Economic Analysis of Invasive Species: Small Indian Mongoose in Fiji

Overview

Invasive name:

- Small Indian Mongoose (*Herpestes javanicus*)

Study Location:

- Eastern Viti Levu, Fiji

How it got there:

- Invasive mammal introduced to in 1883 primarily to control rats in sugar cane fields

Spread and current state of invasive:

- Eventually escaped cane fields and now dominates disturbed lands throughout much of the country.

Overview

- Impacts (i.e., damages)
  - Invades agricultural areas and natural ecosystems, attacks poultry and native birds, can affect human health by biting people.
- Benefits of use
  - Consumption as food, rodent and snake control.

Overview: Economic Analysis

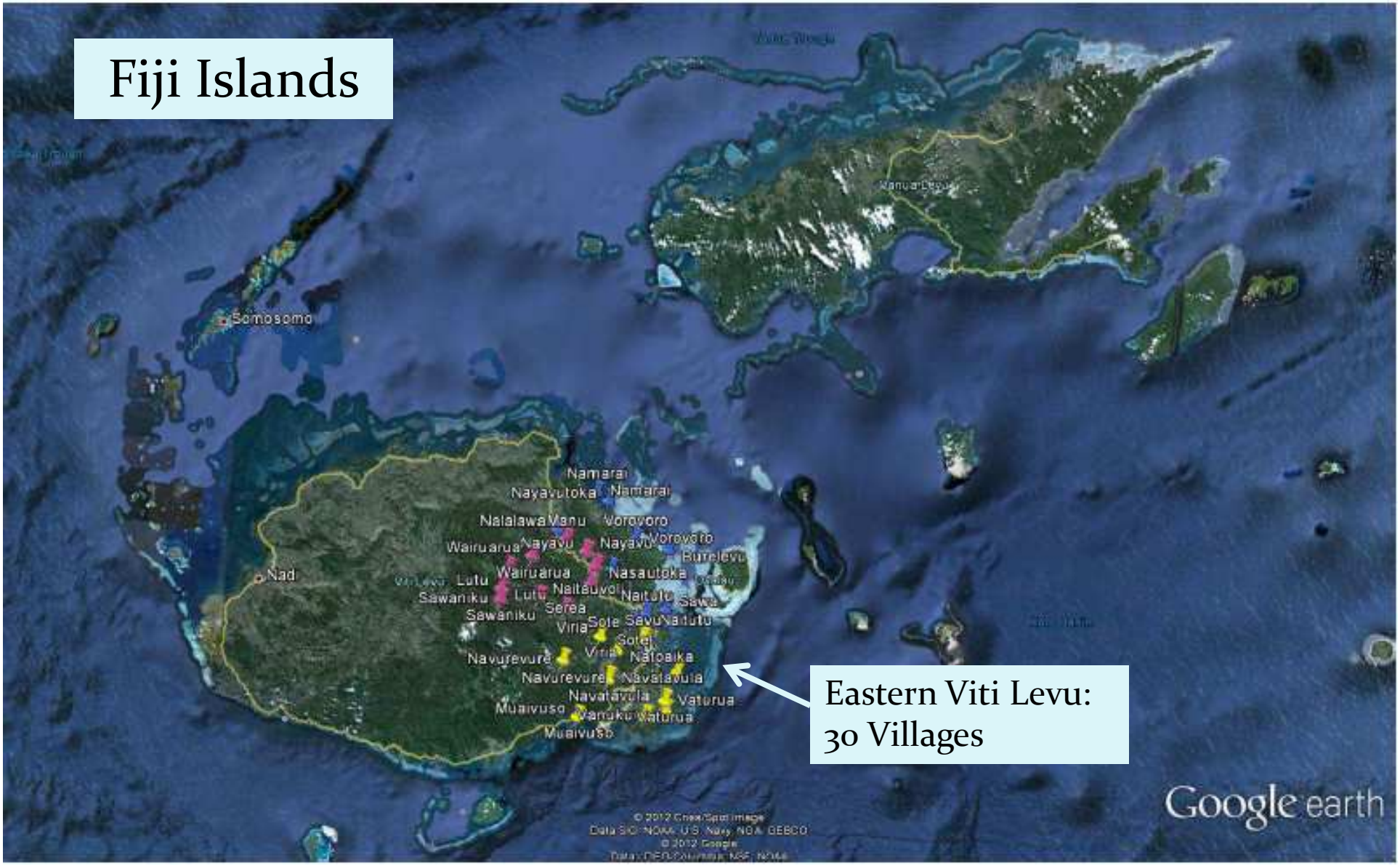
- Approach used: Cost-Benefit Analysis
- Discount Rate: 8%
- Timeframe: 50 years
- Other key assumptions:
  - Economic well-being metric: Wealth
  - project size: 1 ha (but can be scaled up to village area)
- Sensitivity Analysis
  - Management effectiveness
  - Initial population
  - Discount rate

