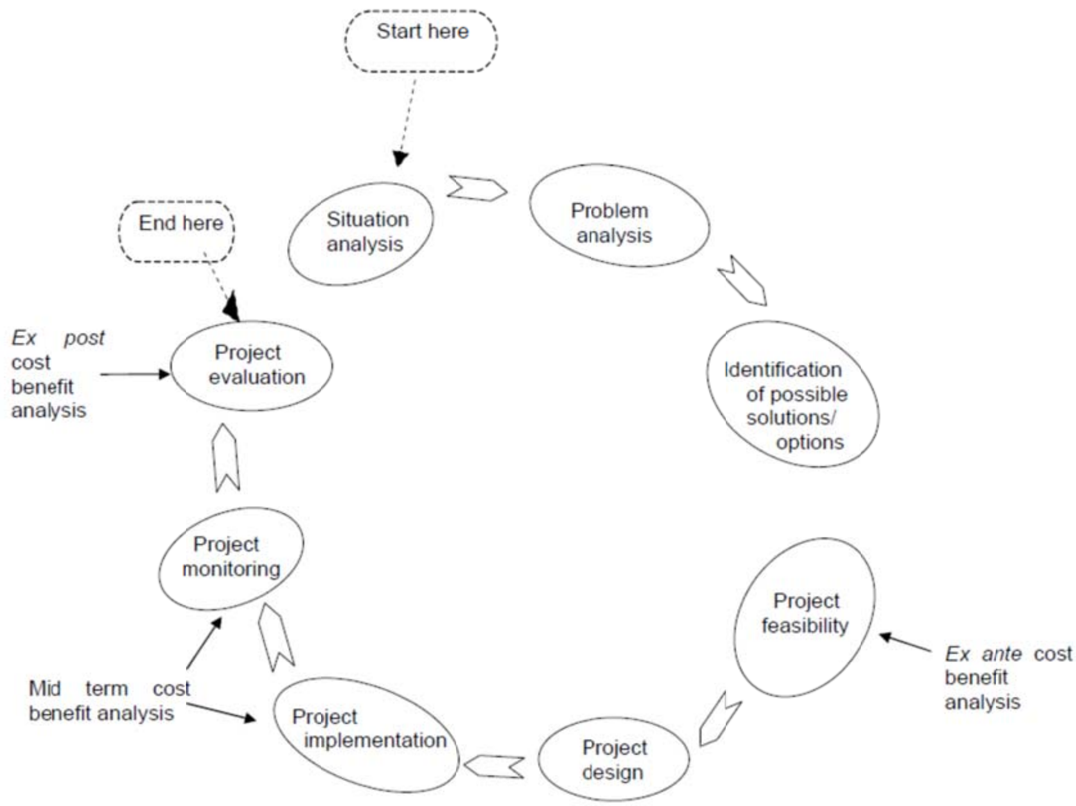


Figure 11 Cost-benefit analysis in the project cycle, adapted from Lal and Holland (2010).

Ex ante CBA. CBA can be undertaken while a project is under consideration, before it is implemented. This is standard CBA as the term is commonly used and is primarily done to help inform the design of the project proposal and appraise whether the proposal(s) is worthwhile/feasible, or not.

As discussed later, because ex ante CBAs are undertaken before the fact, these analyses require forecasts and projections to be made about the proposed project costs and benefits.

Mid-term CBA (or in medias res *CBA)*. CBAs are sometimes also undertaken mid-way through a project to check that it is on track and to inform any project design refinements/adjustments for the remainder of the project period.

Mid-term analyses can be based on observation rather than prediction of some costs and benefits. The usefulness of these types of CBA however are sometimes limited by the fact that project benefits (which include medium-term and long-term outcomes/impacts) are often not realised until the end of the project life.

Ex-post CBA. Finally, CBAs can also be undertaken at the end of the project period to evaluate its performance/success. This provides transparency and accountability in reporting on how well public funds have been spent. In other words, they contribute to "learning" by Government managers and politicians about whether the particular project (or that type of project) is worthwhile and should be financed again in the future. This is especially useful for projects which are pilots.

Because ex-post CBAs are undertaken after the fact, the analyses can use observed data. For this reason, ex-post CBAs are typically more accurate than ex-ante CBAs. An important condition for ex ante CBAs, however, is that proper baseline information is collected before the project is implemented to allow for accurate measurement of the true 'value added'.

CHAPTER 3 – The CBA process

The CBA process follows a logical and systematic sequence of analysis. For a basic CBA, this can be summarised as 6 key steps. This is illustrated in Figure 15.

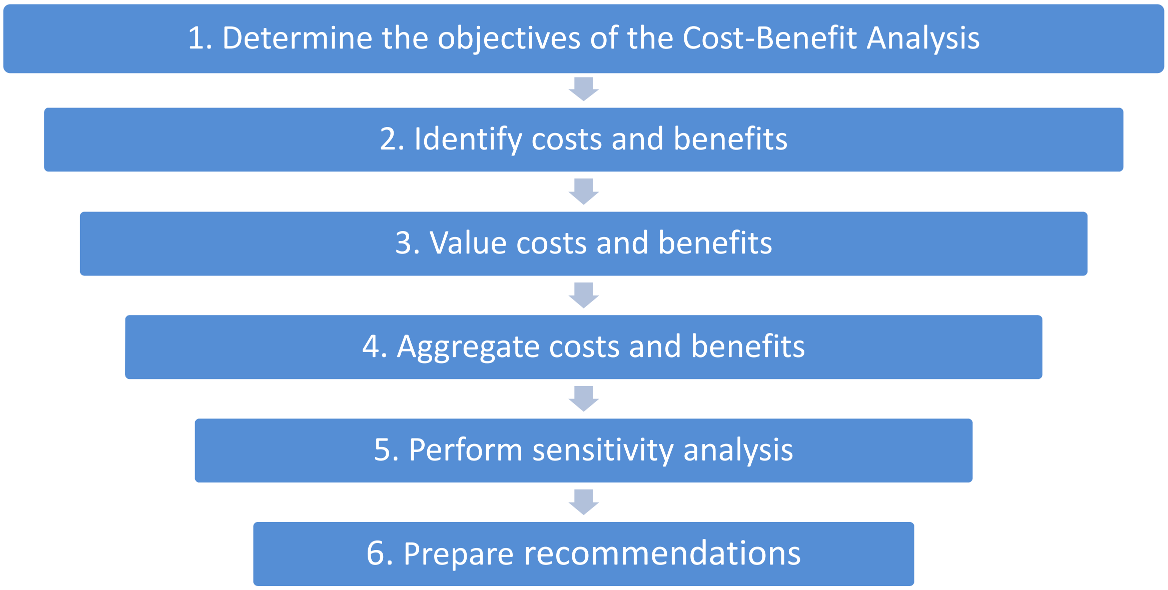


Figure 12 Key steps of the CBA process.

It is important to note that the sequence of steps presented here should not be regarded as rigid. CBA analysts may often find it necessary to return to previous steps as more data/information becomes available and the nature of the problem they are investigating becomes more evident.

The following chapters describe each of the six basic steps of CBA in some further detail. A case study CBA for African tulip tree management in Fiji is used throughout to illustrate key points of each step.

In addition, a planning tool that may help with organising the conduct of a CBA is a "CBA Work Plan". A template CBA Work Plan is provided in Appendix 7.2. This Work Plan essentially follows each step of the CBA procedure and outlines the types of information that will need to be collected and collated at each stage, as well as some of the key questions and considerations that should be given some thought.

CBA Work Plans are also a good way to facilitate inter-disciplinary team input and involvement in the CBA process. This in turn will help ensure all relevant information and data are included. It also promotes ownership and understanding of the CBA report (and broader CBA process) and thus increases the likelihood it will be used successfully in decision-making.

If a consultant is being engaged to help conduct the technical elements of the CBA, it is recommended the project management team firstly develop a CBA Work Plan. The reasons for this are the same as mentioned above. Importantly, a CBA Work Plan will also help negate any disagreements with the consultant that may arise relating to data availability or valuation technique.

CHAPTER 4 – Step 1: Determine objectives of the Cost Benefit Analysis

The first step of the process is to determine the objective(s) of the CBA. As outlined in chapter 2, the primary objective(s) of the CBA is to determine whether the benefits of a project option outweigh its cost and by how much, relative to alternatives. The purpose of this is to (i) determine whether the proposed project is (or was) a sound investment (justification/feasibility); and/or (ii) compare between alternative project options (rank and prioritise).

There may also be other objectives of the CBA that are specific to the problem or project options under consideration, which should also be incorporated. For example, the party commissioning the analysis may also be interested in better understanding the significance of potential environmental impacts of a project proposal and, if substantial, what design modifications can be made or complementary measures introduced to improve the project.

CBA objectives should be specified clearly and correctly at the outset, and all parties involved should agree on these. This provides the direction for the analysis work.

It is very important that the CBA analysts play an active role in determining the CBA objectives. Otherwise there is a risk that the objective will be mis-specified and the CBA incorrectly constructed. CBA is a lot of work to do unnecessarily or incorrectly.

To inform this discussion, the CBA analysts should thoroughly review the documentation that has been prepared as part of the situational analysis, problem analysis, objectives analysis and options analysis. That is thoroughly review work done as part of steps 1, 2, 3, and 4 of the project cycle illustrated in Figure 1.

In reviewing this documentation, it is recommended that CBA analysts keep the following questions in mind:

What is the problem?

- What is the nature of the problem? What is the magnitude of this problem? What is the evidence for this? Is the source of this information/evidence reliable?
- How many people are affected? Over what geographical area? Is this problem expected to change over time? If so, how?
- Is the problem substantial, and efforts to address it warranted?
- What are the causes and drivers of the problem? Have all causes and drivers of the problem been identified? Are these causes and drivers well-understood? What is the relative importance of each of the identified causes and drivers of the problem? Is government intervention to address these causes of the problem appropriate?

What is the project objective?

- What is the stated objective of the project? Does this objective directly link to one or more of the identified causes of the problem?
- Can the stated objective be made more specific or clear?

- Are there any financial or budget constraints on meeting the projective objective? Is there a time period for which all funds must be spent?

What are the alternative project options?

- What are the project options that have been identified? How were these options identified? Was this a thorough process, including review of what has been done in other parts of the country and the broader Pacific region as well as consultations with communities?
- Do these options clearly align with the project objective (and causes/drivers of the problem)?
- Are these options feasible given the budget limit for this project? Are there any other constraints which may impact on the feasibility of this option?
- If identified options have been implemented previously or elsewhere in the region, were they successful and what were the enablers and barriers? Was a formal evaluation report prepared for these projects and if so, has this been considered?
- Are the number of alternative options identified sufficient to provide the decision-maker with real scope for exercising choice? Are alternatives clearly distinguishable from one another?

In practice, the preceding assessments undertaken up to this stage of the project cycle may not be able to provide adequate answers to some of the questions listed above. This is often the case for projects in the Pacific region, which tend to jump straight to the project options/solutions without doing proper situational, problem, objectives, and options analyses. In this case, it is up to the analyst to ask relevant stakeholders and experts for this information and undertake further literature research.

Essentially, the CBA analyst/team should be clear about the nature and causes of the problem and that identified options to address it are appropriate before delving into the quantitative aspects of the CBA.

Box 1 below provides an example problem statement and objectives statement taken from a CBA of the management of the African tulip tree, an invasive plant, in Fiji.

Box 1 Problem Statement and objectives for CBA for African tulip tree Management in Fiji

The purpose of this cost-benefit analysis is to estimate the economically efficient options to manage the African tulip tree (*Spathodea campanulata*) at the village-level in Eastern Viti Levu, Fiji. The African tulip tree was introduced to Fiji in 1936 as an ornamental plant. It quickly escaped suburban gardens and now dominates disturbed lands throughout much of the country. It invades agricultural areas, forest plantations, and natural ecosystems, smothering other trees and crops as it grows to become the prevailing tree in these areas. Although it is considered an agricultural pest, it may also provide benefits such as building materials, habitat provision, carbon sequestration, and erosion control. The African tulip tree has high water content and hence is not a particularly desirable source of firewood.

It is often difficult for landowners to clear and control the African tulip tree with conventional methods such as manual weeding. The level of infestation has led some farmers to clear more natural forests in the area, resulting not only in the clearing of native bush but also in exacerbating the further spread of the invasive tree.

To investigate the socio-economic impacts of invasive species in Fiji, we surveyed 360 households in 30 villages in eastern Viti Levu. Additional information on the impact at the village-level was obtained through a community-level focus group. Information on the biophysical growth and effectiveness of various management options to control the invasive were primarily obtained from scientific literature and checked by regional experts.

CHAPTER 5 – Step 2: Identify costs and benefits for each option

The second step of the CBA process is to identify all of the costs and benefits relating to each of the project options.

With and Without Analysis

To do this, the analyst should define what is expected to happen if no project options are implemented to address the identified problem, i.e. the 'without-project' scenario. This provides the 'baseline' from which costs and benefits of the (with) project can be identified and measured. The intent of "with and without analysis" is to identify only the changes that are clearly associated with the project options, and not include changes that would have occurred anyway (Brouwer & Pearce 2005).

To identify types of costs and benefits, with and without analysis can be performed in approximate, qualitative terms in the first instance[4]. More detailed, quantitative with and without analysis can be undertaken as part of valuation of costs and benefits in the next step. The advantage of doing a qualitative with and without analysis first up is that it helps to avoid unnecessary research and data collection efforts which can be very time-consuming and expensive.

One way to do qualitative with and without analysis is by constructing a without-project and with-project table. This is illustrated using the example of the management of a key invasive species in the Pacfic, the African tulip tree. Details are listed in Table 6 below.

[4]To measure costs and benefits, the without project scenario will need to be defined more thoroughly and, where possible, in quantitative terms. In doing this the CBA analysts should make a special effort to forecast what the level of the relevant outcomes are expected to be over the lifespan of the proposed project taking into account any trends observed for the relevant impacts/outcomes, trends observed for the identified causes and drivers of the problem including population growth, and other activities which seek to address the same or similar problems in the same area. This will be discussed further in chapter 6.

Table 6 Without-project and with-project table for the African tulip tree Management Option project

Without (no management)
Management: There is no management **Invasive Pathway:** The tree follows typical progression of growth and spread across the landscape with no management. Under this scenario, the African tulip tree eventually occupies all ecologically suited environments when it reaches carrying capacity about 40 years after being introduced to the study site. **Key Stakeholders:** Community and government **Costs:** There are no management costs **Benefits:** There are no benefits as this option results in the maximum likely damages to land-based production. **Impacts:** Agriculture, livestock, forestry yields; biodiversity all adverseley impacted by growth and spread of invasive
With #1 (light management)
Management: Mix of labour and herbicides **Invasive Pathway:** The population of the African tulip tree is reduced by about 50% relative to the do nothing scenario **Key Stakeholders:** Community and government **Costs:** Labour, herbicides, spraying and cutting materials **Benefits:** This option results in some avoided damages to land-based production relative to the without case. **Impacts:** Agriculture, livestock, forestry yields; biodiversity all still impacted by growth and spread of invasive, but at a lesser degree than the 'without' scenario.
With #2 (intenstive management)
Management: Mix of labour, herbicides, and integrated management **Invasive Pathway:** The population of the African tulip tree is reduced to about 10% of what it could be under the do nothing scenario **Key Stakeholders:** Community and government **Costs:** Labour, herbicides, spraying and cutting materials, for small trees, digger hire for large tree clearing **Benefits:** This option results in significant avoided damages to land-based production relative to the without case. **Impacts:** Agriculture, livestock, forestry yields; biodiversity all slightly impacted by growth and spread of invasive, but at a much lesser degree than the 'without' scenario

The top part of this table qualitatively describes what inputs, outputs, and outcomes/impacts relevant to the project problem are expected to be experienced by each stakeholder group without any project options being implemented. That is, what would likely happen if we just followed 'business as usual' taking into consideration any trends observed for the relevant impacts/outcomes, trends observed for the identified causes and drivers of the problem including invasive species population growth and spread, and whether any other activities are planned which seek to address the same or similar problems in the same area.

The bottom 2/3 of the table describes these same inputs, outputs and outcomes/impacts for the scenario where the proposed project option(s) *relative to the without-project scenario* (i.e. what change will the project result in against 'business as usual'). These rows also include the additional inputs required to implement the project options. These are the up-front (i.e. capital) and operational costs of the project option.

It is worth emphasising the importance of properly applying with and without analysis to the CBA. To do this, a thorough understanding of the chain of causation of the project is needed as was outlined in the previous chapter. If with and without analysis is not done properly and instead a simplistic 'before and after' approach is undertaken – whereby impacts and outcomes are measured just prior to project implementation and presumed to remain constant at that level over the lifespan of the proposed project, then this will likely overlook some costs and benefits and/or under/overestimate the true value of identified costs and benefits. This in turn may lead to major errors in the analysis.

Identifying costs and benefits

The costs and benefit items identified for the project options correspond to the inputs, outputs, and outcomes/impacts identified in the with and without analysis.

As would be expected, there are many different inputs, outputs, and outcomes/impacts that could be relevant to a given project.

Typical benefit items include:

- The value of outputs as reflected in revenues generated by a particular project
- Productivity savings – reductions in existing levels of input expenditure that can be shown to result from the project; and
- Avoided costs – the value of inputs or lost outputs that would have been incurred in the 'without project' scenario
- (Positive) health and other social outcomes/impacts that can be shown to result from the project
- (Positive) environmental outputs and outcomes/impacts that can be shown to result from the project
- A reduction in unemployment.

Typical cost items include:

- Up-front costs
  - research, design and development costs
  - capital expenditures
  - labour costs
  - land, facilities, or machinery already in the public domain
- Operating and maintenance costs for the entire expected economic life of the project
  - costs of regular inputs (fuel, materials, manufactured goods, transport and storage, etc.)
  - labour costs
- Negative health outcomes/impacts on third parties that can be shown to result from the project
- Negative environmental impacts on third parties that can be shown to result from the project.

It is important to note that health, social, and environmental benefits/costs listed above are either not marketed (that is, these items are not purchased or sold in markets) or are characterised by prices that reflect less than the full value of the benefits/costs. While these characteristics sometimes make it difficult to identify and measure such costs and benefits, it is important that these items are included in the analysis. At a minimum, they should be discussed and described in qualitative terms.

Similarly, it is important to include land, facilities, machinery and such items already in the public domain as costs of the project – even though these items are not purchased explicitly for the project. This is because these items could be used for an alternative value-generating activity and so by using them in the proposed project we are foregoing the value that could be generated from its alternative use. In economics, this concept is known as 'opportunity cost'. More details on opportunity costs are provided in Box 1. The valuation of costs and benefit items and some of the key economic concepts underpinning this exercise are discussed further in the next chapter.

Box 1 Examples of Opportunity Costs

Assessing opportunity costs is fundamental to assessing the true cost of an activity. Opportunity costs do not always have to be assessed in monetary terms. They can be assessed in terms of anything that is of value to the stakeholders in the analysis. For example, a forest that is primarily used to produce timber and pulp may have a next-best-alternative use as habitat for threatened species. Examples of opportunity costs that are typically included in an economic analysing include:

Family labour: Family members who become involved in an activity would otherwise be engaged in alternative activities such as cooking, gardening, and fishing

Resources: Resources used of a particular activity may be scarce or expensive and difficult to source for alternative activities

Protected areas: An area that is closed off could be a source of food, fibre, fuel and medicine that would need to be collected from elsewhere

Agricultural production: A farmer that chooses to grow and harvest taro could have planted alternative crops instead

Note that in some cases there is no viable alternative and therefore it is possible to have zero opportunity cost.

The key costs and benefits identified for the African tulip tree management example are shown in Box 2.

Box 2 Identifying costs and benefits for African tulip tree Management in Fiji

Several benefits can accrue within the community as a result of managing the African tulip tree, mostly in terms of avoided damages. Possible benefits include improved crop, livestock, and forest productivity, reduced deforestation of native forest, and resulting co-benefits such as improved biodiversity, reduced soil erosion, and a resource of standing dead trees that could be used as firewood. Unfortunately, these benefits are not easily quantified, either physically or monetarily. As a result, this analysis only quantifies the benefits of avoided damages in livestock, crop, and forestry yield.

Quantifying the costs of invasives management is often more straightforward. Typical costs of controlling the African tulip tree include labour, herbicides, bulldozer or digger rental, and capital costs such as chainsaws, herbicide sprayers, machetes, and gloves.

CHAPTER 6 – Step 3: Valuing costs and benefits

The third step of the CBA procedure is to measure costs and benefit items identified for each option. As far as possible, this should be done in monetary terms. The rationale for doing this is that it enables direct comparison of different cost and benefit items.

Building on the qualitative with and without analysis outlined in the previous chapter, the initial step to valuing costs and benefits is to determine the physical amounts of inputs required outputs created over time (i.e. for every year of the proposed project) from implementing a given activity. Remember, the (physical) amount of costs and benefits attributable to a project are only those that result from the project activities. That is, costs and benefits for an option must be additional/incremental to what would happen under business as usual (i.e. without).

After physical units are quantified, dollar figures need to be added to the inputs and outputs.In general, all benefits and costs should be quantified and valued in dollar terms unless itis clearly impractical to do so. Situations where it may be impractical to value in monetary terms include:

- physical and monetary values cannot be reliably measured, or
- cost or benefit items are not significant to the analysis, or
- the cost of attempting to value them outweighs the benefit of including them in the analysis.

Monetary costs and benefits can be estimated using several methods, although values are typically based upon market prices, as they are the easiest to identify. Market prices are defined as the value of inputs and outputs that are readily available in a market setting. Note that market prices should reflect the value of money exchanged between the buyer and seller and may need to be adjusted to remove the value of government taxes and subsidies that are often included in the 'retail' price of a good.

There are often cases where a market does not exist or market prices are not directly observable or easy to estimate. In such cases, it may be difficult to estimate costs and benefits (or even to determine to whom the costs and benefits accrue). This is a relatively common occurrence in the context of environmental management, as wider social and environmental costs and benefits commonly fall into this category. These values should not be ignored simply because they cannot easily be monetised though, and there are methods that can be used to obtain estimates.

Quantifying non-market costs and benefits can often require extensive data that can be costly to obtain. Therefore it should only be undertaken if it is believed that the benefits of collecting the data will significantly outweigh the cost of doing so. For example, while biodiversity might be a key benefit to setting up a protected area, there are many components that would go into placing a monetary value on the improvement in biodiversity as a result of the intervention (e.g. change in species relative to status quo, value of species to various stakeholders, etc.).

Common approaches for monetising costs and benefits along with the relative level of effort (time and/or money) that is generally required to collect the data are shown in Figure 13. A short description of each method is as follows:

Market prices: The value of inputs and outputs readily available in a market setting. They are generally applied to tangible goods and services. Labour wages and capital costs can also be determined from market prices.

Cost-based approach: Values are determined by assessing the cost of value added products, infrastructure or technologies that could replace non-market goods and services. In addition, the costs of mitigating or averting the impacts of lost services (i.e. avoided damages or mitigation) can be also used to determine the value of a non-market cost or benefit.

Production function: This approach estimates value of goods and services by relating changes in the output of a marketed good or service to a measurable change in the quality of other goods and services by establishing a measureable response relationship between the quality and production of a particular good or service.

Surrogate market approach: Derived from cases in an indirect-market setting where people have historically made trade-offs between costs and benefits. An example is the travel cost method, which uses the value of traded goods (e.g. time and money spent travelling to a recreation site) and services to estimate the value of non-traded goods (e.g. the benefits derived from the particular set of attributes in the site).

Stated-preference method: Typically a survey based approach where stakeholders are asked to identify their preferences for trading off costs and benefits for well-defined scenarios or activities. The approach can simulate a market by estimating a consumer's willingness to pay for good or service or their willingness to accept compensation to tolerate a negative or bad economic outcome.

More details on these methods and examples of how they are used are listed in Appendix 7.3.

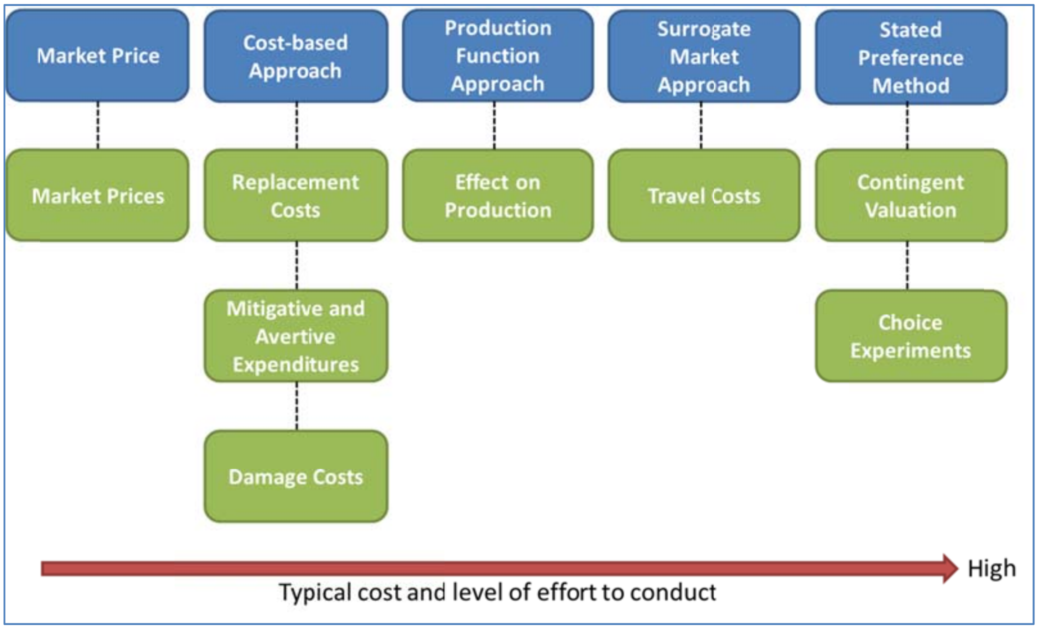


Figure 13 Methods for quantifying and valuing benefits, based on Emerton and Bos (2004)

Costs and benefits should almost always be valued in real terms (constant prices) over time as opposed to nominal terms (prices at the time the goods or services were/are provided). In other words, the impact of inflation should be removed from the CBA so the costs and benefits are measured in a common money value over time. Prices can, however, be adjusted over time if the price of a particular good or service is expected to increase or decrease relative to all other goods and services. This can occur with environmental management projects where a proposed activity might constrain the use of a natural resource, thus making the supply of that resource scarce and creating a local price spike. For example, designating a forest as a protected area or national park could eliminate access to firewood and timber by local communities, thus increasing the local price of these goods if there is no substitute available.

Data collection in the Pacific can be difficult as it is often time consuming and costly to obtain. Data may need to be bought or sourced through primary collection. There are also only a limited number of agencies in the Pacific that routinely conduct economic analysis of development projects that link with the natural environment and as a result, it may be difficult to find the necessary expertise to conduct the work. While effort should be made to collect data on all key costs and benefits, that might not always feasible. If it is still not possible to quantify some costs and benefits with any accuracy, inclusion as the quantitative analysis may be more misleading than helpful. In this case it is important to include a robust sensitivity analysis on key variables as well as a qualitative evaluation of the key costs and benefits that could not be monetised, as discussed in detail below.

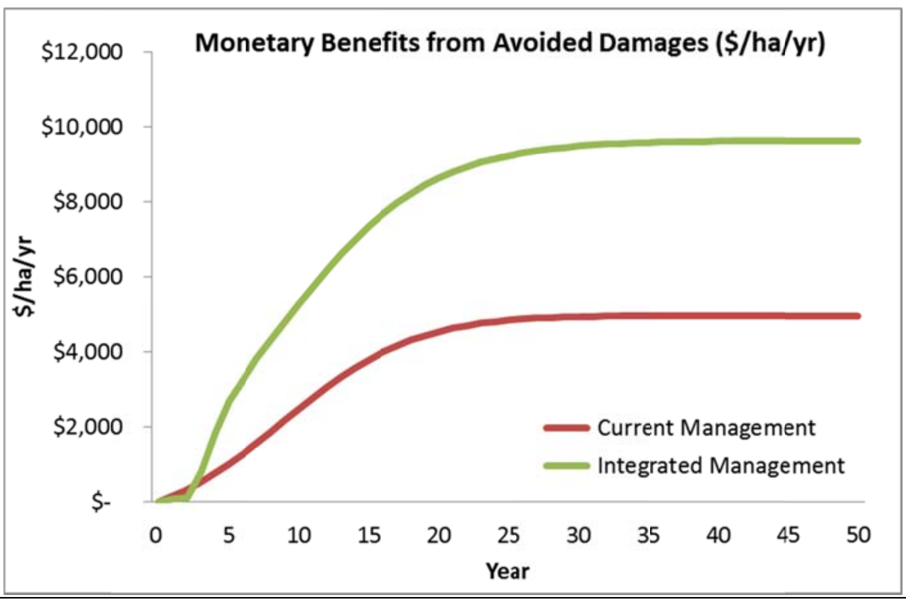
The value of costs and benefits quantified for the African tulip tree management example are shown in Box 3.

Box 3 Valuing costs and benefits for African tulip tree management in Fiji

The benefits specified in Box 3 must be valued by first expressing them in terms of physical units of damage that would likely accrue under the 'do nothing' in the initial period (year 1). For this study, we estimate that crop, livestock, and forestry production diminishes by 20% in the presence of African tulip trees due to the initial assumption about the amount of space that it takes up in the field. Future damages to land-based production are estimated to change using the functional assumption that the damage is directly correlated with the maximum potential capacity of the invasive population. The physical values of benefits can then be monetised by applying the following unit values over time:

Category	Unit Measurement	Unit Value ($/unit)
Crop income	$/kg	$ 1
Livestock income	$/kg	$ 2
Forestry Income	$/m3	$ 35

These values are then used to estimate the level of damages that could be avoided if one of the active management options were implemented instead of the 'do nothing' case. The differences between the monetised values of the damage curves for the current and more expensive but more effective intensive management approach represent the benefits that accrue from avoiding damages that would have occurred under the do nothing option, as shown in the following figure:



The monetised costs can be estimated by multiplying unit costs incurred in each year by the physical values of each input (labour, herbicides, capital costs, etc.):

Category	Unit Measurement	Unit Value ($/unit)
Glyphosate herbicide	$/litre	$ 15
2,4 D + dicamba herbicide	$/litre	$ 125
Triclopyr herbicide	$/litre	$ 45
Labour	$/man day	$ 30
Bulldozer or digger hire	$/day	$ 300
Machete, gloves, and hand saw	$/item	$ 75
Knapsack sprayer	$/item	$ 210
Precision drench gun	$/item	$ 120

The costs of each management option can then be specified on annual basis by summing the total cost of each input. Total annual costs are estimated to be the following:

Option	Year 0	Years 1-5	Years 6-50
Do Nothing	$0	0	0
Current Management	–$300	–$1,472	–$722
Integrated Management	–$420	–$1,950	–$1,200

Note that all most costs are estimated to occur at the end of each period (year). Exceptions are the capital costs, which only occur during the initial period, and some costs that only occur in the first 5 years of the project.

CHAPTER 7 – Step 4: Aggregating costs and benefits

Step 4 of the CBA process is to aggregate costs and benefits. Aggregation refers to the bringing together of all the different costs and benefits over the life of the project, and presenting it as one number (value or ratio). The purpose of this step is to convert available data into manageable information to facilitate the comparison and decision of all options considered. Aggregating costs and benefits is undertaken in two parts: (1) discounting costs and benefits to account for values that accrue at different points in time, and (2) summing these discounted values into a single metric called 'net present value' that can be used to compare the relative benefit of all options considered. Both parts are described in detail below, as are alternative ways to measure and compare the relative effectiveness of different options.

Discounting

The lifetime of many projects under consideration can stretch over many periods of time, and accounting for time is a critical component of a cost-benefit analysis. This is because people typically place more weight on costs and benefits that accrue at earlier in the lifecycle of the project. This is achieved by applying a technique known as 'discounting' that allows benefits and costs that occur in different time periods to be comparable by expressing their values in present terms, otherwise known as present value (PV). Discounting reflects that people prefer consumption today to future consumption. For example, individuals typically value a dollar that is received today more than a dollar received a year from now.

Discounting is done by multiplying the changes in future consumption caused by an activity by a discount factor (*r*). In other words, it converts the future value (FV) of a given cost or benefit to a present value (PV). This is represented mathematically as:

$$PV = FV / (1+r)^t$$

The present value of costs and benefits can vary significantly based on the chosen discount rate (see

Table 7). There is no set rule on what the appropriate discount rate for an economic analysis should be. Some studies use the real interest rate, which is the commercial interest rate adjusted for inflation; others use a low social discount rate because of the philosophy that benefits that could accrue over multiple generations should be accounted for. Other government and private investments may use a higher discount rate because it accounts for the opportunity cost of capital, which represents the prevailing rate of return on investments elsewhere in the economy.