7 Steps of a CBA

1. Determine the objectives of the Cost-Benefit Analysis
2. Identify costs and benefits
3. Value costs and benefits
4. Aggregate costs and benefits
5. Perform sensitivity analysis
6. Consider distributional impacts
7. Prepare recommendations

Step 1. Objective

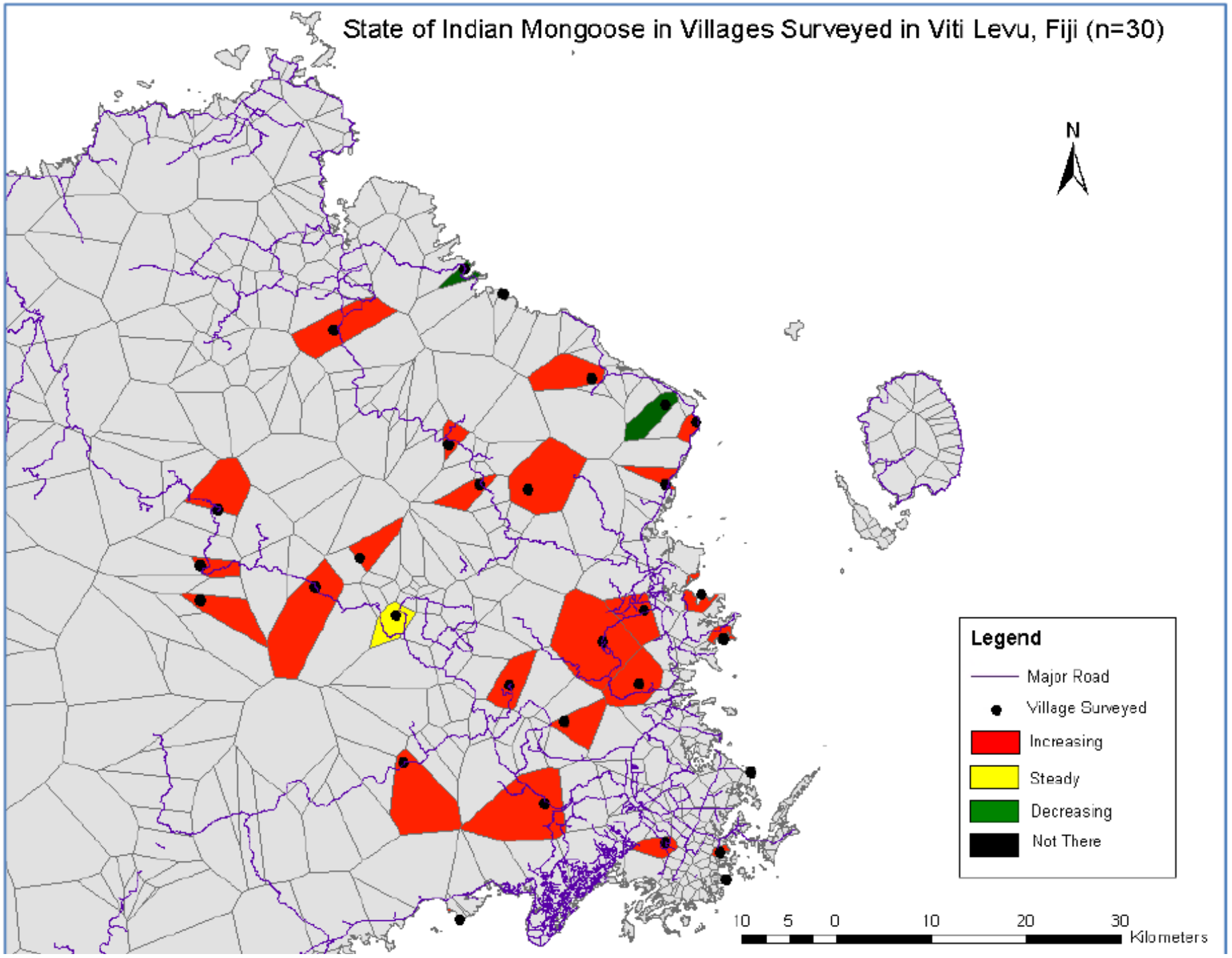
- The purpose of this cost-benefit analysis is to estimate the economically efficient options to manage the Small Indian Mongoose (Herpestes javanicus) at the village-level in Eastern Viti Levu, Fiji.
- Note: Due to its establishment more than 100 years ago and presence throughout the island, eradication is not likely