Table 7 Present values of $100 earned during various project periods and discount rates

Discount Rate (r)	Year 0 (today)	Year 1	Year 2	Year 3	Year 4	Year 5
0%	$100	$100	$100	$100	$100	$100
5%	$100	$ 95	$ 91	$ 86	$ 82	$ 78
10%	$100	$ 91	$ 83	$ 75	$ 68	$ 62

Activities that are intended to provide environmental benefits such as climate change mitigation or habitat protection can be highly impacted by the discount rate, especially if a majority of the benefits are estimated to be in the distant future. This is because using a high discount rate could make projects with long-term impacts economically infeasible relative to those that might provide less benefits but in the more near-term. Thus, some projects with large benefits over the long run might be rendered infeasible if the discount rate is too high. Regardless, the chosen discount rate used for a specific CBA should be supported with appropriate justification.

The analysis should always use the same discount rate be used for both benefits and costs and between project options. This is because almost any activity can be justified by choosing a sufficiently low discount rate for benefits, by choosing sufficiently high discount rates for costs, or by choosing a sufficiently long time horizon. Likewise, making sufficiently extreme opposite choices could result in any policy being rejected.

It is ultimately up to the analyst to choose which discount rate is most appropriate and back it up with a logical explanation. Alternative discount rates can be used in a sensitivity analysis (discussed below) to assess if this changes the rank of options under consideration. A list of discount rates used in recent studies conducted in the Pacific is shown in Appendix 7.1. Many of these studies use an initial rate of 7–10%

Calculating Net Present Value

Once costs and benefits accruing in different time periods are discounted to their present value, they can then be aggregated into a single metric. The net present value (NPV) is the most common approach for doing this in CBA, and is intended to represent the overall net benefit of a project to society.

NPV is expressed mathematically as:

$$NPV = \sum_{t=1}^{T} \frac{B_t - C_t}{(1+r)^t}$$

where B_t is value of benefit at time t, C_t is value of cost at time t, T is final time period of project, and r is the real interest rate that is used to discount costs and benefits to the present value.

Said another way, this is the sum of all discounted project benefits minus the sum of all discounted project costs.

When estimating the NPV, it is important to state explicitly how time periods are designated and when costs and benefits accrue in each time period. Time periods are often expressed in years, but alternative time periods can be justified if costs or benefits accrue at irregular or non-annual intervals.

The NPV formula used for the calculation assumes that t=0 designates the beginning of the first period. Therefore, the net benefits at time zero only includes costs for initial start-up and capital costs that occur immediately after the activity has begun (hence the designation of year=0). No additional costs are incurred until the end of the first year. All benefits are assumed to accrue at the end of each time period.

Only options with a NPV greater than zero should be considered economically feasible and preferred over the 'without' or 'business as usual' case. This means that the benefits of the proposed project are greater than the costs. If several options are evaluated, the option with the highest NPV is the one that would yield the most net economic benefits to society. In economics, this is said to be the most 'efficient' option.

For many situations, particularly in developed countries where there is a well-functioning tax-welfare system, economic efficiency is the main criterion for formulating advice and making decisions about whether to invest in a particular project option or to select between competing options. However, in the Pacific and other developing countries this is not the only criterion that needs to be considered when formulating our advice. Equity and other considerations can also be important. This is discussed further in chapter 9.

An example of how to calculate NPV for the intensive integrated management option for the African tulip tree is listed in Table 8. Management is expected to occur for 50 years and the discount rate is 8%.

Table 8 Calculation of NPV for African tulip tree Management Case Study, Intensive management approach (r=8%, T=50 years)

Year	Cost	Benefit	Discounted Cost	Discounted Benefit	Net Present Value
0	-$420	$0	-$420	$0	
1	-$1,950	$94	-$1810	$87	
2	-$ 1,950	113	-$1555	$97	$44,100
…	…	…	…	…	
50	-$1,200	$9,630	-$26	$205	

Alternative Decision Guidance Methods

There are several different methods that can be used to compare relative costs and benefits besides using NPV. Two common alternatives include estimating the benefit-cost ratio (BCR) and the internal rate of return (IRR).

BCR is the ratio of the net present value (NPV) of benefits associated with an activity, relative to the NPV of the costs of the same activity. The ratio indicates the benefits expected for each dollar of costs. This ratio is not an indicator of the magnitude of net benefits though, as two projects with the same BCR can have vastly different estimates of benefits and costs. In general, any project with a BCR greater than 1 should be considered a viable alternative.

The internal rate of return (IRR) is the maximum discount rate that could be applied to all monetised costs and benefits for a project that would still allow for it to break even (i.e. have a NPV = 0). In the case study example for calculating NPV, we saw that the project with an assumed discount rate of 8% yielded a net benefit of $44,100. Calculating the IRR for that same project would reveal that the discount rate would have to be about 35% for the activity to break even, or yield no net benefits. Because the IRR is estimated to be quite high, it reinforces that this option should be preferred over the do nothing scenario.

Cost-effective Analysis (CEA)

Cost-effective analysis (CEA) is an approach often used to rank intervention options when one cannot derive monetary benefits from key categories in a given project. In this approach, monetary costs of option typically compared with physical changes (benefits). Examples of when CEA could be used include:

- Health Benefits: Cost per lives saved from hazard mitigation (e.g. flood control)
- Environmental Benefits: Cost per unit reduction of pollution (e.g. GHG emissions)
- Conservation: Cost per species or geographic area protected (e.g. native birds, conservation park)

Cost-effectiveness is estimated by dividing the net present value of the costs of an intervention by a non-monetised benefit category to estimate the average cost per unit of the benefit created from a given intervention. This ratio can then be used to rank options in terms of cost per physical unit of benefit. This is expressed mathematically as:

$$CE = {}^{C}\!/_{\mathrm{B}}$$

where CE is the cost-effectiveness of the project option, C is the net present value of the monetised costs of the intervention, and B is the effectiveness of the project option measured in physical units. The smaller the CE ratio is, the greater is the cost-effectiveness of an intervention.

CEA is different from CBA in various ways. First, the benefits are expressed in physical units and not monetary units. Second, the need to divide by a physical unit means that the options being assessed must be similar in nature. Third, the theory of discounting is only applied to the monetary cost component of the estimate. This means that the effectiveness component of the calculation for each option must be consistently estimated at the same point in time.

An example of how to use cost-effectiveness analysis to assess two options for a forest conservation project is shown in Box 4.

Box 4 Estimating the most Cost-effective Option for Forest Conservation

Consider the following example where a specific area in two forests is being considered for forest conservation and species protection. One is 17 hectares in are and the other is 10 hectares. Option 1 produces an annual stream of timber that creates a net present value of $2,000 over the next 30 years. Option 2 produces an annual stream of timber that creates a net present value of $3,000 over the next 30 years. Protecting the forest would remove the timber from production and hence be considered a cost.

Activity	NPV Cost	Area Protected	Cost-Effectiveness
Option 1	$2,000	10 ha	$200/ha
Option 2	$3,000	17 ha	$176/ha

Despite the impact to the local economy, the government still sees a benefit from protecting the forest and is willing to compensate landowners for their loss in production. In many cases, analysts will not have the data to put a non-market value on the benefit of protecting the forest, so they must resort to a cost-effectiveness analysis to guide their decision-making. However, their budget of $3,000 is only large enough to implement one of the projects. Option 1 costs $200 per ha protected, while option 2 costs $176 per ha. Based purely on cost-effectiveness, option 2 is the preferred option.

Comparing Options

The most-appropriate method to use to compare activities under consideration in a CBA often depends on the objective and level of data available. Simple rules for when each approach could be used are listed in Table 9.

Table 9 Best approach to use given data available

Metric	When Appropriate to Use
Net Present Value	Can monetise all key costs and benefits of activities
Benefit-Cost Ratio	Can monetise all key costs and benefits of activities, and there is a budget constraint which limits the combination of options that can be implemented.
Cost-Effectiveness	Can monetise key costs of activities but not able to place monetary values on key benefit trying to achieve. There is only 1 key benefit and this is the same for all options under consideration.
Internal Rate of Return	Activities have similar time frame

After conducting the quantitative analysis for each option, the analyst must determine if it is a viable option relative to the status quo. Criteria for each method are listed in Table 10. Cost-effectiveness is excluded from this table because an option cannot be compared relative to the status quo using a single calculation. Rather it is deemed feasible if (1) there is a measurable benefit relative to the status quo and (2) the budget for the specified activity is available.

Table 10 Criteria used to determine if options are improvement over the status quo

Method	Calculation	Consider Option?
Net Present Value	$PV_{Benefits} – PV_{Costs} > 0$ or $NPV > 0$	YES
	$PV_{Benefits} – PV_{Costs} < 0$ or $NPV < 0$	NO
Benefit-Cost Ratio	$PV_{Benefits} / PV_{Costs} > 1$	YES
	$PV_{Benefits} / PV_{Costs} < 1$	NO
Internal Rate of Return	$IRR > r$	YES
	$IRR < r$	NO

After determining which options are an improvement over the status quo, the can be ranked relative to each other. The ultimate decision on which activity to undertake from a purely economic perspective should be based on:

- Maximum net present value
- Highest benefit cost ratio
- Highest internal rate of return
- Minimum net present value of cost per unit benefit (cost-effectiveness analysis)

Note that some options might be ‘optimal’ from an economic perspective, but be very sensitive to the greater community and/or key stakeholders. Some of the issues surrounding possible distributional impacts are discussed in Chapter 9, and suggestions on how to make a judgement call are included in Chapter 10.

The estimates for NPV and BCR for the African tulip tree management example are shown in Box 5.

Box 5 NPV and BCR for African tulip Tree Management in Fiji

Results of the benefit-cost analysis for the African tulip tree management are listed in the table below, and measured relative to the ‘do nothing’ scenario.

Option	PV Costs	PV Benefits	Total NPV	Benefit-Cost Ratio	Rank
Do Nothing	$ -	$ -	$ -	1.0	3
Current Management	-$ 11,201	$ 30,305	$ 19,104	2.7	2
Integrated Management	-$ 16,255	$ 60,351	$ 44,097	3.7	1

Results indicate the integrated approach yields the highest NPV and is therefore considered the most efficient management option from an economic perspective, provided that people have the additional funding and knowledge to implement it. Nevertheless, the current management option also yields a positive NPV, indicating it would be preferred over doing no management at all.

CHAPTER 8 – Step 5: Perform sensitivity analysis

The 5th step of the CBA process is sensitivity analysis to account for uncertainty about the values of future costs and benefits. This is achieved by changing the values of key variables in the analysis, such as the discount rate and significant costs and benefits, and the re-estimating the NPV. Conducting a sensitivity analysis to account properly for uncertainty in the initial results will reduce the risk that the option as a result of the CBA is indeed sub-optimal.

Uncertainty arises because it is often difficult to forecast how future costs and benefits estimated in a CBA will accrue over time. Stakeholders may also have a different discount rate than what was used in the initial analysis. Many CBAs require extensive data to be completed, and estimating the flow of some key costs and benefits may require the use of assumptions and expert opinion that could vary in reality. Conducting a sensitivity analysis that varies key metrics can provide some insight as to whether the findings under the conditions of the initial BCA are consistent under a variety of assumptions. Some possible options for selecting what to consider in a sensitivity analysis are:

- Costs and benefits that make up the largest proportion of the value for the activity
- Values most likely to be scrutinised by decision-makers
- Values estimated with relatively high degree of uncertainty

There are three stages of conducting sensitivity analysis. First, identify key parameters that are uncertain. Second, determine alternative values for uncertain parameters. A standard way to do this for relatively simple analyses is to determine feasible upper-bound and lower-bound parameter values, provided that the parameter values used are supported by a reason for why they were selected. Third, examine the impact that a change in the value of each parameter would have on the project's net present value and BCR.

The sensitivity analysis should be clearly presented so that it provides realistic picture of the extent to which the options considered are still worthwhile to implement even if there are significant changes in key variables. Table 11 shows key areas of uncertainty that could be included in a sensitivity anlaysis for the African tulip tree CBA.

Table 11 Key areas of uncertainty for the African tulip tree management CBA sensitivity analysis

Variables	Reason for Uncertainty	Sensitivity Analysis
Discount Rate	Varying rate of time preferences	Use a range of discount rates above and below the baseline value
Management effectiveness	Varying impacts of management over space and time	Use range of effectiveness trajectories
Initial population	Varying levels of population densities across project sites	Use range of population densities
Non-market values	Difficult to quantify value of native species protection methods	Use benefits transfer from other analyses conduced in Pacific Island
Market Prices	Market conditions could change over time	Use range of prices
Flow of impacts over time	Environmental conditions could change	Use range of estimates

The range of NPVs from a sensitivity anlaysis for the CBA for the African tulip tree management example evaluated the impacts of the first three variables listed in the above table are shown in Box 6.

Box 6 Sensitivity Analysis for African tulip Tree Management in Fiji

The population of the invasive species in the initial period can also vary across space. As a result, we undertake a sensitivity analysis to assess the robustness of our results. Specifically, we now analyse the results in the light of the following variable assumptions:

1. Initial population (as % of max) – 0.5 and 2 times base assumption. This changes the initial population of the African tulip tree from 20 to 10% or 40%.

2. Effectiveness of management – 0.5 and 2 times base assumption. This adjusts the pathway of the population growth curves for the two intervention options. An option that is assumed to be twice as effective means that the species is controlled in about half the time as the initial assumption.

Results for NPV on a per hectare basis are displayed in the following table, where the project length is still 50 years and the discount rate is 8%.

Option	Effectiveness	Initial Population (relative to max)		
		10%	20%	40%
Current Management	0.5 x base	$11,899	$8,320	$8,827
	1.0 x base	$18,748	$19,104	$27,472
	2.0 x base	$26,371	$31,258	$49,334
Integrated Management	0.5 x base	$16,490	$34,445	$28,973
	1.0 x base	$30,158	$44,097	$64,553
	2.0 x base	$35,063	$47,858	$73,147

We also look at the impact of the discount rate on the initial assumptions about baseline populaiton and management effectiveness. Here we, use rates of 4% and 12%, as they are at the tails of the range of discount rates used for environmental management projects in the region. The ranges of NPV on a per hectare basis are:

Option	4%	8%	12%
Do Nothing	$ -	$ -	$ -
Current Management	$ 50,229	$ 19,104	$ 8,031
Integrated Management	$ 106,951	$ 44,097	$ 21,184

For all sensitivty analysis cases, both management options yielded a positive NPV, indicating that management of the African tulip tree should be actively pursued over the ‘do nothing’ scenario.

Chapter 10 – Step 6: Report the results and prepare recommendations

The final step in conducting a CBA process is to write up the analysis and prepare recommendations. After comparisons are made, reasons for a particular recommendation should be clearly set out. In many cases, it is important to revisit the key assumptions used in forecasting the costs and benefits of the proposal or programme. The report should be clear, concise, and be written to the level of the intended audience. In many cases, the detailed analysis including the full list of assumptions can be included in an appendix. A possible structure of the report is described briefly in Appendix 7.2.

The rationale for recommending the preferred option should be clear and defensible. The report should include sufficient evidence for the reason a given option was selection. In some cases, the preferred option may not be the proposal with the highest net present value due to some critical qualitative or non-quantifiable factors. Examples include having a strong desire to protect biodiversity that was not valued or that the project would have a significant impact on a particular group of stakeholders. If this is the case, specific reasons why the quantitative findings from the CBA have been overridden need to be made clear.

The recommendation for the African tulip tree management example is highlighted in Box 7. The complete CBA for the African tulip tree is provided in Appendix 13.

Box 7 Recommendation for African tulip Tree Management in Fiji

The benefit-cost analysis estimated three options to manage the African tulip tree: (i) do nothing, (ii) continue current management regime, (iii) implement a more intensive integrated approach. The integrated approach to managing the African tulip tree was estimated to yield the highest net present value of all management options investigated in this study, as benefits of management outweighed costs by a ratio of almost 4 to 1. It is the preferred option, provided that the resources are available.

The current management approach was not as effective, although it still yielded positive net benefits for landowners (benefit-cost ratio of 2.7:1) and should thus be considered a viable option over the do nothing approach. This is particularly the case if herbicides and machinery are difficult to obtain.

Increasing the level of effort for manually weeding, cutting and burning the African tulip tree should also be considered, but landowners should be trained to manage the invasive more effectively than the current case in which the African tulip tree continues to spread even when households spend about 4 hours per week clearing it.

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APPENDIX 7.1: Examples of Recent Cost Benefit Analyses Conducted in the Pacific

Sector	Reference	Country	Topic	Web link	Discount rate	Timing
Water	Ambroz 2011	Niue	Water supply	http://ict.sopac.org/VirLib/TR0447.pdf	3, 7, 10	Ex ante
	Gerber 2010	Palau	Water safety planning	http://www.sopac.org/sopac/docs/TR440%20final.pdf	3, 7, 10	Ex ante/ ongoing
	Gerber 2011	RMI	Water resource	http://ict.sopac.org/VirLib/TR0438.pdf	3, 7, 10	Ex ante/ ongoing
	Gerber et al. 2011	Tuvalu	Water supply	n/a	3, 7, 10	Ongoing
	Talagi 2011	Niue	Water safety planning	http://ict.sopac.org/VirLib/TR0443.pdf	3, 7, 10	Ex ante/ ongoing
Coastal management	Ambroz, 2009	Tuvalu	Aggregate supply	http://ict.sopac.org/VirLib/ER0137.pdf	3, 7, 10	Ex ante
	Greer Consulting Services 2007	Kiribati	Aggregate supply	http://ict.sopac.org/VirLib/ER0071a.pdf	10	Ex ante
Disaster risk	Holland 2008	Fiji	Flood early warning	http://ict.sopac.org/VirLib/ER0122.pdf	3, 7, 10	Ex ante
	Woodruff 2007	Samoa	Flood mitigation	http://ict.sopac.org/VirLib/ER0069g.pdf	7	Ex ante
	Lal et al. 2009	Fiji	Flood impacts	http://cmsdata.iucn.org/downloads/flood_report_final_compressed.pdf	n/a	Ex post
Fisheries	Vunisea 2005	RMI	Tuna sector	http://www.spc.int/DigitalLibrary/Doc/FAME/InfoBull/WIF/15/WIF15_03_Vunisea.html	n/a	n/a
	Sharp 2011	Regional	Fish aggregating devices	http://www.spc.int/DigitalLibrary/Doc/FAME/InfoBull/FishNews/135/FishNews135_27_Sharp.pdf	n/a	n/a
Biodiversity	Pascal 2011	n/a	n/a	n/a	n/a	n/a
	Lal and Cerelala 2005	Fiji	Coral reef extraction	n/a	5	n/a
	Jacobs 2004	American Samoa	Coral reefs	n/a	3	n/a
Pollution	Hajkowicz et al. 2005	Palau	Solid waste management	http://archive.iwlearn.net/www.sprep.org/solid_waste/documents/Economic%20costs%20of%20waste%20-%20%20Palau.pdf	3, 5, 9	n/a

	Lal et al. 2006	Tonga	Solid waste management	http://www.sprep.org/att/publication/000521_IWP_PTR33.pdf	10	n/a
	Lal et al 2007	Tuvalu	Liquid waste management	http://www.pacificwater.org/userfiles/file/IWRM/Toolboxes/financing%20IWRM/LIQUID%20MANAGEMENT-TUVALU.pdf	n/a	n/a
Recycling	IWP-Kiribati et al. 2005	Kiribati	Solid waste management	n/a	n/a	n/a
Agriculture	Bower 2012	Fiji	Fair trade	n/a	n/a	n/a
	MacGregor et al. 2011	Samoa, Vanuatu	Germplasm	n/a	n/a	n/a
Forestry	Pesce et al. 2004	Solomon Islands	Forestry certification	n/a	10	n/a
	Zieroth et al. 2007	Fiji	Biofuel	http://www.rotuma.net/os/Publications/Biofuel_Rotuma.pdf	15	n/a
Invasive Species	Daigneault et al. 2013	Fiji	Invasive species management	In Press (CEPF Report)	4, 8, 12	Ex ante

Appendix 7.2: Structure of CBA Work Plan and Report

Problem Overview

Provide a short description of problem that the project(s) is trying to address. This should include information on nature and extent of the problem. Details should include:

- List the main causes and drivers of the problem.
- Short statement of objective, with specific and direct links to one or more of the causes of the problem.

With and Without Analysis

This section specifies the options identified to achieve the stated objective (and thus address the identified problem) and lists the various costs and benefits that need to be considered for each of these options. Importantly, one of the options should be the status quo or baseline scenario (i.e. costs and benefits to be experience if none of the projects were implemented - 'without project' scenario).

Measuring costs and benefits

This section should detail the data/information needed to estimate each of the costs and benefits identified in the with and without analysis. It should also list where this data/information can be sourced. This information should be summarised in the a table.

Aggregating costs and benefits

This section will detail how costs and benefits will be aggregated/computed over time. Key issues to be outlined here include choice of discount rate and how the timeframe of the analysis will be determined, amongst others.

Sensitivity Analysis

First, list key parameters (e.g. discount rate, biophysical impacts) for which there are a significant amount of uncertainty. Next, describe how these uncertainties are tested through a sensitivity analysis, i.e. detail upper and lower bound values and the basis for selecting these values. Third, present the estimates from the sensitivity analysis

Summarise Findings and Make Recommendation

Revisit the key assumptions used in forecasting the costs and benefits of the proposal or programme, and highlight the key findings from the CBA. Compare estimates, and provide reasoning for a particular recommendation.

Appendix 7.3: Methods for Valuing Costs and Benefits in Economic Analyses

Method	**Description**	**Example**
Market Prices	The amount it costs to buy, or what it is worth to sell a good or service in a market.	The price of taro or bananas at the local market
Replacement Costs	The value of a good or service is determined by estimating the cost of man-made products, infrastructure or technologies that could replace a non-market good or services.	The cost of a seawall is used as a proxy to estimate the benefit of mangroves for coastal protection
Mitigative and Avertive Expenditures	The cost to mitigate or avert economic losses resulting from the loss of a specific good or service.	Household surveys on time and money spent for healthcare
Damage Costs	The value a good or service provides by reducing the damage would have occurred otherwise under an alternative scenario	Reduction in crop yields caused by invasive species from implementing an integrated pest control programme.
Production Function	The relationship between changes in the quality or quantity of a particular good or service with changes in the market value of production.	Value of additional clean water to a community estimated from the cost of constructing rainwater tanks
Travel Cost Method	Survey or observations are used to calculate the value of a recreational experience from trips to a particular site.	How much visitors are willing to pay for access to a resource, considering travel time, fuel, lodging, and entry fees.
Hedonic Pricing	Market transactions are compared for goods or services that differ primarily because of the influence of the nonmarket good or service that is of interest	Sales prices of similar homes could be compared where some overlook a healthy salt marsh and others do not. This comparison could estimate the value of the salt marsh to the market value of the homes that surround it.
Contingent Valuation	Surveys are used to help respondents estimate personal willingness to pay for nonmarket goods or services like clean beaches or healthy corals.	Phone survey on willingness to pay to protect native forest
Choice Experiments	Stakeholders given a series of alternative options, each of which is defined by various attributes including price, amenities, and quality.	In-person survey on willingness to pay for various degrees of water quality
Benefit Transfer	Estimates of value derived from a study of one area can be adapted for use in another area	The value of fishing that will result from the restoration fisheries in Nadi could be estimated using studies of similar fisheries near Lautoka (both in Western VitiLevu, Fiji).

Appendix 8: Fact Sheet – African tulip tree

FACT SHEET:
Impacts and Management of African tulip tree in Fiji

African tulip tree (*Spathodea campanulata*)

History

Native to Africa, the African tulip tree was brought to Fiji in 1936 as an ornamental plant. It has escaped suburban gardens and now dominates disturbed lands through much of the country.

General Information

The African tulip tree favours moist habitats, growing best in sheltered tropical areas. It invades agricultural areas, forest plantations, and natural ecosystems, shading-out crops when it becomes the dominant tree in the landscape. Although it is considered an agricultural pest, it also provide benefits such as building materials, habitat provision, carbon sequestration, and erosion control. The timber has high water content making it a less desirable source of firewood.

It is difficult for landowners to control the African tulip tree with conventional methods such as manual weeding. High infestation levels have led some farmers to abandon existing fields and clear nearby natural forests, further contributing to biodiversity loss and exacerbating its spread.

Socio-economic impacts

Surveys of 360 households in 30 randomly selected villages in eastern Viti Levu, Fiji were carried out to assess the socio-economic impacts of the tulip tree. The majority of respondents identified tulip tree impacts on their communities as: reduced agricultural yield and grazing land, and competition with other, more desirable more desirable trees used for medicinal purposes and/or firewood.

Some respondents indicated that they use the tree for building materials and fire wood despite its high moisture content. Others reported that the tree attracts birds and other wild animals. The tree was viewed extremely negatively by most respondents, though a small number viewed it favourably.

One of the survey teams talks to a villager

Current control practices, which involve cutting the tree down and burning stumps, appear to be ineffective and respondents reported that farmers had stopped growing crops altogether in severely impacted fields. Most respondents stated that the tulip tree had some negative impact on their livelihoods, with some spending considerable effort to control the tree. The average household currently spends about 35 hours/week managing their crops, with about 10% of that time to specifically control the tulip tree. This emphasizes their high willingness to work to alleviate the problem, provided cost-effective methodologies are available. Despite putting some effort into tulip tree management, more than 95% of villages indicated tree populations were increasing (see figure 1, overleaf).

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Asked to reallocate Fiji's national budget according to their own spending priorities, survey respondents allocated about 7% of the budget to invasive species management. They would further allocate 33% of that budget to specifically control the African tulip tree.

Fig.1. State of African Tulip Tree in villages surveyed in Viti Levu (n=30)

Benefits and costs

Benefit-cost ratios of the African tulip tree at the village level were calculated for the following management options:

Do nothing

This option represents the natural growth and spread of the tree across the landscape with little to no management, and in time the African tulip tree will occupy all ecologically suited environments.

Current management approach

From the survey findings, households spend an average of 24 person days/year clearing tulip trees, using a mix of cutting, stacking and drying plant material, and later burning this material including some stumps. Regrowth from cut stumps, roots and other plant material left in contact with the ground is common. Tractors, and occasionally diggers, have been used to clear smaller trees but this disturbance often leads to increased germination of seeds in the seed bank. On occasion herbicides are applied, but incorrect herbicide use often results in poor levels of control. Although, this approach can reduce some of the potential damage caused by the tulip tree, most villages surveyed reported an increase in trees in their community. This scenario assumes the tulip tree population is reduced about 50% relative to the "do nothing" scenario.

Integrated management approach

This approach involves the selection of a suitable treatment method appropriate to the site, size and extent of the infestation, and the planned land-use following tulip tree management. Treatment methods include:

- 'Hack-and-squirt' for trees greater than 10 cm in diameter at breast height.
- Ring barking of some larger trees.
- Cut-stump treatment used on saplings and small trees.
- Hand pulling of seedlings

If possible, land is mechanically cleared with bulldozers after treatment followed by crop/pasture replanting. Subsequently, herbicides and/or hand-pulling are used to control all emerging seedlings including other invasive plant species. As eradication is not an option, this scenario assumes an integrated management programme could reduce infestations by 90% and maintain it at that level.

Benefit-cost ratios indicate that managing the tulip tree at the village level using an integrated management approach provides benefits that are two times larger than the current management approach and four times larger than "Do nothing" approach.

Conclusion

Survey results indicate that the African tulip tree is viewed extremely negatively at the village level because of the socio-economic impacts it inflicts on communities. Of the 7% of the national budget they would like government to allocate for invasive species management, they believe 33% should be allocated to control the African tulip tree.

Current community efforts to control African tulip trees on productive land are not effective, but the people would be willing to invest time and effort to manage the tree if effective methods were available. Cost-benefit analysis results suggest that a fully integrated management approach is currently the best approach to control the African tulip tree.

Appendix 9: Fact Sheet – small Asian mongoose

FACT SHEET:
Impacts and management of Small Indian Mongoose in Fiji

Small Indian Mongoose (*Herpestes javanicus* or *H. auropunctatus*)

History

The small Asian mongoose is reported to have been introduced to Fiji in 1883 to primarily control rats in sugar cane fields. Although, it is widespread on Fiji's largest islands, Viti Levu and Vanua Levu, it has not reached many smaller islands such as Taveuni.

General Information

The small Asian mongoose can be found in a range of habitats from desert to forest. Mongooses are agile predators, feeding on a variety of small mammals, birds and their eggs, reptiles, insects, and crabs. It is a threat to native species and livestock. The small Asian mongoose has had a major impact on native species in the areas where it has been introduced especially, on tropical oceanic islands. It is listed by the IUCN/ISSG as one of the 100 world's worst invasive species. Island native wildlife having evolved in the absence of predatory mammals, are particularly threatened by the mongoose. The mongoose is also a carrier of human and animal disease, including rabies and human Leptospira bacterium.

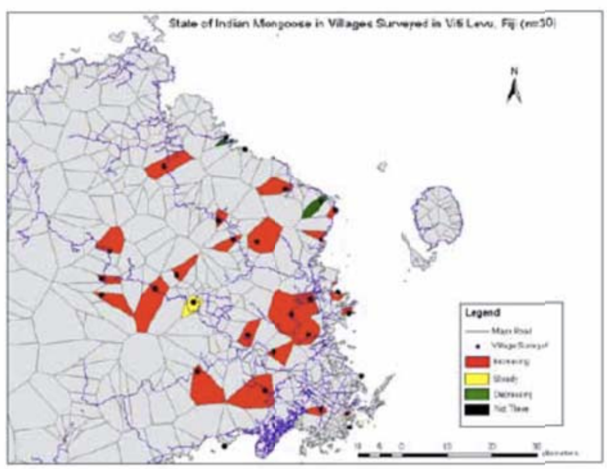
Socio-economic impacts

Surveys of 360 households in 30 randomly selected villages in eastern Viti Levu, Fiji were carried out to assess the socio-economic impacts of the mongoose. The majority of respondents identified the impacts of the mongoose on their communities as: predation on livestock especially, chickens and causing declines in bird or animal populations. However, the economic impacts of the mongoose are perceived to be minor.

Some respondents indicated that mongoose was useful as a food source and for controlling snakes. Nevertheless, the tree was viewed extremely negatively by most respondents.

Current control efforts are very limited and involve trapping and hunting to protect crops and livestock, and for eating; appear to be ineffective. 90% of the respondents reported that the mongoose population was increasing in their village.

Survey respondents were asked to reallocate Fiji's national budget according to their own spending priorities. They would allocate 7% of the budget to invasive species management, on average. Of that 7% of the national budget, the respondents believe that 12% should be directed towards specifically controlling the small Asian mongoose.



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Benefits and costs at village level

An economic analysis was conducted to assess the relative costs and benefits for the following management options and assumptions:

Do nothing

This option represents the natural growth and spread of the mongoose across the landscape in the absence of management; eventually, the mongoose will occupy all ecologically suitable environments at around its carrying capacity of up to 10 individuals per hectare.

Live Trapping

Live trapping can be effective at removing animals in the short-term, but can be expensive to purchase and maintain. Traps must be checked regularly, as if neglected, mongooses can rapidly re-colonise trapped areas. Non-target catch should be monitored and trapping should be altered to minimize this. Costs associated with live trapping include mainly the initial investment in acquiring the traps and manpower for daily checking and/or re-baiting the traps. Mongooses captured in live traps can be consumed as food. This option could potentially reduce the mongoose population to about than 30% of carrying capacity over the project period, although it could vary by site and number of traps per hectare.

Kill Trapping

Kill traps have a number of advantages over live traps but perhaps the biggest advantage is that they require lower labour costs as they do not need to be checked daily and so can be used over large areas. Key consideration is minimising the risk from the kill traps to non-target species and hence, trialling of the trap settings must be carried prior to wide-spread implementation. Similar to live trapping, kill traps can be set in a grid and cover the entire boundary where the mongoose is present. Traps must be checked daily initially, but longer-term programs require less frequent checks. This option can potentially reduce the mongoose population to less than 20% of carrying capacity over the long run.

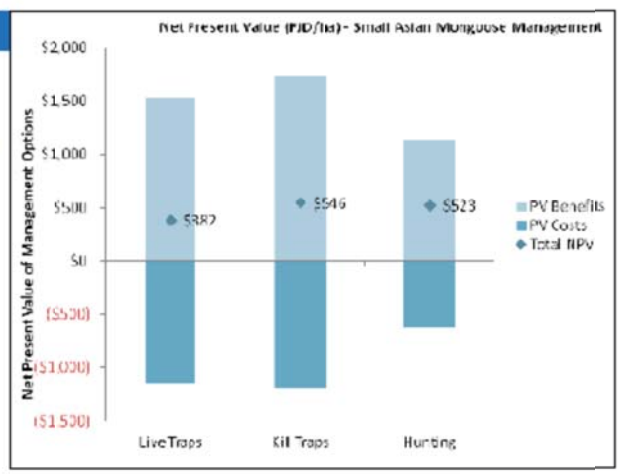
Hunting

This method requires significant labour as well as capital for hunting (e.g. guns and ammunition). This approach could be effective when the population is high, but it requires a high level of effort per kill for lower populations. Experts have argued that hunting is could be less effective at reducing mongoose population than trapping, perhaps only reducing the population to about half of carrying capacity.