Fiji Islands
Somosomo
Namarai
Nayavutoka
Namarai
Nalalawa
Vanu
Vorovoro
Wairuarua
Nayavu
Nayavu
Vorovoro
Burelevu
Nad
Wairuarua
Nasautoka
Lutu
Naitauvoi
Naitutu
Sawa
Sawaniku
Lutu
Serea
Sawaniku
Viria
Sote
Sevuvatutu
Sotet
Viria
Navurevure
Natoaika
Navurevure
Navatavula
Navatavula
Vaturua
Muaivuso
Vaturua
Muaivuso
Eastern Viti Levu:
30 Villages
Google earth
Google earth
miles
100
km
200

Key Data Source - Survey

- Study Site: Eastern Viti Levu, Fiji
- Survey conducted in 30 villages
- 1 community survey + 12 household survey per village
- Total of 360 households


Eastern Viti Levu:
30 Villages
Namarai
Nayavutoka
Nayavutoka
Manu
Vorovoro
Dranu
Lawaki
Burelevu
Nayavu
Wairuarua
Udu
Nasautoka
Nasau
Ovalau
Levuka
Lodoni
Viti Levu
Nukuloa
Lutu
Sawaniku
Naitauvoli
Serea
Korovou
Naitutu
Sawa
Sote
Naivuruvuru
Vinia
Savu
Natoaika
Navurevure
Vatoa
Navatavula
Nausori
Vaturua
Navilaca
Muaivuso
Vanuku
Suva
Suva Harbour
Laucala Bay
Navua
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2012 Google
© 2012 Cnes/Spot Image
Google earth
Google earth
miles
30
km
60


State of Indian Mongoose in Villages Surveyed in Viti Levu, Fiji (n=30)
N
Legend
Major Road
Village Surveyed
Increasing
Steady
Decreasing
Not There
10 5 0 10 20 30
Kilometers

Key Summary Statistics

key economic indicators for households in villages surveyed

Variable	Obs*	Mean** (FJD)	Std. Dev. (FJD)	Min (FJD)	Max (FJD)
Annual Income	30	$12,530	$9,260	$4,510	$41,480
House Value	30	$10,070	$4,530	$2,500	$20,000

* Average of 12 household surveys from each of 30 villages
** 1 FJD = 7.75 Mexican Pesos = 0.46 USD

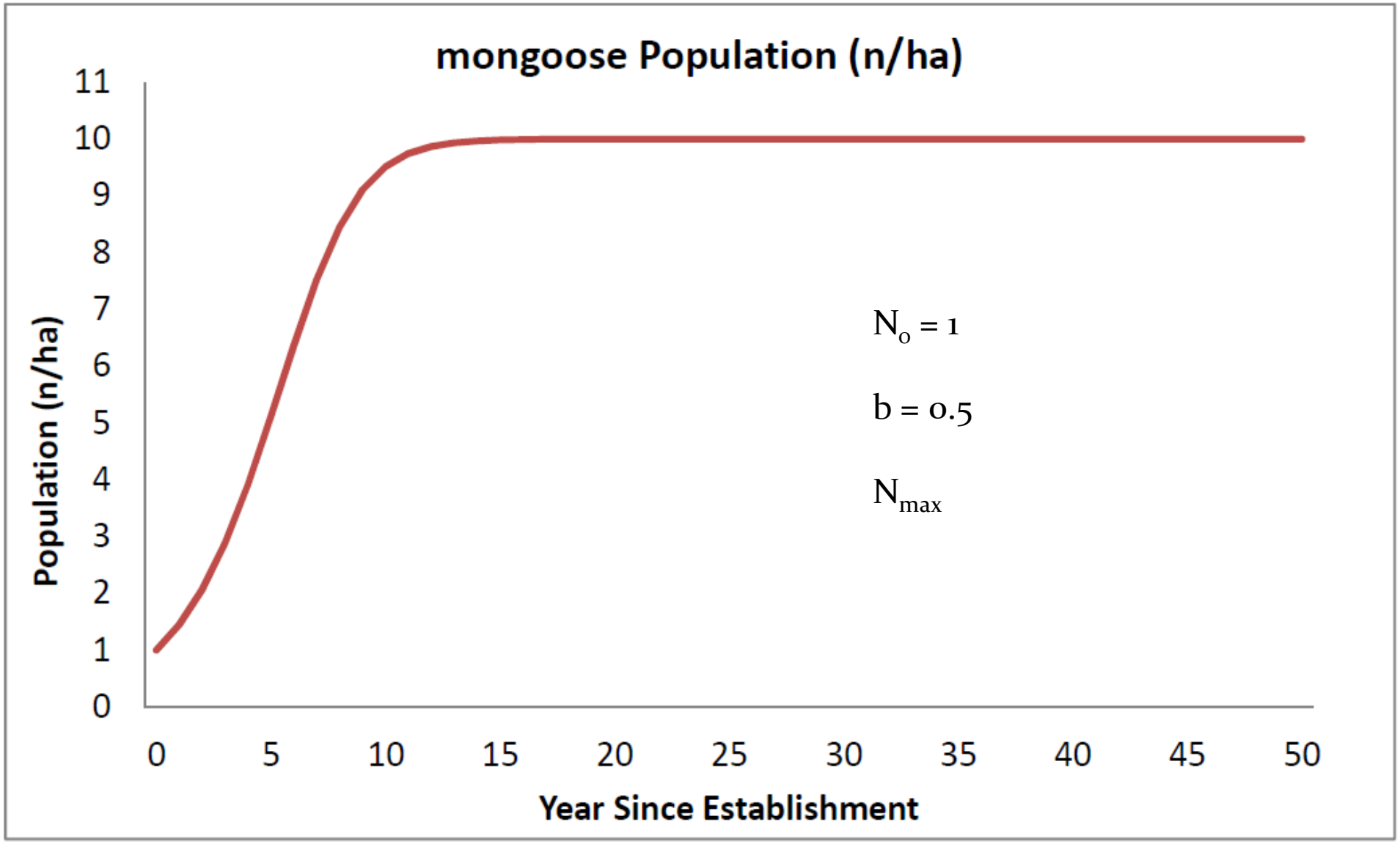
Management

In terms of management:

- 87% of the surveyed villages actively trap mongooses
- 47% of surveyed villages hunt it.