Conclusion

The cost-benefit analysis of the three management options reveals that hunting offers the greatest value, as each dollar spent produced almost $1.85 in benefits (a benefit-cost ratio of 1.85:1). The live and kill trap options were estimated to have benefit-cost ratios of 1.33:1 and 1.45:1 respectively. Thus, all three management options are preferred over undertaking no management at all.

The cost-benefit analysis is available from the authors of this factsheet.



Appendix 10: Fact Sheet – taro beetle

FACT SHEET:
Impacts and management of taro beetle in Fiji

Taro beetle (*Papuana uninodis*)

History

Native to Papua New Guinea, the taro beetle was introduced to Fiji in 1981.

General Information

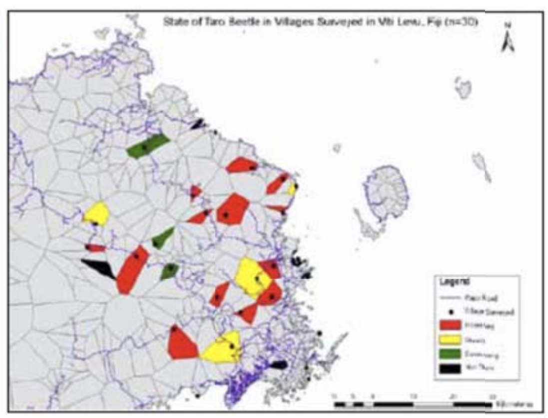
The taro beetle is commonly found in disturbed areas. The beetle reduces taro yields – a key staple food and cash crop in Fiji and other parts of the Pacific – by up to 30% by burrowing into the plant's corms and forming holes and tunnels that make the taro susceptible to fungal infection and death. The taro beetle also causes similar damage to other root crops such as sweet potatoes, yams, and bananas and ornamental and cultivated plants from the Araceae family.

Socio-economic impacts

Surveys of 360 households in 30 randomly selected villages in eastern Viti Levu, Fiji were carried out to assess the socio-economic impacts of the taro beetle. The taro beetle was found to be present in 25 out of the 30 villages surveyed. According to the survey results, the beetle significantly reduced agricultural yield and increased the susceptibility of plants to disease. Approximately 36% of villages in which the beetle is present reported that farmers had stopped growing crops in severely affected areas, and 32% of villages noted that the taro beetle had prompted community members to switch out of taro in favour of other crops such as cassava.

Over 97% of respondents held negative views of the taro beetle, with 88% of respondents viewing the species extremely negatively. No respondent attributed any benefits to this invasive species.

The average household surveyed spends about 35 hours/week managing their crops, of which about 2% of that time is specifically to controlling the taro beetle. Despite putting some effort into managing the beetle, 53% of the villages surveyed stated that the beetle has been spreading in recent years. Farmers in a few villages recently switched back to taro after planting cassava for several years because the beetle population had been reduced significantly, suggesting that the problem pest can be managed under certain conditions.



Survey respondents were asked to reallocate Fiji's national budget according to their own spending priorities. They would allocate 7% of the budget to invasive species management, on average. Of that 7% of the national budget, respondents believe that 38% should be allocated to controlling taro beetle. Furthermore, the median household among those who view the beetle extremely negatively offered to volunteer 11 hours/adult household member/week if their efforts would eradicate the taro beetle from their villages, underscoring the perceived magnitude of the problem among Fiji's farmers. It also emphasizes survey respondents' high willingness to work to alleviate the problem provided the availability of cost-effective control methods.

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Benefits and costs at village level

An economic analysis was conducted to assess the relative costs and benefits for the following management options and assumptions:

Do nothing

Households currently spend close to zero time actively managing the taro beetle, thus allowing this invasive species to reach the estimated carrying capacity within about 10 years. At that time, taro yield will fall by approximately 30% (SPC 2008).

Switch cropping

If farmers in affected villages replant their taro fields with cassava, both the population of taro beetle and the total production of taro will fall to zero. While it is feasible that taro could be replanted after the beetle is eradicated, we assume that cassava is planted instead for the 50-year duration of the cost-benefit analysis.

Cultural control

In this case, farmers are assumed to continue planting taro but also to implement more effective crop management practices such as more frequent crop rotation, use of clean planting material, and flooding, trap cropping, and destroying taro beetle breeding sites. Additional costs will largely comprise labour required to closely monitor and manage the taro crop. In this scenario, the population of the beetle will be maintained at the same initial level for the duration of the cost-benefit analysis.

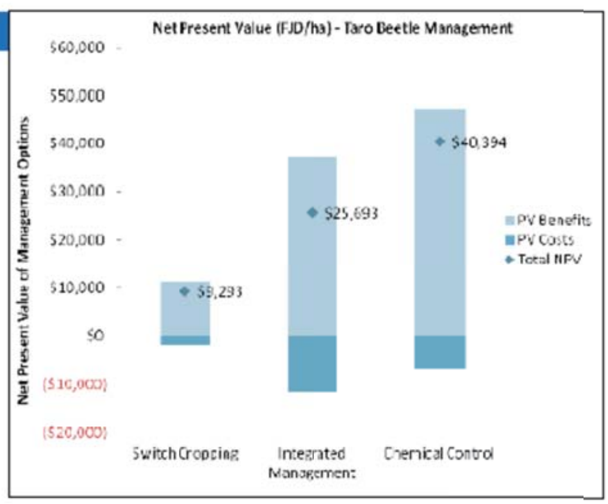
Chemical control

Confidor applied at a rate of 5g per plant could raise the yield of marketable taro corms by as much as 97% of the expected production with no beetle-related impacts (Lal et al 2008). As a result, we assume that annual spraying will eradicate the pest within 10 years.

Conclusion

The cost-benefit analysis reveals that the chemical control option produces the greatest benefit per dollar spent, i.e. it is the most efficient use of funds. Cultural control through the use of more intensive crop management was found to yield the next highest net present value, but it was more costly to implement. Switching all taro crops to cassava was the least preferred option from an economic perspective, although the approach still yielded positive net benefits for landowners and should thus be considered a viable option compared with the do nothing scenario.

The cost-benefit analysis is available from the authors of this factsheet.



Appendix 11: Fact Sheet – Red-Vented Bulbul

FACT SHEET:
Impacts and management of red-vented bulbul in Fiji

Red-vented bulbul (*Pycnonotus cafer*)

History

The red-vented bulbul is a bird approximately 20 cm in length, native to parts of Asia. It is reported to have been introduced to Fiji in 1903 by labourers arriving from India. Red-vented bulbul is listed by the IUCN/ISSG as one of the world's 100 worst invasive species.

General Information

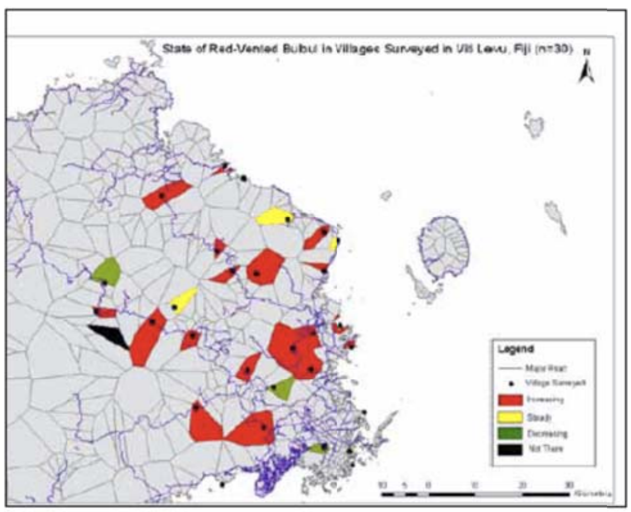
On Viti Levu, the red-vented bulbul is abundant in agricultural and suburban habitats. It is often observed in clearings and patches of secondary growth in forests and can occasionally be found in mature forest. In Fiji, it primarily feeds on the fruit of two primary colonist invasive plant species: prickly solanum (Solanum torvum) and Piper aduncum. It is also known to consume the fruits of other weed species and agricultural crops, such as lantana, guava, cape gooseberry and passion fruit.

Socio-economic impacts

Surveys of 360 households in 30 randomly selected villages in eastern Viti Levu, Fiji, were carried out to assess the socio-economic impacts of red-vented bulbul. The red-vented bulbul was present in 29 of 30 villages surveyed in Viti Levu (97%). Respondents to the community survey identified reduction of agricultural yields and particularly reduced production of some fruit crops as a primary cost associated with the bulbul in areas where the bird was present.

However, about 47% of village focus groups reported that the bulbul was actually good for their community: key benefits included that the bulbul is effective in controlling some problem insect species; they sound a warning when a mongoose is about to attack chickens; and that the bulbuls themselves are sometimes consumed as a food resource.

In terms of control, only 6 % of the villages attempted to control the bulbul via hunting, while 94% of the villages did nothing. As a result, 80% of villages surveyed indicated that the population of the bulbul was either steady or still increasing.



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Benefits and costs at village level

Different management options could have varying effects on impacts from bulbuls on agricultural crops. As the red-vented bulbul has been established in Fiji for more than a century, we can assume that about 100% of the potential carrying capacity has been reached. The bird also causes other impacts such as dispersal of weedy plant species and subsequent displacement of indigenous species. However, there is very limited information on effective management options. As a result, the cost-benefit analysis only considers a "do nothing" approach and two possible management options to reduce impacts of the red-vented bulbul to agricultural crops: a crop management approach and a crop protection approach. The analysis does not examine options for reducing the population of the bulbul, such as placing traps in the affected area, because there is limited knowledge as to whether this would be a feasible option in eastern Viti Levu. The crop damage values for the initial cost-benefit analysis are calculated using the following management options and assumptions:

Do nothing

This option assumes that communities maintain the status quo of putting no noticeable effort into controlling the red-vented bulbul or protecting crops. This approach results in the bulbul continuing to have a steady annual impact on agriculture.

Crop Management Approach

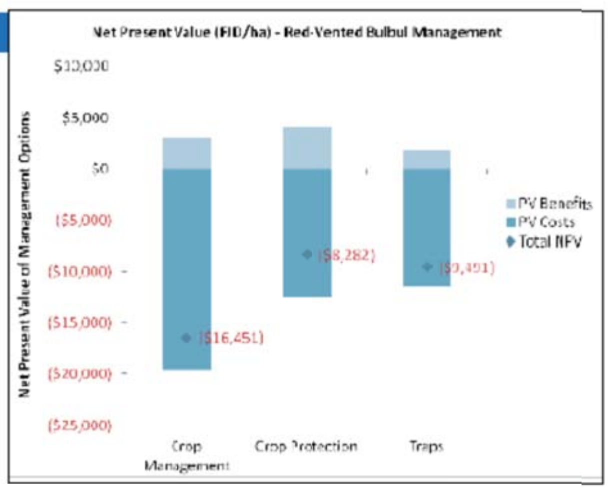
Bulbuls are attracted to edible weeds, so frequent weeding or application of suitable herbicide to weed species may reduce weed infestation levels in cropping areas, and subsequently reduce the population level of bulbuls. Staking crops so that they are raised above the ground could also increase yield. Some fruit and vegetable crops are also harvested and stored under cover before they ripen.

Under this management option, households could invest more time and effort into managing their crops against bulbuls. Some fruit and vegetable crops could be harvested earlier in the season and ripened under cover to avoid being consumed by bulbuls. Under the crop management approach, it is assumed that the impacts from the bulbul would be reduced by half.

Crop Protection Approach

This option assumes that placing nets over vulnerable crops could reduce the damage created by the bulbul. In this case, we assume that farmers place netting over all possible crops. Crops that cannot be covered with nets are, if possible, harvested and stored under cover before they ripen. We assume that crop protection work is undertaken in all agricultural land in the village as that is the area most sensitive to the harmful effects of red-vented bulbuls. Under this management approach, it is assumed that the impacts from the bulbul would also be reduced by about one-half.

Conclusion



The crop management and the crop protection approaches were both estimated to have negative net economic benefits relative to the "do nothing" option. This indicates that the present value cost of implementing either management option outweighs the present value benefit accrued over the same period from maintaining status quo. This is not a surprising result, given that nearly all respondents to both the community and household surveys indicated that they actually spent little or no effort attempting to mitigate impacts of the red-vented bulbul. This suggests it could be more efficient from an economic perspective to let the invasive bird continue to live as is in the study area unless damages to crops are significantly higher than those estimated from our survey or if there are other important considerations (e.g. biodiversity) at risk that were not accounted for in this study.

Appendix 12: Fact Sheet – Merremia Vine

FACT SHEET:
Impacts and management of merremia vine in Fiji

Merremia vine (*Merremia peltata*)

History

The native range of the merremia vine is uncertain. However, it is now distributed from the Indian Ocean islands throughout Malesia (Malaysia, Indonesia and the Philippines) and eastwards into Polynesia and the Society Islands. Merremia is a well-established plant in eastern Viti Levu, Fiji.

General Information

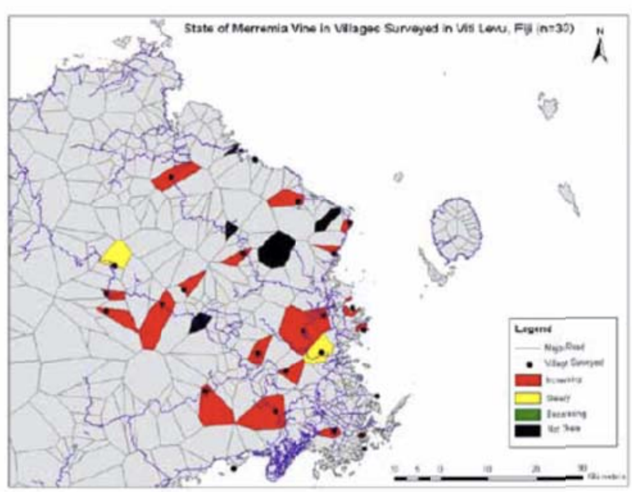
Merremia is a coarse climbing vine with underground tubers that grows in full sunlight. It climbs up and over trees, shrubs, and crops, smothering existing vegetation. Distribution increases vegetatively through creeping stems rooting at the nodes when contacting the ground. Merremia can occasionally produce seeds, but research has indicated a low seed viability rate. Disturbances such as cyclones and land clearing may encourage the introduction and spread of this vine. Benefits of the vine may include reducing soil erosion and nutrient loss and use as a medicinal plant, bundling twine, and animal feed.

Socio-economic impacts

Surveys of 360 households in 30 randomly selected villages in eastern Viti Levu, Fiji were carried out to assess the socio-economic impacts of merremia. Approximately 44% of the sampled households viewed the presence of merremia favourably, using it for purposes such as bundling twine and medicine; 34% viewed the presence of merremia negatively, noting that it reduces agricultural yields and negatively impacts the growth of trees and plants used for building materials and medicines. Some 22% of survey respondents were indifferent to its presence.

Few survey respondents made any effort to reduce merremia infestations. One-third of surveyed households spend time cutting and clearing merremia in a typical week, allocating 1.8 hours to the task, on average. The remaining two-thirds of surveyed households do not clear merremia from their land.

Survey respondents were asked to reallocate Fiji's national budget according to their own spending priorities. They would allocate 7% of the budget to invasive species management, on average. They would further allocate 6% of that budget to specifically control merremia.



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Benefits and costs at village level

An economic analysis was conducted to assess the relative costs and benefits for the following management options and assumptions:

Do nothing

This option represents the natural growth and spread of the tree across the landscape in the absence of management; eventually, the merremia vine will occupy all ecologically suitable environments.

Current management approach

Based on survey results, households spend 13 person days/year clearing merremia, on average. Treatment methods include a mix of cutting the vine, burning vegetative material, and using small amounts of herbicide. The current management approach offsets some of the damage caused by the vine, although most villages surveyed reported an increase in merremia in their community despite some management.

Chemical application approach

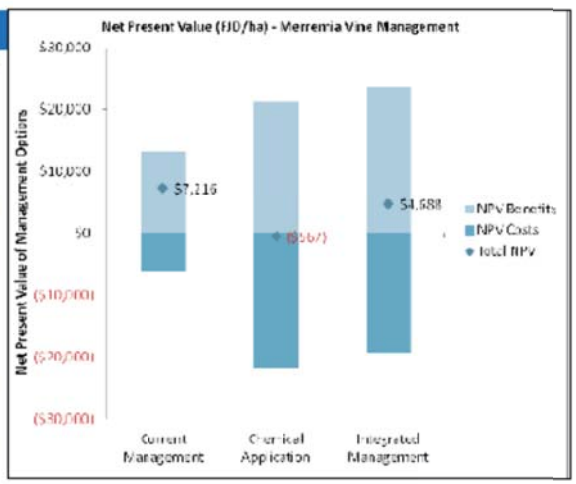
This option assumes that chemical herbicides are the primary means employed to control merremia. We assume that control work is undertaken on all disturbed land in the village as that is the area most sensitive to merremia infestation. Spot treatment is also done on significantly affected areas adjacent to the primary treatment sites. All rooting stems and tubers are treated with suitable herbicide, but the exact treatment method used depends on the site and number of established vines. Effort is also made to only apply herbicides to the target plant (i.e., treatment methods must avoid any off-target damage to native plant species). As a result, we assume that annually spraying herbicides at the recommended rate will keep the population of merremia steady at about 20% of carrying capacity.

Integrated management approach

This approach employs the methods used in the other two management options in a more integrated and rigorous manner. First, a machete can be used to slash merremia stems out of host trees, after which vines are cut as close as practical to ground level. Second, all rooting stems and tubers are treated with suitable herbicide in the same manner as the chemical application option. Third, emerging merremia plants are dug out or treated with suitable herbicide, and any seedlings germinating from seed are hand-pulled. Fourth, trees are planted to promote shade and minimise spread of the vine to native vegetation areas.

Conclusion

The current approach to managing merremia was estimated to yield the highest net present value of all management options investigated in this study as benefits of management outweighed costs by a ratio of 2.2 to 1. This is an interesting finding as it was assumed that implementing this option would still allow the population of the merremia to increase from 20% to 50% over the 50-year lifetime of the project. The integrated management approach was more effective at controlling the merremia population but at a much higher cost than the current management approach. It still yielded positive net benefits for landowners and should thus be considered a viable option over the do-nothing approach.



Appendix 13: CBA Analysis – African tulip tree

Overview

The purpose of this study is to conduct a benefit-cost analysis that estimates the economically efficient options to manage the African tulip tree (*Spathodea campanulata*) at the village-level in Eastern Viti Levu, Fiji. The African tulip tree was introduced to Fiji in 1936 as an ornamental plant. It quickly escaped suburban gardens and now dominates disturbed lands throughout much of the country. The African tulip tree favours moist habitats and will grow best in sheltered tropical areas. It invades agricultural areas, forest plantations, and natural ecosystems, smothering other trees and crops as it grows to become the prevailing tree in these areas. Although it is considered an agricultural pest, it may also provide benefits such as building materials, habitat provision, carbon sequestration, and erosion control. The African tulip tree has high water content and hence is not a particularly desirable source of firewood.

It is often difficult for landowners to clear and control the African tulip tree with conventional methods such as manual weeding. The level of infestation has led some farmers to clear more natural forests in the area, resulting not only in the clearing of native bush but also in exacerbating the further spread of the invasive tree.

To investigate the socio-economic impacts of invasive species in Fiji, we surveyed 360 households in 30 villages in eastern Viti Levu. Additional information on the impact at the village-level was obtained through a community-level focus group. Information on the biophysical growth and effectiveness of various management options to control the invasive were primarily obtained from scientific literature and checked by regional experts.

Plant biology and ecology

Mature tulip trees grow to 25 m or more high, with the trunk buttressed at the base. Bright red flowers later produce capsules containing many winged seeds. Mature trees can produce thousands of seeds which have been recorded as having up to 80% viability rate. Its seed has a higher germination rate in semi-shade rather than full light situations. Beside the wind-borne seeds, reproduction can also be via sucker plants growing from roots, or new growth forming on any plant stem or trunk section that has prolonged contact with the soil. Regrowth is especially vigorous from any trees cut at stump level and not treated with suitable herbicide. High numbers of seedlings can establish in any disturbed ground. Stands often contain 4000 plants per ha, with a mixed age of plants, i.e. mature trees, saplings and seedlings. Stands of 12 000 plants per ha have been recorded.

The growth of the African tulip tree is assumed to follow a logistical biological growth curve:

$$N_{t+1} = N_t + bN_t \left(1 - \frac{N_t}{N_{Max}}\right) \quad (1)$$

where N_t is the population at time t, N_{max} is the carrying capacity, and b is the growth parameter. Parameters and carrying capacity were derived from Lugo (2004), which states the carrying capacity of African tulip tree is approximately 4000 trees per hectare, reached around 40 years after the first tree is establishment on open land, and that about half of N_{max}

is estimated to be reached between 25 and 30 years after establishment. Using values of $N_0 = 1$, b =0.18 and N_{max} =100 produces an s-shaped curve tracing the percenage of population relative to carrying capacity that goes through these two points, as shown in Figure 14.

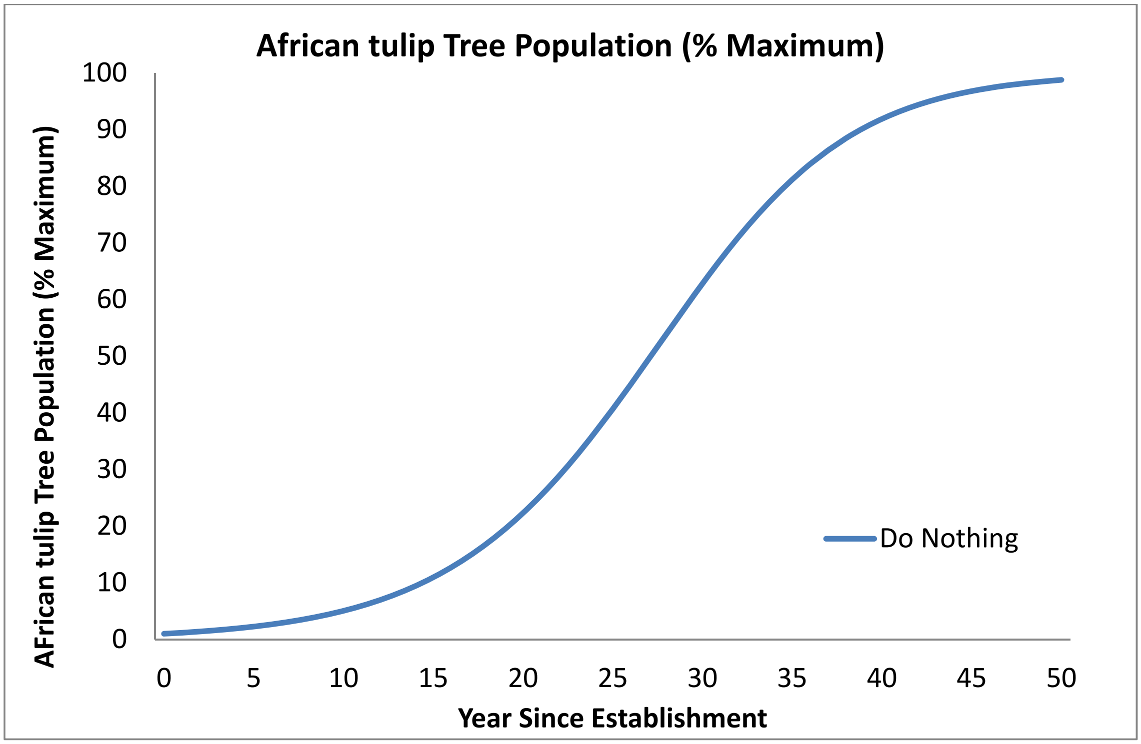


Figure 14 Biological growth function of African tulip tree.

Study Site and Survey Methodology

To investigate the socio-economic impacts of invasive species in Fiji, we surveyed 360 households in 30 villages in eastern Viti Levu. These villages were stratified by geography and randomly drawn; one village that is inaccessible by road due to construction was replaced with another remote village. Within each of the 30 villages, households were drawn at random. Each survey was administered directly to the head of household, and topics covered demographics; farming, fishing, wage work, and other income-generating activities; wealth and durables; education; health; and extension activities. The survey also included several novel elements relevant to the social and economic impacts of invasive species.

First, respondents were asked to assume the role of Fiji's budget minister and to identify spending priorities by allocating budgetary shares to a broad range of categories, including education, healthcare, defence, trade, infrastructure development, and environmental protection. Respondents who allocated money to environmental protection were further asked to prioritise controlling specific invasive species compared with other environmental spending.

Second, a series of questions was asked to elicit willingness to contribute personally to controlling invasive species via volunteer labour. In most developed countries, willingness to pay is identified via questions about tax increases; however, few rural Fijian households pay taxes, while virtually all of them contribute labour to maintaining the village, suggesting this approach is culturally relevant. Opening values were assigned via dice rolls to eliminate concerns about starting point bias.

Third, respondents were asked to state the extent to which they agreed with statements on the value of controlling invasive species (e.g. "It is good that the African tulip tree is found in this village.") via a 5-point Likert scale. To eliminate concerns of yea-saying, some statements read in the negative (e.g. " It is bad that the African tulip tree is found in this village.").

A complementary survey was administered to a focus group in each of the 30 sampled villages. The village-level questionnaire consisted of open-ended questions regarding the presence and state of each species and, where applicable, the consequences of its presence (both positive and negative), and community practices for encouraging or limiting its spread.

Survey Results

Respondents to the community survey identified a number of costs associated with the African tulip tree, including:

- 76% of villages responded that the African tulip tree reduces agricultural output
- 36% said it reduces the quantity of land available for grazing
- 48% of villages stated it competes with other, more desirable, trees that are used for medicinal purposes and/or firewood

However, 52% of villages reported using the tree for building materials, and 27% used the tree as firewood for cooking despite its high moisture content. About 9% of the villages stated the African tulip tree attracts birds and wild animals. Nevertheless, about 30% of the villages reported that the invasive tree provides no benefit to their community.

To control the spread of the African tulip tree, 73% of villages report that they prefer to cut the tree down, with 42% of villages further burning the stump after removing the trunk. Some 36% of villages surveyed reported that some farmers had stopped growing crops altogether in severely impacted fields because they could not keep up with the African tulip tree's spread.

Respondents to the household survey conducted on Viti Levu (n=360) were asked a series of questions about their personal views of the species. Over 92% of survey respondents viewed the African tulip unfavourably, with 78% of survey respondents viewing the African tulip extremely negatively. Fewer than 3% of survey respondents had a favourable view of the invasive tree, on balance, and none held an extremely positive view.

Most respondents stated the African tulip tree had some negative impact on their livelihoods, and some were spending considerable effort to address the problem. On average, surveyed households spent 3.7 hours per week (about 24 days per annum) clearing the African tulip tree from their land. To put this in perspective, the average household surveyed spends about 35 hours a week managing their crops, of which about 10% of that time is used specifically to control the invasive tree. Despite putting some effort into managing the invasive, more than 95% of villages surveyed indicated that the population of the tree was increasing (Figure 15).

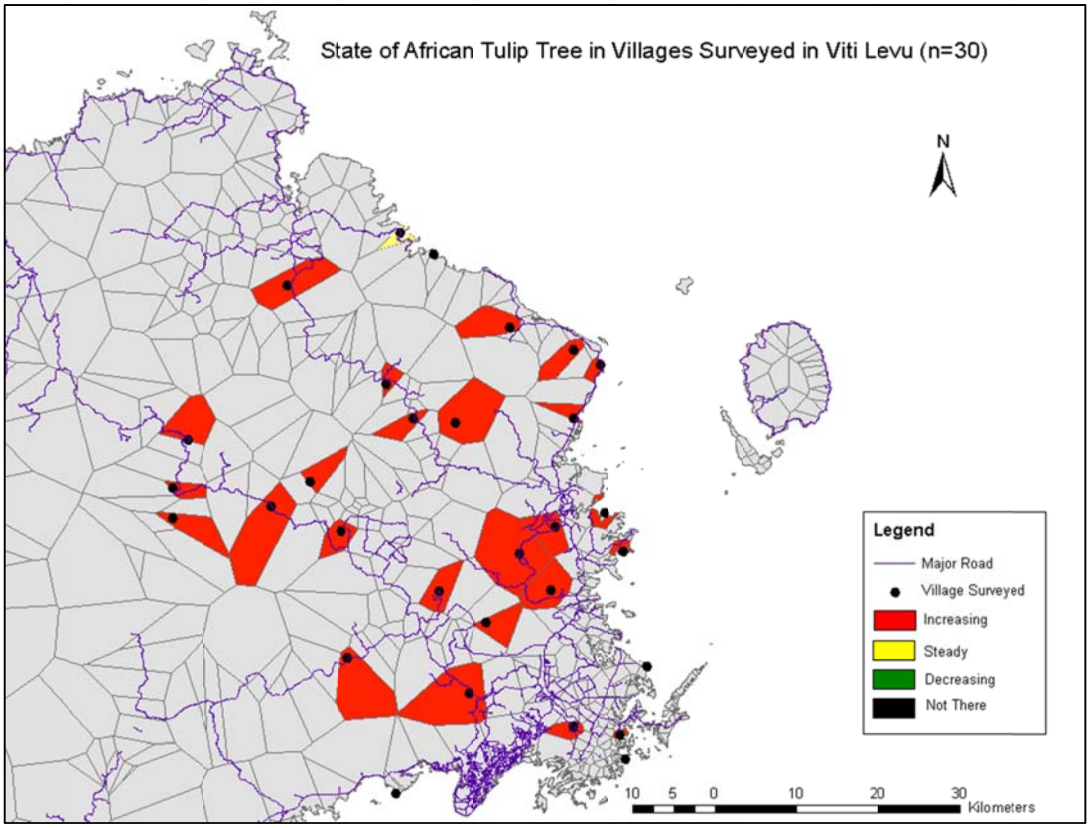


Figure 15 State of African tulip tree in villages surveyed (n=30).

Asked to reallocate Fiji's national budget according to their own spending priorities, survey respondents would allocate approximately 7% of the national budget for invasive species management. They would further allocate 33% of that budget to control the African tulip tree. Furthermore, the median household among those who view the African tulip extremely negatively offered to volunteer 10 additional hours per household per week if their efforts would significantly reduce the density of African tulip tree from their villages. Given the average household surveyed spends about 6 hours per week on all volunteer work, this underscores the perceived magnitude of the problem among Fiji's farmers. It also emphasizes their high willingness to work to alleviate the problem, provided there are methods proven to achieve this.

Management Options

Different management options can have differential impacts on the growth and spread of the African tulip tree (Figure 16). In addition to doing nothing, two management options are considered in this analysis: the current community management approach and a more integrated management approach. The community survey revealed that roughly 20% of productive land in most villages of Eastern Viti Levu is impacted by the African tulip tree, as of July 2012. We use this as the initial population at the start of the management regime. We then use the following assumptions to parameterise the effect of management on species growth from the various options:

Do Nothing (without scenario)

This option represents typical progression of growth and spread across the landscape with little to no management. Under this scenario, the African tulip tree eventually occupies all ecologically suited environments when it reaches carrying capacity about 40 years after being introduced to the study site. All other options are measured relative to the costs and benefits estimated under this option. Obviously, there are no management costs associated with the do nothing option, but it does result in damages to land-based production that could be avoided if the spread of the tree was controlled.

Current management approach

Based on survey findings, households spend the survey average of 24 man-days per year clearing some of the trees. Treatment methods include a mix of cutting, stacking and drying plant material, and later burning this material including some African tulip tree stumps Regrowth from the cut stumps, viable roots and any plant material left in contact with the ground is common. Tractors, and occasionally diggers, have been used to pull smaller trees from the ground. Ground disturbance often leads to a heavy germination of plants from viable dormant seed. There is the occasional application of herbicide, but some herbicides result in a poor level of plant destruction. This approach can mitigate the potential damage caused by the invasive tree, but only to a certain degree. Most villages surveyed reported an increase in the number of trees in their community despite some management, and therefore we assume that the long-run population of the African tulip tree is reduced by about 50% relative to the do nothing scenario.

Integrated management approach

This approach builds on the methods used but in a more integrated and rigorous manner. Additional details on the integrated management approach are listed in Appendix 13.1.

First, the “hack-and-squirt” control treatment method is used for all trees greater than 10 cm diameter breast height (DBH). Second, some large trees receive the ringbark treatment method. Third, saplings and small trees receive a “cut-stump” treatment. smaller seedlings are hand-pulled. If possible, these treatments are followed by mechanical clearance with bulldozer and pasture and crops are re-grassed or replanted. Herbicides are applied in subsequent years on cleared site to ensure that regression to further infestation does not occur. The high level of disturbance created by mechanical clearance in the first period will cause many seeds to spread and germinate in the periods that immediately follow, possibly creating an initial increase in the population. New weeds may also appear. Thus, follow up treatment with manual weeding and herbicides must be continued to keep the population of trees in check. Additionally, the long-time presence of the African tulip tree and the manner in which its seeds spread across the landscape make it impossible with realistically available resources to eradicate the tree from Viti Levu, Fiji. As a result, we assume that the long-run population of the tree in treated areas is reduced to about 10% of what it could be under the do nothing scenario.

We assume that control work is only undertaken in areas that will be actively managed (i.e. cleared land). Follow-up treatment is completed and the area is cropped or grazed to help prevent reinvasion of African tulip tree. We conduct sensitivity analysis to assess the change in relative costs and benefits under alternative population and management effectiveness later in the study.

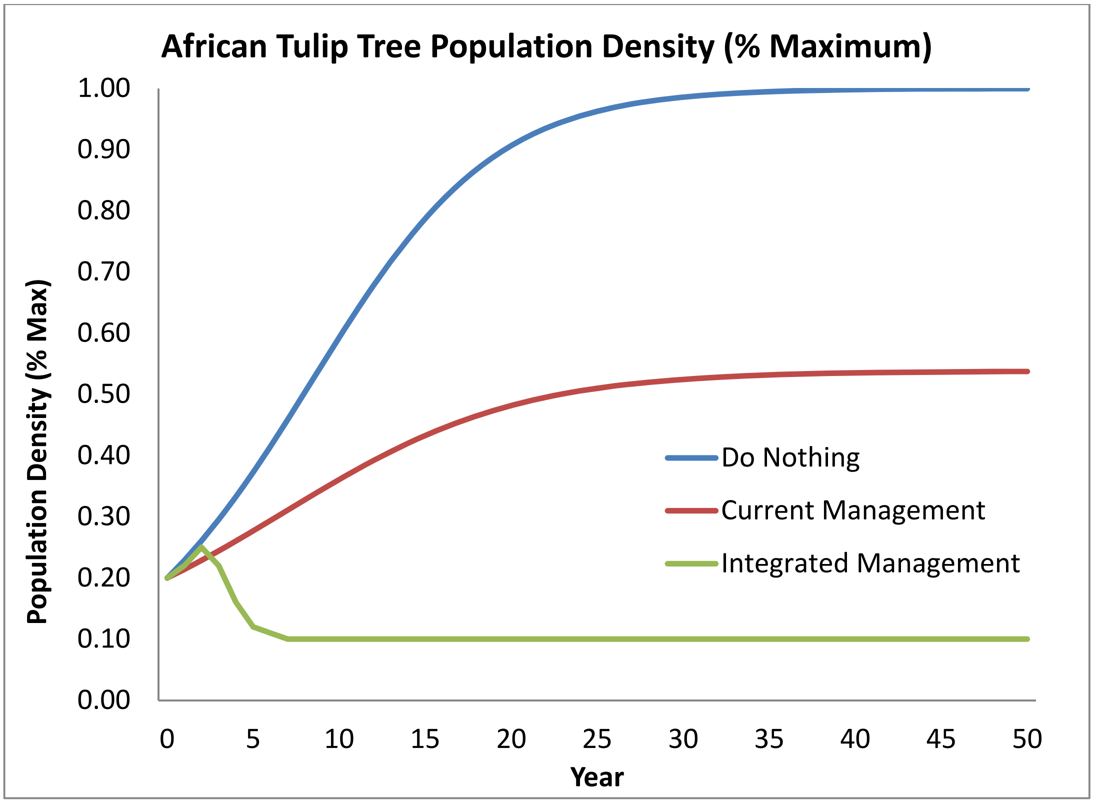


Figure 16 African tulip tree population density (as % carrying capacity) over time.

Quantifying Benefits and Costs of Invasive Management

Several benefits can accrue within the community as a result of managing the African tulip tree, mostly in terms of avoided damages. Possible benefits include improved crop, livestock, and forest productivity, reduced deforestation of native forest, and resulting co-benefits such as improved biodiversity, reduced soil erosion, and a resource of standing dead trees that could be used as firewood. Unfortunately, these benefits are not easily quantified, either physically or monetarily. As a result, this analysis only quantifies the benefits of avoided damages in livestock, crop, and forestry yield. Note that it is likely the non-quantified benefits will also be positive, as landowners would not need to expand their area of cultivated land to make up for lost production. In addition, the reduction in the African tulip tree relative to the status quo may result in less degradation of Fijian native forest.

These specified benefits then need to be expressed in terms of physical units of damage that would likely accrue under the ‘do nothing’ in the initial time (*t*) period (year 0). For this study, we estimate that crop, livestock, and forestry production diminishes from the optimal yield (i.e. expected production in the absence of the invasive) by 20% in the presence of African tulip trees due to the initial assumption about the amount of space that it takes up in the field. Future damages to land-based production are estimated to change using the functional assumption that the damage is directly correlated with the maximum potential capacity of the invasive population (see Figure 16). The damages in the initial period are listed in Table 12. The figures can be interpreted as mixed land use with multiple crops and livestock types on a typical hectare in the project area. Note that the initial values are the same for all management options because it represents the state of the invasive at the start of the project.

Table 12 Initial physical values (t=0) to quantify annual benefits of avoided damages from invasive management

Damages	Units	Optimal Yield	Damage Impact	Initial Period Damages
Crop Yield	kg/ha	10,000	20%	2,000
Livestock Yield	kg/ha	100	20%	20
Forestry Yield	m3/ha	5	20%	1

Quantifying the costs of invasives management is often more straightforward. Typical costs of controlling the African tulip tree include labour, herbicides, bulldozer or digger rental, and capital costs (e.g. chainsaws, herbicide sprayers, etc.). All costs are estimated to occur at the end of each period (1 year) for the duration of the intervention, with the exception of capital costs, which only occur during the initial period. The physical units listed in Table 13 are based on literature, survey responses, and expert knowledge.

Table 13 Initial physical values (per ha) to quantify annual costs of invasive management

Cost	Units	Years Incurred	Do Nothing	Current approach	Integrated approach
Annual Costs					
Glyphosate herbicide	Litres	1–50	0	5	20
2,4 D + dicamba herbicide	Litres	1–50	0	3	0
Triclopyr herbicide	Litres	1–5	0	0	1
Labour	Man days	1–50	0	24	40
Bulldozer or digger hire	Days	1	0	1	2
Capital costs					
Machete, gloves, and hand saw	Number	0	0	1	1
Knapsack sprayer	Number	0	0	1	1
Precision drench gun	Number	0	0	0	1

Aggregating Costs and Benefits

The physical values of benefits and costs listed above can then be monetised by applying unit values over time. The monetary units listed in Table 14 are all listed in Fijian dollars (FJD) and are average values elicited from household and market surveys and expert input. Capital costs (e.g. machete, sprayers, etc.) are broken out as $/item.

Table 14 Unit values for monetised benefit and costs

Category	Category	Unit Measurement	Unit Value ($/unit)
Benefits	Crop income	$/kg	1.00
	Livestock income	$/kg	2.00
	Forestry Income	$/m^3	35.00
Costs	Glyphosate herbicide	$/litre	15.00
	2,4 D + dicamba herbicide	$/litre	125.00
	Triclopyr herbicide	$/litre	45.00
	Labour	$/man day	30.00
	Bulldozer or digger hire	$/day	300.00
	Machete, gloves, and hand saw	$/item	75.00
	Knapsack sprayer	$/item	210.00
	Precision drench gun	$/item	120.00

The monetised values for damages that accrue in the initial period under the do nothing case and each management option can be estimated by multiplying the unit monetary values in Table 14 by the initial physical damage estimates in Table 12.

Table 28. These damages can be estimated over time by tracking the change in the respective population curves. Estimated damage values are displayed in Figure 17.

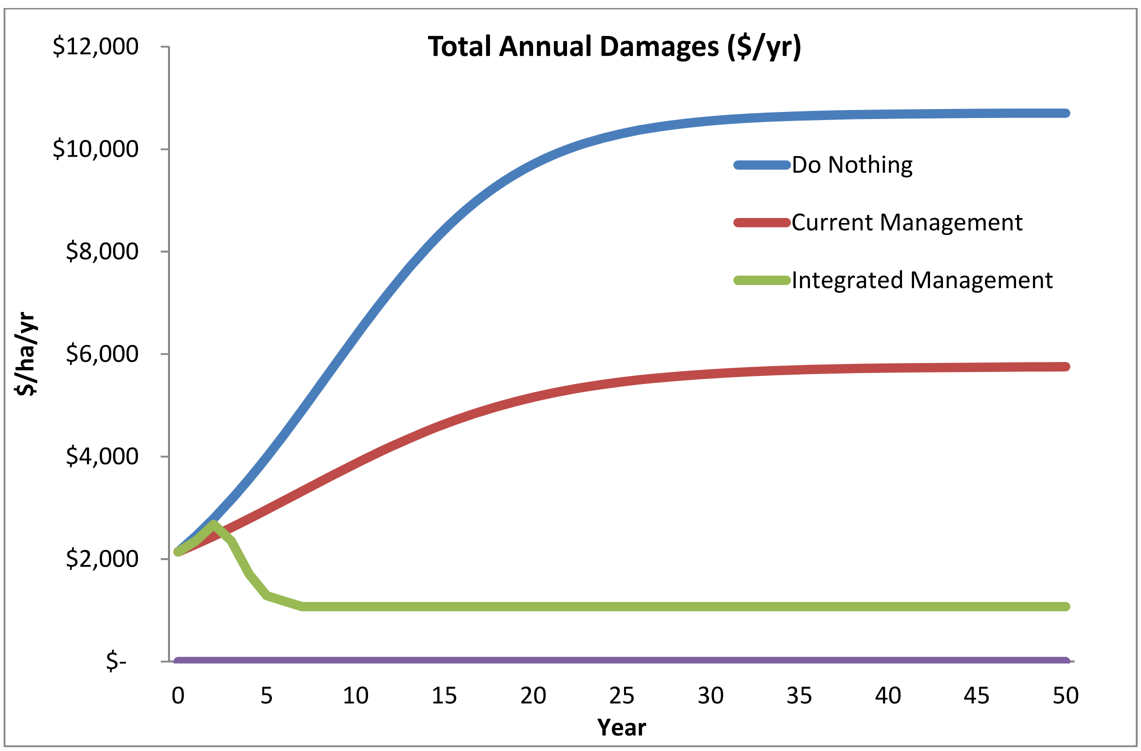


Figure 17 Total value of annual damages ($/ha) from for African tulip tree under various management options.

The differences between the damage curves for do nothing and a specific management option represent the benefits that accrue from avoiding damages that would have occurred under the do nothing option. These benefits are displayed in Figure 18.

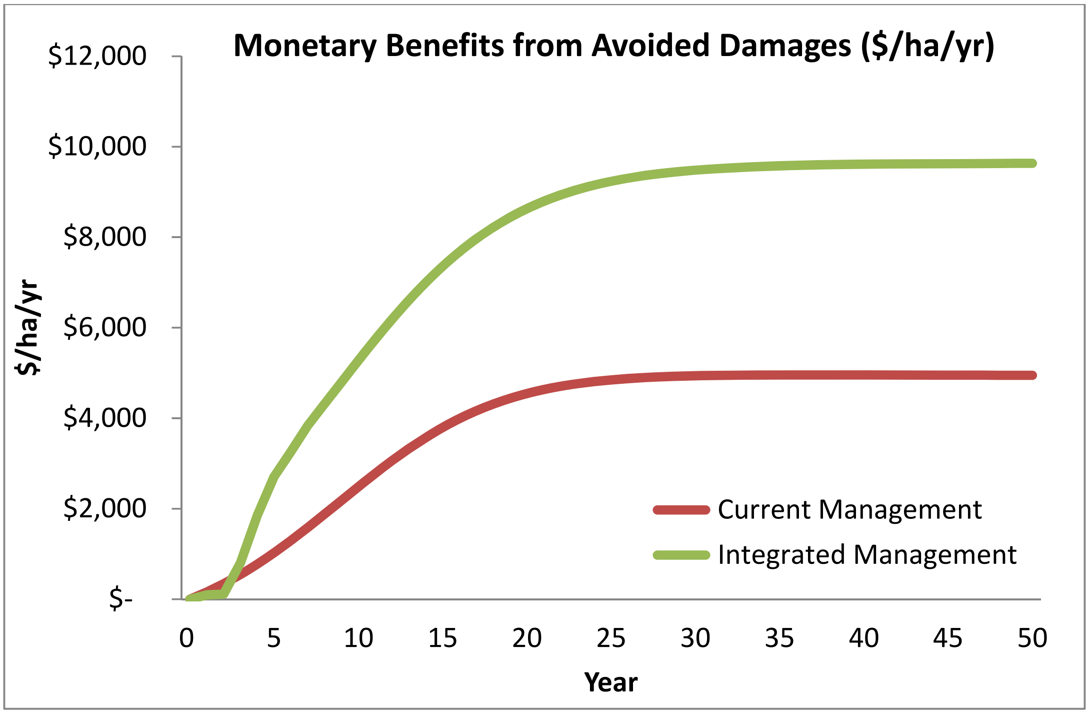


Figure 18 Monetised benefits of avoided damages from management of African tulip tree.

The total monetised costs can be estimated by multiplying the unit costs incurred in each year (Table 14) by the physical values (Table 13). Total annual costs of each management option are listed in Table 5.

Table 15 Total annual costs of management options ($/ha)

Option	Year 0	Years 1-5	Years 6-50
Do Nothing	$0	$0	$0
Current Management	–$300	–$1,472	–$722
Integrated Management	–$420	–$1,950	–$1,200

We then calculate the net present value (NPV) to aggregate the stream of benefits and costs that accrue over time into a single metric so that the relative benefits of various interventions can be compared consistently against each other. This is expressed mathematically as:

$$NPV = \sum_{t=1}^{T} \frac{B_t - C_t}{(1+r)^t} \tag{2}$$

where NPV is the net present value of the option, B_t and C_t are the respective benefits and costs that accrue at time s, T is final time period of project, and r is the real interest rate that is used to discount costs and benefits to the present value. For this study, we assume a project length of 50 years and a discount rate of 8%, which is in the middle of the range of discount rates used for long-term environmental management projects in the Pacific (Lal & Holland 2010).

Results of the benefit-cost analysis for the African tulip tree management are listed in Table 16, and measured relative to the 'do nothing' scenario. Results indicate the integrated approach yields the highest NPV and is therefore considered the most efficient management option from an economic perspective, provided that people have the additional funding and knowledge to implement it. Nevertheless, the current management option also yields a positive NPV, indicating it would be preferred over doing no management at all.

Table 16 Summary of benefit-cost analysis ($/ha) for African tulip tree Management (r = 8%, T= 50 years, study area = 1 ha)

Option	PV Costs	PV Benefits	Total NPV	Benefit-Cost Ratio	Rank
Do Nothing	$0	$0	$0	1.0	3
Current Management	–$11,201	$30,305	$19,104	2.7	2
Integrated Management	–$16,255	$60,351	$44,097	3.7	1

Sensitivity Analysis

Cost-benefit analyses of invasive species management typically depend on extensive data and strong assumptions, and this analysis is no different. Analyses often obtain data from an array of sources with varying levels of quality and certainty. Some of the costs and benefits may be difficult to value accurately, and key biophysical data can be difficult to obtain. The population of the invasive species in the initial period can also vary across space. As a result, we undertake a sensitivity analysis to assess the robustness of our results. Specifically, we now analyse the results in the light of the following variable assumptions**:**

1. Initial population (as % of max) – 0.5 and 2 times base assumption. This changes the initial population of the African tulip tree from 20 to 10% or 40%.

2. Effectiveness of management – 0.5 and 2 times base assumption. This adjusts the pathway of the population growth curves for the two intervention options. An option that is assumed to be twice as effective means that the species is controlled in about half the time as the initial assumption.

3. Discount rate – Rates of 4 and 12% are at the tails of the range of discount rates used for environmental management projects in the region

A summary of the NPV estimates for these sensitivity analyses is presented inTable 33. Estimates show that integrated management yields the highest NPV figures regardless of assumptions about the initial population or relative effectiveness. It also revealed that manually weeding, cutting, and burning the African tulip tree would yield a negative NPV in cases where it was only half as effective as under the initial set of assumptions, suggesting it is more efficient to let the invasive continue to grow and spread under these conditions.

Table 17 NPV ($/ha) of sensitivity analyses for African tulip tree management options (r = 8%, T= 50 years, study area = 1 ha)

Option	Effectiveness	Initial Population (relative to max)		
		10%	20%	40%
Current Management	0.5 × base	$11,899	$8,320	$8,827
	1.0 × base	$18,748	$19,104	$27,472
	2.0 × base	$26,371	$31,258	$49,334
Integrated Management	0.5 × base	$16,490	$34,445	$28,973
	1.0 × base	$30,158	$44,097	$64,553
	2.0 × base	$35,063	$47,858	$73,147

The sensitivity analysis was also done where a discount rate of 4% and 12% was applied to the initial assumptions. Estimates revealed that integrated management option still yielded the highest NPV regardless of the discount rate (Table 18). The current management option still yielded a positive NPV for even the 12% discount rate scenario indicating that it would be preferred over the 'do nothing' option. Therefore, active management of the African tulip tree should be promoted and actively pursued.

Table 18 NPV of discount rate sensitivity analyses for African tulip tree (T= 50 years, study area = 1 ha)

Option	4%	8%	12%
Do Nothing	$0	$0	$0
Current Management	$50,229	$19,104	$8,031
Integrated Management	$106,951	$44,097	$21,184

Results from a sensitivity analysis that varies the initial population, management effectiveness, and discount rate are listed in Appendix 13.2. The findings are generally consistent with those discussed above, and the integrated management approach is still the preferred approach. The current management approach still yields a positive net present value and should be considered economically preferable over the do nothing scenario.

Scaling Up Results

The typical village in Eastern Viti Levu comprises 45 households that each maintain about 0.6 ha of productive land. The values presented above can be scaled up to the village level by using a factor of 45*0.6 = 27 ha/village. This would increase the NPV estimates in Table 16 for managing the tree for all productive land in the village to a total of $1,322,900/village and $515,800/village for the integrated approach and current management approach, respectively. Actual results will obviously differ across villages because of the initial population density and degree of damages created from the African tulip tree. Alternative scaling can be undertaken if monetised values and management options are also accounted for non-productive (e.g. native) land. Scaling up results will not change the overall ranking of each option because we assume constant economies of scale.

Summary and Conclusions

The purpose of this study is to conduct a benefit-cost analysis that estimates the economically efficient options to manage the African tulip tree (*Spathodea campanulata*) at the village-level in Eastern Viti Levu, Fiji. Introduced in 1936 as an ornamental plant, it now dominates disturbed lands throughout much of the country, invading agricultural areas, forest plantations, and natural ecosystems. It is often difficult for landowners to clear and control the African tulip tree with conventional methods such as manual weeding. The level of infestation has led some farmers to clear more natural forests in the area, resulting not only in the clearing of native bush but also in exacerbating the further spread of the invasive tree. Although it is generally considered an agricultural pest, some argue that the invasive tree provides benefits such as building materials, habitat provision, carbon sequestration, and erosion control.

Despite putting some effort into managing the invasive, more than 95% of villages surveyed indicated that the population of the tree was increasing. On average, surveyed households spent 3.7 hours per week (about 24 days per annum) clearing the African tulip tree from their land. To put this in perspective, the average household surveyed spends about 35 hours a week managing their crops, of which about 10% of that time is used specifically to control the invasive tree. The median household among those who view the African tulip extremely negatively offered to volunteer 10 additional hours per household per week if their efforts would significantly reduce the density of African tulip tree from their villages. Given that the average household surveyed spends about 6 hours per week on all volunteer work, this underscores the perceived magnitude of the problem among Fiji's farmers. It also emphasizes their high willingness to work to alleviate the problem, provided there are methods proven to achieve this.

The benefit-cost analysis estimated three options to manage the African tulip tree: (i) do nothing, (ii) continue current management regime, (iii) implement a more intensive integrated approach. The integrated approach to managing the African tulip tree was estimated to yield the highest net present value of all management options investigated in this study, as benefits of management outweighed costs by a ratio of almost 4 to 1. The current management approach was not as effective, although it still yielded positive net benefits for landowners (benefit-cost ratio of 2.7:1) and should thus be considered a viable option over the do nothing approach. This is particularly the case if herbicides and machinery are difficult to obtain. Increasing the level of effort for manually weeding, cutting and burning the African tulip tree should also be considered, but landowners should be trained to manage the invasive more effectively than the current case in which the African tulip tree continues to spread even when households spend about 4 hours per week clearing it.

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Appendix 13.1: Details of African Tulip Tree Integrated Management Option

1. Hack-and-squirt treatment method: This method is suitable for treating mature standing trees. Using a hatchet or tomahawk, make a series of downward cuts around the entire circumference of the tree trunk. The cuts should be as close as practical to ground level and at least one cut per 10 cm of trunk diameter. The cuts are likely to be 1–3 cm long. Use a precision stock injector gun to apply 100% glyphosate into all cuts at a rate of 10 mls/10 cm DBH. Note that on a mature tree the cuts are likely to include the buttressed section of the tree trunk, i.e. probably within 10–30 cm of ground level. This will gradually kill the tree over a period of time (up to 2 years).

2. Ringbarking method: A treatment method that requires cutting through the inner and outer bark, cambium and phloem (not xylem) tissues on a tree to prevent nutrients (sugars and starches) from reaching the roots so that the plant dies from the roots up. This method can be more time-consuming but does not normally require the use of herbicide. It is necessary to check regularly as it is difficult to kill an African tulip tree.

3. Cut-stump treatment method: Suitable for saplings or small trees. The plant trunk is completely removed with a chainsaw or pruning saw, horizontally and as close to ground level as possible. Herbicide is applied to the top of the cut trunk paying particular attention to the cambium layer. Note that the herbicide mixture must be applied within 10 minutes of cutting the stump. Glyphosate, 1 part to 5 parts water, is a suitable herbicide mixture, applied via a knapsack sprayer. A paint brush and suitable container for herbicide can be used as an alternative to a knapsack sprayer. Glyphosate can also be applied directly to the cambium layer in a 100% mixture with a suitable application tool, e.g. syringe. The stump should not be any higher than 5–10 cm above ground level. The cut tree trunks should be stacked in a tidy heap, preferably off the ground, to avoid any trunks taking root and regrowing. To prevent re-invasion the heap of trunks and cleared area need to be monitored every 2 weeks and follow-up treatment of any regrowth or seedlings completed.

4. Control seedlings method: Destroy seedling plants by hand-pulling them, removing all soil from the roots and preferably leaving the plants off the ground so that they dry out and die.

5. Bulldozer or digger mechanical removal: Undertaken in suitable weather conditions, e.g. before the rainy season, and on land with suitable topography, i.e. not steep. Areas of saplings or small trees are pushed or dug into heaps suitable for later burning. Grass seed (non-invasive and low fire-risk species) is sown to form a ground cover which assists in minimising the amount of African tulip tree germination from dormant seed. In areas identified for grazing, selective herbicide, e.g. Triclopyr, is applied to African tulip tree seedlings before they reach 35 cm height. If cropping is the intended land use on the cleared area then glyphosate should be used to control African tulip tree seedlings, at the rate of 1 part to 100 parts water and applied to the seedlings before they reach 20 cm height.

Note: Follow all requirements on the herbicide label. Protective clothing and footwear must be worn and health and safety requirements followed. Application of herbicide must not result in any non-target damage.

Appendix 13.2: African Tulip Tree Management Sensitivity Analysis

Table 19 NPV ($/ha) of sensitivity analyses for African tulip tree management options (r = 8%, T= 50 years, study area = 1 ha)

Discount Rate = 4%				
Option	**Effectiveness**	**Initial Population (relative to max)**		
		10%	20%	40%
Current Management	0.5 × base	$31,875	$23,978	$23,944
	1.0 × base	$51,481	$50,229	$63,812
	2.0 × base	$72,006	$78,220	$107,598
Integrated Management	0.5 × base	$62,073	$87,735	$69,315
	1.0 × base	$85,864	$106,951	$133,965
	2.0 × base	$95,629	$115,237	$147,814
Discount Rate = 8%				
Option	**Effectiveness**	**Initial Population (relative to max)**		
		10%	20%	40%
Current Management	0.5 × base	$11,899	$8,320	$8,827
	1.0 × base	$18,748	$19,104	$27,472
	2.0 × base	$26,371	$31,258	$49,334
Integrated Management	0.5 × base	$16,490	$34,445	$28,973
	1.0 × base	$30,158	$44,097	$64,553
	2.0 × base	$35,063	$47,858	$73,147
Discount Rate = 12%				
Option	**Effectiveness**	**Initial Population (relative to max)**		
		10%	20%	40%
Current Management	0.5 × base	$4,392	$2,657	$3,282
	1.0 × base	$7,304	$8,031	$13,818
	2.0 × base	$10,764	$14,440	$26,988
Integrated Management	0.5 × base	$2,230	$15,449	$13,925
	1.0 × base	$11,573	$21,184	$37,317
	2.0 × base	$14,488	$23,186	$43,540

Appendix 14: CBA Analysis – Small Asian Mongoose

Overview

The purpose of this study is to conduct a benefit-cost analysis that estimates economically efficient options to manage the small Asian mongoose (*Herpestes auropunctatus*) at the village-level in Eastern Viti Levu, Fiji. The small Asian mongoose can be found in a range of habitats from desert to forest. Mongooses are agile predators, feeding on a variety of small mammals, birds, reptiles, insects, crabs, and bird eggs (Veron et al. 2010). It is a threat to livestock and can damage production of a variety of crops (taro, potatoes, melons, bananas, etc.). The small Asian mongoose has had a major impact on native species in the areas where it has been introduced and is listed by the IUCN as one of the world's 100 worst invasive species. Native wildlife in Fiji evolved in the absence of predatory mammals, so they are particularly threatened by mongoose predation. The mongoose is also a carrier of human and animal disease, including rabies and human leptospira bacterium.

Native to Asia, the mongoose is reported to have been introduced to Fiji in 1883 primarily to control rats in sugar cane fields. Although it is widespread on Fiji's largest islands, Viti Levu and Vanua Levu, it has not reached many smaller islands such as Taveuni. This species is believed to have impacted several species in Fiji, and been responsible for the possible extinction of skinks (*Emoia nigra* and *E. trossula*) and possibly the banded rail (*Rallus philippensis*), sooty rail (*Porzana tabuensis*), white-browed rail (*Poliolimnas cinereus*), purple swamphen (*Porophyrio porphyrio*), and bar-winged rail (*Nesoclopeus poecilopterus*). It is also believed to have had a negative impact on some of Fiji's native frogs, birds, and bats (Veron et al. 2010). Despite the large list of biodiversity impacts, there are no known attempts to eradicate the mongoose from any of the Fijian islands at the time of this study (Barun et al. 2011).

To investigate the socio-economic impacts of invasive species in Fiji, we surveyed 360 households in 30 villages in eastern Viti Levu. Additional information on the impact at the village-level was obtained through a community-level focus group. Information on the biophysical growth and effectiveness of various management options to control the invasive was primarily obtained from scientific literature and checked by regional experts

Biological Growth

The growth and spread of the small Asian mongoose is assumed to follow a logistical biological growth curve:

$$N_{t+1} = N_t \ + bN_t \ \left(1 - \frac{N_t}{N_{Max}}\right) \tag{1}$$

where N_t is the population at time *t*, N_{max} is the carrying capacity, and *b* is the growth parameter.

Research indicates that the small Asian mongoose typically breeds 2–3 times a year, producing litter size of 2–4 (Gilchrest et al. 2009). Home ranges average 2.2 – 3.1 ha for females and 3.6 – 4.2 ha for males. The home ranges often overlap and can be as small as 0.75 ha (Nellis & Everard 1983). Populations generally average 2.5 individuals per ha

(Pimentel 1955), but carrying capacity on some islands can be as high as 10 mongoose per hectare (Nellis 1989). The lifespan of species in wild averages about 4 years (ISSG Database). Additional details on the biology of the mongoose can be found in Gorman (1979) and Tomich (1969).

The dynamics of growth and death based on this prior research provides us with a rough estimate that a carrying capacity of 10 mongooses per ha could be reached after about 10 years after the mongoose is established in the study area. This information is then used to calibrate equation (1) for using parameter values of $N_0 = 1$ mongoose $b = 0.5$, and $N_{Max} = 10$ as shown in Figure 19.

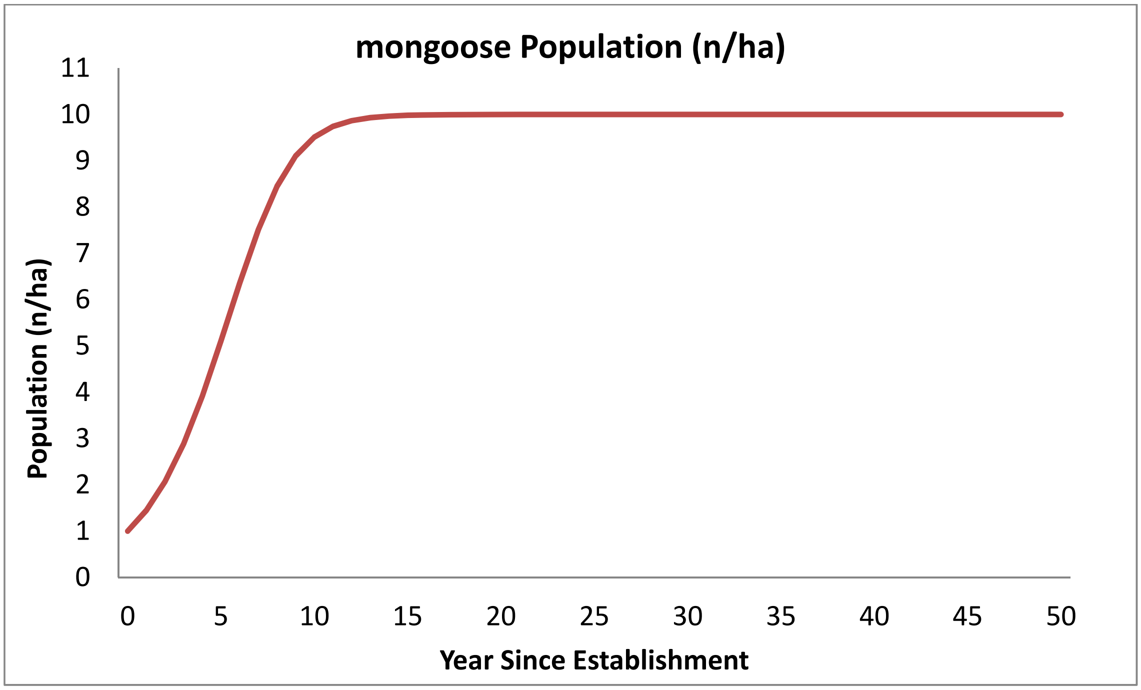

Figure 19 Biological Growth Function of small Asian mongoose

Study Site and Survey Methodology

To investigate the socio-economic impacts of invasive species in Fiji, we surveyed 360 households in 30 villages in eastern Viti Levu. These villages were stratified by geography and randomly drawn; one village that is inaccessible by road due to construction was replaced with another remote village. Within each of the 30 villages, households were drawn at random. Each survey was administered directly to the head of household, and topics covered demographics; farming, fishing, wage work, and other income-generating activities; wealth and durables; education; health; and extension activities. The survey also included several novel elements pertaining to the social and economic impacts of invasive species.

First, respondents were asked to assume the role of Fiji's budget minister and to identify spending priorities by allocating budgetary shares to a broad range of categories, including education, healthcare, defence, trade, infrastructure development, and environmental protection. Respondents who allocated money to environmental protection were further asked to prioritise controlling specific invasive species relative to other environmental spending.

Second, a series of questions was asked to elicit willingness to contribute personally to controlling invasive species via volunteer labour. In most developed countries, willingness to pay is identified via questions pertaining to tax increases; however, few rural Fijian households pay taxes, while virtually all of them contribute labour to maintaining the village, suggesting this approach is culturally relevant. Opening values were assigned via dice rolls to eliminate concerns about starting point bias.

Third, respondents were asked to state the extent to which they agreed with statements on the value of controlling invasive species (e.g. "It is bad that the mongoose is found in this village.") via a 5-point Likert scale. To eliminate concerns of yea-saying, some statements read in the negative (e.g. " It is bad that the mongoose is found in this village.").

A complementary survey was administered to a focus group in each of the 30 sampled villages. The village-level questionnaire consisted of open-ended questions regarding the presence and state of each species and, where applicable, the consequences of its presence (both positive and negative) and community practices for encouraging or limiting its spread.

Survey Findings

Respondents to the community survey identified a number of costs associated with the mongoose, including:

- 83% of villages reported mongooses had attacked livestock, primarily chickens
- 17% of villages reported mongooses have reduced bird or animal populations
- 13% of villages reported mongooses have reduced agricultural output

Villagers also reported perceived benefits of the mongoose, however, including:

- 73% of villages reported mongooses were eaten by villagers
- 27% of villages noted the mongoose was useful for snake control

About 17% of surveyed villages reported mongooses brought no benefits to the local area.

In terms of control, villagers in 87% of the surveyed villages actively trap mongooses and villagers in 47% of surveyed villages hunt it. These interventions are for both protecting crops and livestock and food consumption. Despite putting some effort into managing this invasive species, 90% of villages surveyed indicated that the population of the mongoose was still increasing (Figure 20).