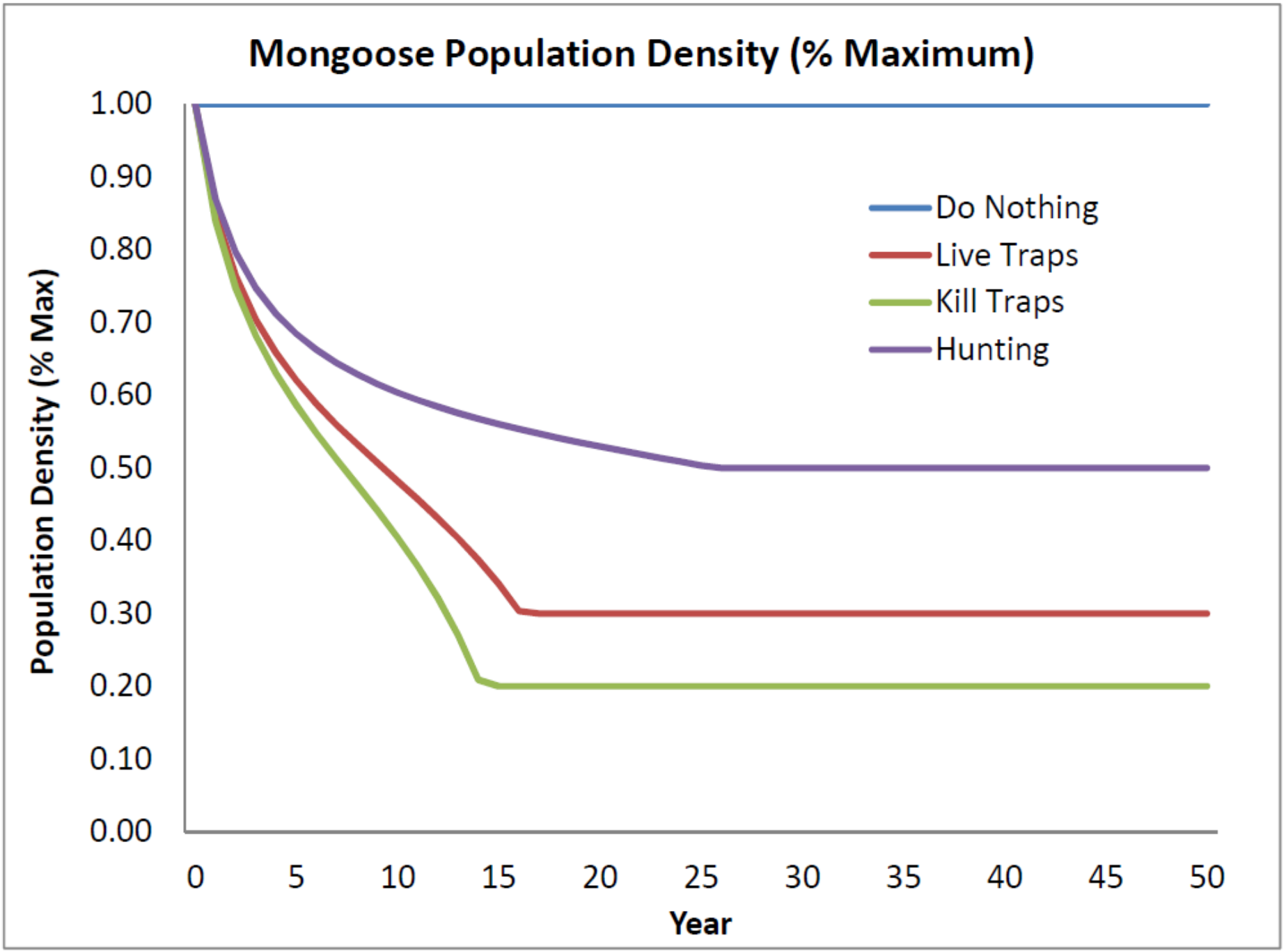
These interventions are for both protecting crops and livestock and food consumption.

Despite putting some effort into managing this invasive species, 90% of villages surveyed indicated that the population of the mongoose was still increasing


mongoose Population (n/ha)
Population (n/ha)
11
10
9
8
7
6
5
4
3
2
1
0
0
5
10
15
20
25
30
35
40
45
50
Year Since Establishment
$N_o = 1$
b = 0.5
N_{max}

Options Evaluated

1. Do Nothing/Status Quo
   - Allow the mongoose to continue to thrive in current environment
   - Initial population density at 100% of carrying capacity
2. Live traps
   - Set at density of 1 per every 200 metres
   - Reduces long run carrying capacity to 30% of max
3. Kill traps
   - Set at density of 1 per every 200 metres
   - Reduces long run carrying capacity to 30% of max
4. Hunting
   - Relatively effective at high density rates, but less effective otherwise
   - Reduces long run carrying capacity to 50% of max


Mongoose Population Density (% Maximum)
Population Density (% Max)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
5
10
15
20
25
30
35
40
45
50
Year
Do Nothing
Live Traps
Kill Traps
Hunting

2. Identify Costs and Benefits

Impacts from presence*

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

* Impacts can be used to value benefits of avoided damages from management

Benefits

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.