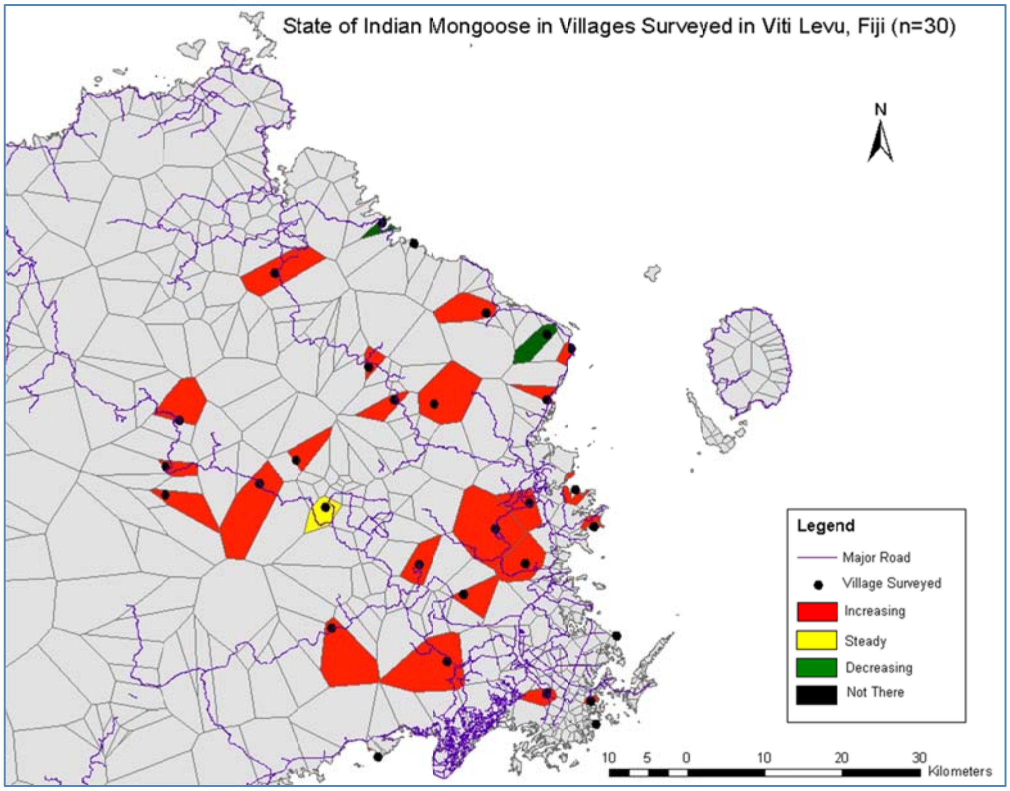

Figure 20 State of small Asian mongoose in villages surveyed (n=30)

Respondents to the household survey were asked four questions on negative and positive attributes of the mongoose to elicit their personal views of the invasive. Only about 7% of survey respondents viewed the presence of the mongoose favourably, while 77% viewed the mongoose unfavourably. Of that, 56% of households answered all four attribute questions for the mongoose with an extremely negative response.

Despite the fact that survey respondents overwhelmingly held negative views of mongooses and that most villages reported minor economic losses from mongoose, few survey respondents spent significant effort to address the presence of mongooses at the household level. On average, households in the surveyed areas spend just 3 minutes per week controlling the mongoose through hunting and trapping activities. The maximum value for time spent on control was a total of 8 hours per week and the standard deviation was about 0.5 hours/wk.

Asked to reallocate Fiji's national budget according to their own spending priorities, survey respondents would allocate approximately 7% of the national budget for invasive species management. They would further allocate 12% of that budget to control Asian mongoose. No respondents stated that the small Asian mongoose was the worst invasive species in their village.

Management Options

Different management options can show differential impacts on the growth and spread of the mongoose (Figure 21). In addition to doing nothing, three management options are considered in this analysis: live trapping, kill trapping, and hunting. Because the mongoose has been established for more than a century in Viti Levu, Fiji, we can safely assume about 100% of the potential carrying capacity is already present in most villages. We then used the following assumptions to parameterise the effect of management on species growth from the various options:

Do Nothing (without scenario)

This option represents typical progression of growth and spread across the landscape no management. Under this scenario, the small Asian mongoose continues to occupy all ecologically suited environments at its carrying capacity. All other options are measured relative to the costs and benefits estimated under this option. Obviously, there are no management costs associated with the do nothing option, but it does result in damages that could be avoided if the spread of the mongoose was controlled.

Live Trapping

A relatively cheap approach that is often very successful at removing animals in the short term. Traps need to be regularly maintained as mongooses can rapidly re-colonise trapped areas. Mongoose can follow scents up to 500 m, so relatively inexpensive live traps (e.g. Haguruma) are set on a grid every 200 m (or about 1 trap/ha) to ensure appropriate coverage for the entire village boundary (William Pitt, USDA, pers. comm.). Because mongooses appear to have low selectivity and consume most bait types (Creekmore et al. 1994), trapping is likely to be highly effective. This method requires skilled and intensive labour as traps must be checked daily and captured animals are dispatched humanely on site. Live traps also have the advantage that non-target captures can often be released unharmed (Barun et al. 2011) and as a result non-toxic bait should be used. Mongoose captured in live traps can be consumed as food. We assumed that this option could potentially reduce the mongoose population to about than 30% of carrying capacity over the project period, although it could vary by site and number of traps per hectare.

Kill Trapping

Similar to live trapping, kill traps are set on a grid every 200 m (or about 1 trap/ha) for the entire village boundary (William Pitt, USDA, pers. comm.). Non-toxic bait should be used and mongoose captured in kill traps could be consumed as food if the kills are fresh. Traps must be checked daily initially (to refill stations) but longer term programs require less frequent checks. Key considerations include toxin type, bait type, baiting density, non-target species, and timing (Barun et al. 2011). We assumed that this option could potentially reduce the mongoose population to less than 20% of carrying capacity over the project period, although it could vary by site and number of traps per hectare.

Hunting

This approach requires significant labour as well as capital for hunting (e.g. guns and ammunition). This approach could be effective when the population is high but could require a high level of effort per kill (e.g. search costs) for lower populations. Some experts have stated that hunting is not known to be employed or expected to be effective (Barun et al. 2011), althought our study found that it is currently being done in nearly 50% of the villages surveyed. Therefore, we assume this option is less effective than trapping at controlling mongoose population, reducing it to about 50% below carrying capacity.

We assume control work undertaken in all areas of the village (i.e. cleared land and native bush). Because estimates could be highly variable based on some of our assumptions, we conduct sensitivity analysis to assess the change in relative costs and benefits under alternative population and management effectiveness later in the study.

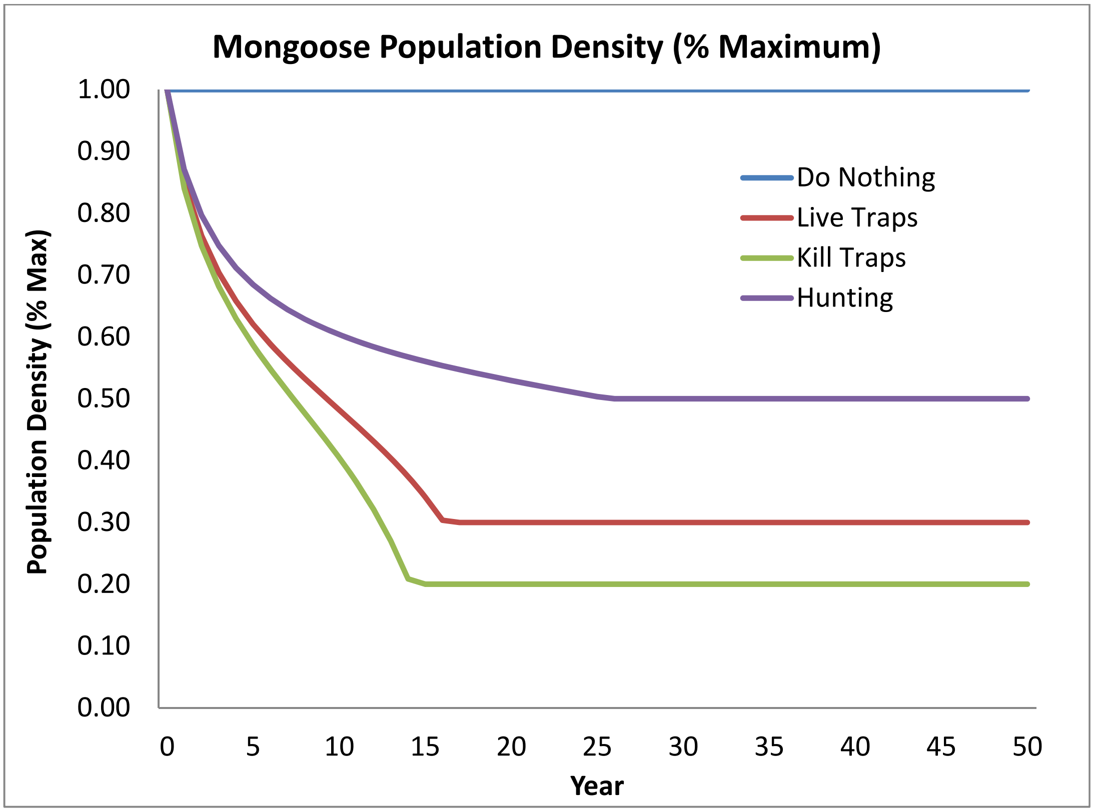

Figure 21 Mongoose population (as % carrying capacity) over time and management option.

Quantifying Benefits and Costs of Invasive Management

Several benefits can accrue within the community as a result of managing the mongoose, mostly in terms of avoided damages. Possible benefits include improved livestock and crop productivity, increased biodiversity, and reduction in impacts to human health from bites. Unfortunately, some of these benefits are not easily quantified, either physically or monetarily. As a result, this analysis only quantifies the benefits of avoided damages in livestock and crop yields. Note that it is likely the non-quantified benefits will also have positive economic value in actuality, and thus the figures listed here are likely to be underestimates of the total benefits from managing the invasive.

These specified benefits then need to be expressed in terms of physical units of damage that would likely accrue under the status quo 'do nothing' in the initial period (year 1). For this study, we used the household survey and anecdotal evidence to estimate that

crop production[5] diminishes by 2.5% due to the presence of the mongoose and that about 1 chicken per household per year is killed by the invasive species[6]. As the mongoose is already near carrying capacity, damages are expected to hold steady across time if there in the absence of any intervention (see Figure 21). The damages in the initial period are listed in Table 20. Note that these figures can be interpreted as mixed land use with multiple crops and livestock types on a typical hectare in the project area.

Table 20 Initial physical values (per ha) to quantify annual benefits of avoided damages from invasive management

Damages	Units	Optimal Yield	Damage Impact	Initial Period Damages
Livestock	Head	10	10%	1
Crops	Kg	10000	2.5%	250

Quantifying the costs of invasive species management is often more straightforward. Typical costs of controlling the mongoose include labour, non-toxic bait, ammunition, maintenance, and initial capital costs (e.g. guns, traps, etc.). All costs are estimated to occur at the end of each period for the duration of the intervention, with the exception of capital costs, which only occur during the initial period. The physical units listed in Table 21 are based on literature, survey responses, and expert knowledge. Non-toxic bait is assumed to be a mix of readily available animals or food products such as eggs, chicken scraps, or rats. Some per hectare costs presented here are scaled down from the total costs of the management options that likely to be shared across the entire village area of approximately 300 ha. For example, we assume that 3 rifles are purchased at the onset of the project, and hence there is only 1/100th of a rifle required for hunting on any particular hectare. Additionally, we assume that labour to bait and check the traps or hunt is spread across the entire project area such that one person can work across several hectares (and households) in a day.

We also note that estimates presented in this study are for a generalised and hypothetical control programme in Fiji and the level of bait and manpower required is likely to vary for specific areas. Thus, things such as optimal types and amounts of bait should be trialed prior to implementing a large project to determine appropriate baiting densities required for mongooses in specific situations (Wegmann et al. 2011).

[5] Includes a mix of crops based on the average area of crops planted and harvested obtained from the household survey. This is primarily taro and cassava, but also includes other fruits and vegetables.

[6] The household survey estimated that households that raised poultry had an average of 6 chickens killed per year by the mongoose. However, less than 20% of the households surveyed raised poultry.

Table 21 Initial physical values (per ha) to quantify annual costs of invasive management

Cost	Units	Years Incurred	Do Nothing	Live Trapping	Kill Trapping	Hunting
Annual Costs						
Labour	Man days	1–50	0	1.3	1.0	1.0
Non-toxic bait	Kg	1–50	0	4	4	0
Ammunition	Boxes	1–50	0	0	0	1
Trap repair and replacement	Traps	1–50	0	0.2	0.2	0
Capital Costs						
Traps	Units	0	0	1	1	0
Rifle*	Units	0	0	0	0	0.01

*We assume that a single rifle is shared across several households and hectares.

Aggregating Costs and Benefits

The physical values of benefits and costs listed above can then be monetised by applying unit values over time. The monetary units listed in Table 22 are all listed in Fijian dollars (FJD) and are average values elicited from household and market surveys and expert input.

Table 22 Unit values for monetised benefit and costs

Category	Category	Unit Measurement	Unit Value ($/unit)
Benefits	Crop income	$/kg	1.00
	Livestock income	$/Head	5.00
Costs	Labour	$/man day	30.00
	Non-toxic bait	$/kg	2.00
	Ammunition	$/box	20.00
	Live Traps	$/trap	50.00
	Kill Traps	$/trap	100.00
	Rifle	$/rifle	500.00

The monetised values for damages that accrue in the initial period under the ‘do nothing’ case and each management option can be estimated by multiplying the unit monetary values in Table 22 by the initial physical damage estimates shown in Table 20. These damages can be estimated over time by tracking the change in the respective population curves, as displayed in Figure 22.

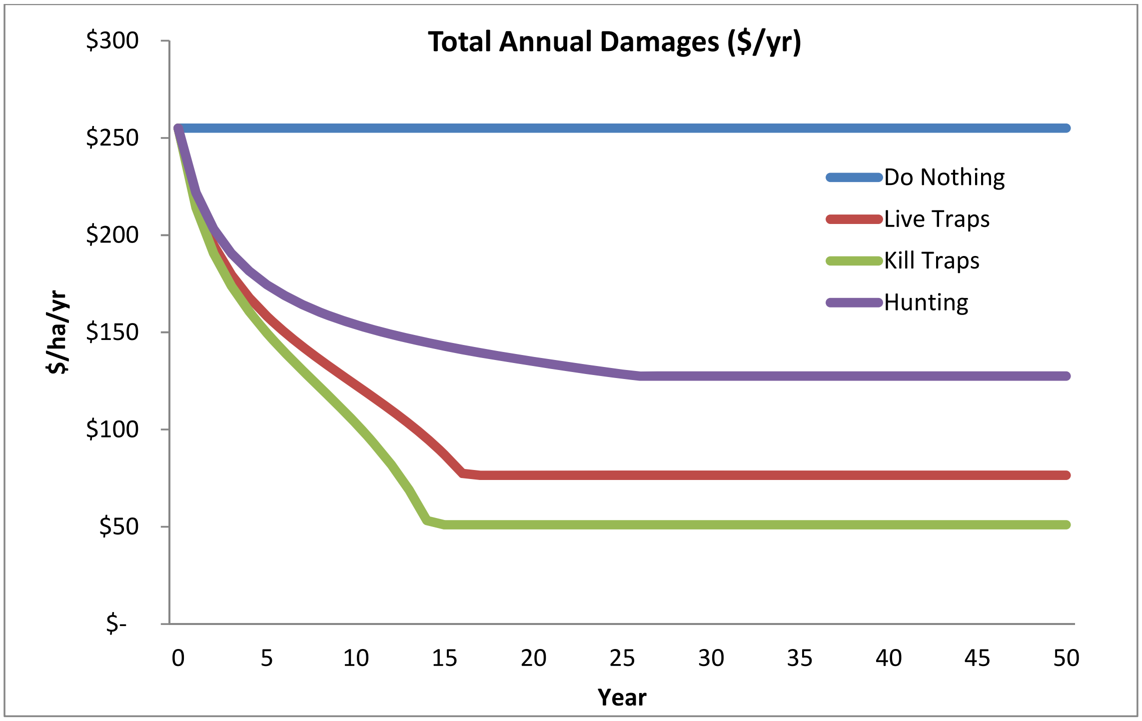

Figure 22 Total value of annual damages ($/ha) from small Asian mongoose under various management options.

The differences between the damage curves for 'do nothing' and a specific management option represents the benefits that accrue from avoiding damages would have occurred under the 'do nothing' option. These benefits are displayed in Figure 23.

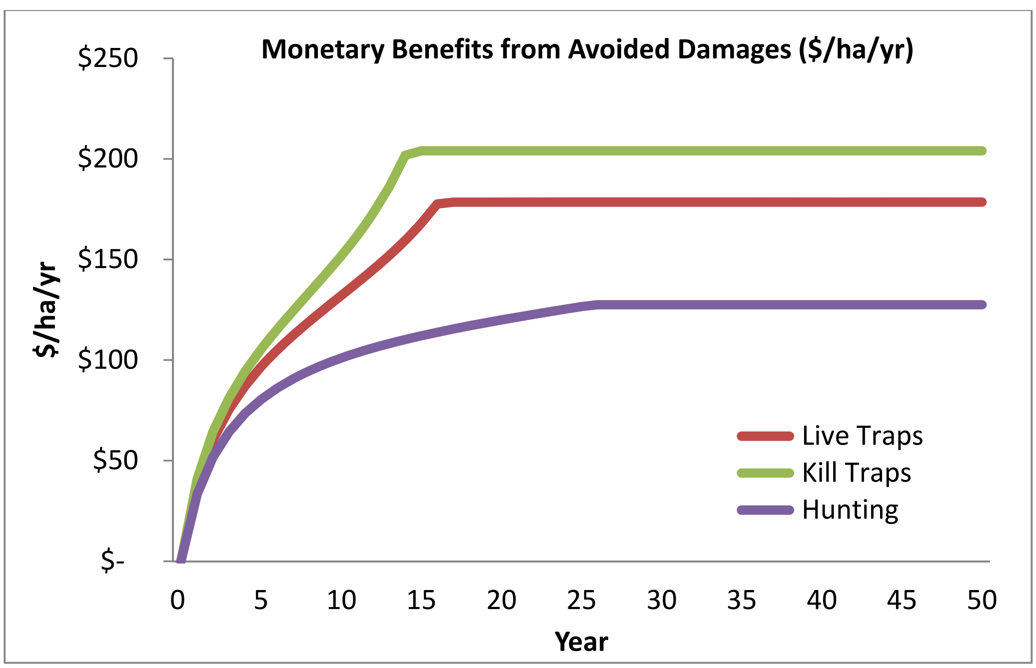

Figure 23 Monetised benefits of avoided damages from management of small Asian mongoose.

The total monetised costs can be estimated by multiplying the unit costs incurred in each year (Table 22) by the physical values (Table 21). Total annual costs of each management option are listed in Table 23.

Table 23 Total annual costs of management options ($/ha)

Option	Year 0	Years 1–50
Do Nothing	$0	$0
Live Trapping	–$50	–$90
Kill Trapping	–$100	–$90
Hunting	–$5	–$50

We then calculate the net present value (NPV) to aggregate the stream of benefits and costs that accrue over time into a single metric so that the relative benefits of various interventions can be compared consistently against each other. This is expressed mathematically as:

$$NPV = \sum_{t=1}^{T} \frac{B_t - C_t}{(1+r)^t} \tag{2}$$

where NPV is the net present value of the option, B_t and C_t are the respective benefits and costs that accrue at time s, T is final time period of project, and r is the real interest rate that is used to discount costs and benefits to the present value. For this study, we assume a project length of 50 years and a discount rate of 8%, which is in the middle of the range of discount rates used for long-term environmental management projects in the Pacific (Lal & Holland 2010).

Results of the benefit-cost analysis for the small Asian mongoose management are listed in Table 24. Results indicate that the kill traps yield the highest NPV and are therefore considered the most efficient management option from an economic perspective. Nevertheless, all three management options yield a positive NPV, indicating they would be preferred over the status quo.

Table 24 Summary of benefit-cost analysis (r = 8%, T= 50 years, study area = 1 ha)

Option	PV Costs	PV Benefits	Total NPV	Benefit-Cost Ratio	Rank
Do Nothing	$0	$0	$0	1.0	4
Live Traps	–$1,151	$1,533	$382	1.3	3
Kill Traps	–$1,201	$1,747	$546	1.4	1
Hunting	–$617	$1,140	$523	1.9	2

Sensitivity Analysis

Cost-benefit analyses of invasive species management typically depend on extensive data and strong assumptions, and this analysis is no different. Analyses often obtain data from an array of sources with varying levels of quality and certainty. Some of the costs and benefits may be difficult to value accurately, and key biophysical data can be difficult to obtain. The population of the invasive species in the initial period can also vary across space, and not all villages in the study area might currently have a population near carrying capacity. As a result, we undertake a sensitivity analysis to assess the robustness of our results. Specifically, we analyse how the NPV estimates and relative effectiveness for each option could change in light of varying the following assumptions:

1. Initial population (as % of max) – 0.33 and 0.66 times base assumption. This changes the initial population of the small Asian mongoose from 100% to 33 or 66%.
2. Effectiveness of management – 0.5 and 2 times base assumption. This adjusts the pathway of the population growth curves for the three intervention options. An option that is assumed to be twice as effective means the species maximum effectiveness of the intervention is cut in half.
3. Discount rate – Rates of 4 and 12% are at the tails of the range of discount rates used for environmental management projects in the region

A summary of the NPV estimates for sensitivity analyses #1 and #2 is presented in Table 33. Estimates show that kill traps yield the highest NPV figures regardless of assumptions about the initial population or relative effectiveness. The summary also revealed that live traps would yield a negative NPV in cases where population was already at carrying capacity, and it was half as effective as the initial assumption at reducing the population. This suggests it could be more efficient, from an economic perspective, to let the mongoose continue to grow and spread under these conditions. However, as these figures do not account for the value of biodiversity protection, it is likely that live traps do indeed yield a positive value relative to the do-nothing option.

Table 25 NPV of sensitivity analyses for small Asian mongoose management options (r = 8%, T= 50 years, study area = 1 ha)

Option	Effectiveness	Initial Population (relative to max)		
		33%	66%	100%
Live Traps	0.5 x base	$1,488	$543	–$34
	1.0 x base	$4,298	$1,389	$382
	2.0 x base	$5,512	$1,634	$500
Kill Traps	0.5 x base	$3,311	$1,210	$302
	1.0 x base	$5,108	$1,687	$546
	2.0 x base	$5,876	$1,884	$645
Hunting	0.5 x base	$617	$385	$125
	1.0 x base	$2,959	$1,265	$523
	2.0 x base	$5,219	$1,329	$545

The sensitivity analysis was also undertaken where a discount rate of 4 and 12% was applied to the initial assumptions. Estimates revealed that kill traps still yielded the highest NPV regardless of the discount rate (Table 26). All options still yielded a positive NPV for the 12% discount rate scenario, indicating that they would be still preferred over the do-nothing option, even if the only benefits accounted for were improvements in crop and livestock yields.

Table 26 NPV of discount rate sensitivity analyses for small Asian mongooses (T= 50 years, study area = 1 ha)

Option	4%	8%	12%
Do Nothing	$0	$0	$0
Live Traps	$1,070	$382	$130
Kill Traps	$1,460	$546	$204
Hunting	$1,142	$523	$286

Results from a sensitivity analysis that varies the initial population, management effectiveness, and discount rate are listed in Appendix 14.1. The findings are generally consistent with those discussed above, but the preferred option can vary depending on the level of effectiveness and discount rate. For example, hunting was found to have a lower relative NPV compared to the two trapping optinons for nearly all cases that had a 4% discount rate or in the case where the initial population was less than carrying capacity. Regardless, all options still yielded a positive net present value relative to the do nothing case for nearly all scenarios, suggesting that some management to control the mongoose is preferred to no management at all.

Scaling Up Results

The typical village in Eastern Viti Levu comprises 45 households, each of which maintain about 0.6 ha of productive land. The values for avoided damages presented above can be scaled up to the village level by using a factor of 45*0.6 = 27 ha/village. Alternative scaling of the cost figures presented in this analysis can be undertaken if the intent of the project is to also control mongoose in non-productive (e.g. native) land surrounding the village (approx. 300 ha). Scaling up results will not change the overall ranking of each option unless one assumes non-constant economies of scale.

Summary and Conclusions

Using kill traps to control the small Asian mongoose was estimated to yield the highest net present value for all the management options. Hunting and the use of live traps were not as effective, although the approach still yielded positive net benefits for landowners and should thus be considered a viable option over the ‘do nothing’ scenario. Sensitivity analyses that varied the initial population, effectiveness of an intervention in reducing mongoose population, and the rate to discount future costs and benefits resulted in a positive net present value for nearly all scenarios, suggesting that any management option is likely to be beneficial relative to the do nothing case. This is particularly the case as the study excluded any possible benefits for biodiversity protection, primarily because there was a lack of data. Thus, the estimates presented here can be considered a lower bound.

These results should also be interpreted with a degree of caution as the analysis used several assumptions to estimate the physical and monetary costs and benefits of mongoose control. For the trapping interventions, the most-effective bait/lure will vary depending on many environmental and behavioural factors. Thus, it is wise to conduct mongoose trials at smaller scales before commencing on the full project. Hunting success could also vary across the landscape and will likely become less successful as the populations decline. There could also be an issue with sourcing and holding firearms for the typical Fijian. Finally, removing mongooses without also removing other invasive species such as cats and rats could still be an issue for native species on the island. Therefore an integrated approach may be necessary.

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Appendix 14.1

Table 27 NPV ($/ha) of sensitivity analyses for small Asian mongoose management options (r = 8%, T= 50 years, study area = 1 ha)

Discount Rate = 4%				
Option	**Effectiveness**	**Initial Population (relative to max)**		
		33%	66%	100%
Live Traps	0.5 x base	$3,377	$1,113	$67
	1.0 x base	$8,312	$2,925	$1,070
	2.0 x base	$10,577	$3,578	$1,425
Kill Traps	0.5 x base	$6,617	$2,465	$836
	1.0 x base	$9,827	$3,567	$1,460
	2.0 x base	$11,292	$4,056	$1,734
Hunting	0.5 x base	$1,814	$794	$250
	1.0 x base	$5,927	$2,494	$1,142
	2.0 x base	$9,952	$2,771	$1,243
Discount Rate = 8%				
Option	**Effectiveness**	**Initial Population (relative to max)**		
		33%	66%	100%
Live Traps	0.5 x base	$1,488	$543	-$34
	1.0 x base	$4,298	$1,389	$382
	2.0 x base	$5,512	$1,634	$500
Kill Traps	0.5 x base	$3,311	$1,210	$302
	1.0 x base	$5,108	$1,687	$546
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Hunting	0.5 x base	$617	$385	$125
	1.0 x base	$2,959	$1,265	$523
	2.0 x base	$5,219	$1,329	$545
Discount Rate = 12%				
Option	**Effectiveness**	**Initial Population (relative to max)**		
		33%	66%	100%
Live Traps	0.5 x base	$732	$308	-$72
	1.0 x base	$2,639	$777	$130
	2.0 x base	$3,413	$882	$175
Kill Traps	0.5 x base	$1,954	$692	$93
	1.0 x base	$3,152	$934	$204
	2.0 x base	$3,630	$1,026	$245
Hunting	0.5 x base	$155	$217	$72
	1.0 x base	$1,745	$768	$286
	2.0 x base	$3,257	$785	$291

Apendix 15: CBA Analysis – taro beetle

Overview

The purpose of this study is to conduct a benefit-cost analysis that estimates the most effective option to manage the taro beetle (Papuana uninodis) at the village-level in Eastern Viti Levu, Fiji. Community- and household-level surveys were conducted in a total of 30 villages in Viti Levu to collect the majority of the economic data presented in this analysis.

The taro beetle is native to Papua New Guinea and commonly found in areas with disturbed land in many countries throughout the Pacific Islands region. The beetles are known to have a negative impact (up to 30%) on taro (Colocasia esculenta) yields, by burrowing into the plant's corms and forming holes and tunnels that make the taro susceptible to fungal infection and death. Taro, a key agricultural crop in Fiji and other parts of the Pacific, has significant cultural attributes as it plays important roles in traditional exchanges and social obligations. Other root crops such as sweet potatoes, yams, and bananas experience similar damage. The beetles have a wide range of hosts and are therefore capable of surviving in harsh environments. They also have an impact on native plant species as they attack ornamental and cultivated aroids.

The beetle was introduced to Fiji in 1981, and has become a problem in some of the islands of Fiji such as Viti Levu. The impact of beetle feeding is considerable, as export markets do not tolerate any damage, and more than 15% damage will also make the crop unacceptable for local markets. Much of the export taro production has shifted to the island of Taveuni, which is currently free of taro beetle. However, the island is quite far from export facilities and forests have been cleared to expand the area of plantation on the island's hills and slopes.

Biological Growth

The growth and spread of the taro beetle is assumed to follow a logistical biological growth curve:

$$N_{t+1} = N_t + bN_t \left(1 - \frac{N_t}{N_{Max}}\right) \tag{1}$$

where N_t is the population at time t, N_{max} is the carrying capacity, and b is the growth parameter.

Research indicates that an adult female taro beetle lays an average of 140 eggs over a period of 27 weeks, and that about 50% of these eggs survive. Therefore, reproduction and population increase is quite rapid. Adults can live up to 22 months.

The dynamics of growth and death based on this earlier research provides a rough estimate that a carrying capacity of taro beetles could be reached about 20 years after the beetle is established in the study area. The approximate figures for the number of beetles living in an area of the study site are unavailable, so we use the limited information to calibrate equation (1) such that it estimates a biological growth curve presented as the percent of beetle population relative to the population at carrying capacity. This is achieved using parameter values of $N_0 = 1$ beetle b=0.5, and $N_{Max} = 100$ as shown in Figure 24.

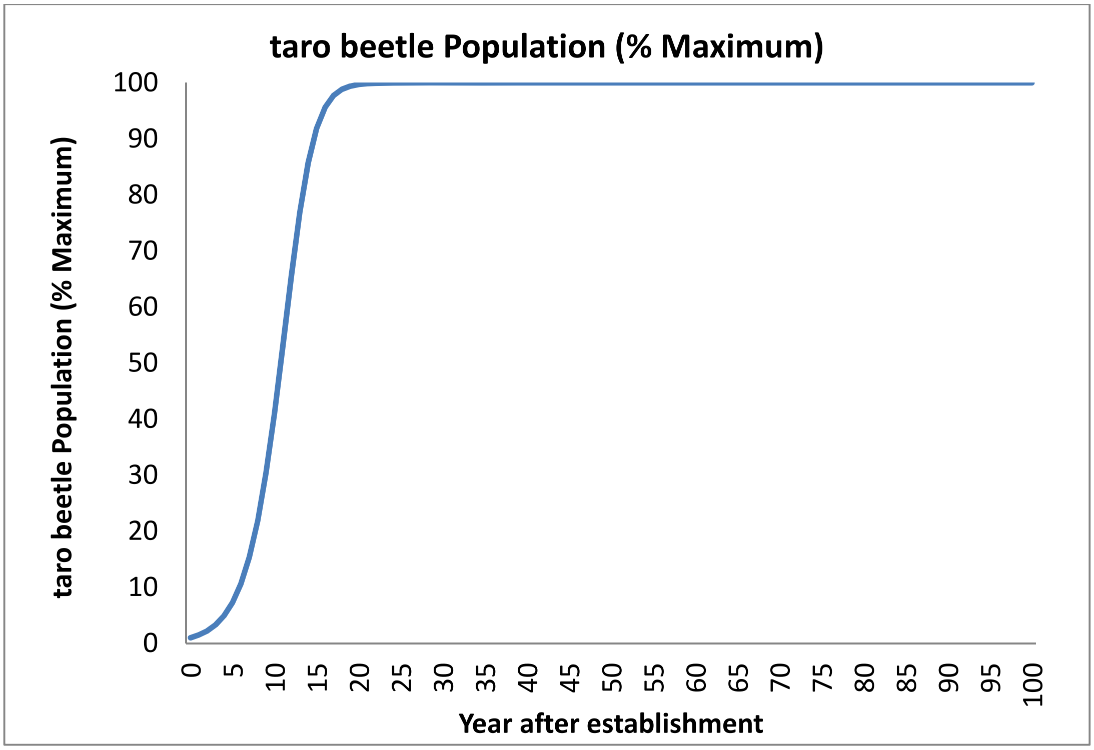

Figure 24 Biological Growth Function of taro beetle

Study Site and Survey Methodology

To investigate the socio-economic impacts of invasive species in Fiji, we surveyed 360 households in 30 villages in eastern Viti Levu. These villages were stratified by geography and randomly drawn; one village that is inaccessible by road due to construction was replaced with another remote village. Within each of the 30 villages, households were drawn at random. Each survey was administered directly to the head of household, and topics covered demographics; farming, fishing, wage work, and other income-generating activities; wealth and durables; education; health; and extension activities. The survey also included several novel elements relevant to the social and economic impacts of invasive species.

First, respondents were asked to assume the role of Fiji's budget minister and to identify spending priorities by allocating budgetary shares to a broad range of categories, including education, healthcare, defence, trade, infrastructure development, and environmental protection. Respondents who allocated money to environmental protection were further asked to prioritise controlling specific invasive species relative to other environmental spending.

Second, a series of questions was asked to elicit willingness to contribute personally to controlling invasive species via volunteer labour. In most developed countries, willingness to pay is identified via questions on tax increases; however, few rural Fijian households pay taxes, while virtually all of them contribute labour to maintaining the village, suggesting this approach is culturally relevant. Opening values were assigned via dice rolls to eliminate concerns about starting point bias.

Third, respondents were asked to state the extent to which they agreed with statements pertaining to the value of controlling invasive species (e.g., "It is good that the taro beetle is found in this village.") via a 5-point Likert scale. To eliminate concerns of yea-saying, some statements read in the negative (e.g. " It is bad that the taro beetle is found in this village.").

A complementary survey was administered to a focus group in each of the thirty sampled villages. The village-level questionnaire consisted of open-ended questions regarding the presence and state of each species and, where applicable, the consequences of its presence (both positive and negative) and community practices for encouraging or limiting its spread.

Survey Findings

The beetle was found to be present in 83% of the villages surveyed. Respondents to the community survey identified two primary impacts associated with the taro beetle, including:

- 92% of villages observed that the taro beetle reduces agricultural output by burrowing into plant corms
- 42% of villages reported that the taro beetle caused plants to be more susceptible to disease

None of the villages surveyed stated that the beetle provided any socio-economic benefits.

In terms of control, 44% of the villages used pesticides and other chemicals on the affected taro, while 20% said they dug up and burned the affected crop. Approximately 36% of villages reported that farmers stopped growing crops in severely impacted areas, and 32% noted that the taro beetle had prompted them to switch from taro in favour of other crops such as cassava and vegetables.

On average, surveyed households spent essentially no time or money managing the beetle. As a result, 53% of the villages surveyed stated that the impact from the taro beetle has been increasing in recent years (Figure 2). Farmers in a few of villages recently started planting taro for the first time in many years because the presence of the beetle has finally been reduced or eradicated, suggesting the problem pest can be managed under certain conditions.

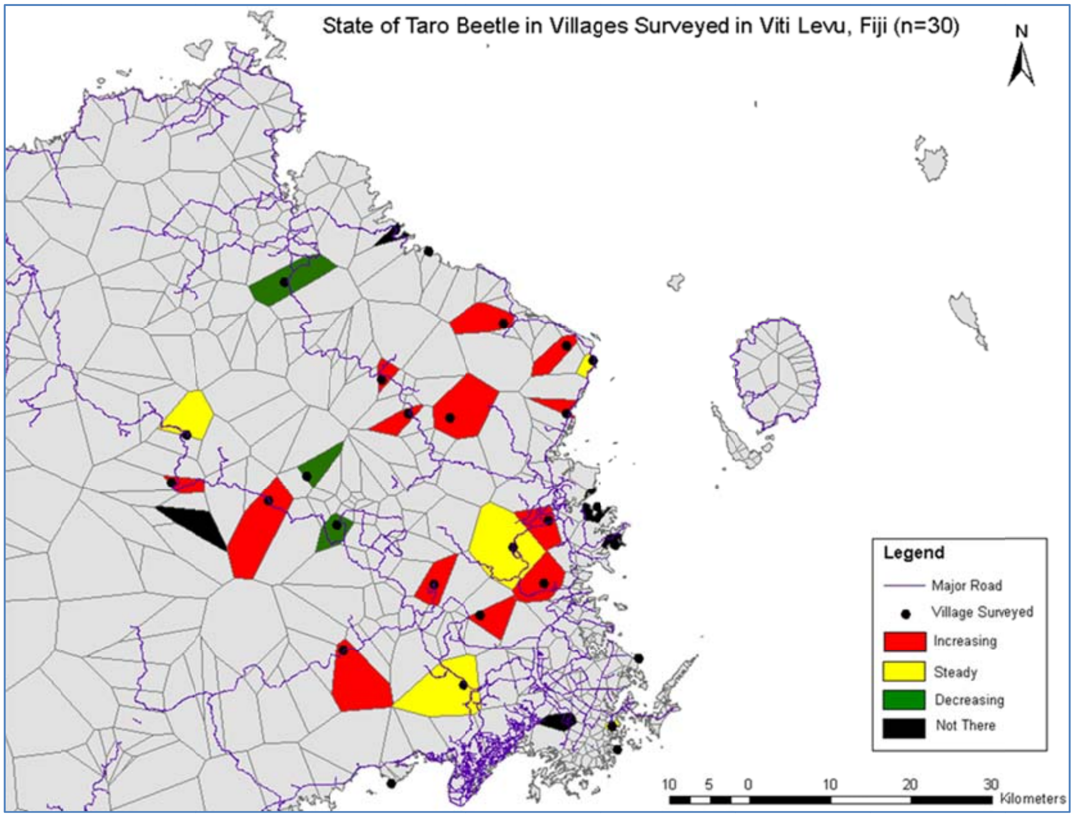

Figure 25 State of taro beetle in villages surveyed (n=30).

Respondents to a household survey (n=360) conducted on Viti Levu were asked a series of questions on their personal views of the species. Over 97% of respondents held negative views of the taro beetle, with 88% of survey respondents viewing the insect extremely negatively. No survey respondent held a favourable view of the invasive pest.

Over 60% of survey respondents in areas in which the taro beetle is present experienced losses to taro crops from pests in the year preceding the survey. The taro beetle was identified as the primary culprit in 89% of these households, reducing total output by an average of 8%

Asked to reallocate Fiji's national budget according to their own spending priorities, survey respondents would allocate approximately 7% of the national budget for invasive species management. They would further allocate 38% of that budget to control the taro beetle. Furthermore, the median household among those who viewed the beetle extremely negatively offered to volunteer 11 hours per adult household member per week if their efforts would eradicate the taro beetle from their villages, underscoring the perceived magnitude of the problem among Fiji's farmers.

Management Options

Different management options can have various degrees of impacts on the growth and spread of the taro beetle (Figure 7). The beetle has been in parts of Fiji for about 30 years, and thus we can assume it is already present to some extent in many villages at the start of the project. This was confirmed by the community surveys which found that beetle was found to be present in 83% of our study area. We then used the following assumptions to parameterise the effect of management on species growth from the various options:

Do Nothing (without scenario)

Households continue to spend essentially no time actively managing the taro beetle, thus allowing it to follow the biological growth path shown in Figure 7. This approach results in a growth of the beetle population from about 25% maximum in the initial period to nearing the estimated carrying capacity within about 10 years. This assumption was drawn by the fact that our survey found that, on average, taro yields were reduced by 8% from presence of the beetle when no management was undertaken and that yields are reduced by 30% when the carrying capacity is reached, (Lal et al. 2008).

Switch cropping

Farmers in affected villages are assumed to replant all their taro fields with cassava. This reduces the taro beetle population over time, but it also reduces the taro output to zero. While it is feasible that taro could be replanted after the beetle is eradicated, we simply assume that cassava is planted instead for the entire project period of 50 years. We assume that switching from taro to cassava results in eradication within 15 years, based on responses from some village surveys that indicated it took about this long before landowners who stopped planting taro were confident that the pest had gone away.

Cultural control

Landowners are assumed to keep planting taro in their fields but implement more effective crop management practices. This includes things such as more frequent crop rotation, using clean planting material, flooding, trap cropping, and destroying breeding sites. Most of the costs incurred are from additional labour required to monitor and manage the taro crop closely. Results are likely to differ across space and time. As a result, we assume that this control approach will allow the population of the taro beetle to be maintained at the same level as the initial period for the duration of the project.

Chemical control

Some chemicals have been proven to control beetles in Fiji. It has been suggested that the insecticide Confidor be applied at a rate of 5g per plant could raise the yield of marketable taro corms to as much as 97% of the expected production with no beetle-related impacts (Lal et al. 2008). As a result, we assume that annually spraying this chemical the taro fields at the recommended rate will eradicate the pest within 10 years, although actual results could vary across sites. Note that this approach could also have negative impacts on other crops, animals, and human health in the study site if not applied properly.

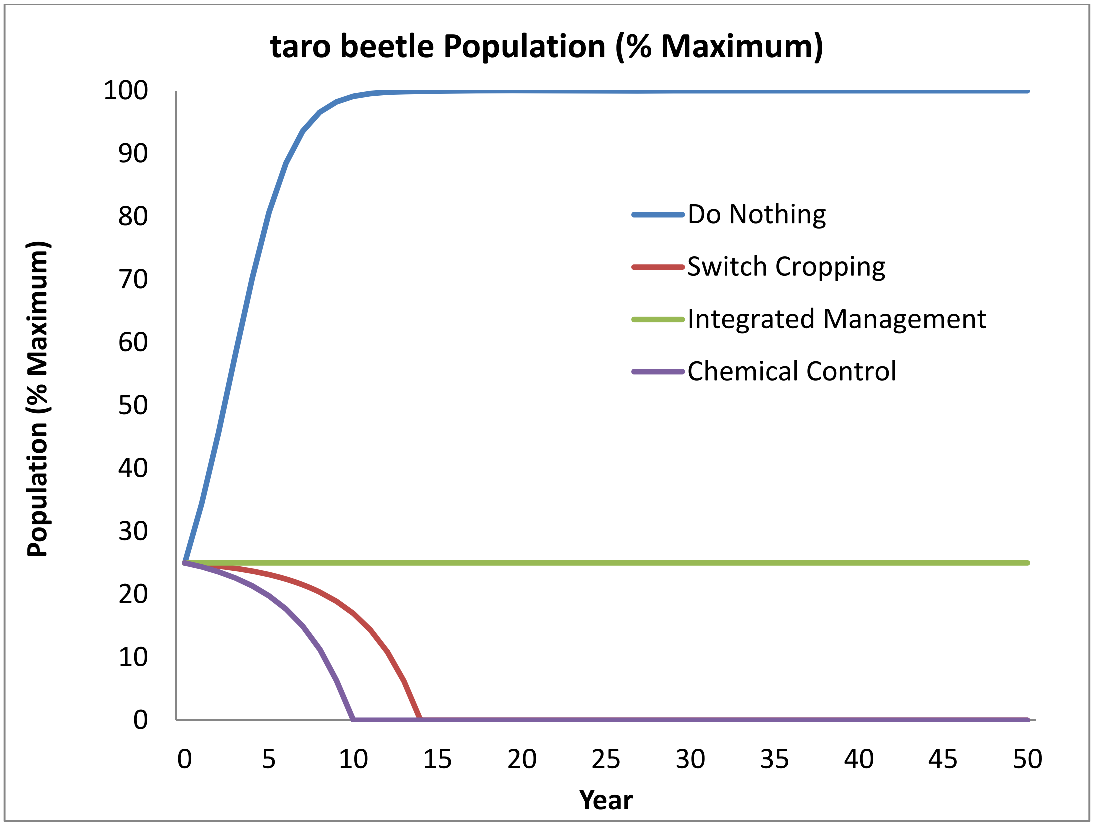

Figure 26 Taro beetle population (as % carrying capacity) over time and management option.

A fourth option, biological control, was also considered for this analysis. Trials of the ability for the fungus Metarhizium to reduce the impacts from taro beetles has under experimental conditions, but as yet there is no recommendation for farmers. A virus has been tried without success (ISSG Database).

We assume that control work has been undertaken in all cleared land in the village as that is the area that was most impacted by taro beetle infestation. Because estimates could be highly variable based on some of our assumptions, we conduct sensitivity analysis to assess the change in relative costs and benefits under alternative population and management effectiveness later in the study.

Quantifying Benefits and Costs of Invasive Management

Several benefits can accrue within the community as a result of managing the taro beetle, mostly in terms of avoided damages. Possible benefits include improved crop productivity, increases in cultural services that the taro provides, and a possible increase in biodiversity[7]. Unfortunately, some of these benefits are not easily quantified, either physically or monetarily. As a result, this analysis can only confidently quantify the benefits of avoided damages in crop yields based on survey data. However, we also try to quantify the cultural

[7] Taro beetles attack several ornamental and cultivated aroid species (Ediblearoids.org)

values that the taro provides to a typical Fijian community by attributing a nominal 10% of the market value of the crop to the cultural services that the use of the taro may provide to the community. Note, it is likely that the non-quantified benefits will also have positive economic value in actuality, and thus the figures listed here are likely to be an underestimate of the total benefits from managing the invasive.

These specified benefits then need to be expressed in terms of physical units of damage that would likely accrue under the status quo do nothing in the initial period (year 1). For this study, we used the household survey and anecdotal evidence to estimate that crop production diminishes by 8% due to the presence of the taro beetle. As the taro beetle is known to destroy up to 30% of the taro crop, damages are expected to increase over time in the absence of any intervention (see Figure 7). The damages in the initial period are listed on a per hectare basis in .

Table 28.

Table 28 Initial physical values (per ha) to quantify annual benefits of avoided damages from invasive management

Damages	Units	Optimal Yield	Damage Impact	Initial Period Damages
Taro (Dalo)	Kg	15 250	8%	1220
Cassava	Kg	15 000	0%	0

Quantifying the costs of invasives management is often more straightforward. Typical costs of controlling the taro beetle include labour, insecticides and initial capital costs (e.g., cassava plants). All costs are estimated to occur at the end of each period for the duration of the intervention, with the exception of capital costs, which only occur during the initial period. The physical units listed in Table 29 are based on literature, survey responses, and expert knowledge. The values are presented on a per hectare basis, and it is assumed that the management would be undertaken by the individual farmers.

We also note that estimates presented in this study are for a generalised and hypothetical control programme in Fiji. The level of manpower and chemicals required is likely to vary for specific areas and severity of the pest.

Table 29 Initial physical values (per ha) to quantify annual costs of invasive management

Cost	Units	Years Incurred	Do Nothing	Switch Cropping	Cultural Control	Chemical Control
Annual Costs						
Labour	man days	1–50	0	0	30	15
Pesticide	litres	1–50	0	0	1	3
Capital Costs						
Cassava plants	plants	0	0	20 000	0	0
Chemical Sprayer	number	0	0	1	1	0

Aggregating Costs and Benefits

The physical values of benefits and costs listed above can then be monetised by applying unit values over time. The monetary units listed in Table 30 are all listed in Fijian dollars (FJD) and are average values elicited from household and market surveys and expert input.

Table 30 Unit values for monetised benefit and costs

Category	Category	Unit Measurement	Unit Value ($/unit)
Benefits	Taro Output	$/kg	1.00
	Cassava Output	$/kg	0.90
	Taro Cultural Value	$/kg	0.10
Costs	Labour	$/man day	30.00
	Pesticide	$/litre	30.00
	Cassava plants	$/plant	0.10
	Chemical Sprayer	$/unit	100.00

The monetised values for damages that accrue in the initial period under the ‘do nothing’ case and each management option can be estimated by multiplying the unit monetary values in Table 30 by the initial physical damage estimates in .

Table 28. These damages can be estimated over time by tracking the change in the respective population curves displayed in Figure 7. The switch cropping option has no damages because taro is no longer planted. However, there will be additional costs of switching to cassava through changes in crop revenue, as discussed below. The estimated values of annual damages from the taro beetle are displayed in Figure 27.

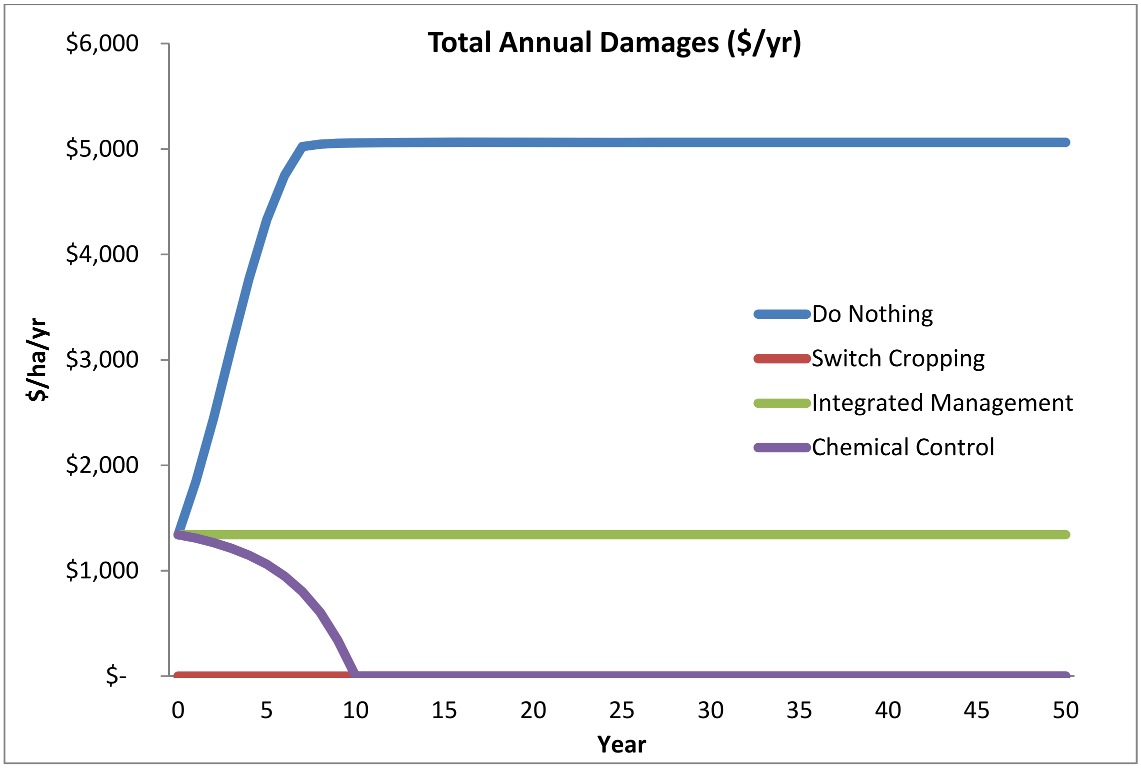

Figure 27 Total value of annual damages ($/ha) from for taro beetle under various management options.

The differences between the damage curves for do nothing and a specific management option represent the benefits that accrue from avoiding damages which would have occurred under the 'do nothing' option. These benefits are displayed in Figure 28. The benefits from switching cropping were adjusted to account for losses in revenue in the early periods from a lower valued crop, cassava. Switching to cassava eventually becomes economically beneficial relative to taro after year 4, when the monetary losses to taro from the beetle are greater than loss revenue from switching to cassava.

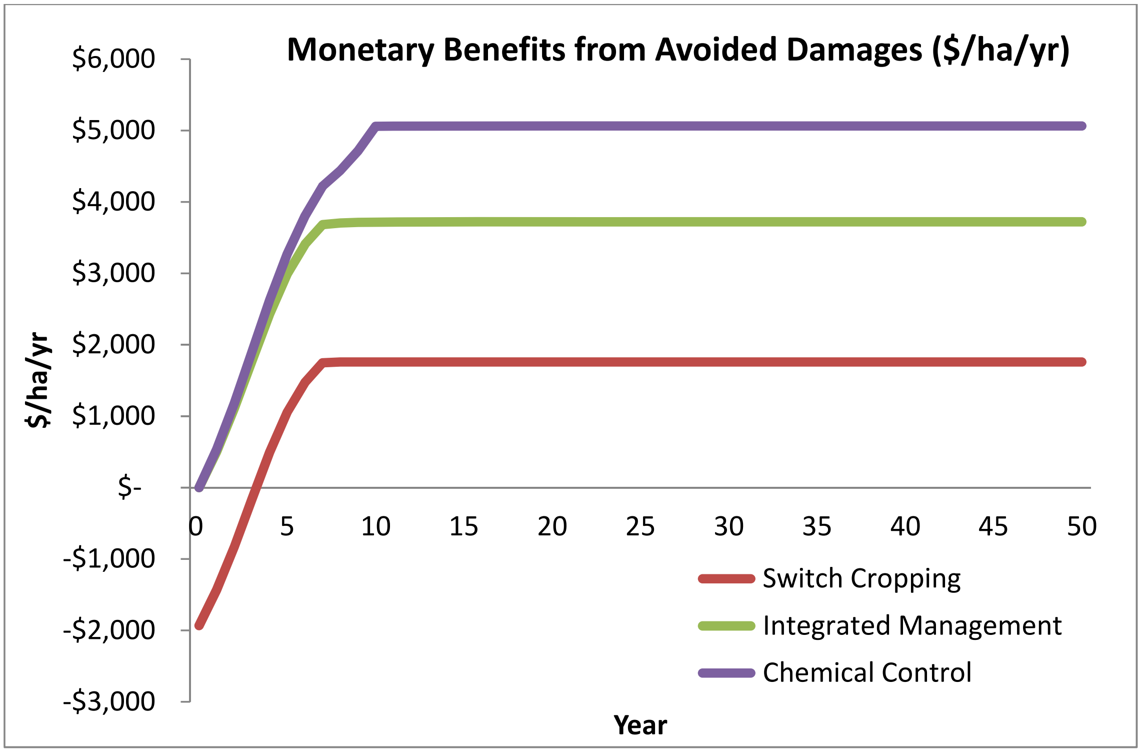

Figure 28 Monetised benefits of avoided damages from management of taro beetle.

The total monetised costs can be estimated by multiplying the unit costs incurred in each year (Table 30) by the physical values (Table 29). Total annual costs of each management option are listed in Table 31.

Table 31 Total annual costs of management options ($/ha)

Option	Year 0	Years 1-50
Do Nothing	$0	$0
Switch Cropping	–$2,000	$0
Cultural Control	$0	–$930
Chemical Control	–$100	–$540

We then calculate the net present value (NPV) to aggregate the stream of benefits and costs that accrue over time into a single metric so that the relative benefits of various interventions can be compared consistently against each other. This is expressed mathematically as:

$$NPV = \sum_{t=1}^{T} \frac{B_t - C_t}{(1+r)^t} \qquad (2)$$

where NPV is the net present value of the option, B_t and C_t are the respective benefits and costs that accrue at time s, T is final time period of project, and r is the real interest rate that is used to discount costs and benefits to the present value. For this study, we assume a project length of 50 years and a discount rate of 8%, which is in the middle of the range of discount rates used for long-term environmental management projects in the Pacific (Lal & Holland 2010).

Results of the benefit-cost analysis for the taro beetle management are listed in Table 32, and are measured relative to the do nothing case. Results indicate the chemical control yields the highest NPV and is therefore considered the most efficient management option from an economic perspective. Nevertheless, all three management options yield a positive NPV, indicating that they would be preferred over the do nothing option. This is true even when accounting for the potential loss in cultural values from not planting and exchanging taro, as in the case of the crop switching option.

Table 32 Summary of benefit-cost analysis (r = 8%, T = 50 years, study area = 1 ha)

Option	PV Costs	PV Benefits	Total NPV	Benefit-cost ratio	Rank
Do Nothing	$-	$-	$-	1.0	4
Switch Cropping	–$2,000	$11,293	$9,293	5.6	2
Cultural Control	–$11,377	$37,071	$25,693	3.3	3
Chemical Control	–$6,706	$47,100	$40,394	7.0	1

Sensitivity Analysis

Cost-benefit analyses of invasive species management typically depend on extensive data and strong assumptions, and this analysis is no different. Analyses often obtain data from an array of sources with varying levels of quality and certainty. Some of the costs and benefits may be difficult to value accurately, and key biophysical data can be difficult to obtain. The population of the invasive species in the initial period can also vary across space, and not all villages in the study area might currently have a population near carrying capacity. As a result, we undertake a sensitivity analysis to assess the robustness of our results. Specifically, we analyse how the NPV estimates and relative effectiveness for each option could change in light of varying the following assumptions:

1. Initial population (as % of max) – 0.5 and 2 times base assumption. This changes the initial population of the taro beetle from about 25% to 12.5% or 50% of maximum population.

2. Effectiveness of management – 0.5 and 2 times base assumption. This adjusts the pathway of the population growth curves for the three intervention options. An option assumed to be twice as effective means the species maximum effectiveness of the intervention is cut in half (e.g. eradication by chemical control is achieved in 5 instead of 10 years)

3. Discount rate – Rates of 4 and 12% are at the tails of the range of discount rates used for environmental management projects in the region

A summary of the NPV estimates for sensitivity analyses #1 and #2 is presented in Table 28. Estimates show chemical control yields the highest NPV figures, regardless of the assumptions about the initial population or relative effectiveness. It also revealed that both cultural control and switching taro crops to cassava would also produce net benefits relative to the do nothing approach. This suggests it could be more efficient from an economic perspective to control the invasive pest under any of these conditions.

Table 33 NPV of sensitivity analyses for taro beetle management options (r = 8%, T = 50 years, study area = 1 ha)

Option	Effectiveness	Initial Population (relative to max)		
		12.5%	25%	50%
Switch Cropping	0.5 x base	$4,982	$11,293	$17,908
	1.0 x base	$4,982	$9,293	$17,908
	2.0 x base	$4,982	$11,293	$17,908
Cultural Control	0.5 x base	$34,791	$30,621	$13,067
	1.0 x base	$43,365	$25,693	$24,679
	2.0 x base	$47,842	$45,279	$40,350
Chemical Control	0.5 x base	$46,878	$42,457	$36,690
	1.0 x base	$50,428	$40,394	$45,234
	2.0 x base	$51,630	$52,120	$53,887

The sensitivity analysis was also done where a discount rate of 4% and 12% was applied to the initial assumptions. Estimates revealed that chemical control still yielded the highest NPV regardless of the discount rate (Table 34). All options still yielded a positive NPV for the 12% discount rate scenario indicating that they would be still preferred over the ‘do nothing’ option, even if the only benefits accounted for were improvements in crop and livestock yields.

Table 34 NPV of discount rate sensitivity analyses for taro beetle (T= 50 years, study area = 1 ha)

Option	4%	8%	12%
Do Nothing	$0	$-	$0
Switch cropping	$26,781	$9,293	$5,047
Cultural control	$70,687	$25,693	$23,134
Chemical control	$92,116	$40,394	$28,696

Results from a sensitivity analysis that varies the initial population, management effectiveness, and discount rate are listed in Appendix 15.1. The findings are generally consistent with those discussed above, and chemical control management approach is still the preferred approach. All other options still yield a positive net present value and should be considered economically preferable over the do nothing scenario, with the exception the case where the initial population is only 12.5% of carrying capacity.

Scaling Up Results

The typical village in Eastern Viti Levu comprises 45 households that each maintain about 0.6 ha of productive land. The values for avoided damages presented above can be scaled up to the village level by using a factor of 45*0.6 = 27 ha/village. This would increase the NPV estimates in Table 32 for managing the pest for all productive land in the village to a total of $1,090,100/village and $693,700/village for the chemical and cultural control management approach, respectively. Scaling up results will not change the overall ranking of each option unless one assumes non-constant economies of scale.

Summary and Conclusions

The purpose of this study was to conduct a benefit-cost analysis to estimate the most economically effective option to manage the taro beetle (Papuana uninodis) at the village-level in Eastern Viti Levu, Fiji. The beetle was introduced to Fiji in 1981, and has become a problem in some of the islands of Fiji such as Viti Levu as it can reduce taro yields by up to 30%. Other root crops such as sweet potatoes, yams, and bananas can experience similar rates of damage from the invasive pest.

Community- and household-level surveys were conducted in a total of 30 villages in the study area to collect a majority of the economic data presented in this analysis. The survey found approximately 36% of villages reported that farmers stopped growing crops in severely impacted areas, and 32% noted that the taro beetle had prompted them to switch from taro to other crops such as cassava and vegetables. On average, surveyed households spent almost no time or money managing the taro beetle. As a result, more than 53% of villages surveyed indicated that the population of the beetle was increasing. On a positive note, some farmers have started planting taro after for the first time in years because the beetle has been reduced or eradicated from their village.

The median household among those who view the taro beetle extremely negatively offered to volunteer 11 additional hours per household per week if their efforts would eradicate the taro beetle from their village. Given that the average household surveyed spends about 6 hours per week on all volunteer work, this underscores the perceived magnitude of the problem among Fiji's landowners. It also emphasizes their high willingness to work to alleviate the problem, provided there are methods proven to achieve this.

The benefit-cost analysis estimated four options to manage the taro beetle: (i) do nothing (ii) switch crop to cassava, (iii) implement a more intensive integrated approach (i.e. cultural control), and (iv) significantly increase the use of pesticide on taro crops. The option to use a relatively high amount of insecticides to control the taro beetle was estimated to yield the highest net present value for all the management options and a benefit-cost ratio of about 6 to 1. Cultural control through the use of more intensive crop management was found to be the yield the next highest net present value, but it was more costly to implement (benefit-cost ratio of about 3.5:1). Switching all taro crops to cassava was the least preferred option from an economic perspective, although the approach still yielded positive net benefits for landowners and should thus be considered a viable option compared with the do nothing scenario.

Sensitivity analyses that varied the initial population, effectiveness of an intervention in reducing taro beetle population, and the rate to discount future costs and benefits resulted in a positive net present value for all scenarios, reaffirming our initial findings that any management option is likely to be beneficial relative to the status quo of leaving the beetle to grow and spread. This is particularly the case as the study excluded any possible benefits for biodiversity protection, primarily because there was a lack of data. Thus, the estimates presented here can be considered a lower bound.

These results should be interpreted with a degree of caution as the analysis used several assumptions to estimate the physical and monetary costs and benefits of taro beetle control. For the chemical interventions, the most effective levels of insecticide application will vary depending on environmental factors specific to the study site. It could also have a negative impact on native insects that play an important role in the local ecosystem.

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Appendix 15.1

Table 35 Sensitivity analysis for taro beetle management with varying discount rates (T = 50 years, study area = 1 ha)

Discount Rate = 4%				
Option	**Effectiveness**	**Initial Population (relative to max)**		
		12.5%	25%	50%
Switch Cropping	0.5 x base	$19,601	$26,781	$33,961
	1.0 x base	$19,601	$24,781	$33,961
	2.0 x base	$19,601	$26,781	$33,961
Cultural Control	0.5 x base	$70,734	$54,518	$22,485
	1.0 x base	$86,063	$50,709	$45,352
	2.0 x base	$93,925	$85,102	$72,870
Chemical Control	0.5 x base	$94,958	$85,170	$75,325
	1.0 x base	$99,722	$80,416	$87,967
	2.0 x base	$101,063	$98,078	$98,150
Discount Rate = 8%				
Option	**Effectiveness**	**Initial Population (relative to max)**		
		12.5%	25%	50%
Switch Cropping	0.5 x base	$4,982	$11,293	$17,908
	1.0 x base	$4,982	$9,293	$17,908
	2.0 x base	$4,982	$11,293	$17,908
Cultural Control	0.5 x base	$34,791	$30,621	$13,067
	1.0 x base	$43,365	$25,693	$24,679
	2.0 x base	$47,842	$45,279	$40,350
Chemical Control	0.5 x base	$46,878	$42,457	$36,690
	1.0 x base	$50,428	$40,394	$45,234
	2.0 x base	$51,630	$52,120	$53,887
Discount Rate = 12%				
Option	**Effectiveness**	**Initial Population (relative to max)**		
		12.5%	25%	50%
Switch Cropping	0.5 x base	–$561	$5,047	$11,182
	1.0 x base	–$561	$3,047	$11,182
	2.0 x base	–$561	$5,047	$11,182
Cultural Control	0.5 x base	$20,271	$20,081	$8,942
	1.0 x base	$25,982	$15,411	$15,989
	2.0 x base	$29,022	$28,707	$26,628
Chemical Control	0.5 x base	$27,609	$25,490	$21,801
	1.0 x base	$30,319	$24,112	$27,787
	2.0 x base	$31,403	$32,976	$35,229

Appendix 16: CBA Analysis – Red-Vented Bulbul

Overview

The purpose of this study is to conduct a benefit-cost analysis that estimates the most effective option to manage the red-vented bulbul (*Pycnonotus cafer*) at the village-level in Eastern Viti Levu, Fiji. Community and household-level surveys were conducted in a total of 30 villages in Viti Levu to collect the majority of the economic data presented in this analysis.

The red-vented bulbul is a bird about 20 cm in length and is native to parts of Asia. It is known to cause significant damage to native fruits, berries, insects, flower nectar, seeds, and buds in many regions of the world. The bulbul has also been known to displace other bird species with its aggressive, competitive nature. As with other fruit- birds, bulbuls play a role in seed-dispersal, potentially facilitating the spread of seeds of other invasive species. This species has been included by the IUCN as one of the world's 'One Hundred Worst Alien Invaders'.

The Red-vented bulbul is reported to have been introduced to Fiji in 1903 by labourers arriving from India (Parham 1955). It is believed to be common only on Fiji's largest island of Viti Levu, where it is abundant in agricultural and suburban habitats, and its small adjacent islands. It is often observed in clearings and patches of secondary growth in the forests and can sometimes be found in mature forest (Watling 1978). It primarily feeds on the fruit of two primary colonist weeds in Fiji, prickly solanum (Solanum torvum) and Piper aduncum. It is also known to consume agricultural crops and fruits such as lantana, guava, Cape gooseberry, and passion fruit.