3. Valuing costs and benefits

Valuing costs

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.

Initial Period Values for Estimating Damages from Invasive (per ha)

Damages	Units	Optimal Yield	Damage Impact	Initial Period Damages
Livestock	Head	10	10%	1
Crops	Kg	10000	2.5%	250

* These are the 'losses' in benefits due to damages relative to a scenario where there is no invasive. The damages will change in proportion to the invasive population over time

Monetary Values

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

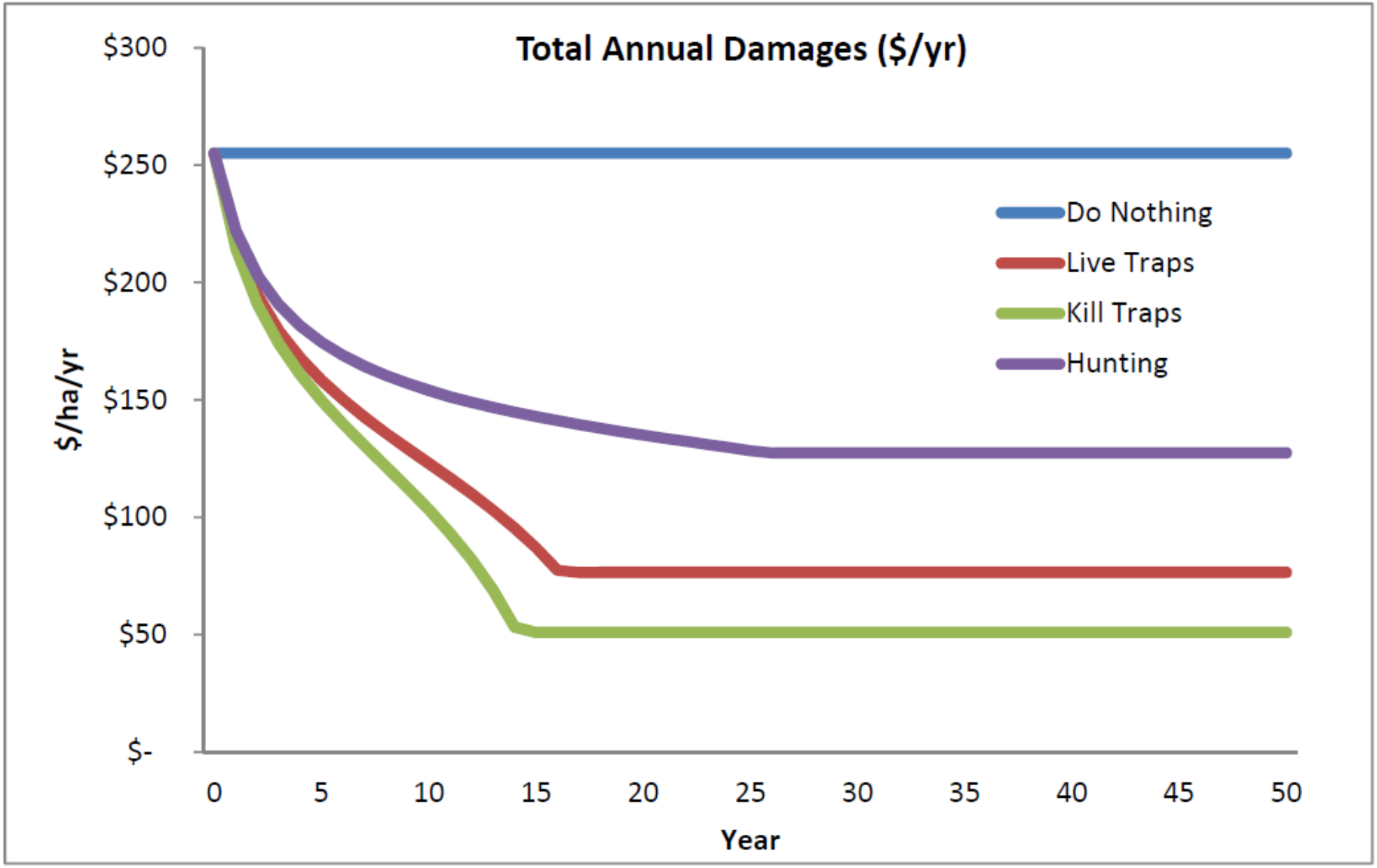


Figure 22 Total value of annual damages ($/ha) from small Asian mongoose under various management options.