Biological Growth

In Fiji, the red-vented bulbul has a distinct breeding season that occurs during the rains. The bulbul has a mean clutch size of 2.5. There is a high rate of egg and nestling loss; 72% of eggs laid do not hatch and 53% of nestlings do not survive. Bulbuls have an extended period of parental care of fledglings and are unlikely to raise more than one brood in a season. Fledgling survival appears to be good, and the annual recruitment rate is probably about 30% (Watling 1983).

The bulbul was introduced to Fiji more than a century ago, and as a result is well established in parts of the island nation. This was confirmed by the community survey that found the species to be present in 97% of the study area of Eastern Viti Levu. As a result, we assume the bird is already at or near carrying capacity.

Study Site and Survey Methodology

To investigate the socio-economic impacts of invasive species in Fiji, we surveyed 360 households in 30 villages in eastern Viti Levu. These villages were stratified by geography and randomly drawn; one village that is inaccessible by road due to construction was replaced with another remote village. Within each of the 30 villages, households were drawn at random. Each survey was administered directly to the head of household, and topics covered demographics; farming, fishing, wage work, and other income-generating activities; wealth and durables; education; health; and extension activities. The survey also included several novel elements relating to the social and economic impacts of invasive species.

First, respondents were asked to assume the role of Fiji's budget minister and to identify spending priorities by allocating budgetary shares to a broad range of categories, including education, healthcare, defence, trade, infrastructure development, and environmental protection. Respondents who allocated money to environmental protection were further asked to prioritise controlling specific invasive species relative to other environmental spending.

Second, a series of questions was asked to elicit willingness to contribute personally to controlling invasive species via volunteer labour. In most developed countries, willingness to pay is identified via questions pertaining to tax increases; however, few rural Fijian households pay taxes while virtually all of them contribute labour to maintaining the village, suggesting that this approach is culturally relevant. Opening values were assigned via dice rolls to eliminate concerns about starting point bias.

Third, respondents were asked to state the extent to which they agreed with statements on the value of controlling invasive species (e.g. "It is bad that the red-vented bulbul is found in this village.") via a 5-point Likert scale. To eliminate concerns of yea-saying, some statements read in the negative (e.g. " It is good that the red-vented bulbul is found in this village.").

A complementary survey was administered to a focus group in each of the 30 sampled villages. The village-level questionnaire consisted of open-ended questions regarding the presence and state of each species and, where applicable, the consequences of its presence (both positive and negative) and community practices for encouraging or limiting its spread.

Survey Findings

The Red-vented bulbul was present in 29 of 30 villages surveyed in Viti Levu (97%). Respondents to the community survey identified one primary cost associated with the bulbul. In the areas where the bird was present, 83% of villages noted that the bulbul reduces agricultural output, particularly fruits. One village also noted that the bulbul has the potential to damage infrastructure. The remaining villages stated that there were no socio-economic or biophysical impacts.

About 47% of the village focus groups reported that the bulbul was good for their community. Key benefits identified include:

- 18% of villages responded that the bulbul is effective at insect control
- 12% of villages noted that the bulbul gives warning when a mongoose is about to attack chickens
- 12% stated the bulbul is sometimes eaten in the village.

In terms of control, only 6% of the villages attempted to control the bulbul via hunting, while 94% of the villages did nothing. As a result, 80% of villages surveyed indicated that the population of the bulbul was still increasing or steady (Figure 29).

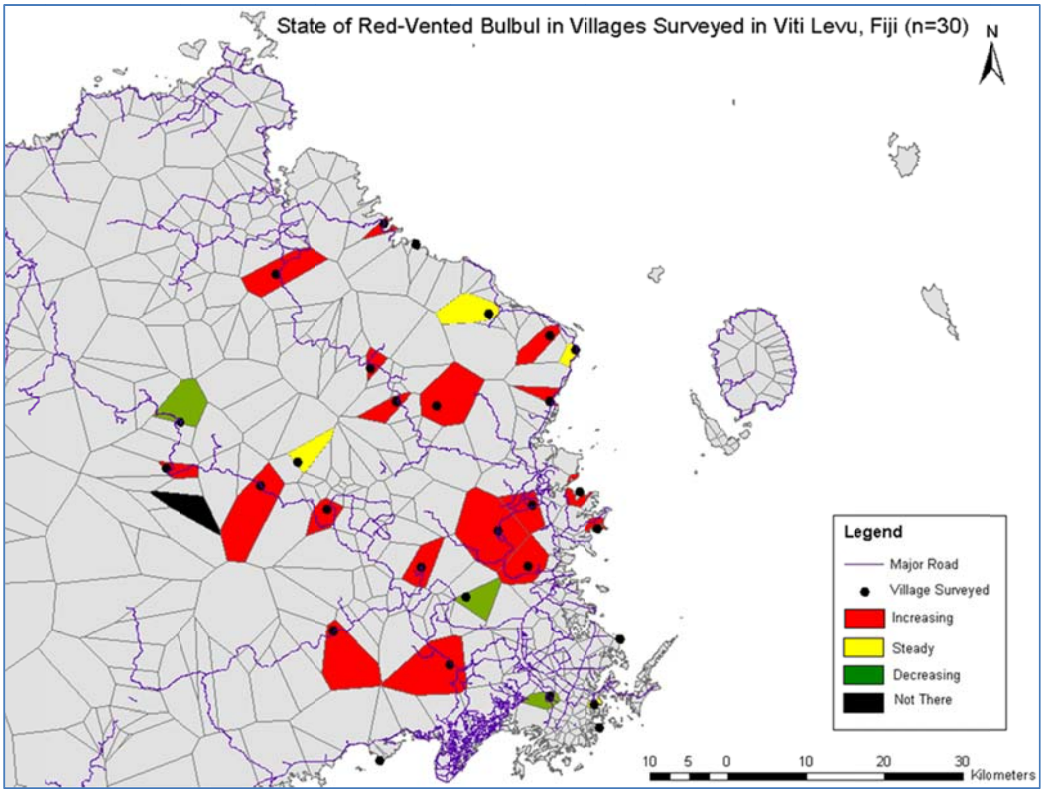

Figure 29 State of Red-vented Bulbul in villages surveyed (n=30)

Respondents to a household survey (n=360) conducted on Viti Levu were asked a series of questions pertaining to their personal views of the species. Some 55% of survey respondents viewed the red-vented bulbul unfavourably, with 31% of survey respondents viewing the invasive bird extremely negatively. Only 12% of survey respondents held favourable views of the bulbul.

Some respondents stated that the Red-vented Bulbul had some negative impact on their livelihood, but none of the surveyed households reported taking any concerted effort to control them. Key crops impacted were pawpaw, plantain, and banana. Tomato, vudi, chili, and guava were also reported to be affected in the study area. Household surveys estimated that:

- Bulbuls affect 39% of surveyed households' pawpaw crops, reducing total output by 13%.
- Bulbuls affect 16% of surveyed households' banana crops, reducing total output by 2%.
- Bulbuls affect 14% of surveyed households' plantains crops, reducing total output by 12%.

On average, a household affected by bulbul experienced about a $150 loss in the value of agricultural output per year.

Asked to reallocate Fiji's national budget according to their own spending priorities, survey respondents allocated approximately 7% of the national budget for invasive species management. They would further allocate about 7% of that budget to control the Red-Vented Bulbul, prioritising control of other species over the bulbul.

Management Options

Different management options could have varying degrees of effect on the impacts of agricultural crops. Because the Red-vented Bulbul has been present for more than a century in Fiji, we can assume that about 100% of the potential carrying capacity is already present in most villages at the start of the project. While the bird also causes other impacts, such as seed dispersal of weeds and displacement of indigenous species (Watling 1979), there is limited information on effective management options to mitigate these concerns. As a result, this analysis only considers a do nothing and two possible management options to reduce impacts to agricultural crops. The study does not examine any options that would reduce the population of the bulbul, such as placing traps in affected areas, because there is limited knowledge of whether this would be a feasible option in the Pacific[8]. The crop damage functions for the initial analysis are parameterised based on the following management options and assumptions:

Do Nothing (without scenario)

This option assumes that communities maintain the status quo of putting no noticeable effort into controlling the invasive or protecting crops. This approach results in the bird continuing to have a steady annual impact on agriculture.

Crop Management

Households invest more time and effort into managing their crops against the bulbul than the do nothing scenario. This includes manual weed control and application of herbicides and staking crops, if possible. Some fruits and vegetables are also harvested earlier in the season and ripened under cover to avoid being consumed when they are ripening. It is assumed the impacts from the bulbul would be reduced by half.

Crop Protection

This option assumes that placing nets over vulnerable crops could reduce the damage created by the bulbul. In this case, we assume farmers place netting over all possible crops, and crops that cannot be covered with nets are harvested and stored under cover before they ripen, if possible. It is assumed the impacts from the bulbul would be also reduced by about one-half.

We assume that control work is undertaken in all agricultural land in the village as that is the area most sensitive to red-vented bulbul infestation. Because estimates could be highly variable based on some of our assumptions, sensitivity analysis to assess the change in

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[8] At the time of this analysis, a pilot study using traps to control the bulbul was being tested in New Caledonia

relative costs and benefits under alternative population and management effectiveness would be conducted later in the study.

Quantifying Benefits and Costs of Invasive Management

Several benefits can accrue within the community as a result of managing the red-vented, mostly in terms of avoided damages. Possible benefits include improved crop productivity, an increase in the population of native species, and a reduction in the dispersal of seeds from invasive weeds. Unfortunately, many of these benefits are not easily quantified, either physically or monetarily. As a result, this analysis only quantifies the benefits of avoided damages in crop yields. Note that it is likely the non-quantified benefits will also have positive economic value in actuality, and thus the figures listed here are likely to be an underestimate of the total benefits from managing the invasive.

These specified benefits then need to be expressed in terms of physical units of damage that would likely accrue under the status quo 'do nothing' in the initial period (year 1). For this study, we used the household survey and anecdotal evidence to estimate the reduction in crop production due to the presence of the bulbul. As the bulbul is already near carrying capacity, damages are expected to hold steady across time if there in the absence of any change in the status quo. The damages per hectare of crop in the initial period are listed in Table 36.

Table 36 Initial physical values (per ha) to quantify annual benefits of avoided damages from invasive management

Damages	Units	Optimal Yield	Damage Impact	Initial Period Damages
Banana	kg	1536	2%	$31
Pawpaw	kg	440	13%	$57
Plantain	kg	247	12%	$30
Other Crops	kg	10000	0.5%	$50

Quantifying the costs of invasives management is often straightforward. Typical costs of protecting crops from the bulbul include labour, herbicides and the initial capital costs for netting. All costs are estimated to occur at the end of each period for the duration of the intervention, with the exception of capital costs, which only occur during the initial period. Other aspects of management that the village might incur (e.g. space to store early harvest) are assumed to have no cost. The physical units listed in Table 37 are based on literature, survey responses, and expert knowledge. Note that estimates presented in this study are for a generalised and hypothetical control programme in Fiji and the level of manpower and materials required is likely to vary across crop mix and study area.

Table 37 Initial physical values (per ha) to quantify annual costs of invasive management

Cost	Units	Years Incurred	Do Nothing	Crop Management	Crop Protection
Annual Costs					
Labour	Man days	1–50	0	30	15
Herbicide	litres	1–50	0	2	1
Netting repair and replacement	m^2	1–50	0	0	500
Capital Costs					
Netting	m^2	0	0	0	2750

Aggregating Costs and Benefits

The physical values of benefits and costs listed above can then be monetised by applying unit values over time. The monetary units listed in Table 38 are all listed in Fijian dollars (FJD) and are average values elicited from household and market surveys and expert input.

Table 38 Unit values for monetised benefit and costs

Category	Category	Unit Measurement	Unit Value ($/unit)
Benefits	Banana value	$/kg	2.50
	Pawpaw value	$/kg	5.00
	Plantain value	$/kg	2.00
	Other crop value	$/kg	1.00
Costs	Labour	$/man day	30.00
	Herbicide	$/litre	20.00
	Netting	$/m^2	0.70

The monetised values for damages that accrue in the initial period under the 'do nothing' case and each management option can be estimated by multiplying the unit monetary values in Table 38 by the initial physical damage estimates in Table 36. These damages can be estimated over time by tracking the change in the respective damage from the bulbul, as discussed in the management section. The estimated values of annual damages from the bulbul are displayed in Figure 30.

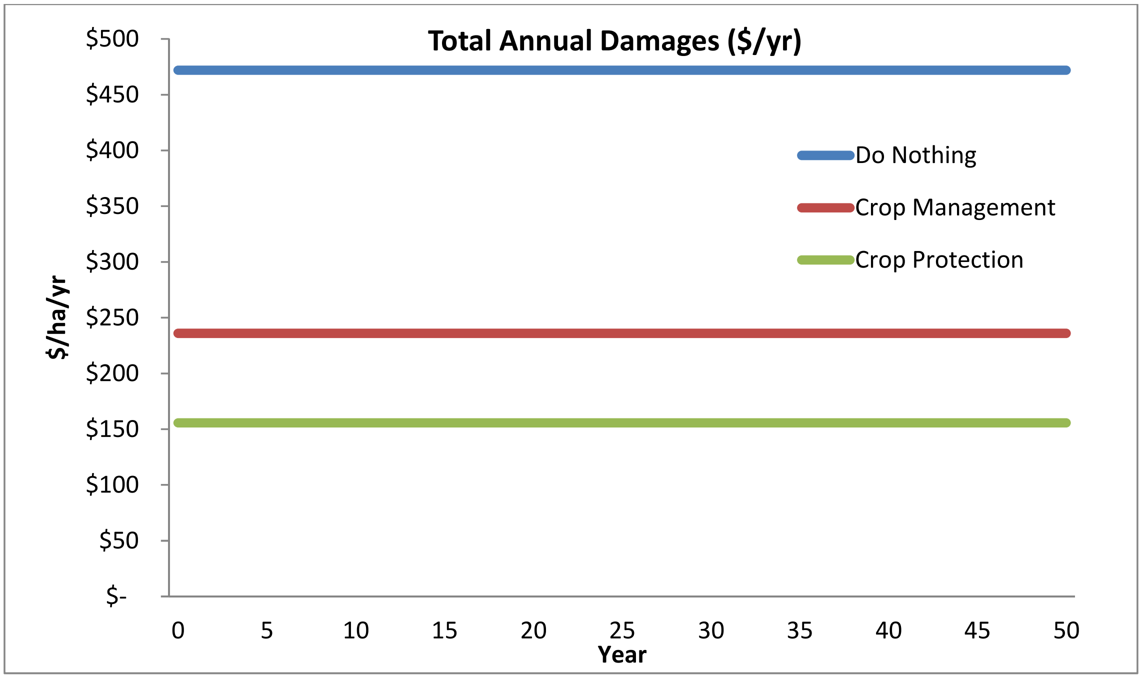

Figure 30 Total value of annual damages ($/ha) from for red-vented bulbul under various management options.

The differences between the damage curves for 'do nothing' and a specific management option represents the benefits that accrue from avoiding damages would have occurred under the 'do nothing' option. These benefits are displayed in Figure 31.

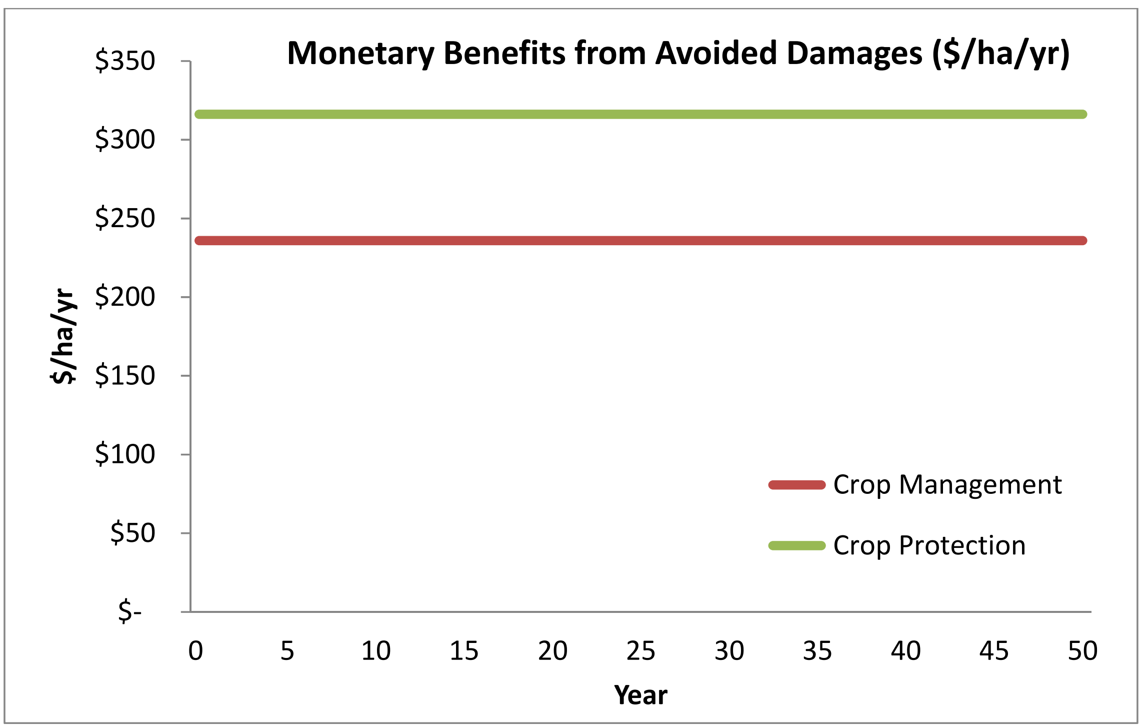

Figure 31 Monetised benefits of avoided damages from management of Red-Vented Bulbul.

The total monetised costs can be estimated by multiplying the unit costs incurred in each year (Table 38) by the physical values (Table 37). Total annual costs of each management option are listed in Table 39.

Table 39 Total annual costs of management options ($/ha)

Option	Year 0	Years 1–50
Do Nothing	$0	$0
Crop Management	$0	$1,600
Crop Protection	$1,949	$860

We then calculate the net present value (NPV) to aggregate the stream of benefits and costs that accrue over time into a single metric so that the relative benefits of various interventions can be compared consistently against each other. This is expressed mathematically as:

$$NPV = \sum_{t=1}^{T} \frac{B_t - C_t}{(1+r)^t} \quad (2)$$

where NPV is the net present value of the option, B_t and C_t are the respective benefits and costs that accrue at time s, T is final time period of project, and r is the real interest rate that is used to discount costs and benefits to the present value. For this study, we assume a project length of 50 years and a discount rate of 8%, which is in the middle of the range of discount rates used for long-term environmental management projects in the Pacific (Lal & Holland 2010).

Results of the benefit-cost analysis for the red-vented bulbul management are listed in Table 40. Estimates for both options to reduce agricultural damages relative to the 'do nothing' option are negative. This indicates that that present value costs of implementing either management option outweigh the present value benefits accrued over the same period compared with the status quo. This is not necessarily a surprising result, given that nearly all respondents to both the community and household surveys indicated they spent little to no effort trying to mitigate the impacts of the bird on their agricultural yields.

Table 40 Summary of benefit-cost analysis (r = 8%, T= 50 years, study area = 1 ha)

Option	PV Costs	PV Benefits	Total NPV	Benefit-cost Ratio	Rank
Do Nothing	$-	$-	$-	1.0	1
Crop Management	–$19,574	$3,122	–$16,451	0.2	3
Crop Protection	–$12,466	$4,184	–$8,282	0.3	2

Sensitivity Analysis

Cost-benefit analyses of invasive species management typically depend on extensive data and strong assumptions, and this analysis is no different. Analyses often obtain data from an array of sources with varying levels of quality and certainty. Some of the costs and benefits may be difficult to value accurately, and key biophysical data can be difficult to obtain. The population of the invasive species in the initial period can also vary across space, and not all villages in the study area might currently have a population near carrying capacity. As a result, we undertake a sensitivity analysis to assess the robustness of our results. Specifically, we analyse how the NPV estimates and relative effectiveness for each option could change in light of varying the following assumptions:

1. Initial damage (as % of max) – 0.5 and 2 times base assumption. This changes the value of initial impact of the red-vented bulbul on agricultural crops from about \$472/ha to \$236/ha and \$944/ha

2. Effectiveness of management – half of baseline effectiveness, and 100% effective. This adjusts the value of avoided damages from the two intervention options. An option that is assumed to be half as effective means the value of avoided damages is cut in half. An option that is 100% effective assumes landowners are able to obtain the optimal yield for their crops.

3. Discount rate – rates of 4% and 12%. They are at the tail of the range of discount rates used for environmental management projects in the region

A summary of the NPV estimates for sensitivity analyses #1 and #2 are presented in Table 41. Estimates show that NPV figures are still negative, regardless of the assumptions about the initial and constant value of damages or relative effectiveness. The one exception was the case where damages to crops are almost \$1000/ha/yr and farmers have 100% effectiveness when protecting their crops with nets. This suggests it could be more efficient from an economic perspective to let the invasive bird continue to live as is in the study area unless damages are significantly higher than those damages estimated from the survey in our study area.

Table 41 NPV of sensitivity analyses for red-vented bulbul management options (r = 8%, T= 50 years, study area = 1 ha)

Option	Effectiveness	Value of Initial Damage (relative to baseline)		
		50%	100%	200%
Crop Management	25%	–\$18,793	–\$18,012	–\$16,451
	50%	–\$18,012	–\$16,451	–\$13,329
	100%	–\$16,452	–\$13,330	–\$7,086
Crop Protection	33%	–\$11,404	–\$10,343	–\$8,219
	67%	–\$10,374	–\$8,282	–\$4,098
	100%	–\$9,343	–\$6,221	\$23

The sensitivity analysis was also undertaken where a discount rate of 4% and 12% was applied to the initial assumptions. Estimates revealed that both management options still have a negative NPV regardless of the discount rate (Table 42). NPV estimates were even more negative for the 4% discount rate scenario because the annual costs of labour and materials were always higher than the annual benefits to agricultural yields that the management option created. This reinforces the notion that unless the damages from agricultural crops are at least

$1,000, it is not worth undertaking new and more costly options to manage against the agricultural impacts of the bulbul.

Table 42 NPV of discount rate sensitivity analyses for red-vented bulbul (T= 50 years, study area = 1 ha)

Option	4%	8%	12%
Do Nothing	$0	$0	$0
Crop Management	–$29,067	–$16,451	–$11,092
Crop Protection	–$13,309	–$8,282	–$6,146

Results from a sensitivity analysis that varies the initial population, management effectiveness, and discount rate are listed in Appendix 16.1. The findings are generally consistent with those discussed above. The only scenarios that yield a postive net present value is for crop protection with an initial damage of 200% relative to the baseline and 100% effectiveness for a discount rate of 4% or 8%. Thus, in most situations, the do nothing case is still the most economical option to pursue.

Scaling Up Results

A typical village in Eastern Viti Levu comprises 45 households, each of which maintain about 0.6 ha of productive land. The values for avoided damages presented above can be scaled up to the village level by using a factor of 45*0.6 = 27 ha/village. Alternative scaling can be undertaken if monetised values also accounted for non-productive (e.g. native) land, although bulbuls are typically observed only on agricultural land or in clearings and patches of secondary growth in the forests (Watling 1978). Scaling up results will not change the overall ranking of each option because we assume constant economies of scale.

Summary and Conclusions

The purpose of this study is to conduct a benefit-cost analysis that estimates the most effective option to manage the Red-vented bulbul (Pycnonotus cafer) at the village-level in Eastern Viti Levu, Fiji. Community- and household-level surveys were conducted in a total of 30 villages in Viti Levu to collect the majority of economic data presented in this analysis.

The analysis found that managing or protecting crops to alleviate the impacts of the red-vented bulbul were not estimated to produce net economic benefits relative to the status quo. This is not necessarily a surprising result, given that nearly all respondents to both the community and household survey indicated they spent little to no effort trying to mitigate the impacts of the bird on their agricultural yields. The one exception was the case where damages to crops are almost $1000/ha/yr and farmers have 100% effectiveness when protecting their crops with nets. Even this set of assumptions only yielded a net present value of just $23. This suggests it could be more efficient from an economic perspective to let the invasive bird continue to live as is in the study area unless damages are significantly higher than those damages estimated from the survey in our study area.

The results presented in this paper should be interpreted with a degree of caution as the analysis used several assumptions to estimate the physical and monetary costs and benefits of bulbul control. Because of the lack of data on management costs or effectiveness the study did not investigate any options that would likely reduce the bulbul population, such as hunting or trapping the invasive bird, which could be beneficial to other plants and animals in the area. Future work is also needed to estimate both the biological growth and spread of the red-vented bulbul and the effectiveness and value of controlling the bird for other purposes besides increasing agricultural output.

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Appendix 16.1

Table 43 Sensitivity analysis for red-vented bulbul management with varying discount rates (T = 50 years, study area = 1 ha)

Discount Rate =4%				
Option	**Effectiveness**	**Value of Initial Damage (relative to baseline)**		
		50%	100%	200%
Crop Management	25%	–$33,045	–$31,719	–$29,067
	50%	–$31,719	–$29,067	–$23,763
	100%	–$29,068	–$23,764	–$13,156
Crop Protection	33%	–$18,613	–$16,810	–$13,203
	67%	–$16,863	–$13,309	–$6,201
	100%	–$15,112	–$9,808	$801
Discount Reate =8%				
Option	**Effectiveness**	**Value of Initial Damage (relative to baseline)**		
		50%	100%	200%
Crop Management	25%	–$18,793	–$18,012	–$16,451
	50%	–$18,012	–$16,451	–$13,329
	100%	–$16,452	–$13,330	–$7,086
Crop Protection	33%	–$11,404	–$10,343	–$8,219
	67%	–$10,374	–$8,282	–$4,098
	100%	–$9,343	–$6,221	$23
Discount Reate =12%				
Option	**Effectiveness**	**Value of Initial Damage (relative to baseline)**		
		50%	100%	200%
Crop Management	25%	–$12,738	–$12,190	–$11,092
	50%	–$12,190	–$11,092	–$8,897
	100%	–$11,092	$8,897	–$4,507
Crop Protection	33%	–$8,342	–$7,595	–$6,102
	67%	–$7,617	–$6,146	–$3,205
	100%	–$6,893	–$4,697	–$307

Appendix 17: CBA Analysis – Merremia Vine

Overview

The purpose of this study is to conduct a cost–benefit analysis that estimates the most effective option to manage the invasive species merremia vine (*Merremia peltata*) at the village-level in Eastern Viti Levu, Fiji. Community- and household-level surveys were conducted in a total of 30 villages in Viti Levu to collect the majority of the economic data presented in this analysis.

Merremia is a coarse climbing vine with underground tubers that grows in full sunlight. It generally crawls up and over trees, shrubs, and crops, strangling existing vegetation. It has been observed climbing over and smothering trees up to 20 m tall and is considered an invasive species of high-concern because of its impact on native vegetation through increased mortality and removal from the soil seed bank (Kirkham 2005). The vine is also known for providing several benefits to the community. These include reducing erosion and nutrient loss and the use for medicinal purposes, bundling twine, and animal feed.

In Fiji, merremia is present in forest or on its edges, in thickets, on open hillsides and along roadsides (Smith 1991). Merremia can also be found in gardens, crop plantations, pasture and forest plantations throughout Eastern Viti Levu. The native range of merremia is uncertain but may include many Pacific locations, including Fiji. Disturbances such as cyclones and land clearing may encourage the introduction and spread of the species. Merremia can occasionally produce seed but research has indicated a low seed viability rate. Distribution is most often increased vegetatively through creeping stems rooting at the nodes when contacting the ground. Because the vine has been prevalent for so long in Fiji, eradication is not considered a feasible option. This study assesses the economic costs and benefits of implementing suggested management options to reduce the density of merremia but not eliminate it completely from affected villages.

Plant Biology and Growth

As noted above, merremia is a coarse, woody twiner with large tuberous roots that typically grows in forest and thickets, crawling up shrubs and trees (Fosberg & Sachet 1977). It is prevalent as a primary or secondary species in disturbed areas of up to 400 m in elevation. In Fiji, merremia is present in forest or on its edges, in thickets, on open hillsides and along roadsides (Smith 1991). The merremia vine can reproduce and spread sprawling into neighbouring areas and rooting from its nodes or less often through the propagation of seeds (Bacon 1982). Little is known of any species that act as pollinators or dispersers of this plant (Kirkham 2005).

The growth and spread of merremia is assumed to follow a logistical biological growth curve:

$$N_{t+1} = N_t + bN_t \left(1 - \frac{N_t}{N_{Max}}\right) \quad (1)$$

where N_t is the population at time t, N_{max} is the carrying capacity, and b is the growth parameter.

There are few to no published studies that estimate the rate of growth and spread of merremia. However, it has been observed that the vine can grow and take over disturbed areas very rapidly (Kirkham 2005). As a result, we use a rough estimate that once established on recently disturbed land, the merremia can grow such that it reaches 50% of carrying capacity in 10 years, and nearly 100% of carrying capacity in 15 years. We use the limited information to approximate equation (1) such that it estimates a biological growth curve presented as the percent of merremia population relative to the population at carrying capacity. This is achieved using parameter values of $N_0 = 1$ beetle $b = 0.6$, and $N_{Max} = 100$ as shown in Figure 32.

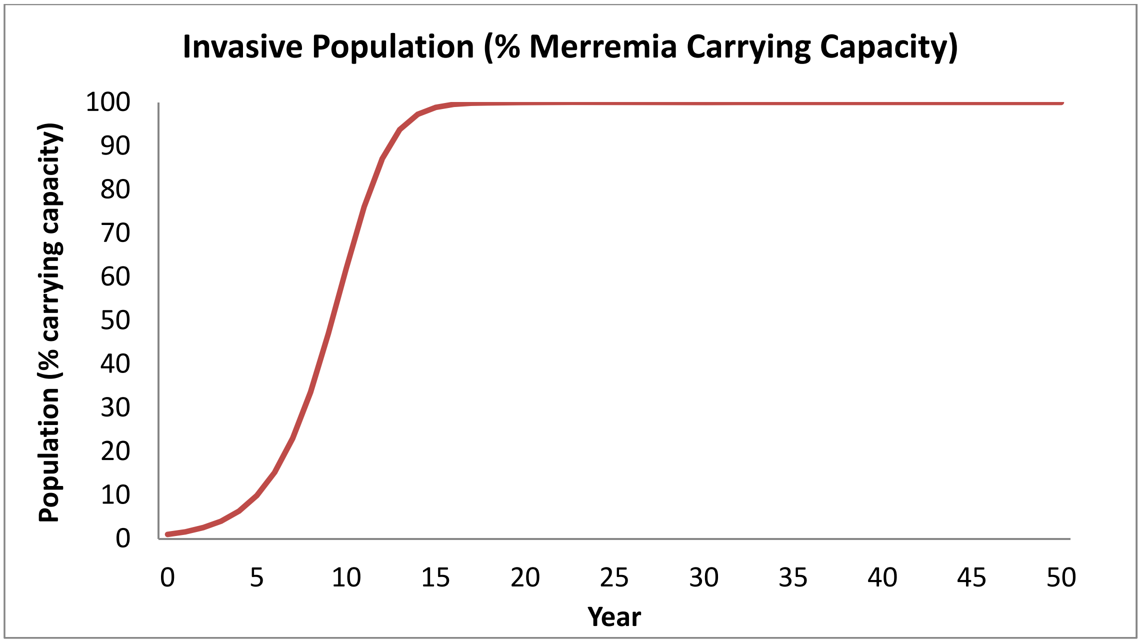

Figure 32 Biological growth function of merremia vine.

Study Site and Survey Methodology

To investigate the socio-economic impacts of invasive species in Fiji, we surveyed 360 households in 30 villages in Eastern Viti Levu. These villages were stratified by geography and randomly drawn; one village that is inaccessible by road due to construction was replaced with another remote village. Within each of the 30 villages, households were drawn at random. Each survey was administered directly to the head of household, and topics covered demographics; farming, fishing, wage work, and other income-generating activities; wealth and durables; education; health; and extension activities. The survey also included several novel elements relating to the social and economic impacts of invasive species.

First, respondents were asked to assume the role of Fiji's budget minister and to identify spending priorities by allocating budgetary shares to a broad range of categories, including education, healthcare, defence, trade, infrastructure development, and environmental protection. Respondents who allocated money to environmental protection were further asked to prioritise controlling specific invasive species relative to other environmental spending.

Second, a series of questions were asked to elicit willingness to contribute personally to controlling invasive species via volunteer labour. In most developed countries, willingness to pay is identified via questions pertaining to tax increases; however, few rural Fijian households pay taxes while virtually all of them contribute labour to maintaining the village, suggesting that this approach is culturally relevant. Opening values were assigned via dice rolls to eliminate concerns about starting-point bias.

Third, respondents were asked to state the extent to which they agreed with statements on the value of controlling invasive species (e.g. 'It is good that the merremia vine is found in this village.') via a 5-point Likert scale. To eliminate concerns of yea-saying, some statements read in the negative (e.g. 'It is bad that the merremia is found in this village.').

A complementary survey was administered to a focus group in each of the 30 sampled villages. The village-level questionnaire consisted of open-ended questions regarding the presence and state of each species and, where applicable, the consequences of its presence (both positive and negative) and community practices for encouraging or limiting its spread.

Survey Findings

The merremia vine was present in 28 of 30 villages surveyed in Viti Levu (93%). Respondents to the community survey identified three primary costs associated with the vine:

- 42% of villages reported that merremia reduces agricultural output
- 37% of villages reported that merremia competes with medicinal trees and plants
- 26% of villages reported that merremia competes with trees used for building materials

Approximately 46% of the villages surveyed stated that there were no socio-economic or biophysical impacts.

More than 85% of the village focus groups reported that merremia was good for their community. Key benefits identified include:

- 53% of villages reported that merremia has important medicinal properties, including the ability to cure colds, stomach aches, and urinary tract infections
- 50% of villages reported using merremia for bundling twine
- 25% of villages stated that it improved soil fertility
- 18% of villages reported that merremia was used for witchcraft

Most villages nevertheless actively manage the vine to control its spread. Specifically:

- 76% of the villages regularly cut or pull merremia
- 16% of villages regularly burn merremia patches

- 11% of villages use herbicides to control the spread of merremia

Although about half of the villages are putting some effort into managing the invasive vine, 70% of the villages surveyed stated that the merremia population was still increasing (Figure 33).

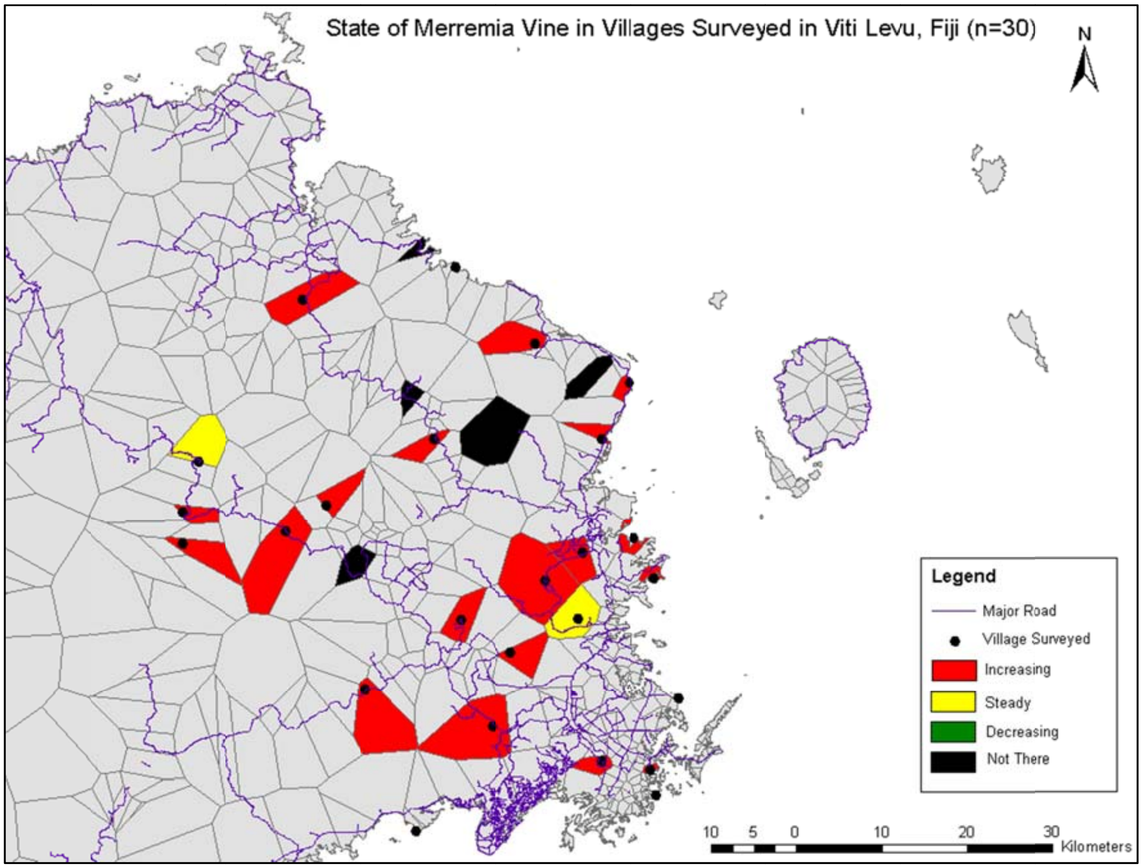

Figure 33 State of merremia in villages surveyed (n = 30).

Respondents to a household survey (n = 360) conducted on Viti Levu were asked a series of questions pertaining to their personal views of the species. Approximately 44% of the sampled households viewed the presence of merremia favourably, 34% viewed its presence negatively, and 22% was indifferent to its presence. Only a handful of survey respondents held an extremely negative view of the merremia vine, and none were entirely positive about its presence.

Some respondents to the household survey stated that the merremia vine had some negative impact on their livelihood, primarily by invading cassava and taro fields, but relatively few were making any effort to reduce the problem. One-third of surveyed households spend time cutting and clearing merremia in a typical week, allocating about 1.8 hours per week (about 13 man-days per annum) to the task on average. To put this in perspective, the average household surveyed spends about 35 hours a week managing their crops, of which about 5% of that time is used specifically to control the invasive vine. The remaining two-thirds of surveyed households do not clear merremia from their land.

Asked to reallocate Fiji's national budget according to their own spending priorities, survey respondents would allocate approximately 7% of the national budget for invasive species management. They would further allocate 6% of that budget to controlling merremia, prioritising control of other species such as the African tulip tree and taro beetle over the merremia vine.

Management Options

Different management options can have differential impacts on the growth and spread of the merremia vine (Figure 34). In addition to doing nothing, three management options are considered in this analysis: the current community management approach, increased application of herbicides, and a more integrated management approach. The community survey revealed that roughly 20% of productive land in most villages of Eastern Viti Levu is covered by the merremia vine, as of July 2012. We use this as the initial population at the start of the management regime. We then use the following assumptions to parameterise the effect of management on species growth from the various options.

Do nothing (without scenario)

This option represents typical progression of growth and spread across the landscape with no management. Under this scenario, the merremia vine eventually occupies all ecologically suited environments when it reaches carrying capacity about 15 years after being introduced to the study site. All other options are measured relative to the costs and benefits estimated under this option. Obviously, there are no management costs associated with the do-nothing option, but it does result in damages to land-based production and native trees that could be avoided if the spread of the tree was controlled.

Current management approach

Based on survey findings, households spend the survey average of 13 man days per year clearing merremia. Treatment methods include a mix of cutting the vine, burning merremia patches, and using a small amount of herbicides. This approach can mitigate the potential damage caused by the invasive vine, but only to a certain degree. Most villages surveyed reported an increase in merremia in their community despite some management, and therefore we assume that the long-run population of the merremia vine is reduced by about 50% relative to the do-nothing scenario.

Chemical application

This option assumes that herbicides such as dicamba, triclopyr, picloram and glyphosate are the primary way to control merremia. We assume that control work is undertaken on all disturbed land in the village as that is the area most sensitive to merremia infestation. Spot treatment is also done on significantly affected areas adjacent to the primary treatment sites. All rooting stems and tubers are treated with suitable herbicide, but the exact treatment method used depends on the site and number of established vines. Options include knapsack application of herbicide to any remaining leaves and stems or application of herbicide granules or spray mixture to the vine stump and/or tuber. Effort is also made to only apply herbicides to the target plant (i.e. treatment methods must avoid any off-target damage to native plant species and/or human health). As a result, we assume that annually spraying herbicides at the recommended rate will keep the population of merremia steady at about 20% of carrying capacity.

Integrated management approach

This approach builds on the methods used in the other two management options but with a more integrated and rigorous manner. First, a machete can be used to slash merremia stems out of host trees, where vines are cut as close as practical to ground level. Second, all rooting stems and tubers are then treated with suitable herbicide in the same manner as the chemical application option. Third, emerging merremia plants are dug out or treated with suitable herbicide, and any seedlings germinating from seed can be hand-pulled. Fourth, trees are planted to promote shade and minimise spread of the vine to native vegetation areas.

The long-time presence of the merremia and the manner in which its seeds spread across the landscape make it nearly impossible to eradicate the tree from Viti Levu, Fiji. As a result, we assume that the long-run population of the tree is reduced to about 10% of what it could be under the do-nothing scenario. This is an acceptable population level as the remaining merremia can be used by the community for benefits such as medicine and animal fodder.

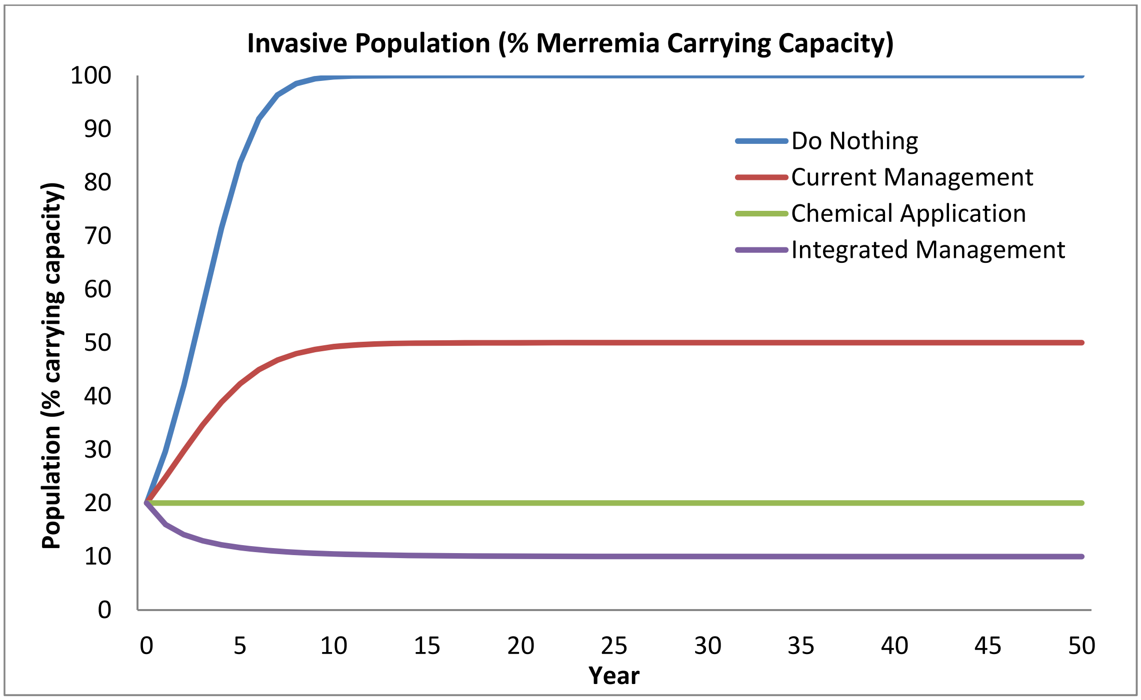

Figure 34 Merremia population (as % carrying capacity) over time and management option.

It has also been suggested that merremia has the potential to be managed through the use of biological control (Paynter et al 2006). Unfortunately, we did not have enough information to confidently evaluate the costs and benefits of this option.

As mentioned above, we assume that most of the control work will be conducted in all cleared land (and affected areas immediately adjacent to treatment sites) in the village as these are the sites most sensitive to merremia infestation. Because estimates could be highly variable based on some of our assumptions, we conduct sensitivity analysis to assess the change in relative costs and benefits under alternative population and management effectiveness later in the study.

Quantifying Benefits and Costs of Invasive Management

Several benefits can accrue within the community as a result of managing the merremia vine, mostly in terms of avoided damage. Key benefits include improved crop and forest productivity and an increase in the population of native species in the surrounding bush. Unfortunately, the benefits to native species are not easily quantified, either physically or monetarily. As a result, this analysis only quantifies the benefits of avoided damage in crop and timber yields. Note that it is likely the non-quantified benefits will also have positive economic value in actuality, and thus the figures listed here are likely to be an underestimate of the total benefits from managing the invasive vine.

These specified benefits then need to be expressed in terms of physical units of damage that would likely accrue under the status quo 'do nothing' in the initial period (year 1). For this study, we used the household survey and anecdotal evidence to estimate the reduction in crop production due to the presence of merremia. As the vine is assumed to be only at about 20% of carrying capacity, damage is expected to increase over time in the absence of any change in the status quo (no management). The damage per hectare of crop and productive forest in the initial period is listed in Table 44, based on rough averages from the survey. Note that these figures can be interpreted as mixed land use with multiple crops and livestock types on a typical hectare in the project area.

Table 44 Initial physical values to quantify annual benefits of avoided damage from invasive vine management

	Units	Optimal yield	Damage impact	Initial Period damage
Crop yield	kg/ha	10,000	5%	500
Forestry yield	m^3/ha	5	20%	1

Quantifying the costs of invasive species management is often straightforward. Typical costs of protecting crops from the merremia vine include labour, herbicides and the initial capital costs (e.g. machete, herbicide, sprayers). All costs are estimated to occur at the end of each period for the duration of the intervention, with the exception of capital costs, which only occur during the initial period. Other aspects of management that the village might incur (e.g. additional time spent gathering merremia for beneficial use) are assumed to have no cost. The physical units listed in Table 45 are based on literature, survey responses, and expert knowledge. Note that estimates presented in this study are for a generalised and hypothetical control programme in Fiji and the level of manpower and materials required is likely to vary across crop mix and study area. For example, while we assume in this study that the level of chemicals applied would be constant over the lifetime of the project, it is likely that the rate would be reduced over time if the merremia population were reduced.

Table 45 Initial physical values (per hectare) to quantify annual costs of merremia management

Cost	Units	Years incurred	Do nothing	Current approach	Chemical application	Integrated approach
Annual costs						
Herbicide	Litres	1–50	0	2	20	10
Labour	Man days	1–50	0	13	25	35
Capital costs						
Machete, and gloves	Number	0	0	1	1	1
Knapsack sprayer	Number	0	0	0	1	1
Tree seedlings	Number	0	0	0	0	10

Aggregating Costs and Benefits

The physical values of benefits and costs listed above can then be monetised by applying unit values over time. The monetary units listed in Table 46 are all listed in Fijian dollars (FJD) and are average values elicited from household and market surveys and expert input.

Table 46 Unit values for monetised benefit and costs

Category	Category	Unit Measurement	Unit Value ($/unit)
Benefits	Crop income	$/kg	1.00
	Forestry Income	$/m^3	35.00
Costs	Labour	$/man day	30.00
	Herbicide	$/litre	25.00
	Tree seedlings	$/tree	1.00
	Machete and gloves	$/set	50.00
	Knapsack sprayer	$/item	210.00

The monetised values for damage that accrues in the initial period under the ‘do nothing’ case and each management option can be estimated by multiplying the unit monetary values in Table 46 by the initial physical damage estimates in Table 44. These damage totals can be estimated over time by tracking the change in the respective damage from merremia, as discussed in the Management section. The estimated values of annual damages from the vine are displayed in Figure 35.

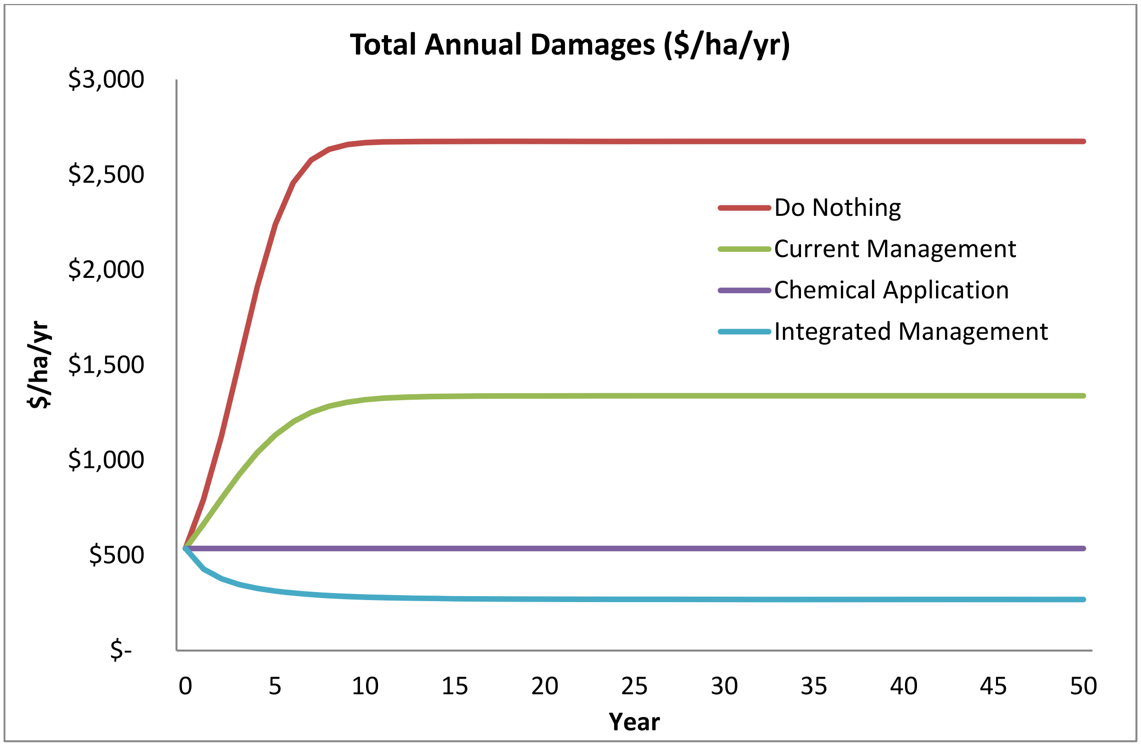

Figure 35 Total value of annual damages ($/ha) from for merremia vine under various management options.

The differences between the damage curves for 'do nothing' and a specific management option represents the benefits that accrue from avoiding damages would have occurred under the 'do nothing' option. These benefits are displayed in Figure 36.

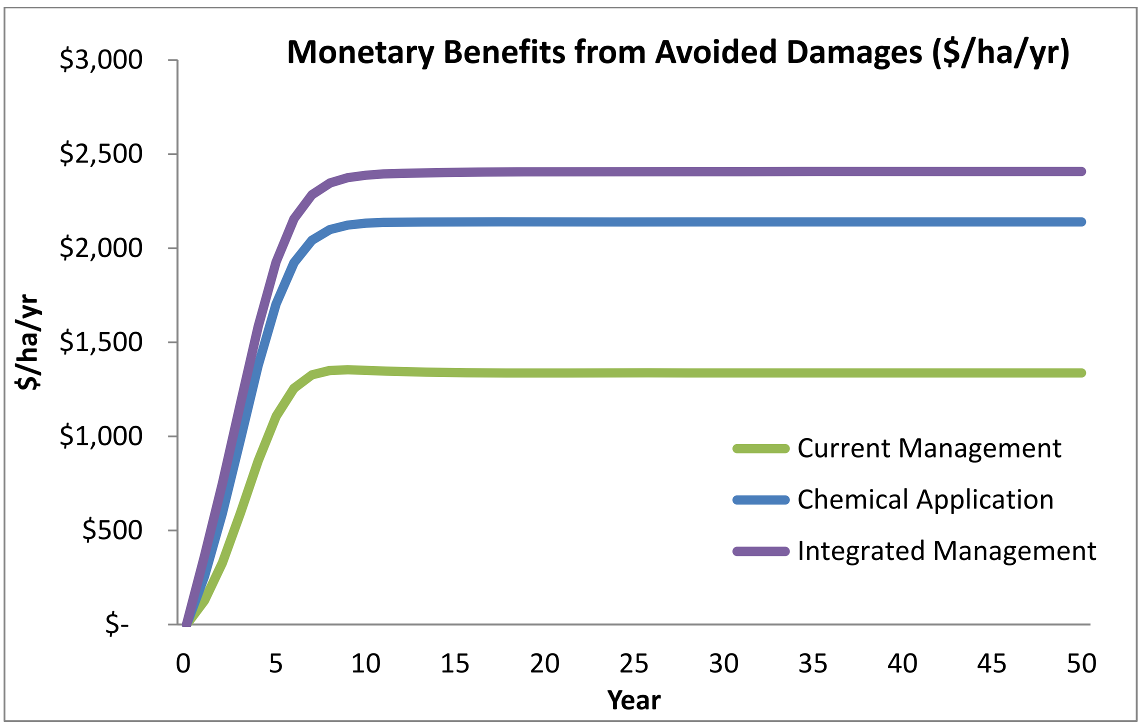

Figure 36 Monetised benefits of avoided damages from management of merremia vine.

The total monetised costs can be estimated by multiplying the unit costs incurred in each year by the physical values. For example, while we assume in this study that the level of chemicals applied would be constant over the lifetime of the project, it is likely that the rate would be reduced over time if the merremia population is reduced. Total annual costs of each management option are listed in Table 47. Apparent is that the current approach is significantly cheaper than the other two proposed options, particularly for those costs that will be incurred on an annual basis (i.e. years 1–50).

Table 47 Total annual costs of management options ($/ha)

Option	Year 0	Years 1–50
Do nothing	$0	$0
Current approach	−$50	−$490
Chemical application	−$260	−$1,750
Integrated approach	−$270	−$1,550

We then calculate the net present value (*NPV*) to aggregate the stream of benefits and costs that accrue over time into a single metric so that the relative benefits of various interventions can be compared consistently against each other. This is expressed mathematically as:

$$NPV = \sum_{t=1}^{T} \frac{B_t - C_t}{(1+r)^t} \tag{2}$$

where *NPV* is the net present value of the option, B_t and C_t are the respective benefits and costs that accrue at time s, T is final time period of project, and r is the real interest rate that is used to discount costs and benefits to the present value. For this study, we assume a project length of 50 years and a discount rate of 8%, which is in the middle of the range of discount rates used for long-term environmental management projects in the Pacific (Lal & Holland 2010).

Results of the cost–benefit analysis for merremia vine management are listed in Table 48. Estimates for the options to reduce damage to crop and forestry yields relative to the 'do nothing' option are mixed. Our initial analysis found that the current and integrated management approaches yielded a positive *NPV* and a benefit–cost ratio (BCR) greater than 1, while the herbicide-application-only option did not.

The current management option yielded the highest *NPV* and a BCR of 2.2 to 1, indicating every dollar spent on managing the merremia vine yielded a monetary benefit of $2.20. It is therefore considered the most efficient management option from a purely economic perspective. However, because merremia is still estimated to grow, it might not be the 'best' option if non-monetised values such as native tree protection are a high concern.

The integrated management approach also yielded a positive *NPV* and a BCR of 1.2:1, indicating that it is also a feasible option relative to the do-nothing scenario. The present value of benefits for control were the highest of all three options considered relative to the status quo; however, the relatively high costs of labour and herbicides compared with the current management approach weighed heavily on the total net present value.

Table 48 Summary of cost–benefit analysis (PV = present value, r = 8%, T = 50 years, study area = 1 ha)

Option	PV costs	PV benefits	Total NPV	Benefit–Cost Ratio	Rank
Do nothing	$	$	$	1.0	3
Current management	-$6,044	$13,261	$7,216	2.2	1
Chemical application	-$21,669	$21,102	–$567	1.0	4
Integrated management	-$19,232	$23,920	$4,688	1.2	2

Sensitivity Analysis

Cost–benefit analyses of invasive species management typically depend on extensive data and strong assumptions, and this analysis is no different. Analyses often obtain data from an array of sources with varying levels of quality and certainty. Some of the costs and benefits may be difficult to value accurately, and key biophysical data can be difficult to obtain. The population of the invasive species in the initial period can also vary across space, and not all villages in the study area might currently have a merremia population near the initial assumption of 20% of carrying capacity. As a result, we undertake a sensitivity analysis to assess the robustness of our results. Specifically, we analyse how the *NPV* estimates for each option could change in light of varying the following assumptions:

1. Initial population (as % of max) – 0.5 and 2 times base assumption. This changes the initial population of the merremia vine from 20% to 10% or 40%.

2. Effectiveness of management – 0.5 and 2 times base assumption. This adjusts the pathway of the population growth curves for the two intervention options. An option that is assumed to be twice as effective means that the species is controlled in about half the time as the initial assumption.

3. Discount rate – rates of 4% and 12% are at the tails of the range of discount rates used for environmental management projects in the region.

A summary of the *NPV* estimates for sensitivity analyses #1 and #2 are presented in Table 33. Results indicate that both the current and integrated management approaches would yield a positive *NPV* regardless of the initial population density and effectiveness of management on controlling merremia. The chemical application option was only estimated to have a positive *NPV* if it was deemed to be twice as effective as the initial assumption and thus reducing the merremia population to 10% of carrying capacity.

With the exception of the case where the effectiveness was low and the initial population was 20% or more, the current management approach was estimated to have the highest *NPV*. This suggests that if native species protection is a high concern and there is time, money, and assistance available, this integrated-management approach could be preferred in some sites where the current management approach already in place has not been very effective.

Table 49 Net present value (*NPV*) of sensitivity analyses for merremia management options (*r* = 8%, *T* = 50 years, study area = 1 ha)

Option	Effectiveness	Initial population (relative to maximum)		
		10%	20%	40%
Current management	0.5 x base	$1,923	$1,525	$1,307
	1.0 x base	$7,093	$7,216	$7,744
	2.0 x base	$12,929	$13,626	$15,002
Chemical application	0.5 x base	–$2,168	–$3,617	–$5,111
	1.0 x base	–$143	–$567	–$588
	2.0 x base	$1,482	$1,771	$2,745
Integrated management	0.5 x base	$1,605	$1,870	$2,777
	1.0 x base	$3,918	$4,688	$6,382
	2.0 x base	$5,069	$5,707	$7,218

The sensitivity analysis was also undertaken where a discount rate of 4% or 12% was applied to the initial assumptions (Table 50). Estimates revealed that all management options have a positive *NPV* regardless when the discount rate is 4%, as the benefits accrued in the later years of the project had a greater impact on the NPV estimate. The 12% scenario returned similar results as the initial case, where current management option was found to have the largest NPV estimate, but the integrated approach was still feasible.

Table 50 Net present value (*NPV*) of discount rate sensitivity analyses for merremia (*T* = 50 years, study area = 1 ha)

Option	4%	8%	12%
Do nothing	$0	$0	$0
Current management	$14,784	$7,216	$4,123
Chemical application	$2,540	-$567	-$1,674
Integrated management	$12,054	$4,688	$1,793

Results from a sensitivity analysis that varies the initial population, management effectiveness, and discount rate are listed in Appendix 17.1. The findings are generally consistent with those discussed above, and the current management approach is most often the preferred approach. Perhaps the most interesting result of the additional sensitivity analysis is that some of the *NPV* estimates for the integrated management approach are found to be negative in the case of a high discount rate and low effectiveness.

Scaling Up Results

A typical village in Eastern Viti Levu comprises 45 households, each of which maintains about 0.6 ha of productive land. The values for avoided damage presented above can be scaled up to the village level by using a factor of 45*0.6 = 27 ha per village. This would increase the *NPV* estimates in Table 16 for managing the vine for all productive land in the village to a total of $126,580 per village and $194,830 per village for the integrated approach and current management approach, respectively. Alternative scaling can be undertaken if monetised values and management options are also considered for non-productive (e.g. native) land not directly adjacent to the primary sites, as we have done in this study. Scaling up results will not change the overall ranking of each option because we assume constant economies of scale.

Summary and Conclusions

The purpose of this study was to conduct a cost–benefit analysis that estimates the most effective option to manage the invasive species merremia vine (*Merremia peltata*) at the village-level in Eastern Viti Levu, Fiji. Community- and household-level surveys were conducted in a total of 30 villages in Viti Levu to collect the majority of the economic data presented in this analysis. Merremia is a coarse climbing vine with underground tubers that grows in full sunlight. It generally crawls up and over trees, shrubs, and crops, strangling existing vegetation. The vine is also known for providing several benefits to the community. These include reducing erosion, soil improvement, medicine, bundling twine, and animal feed. We did not adequately account for these benefits in our model, and could have a negative impact on the net present values presented here.

In Fiji, merremia is present in forest or on its edges, in thickets, on open hillsides and along roadsides. Merremia also can be found in gardens, plantations, pasture and forest plantations throughout Eastern Viti Levu. Because the vine has been prevalent for so long in Fiji (or a likely native), so eradication is not considered a feasible option. This study assesses the economic costs and benefits of implementing suggested management options to reduce the density of merremia but not eliminate it completely from affected villages.

Although almost half the villages reported putting some effort into managing merremia, about 93% of villages surveyed indicated that the vine was present and 70% reported that the population of the vine was increasing. On average, 33% of surveyed households spent some time managing their crops for merremia, averaging about 1.8 hours per week (about 13 days per annum). This is what we considered the current management option. To put this in perspective, the average household surveyed spends about 35 hours a week managing their crops, of which about 5% of that time is used specifically to control this invasive weed.

The cost–benefit analysis estimated four options to manage the merremia vine: (i) do nothing, (ii) continue current management regime, (iii) apply more herbicides to affected areas, and (iv) take a more intensive integrated approach. The current approach to managing merremia was estimated to yield the highest net present value of all management options investigated in this study, as benefits of management outweighed costs by a ratio of about 2.2 to 1. This is an interesting find as it was assumed that implementing this option would still allow the population of the merremia to increase from 20% to 50% over the 50-year lifetime of the project. The integrated management approach was more effective at controlling the merremia population (10% of carrying capacity), but at a much larger cost than the current management approach. It still yielded positive net benefits for landowners though (benefit–cost ratio of 1.2:1) and should thus be considered a viable option over the do-nothing approach.

Our analysis suggests that some management (such as is carried out now) has real benefits that outweigh costs. Despite being widely regarded as problematic in the Pacific, in Fiji at least the concern its impacts seem to be acceptable to most villagers, as such this may be a weed that is relatively easy to live with (from a human use perspective). Furthermore, the use of chemicals to control this species did not appear to bring about a better benefit-cost scenario despite the expected increase in effectiveness (or decrease in hours invested) to control the weed. More needs to be done to understand the potential impacts of Merremia peltata on important endemic biodiversity. Site specific demands may lead to some weed managers favouring the more expensive but more effective "integrated management" option. This is particularly the case if stakeholders have a strong desire to reduce the merremia population and its impact on native vegetation, which was not valued in our study, or if the current management approach is even less effective at controlling the vine than our initial assumption.

The results presented in this paper should be interpreted with a degree of caution as the analysis used several assumptions to estimate the physical and monetary costs and benefits of merremia control. Because of the lack of data on management costs or effectiveness the study did not investigate any options that would likely reduce the merremia population in native bush that was not adjacent to productive land. We also did not estimate the costs and benefits of managing merremia through the use of biological control which has been proposed as a possible solution in the region (Paynter et al 2006). Future work is also needed to estimate both the biological growth and spread of the merremia and the effectiveness and value of controlling the vine for both agriculture and other purposes such as biodiversity conservation and ability for the vine to improve soil fertility.

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Appendix 17.1

Table 51 Sensitivity analysis for merremia vine management with varying discount rates (T = 50 years, study area = 1 ha)

Option	Effectiveness	Initial population (relative to maximum)		
		10%	20%	40%
Discount rate = 4%				
Current management	0.5 x base	$4,171	$3,259	$2,762
	1.0 x base	$15,317	$14,784	$15,020
	2.0 x base	$27,313	$27,169	$28,200
Chemical application	0.5 x base	–$767	–$4,268	–$7,134
	1.0 x base	$4,417	$2,540	$1,743
	2.0 x base	$8,044	$7,129	$7,560
Integrated management	0.5 x base	$7,615	$6,827	$7,265
	1.0 x base	$12,330	$12,054	$13,326
	2.0 x base	$14,635	$14,120	$15,151
Discount rate = 8%				
Current management	0.5 x base	$1,923	$1,525	$1,307
	1.0 x base	$7,093	$7,216	$7,744
	2.0 x base	$12,929	$13,626	$15,002
Chemical application	0.5 x base	–$2,168	–$3,617	–$5,111
	1.0 x base	–$143	–$567	–$588
	2.0 x base	$1,482	$1,771	$2,745
Integrated management	0.5 x base	$1,605	$1,870	$2,777
	1.0 x base	$3,918	$4,688	$6,382
	2.0 x base	$5,069	$5,707	$7,218
Discount rate = 12%				
Current management	0.5 x base	$942	$778	$694
	1.0 x base	$3,787	$4,123	$4,725
	2.0 x base	$7,164	$8,077	$9,491
Chemical application	0.5 x base	–$2,777	–$3,345	–$4,165
	1.0 x base	–$1,801	–$1,674	–$1,388
	2.0 x base	-$911	-$239	$874
Integrated management	0.5 x base	-$624	-$23	$1,000
	1.0 x base	$740	$1,793	$3,541
	2.0 x base	$1,434	$2,404	$3,997