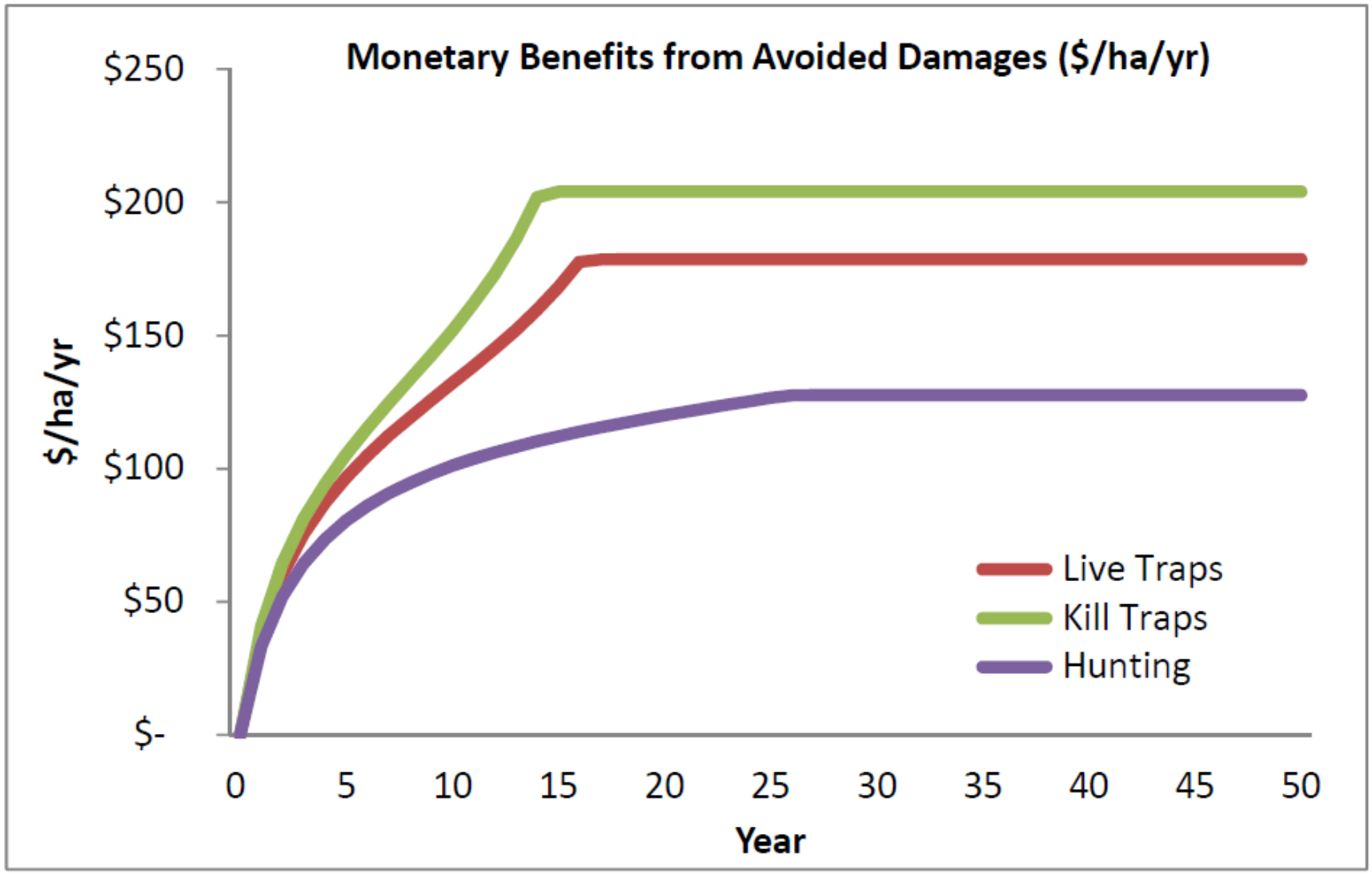


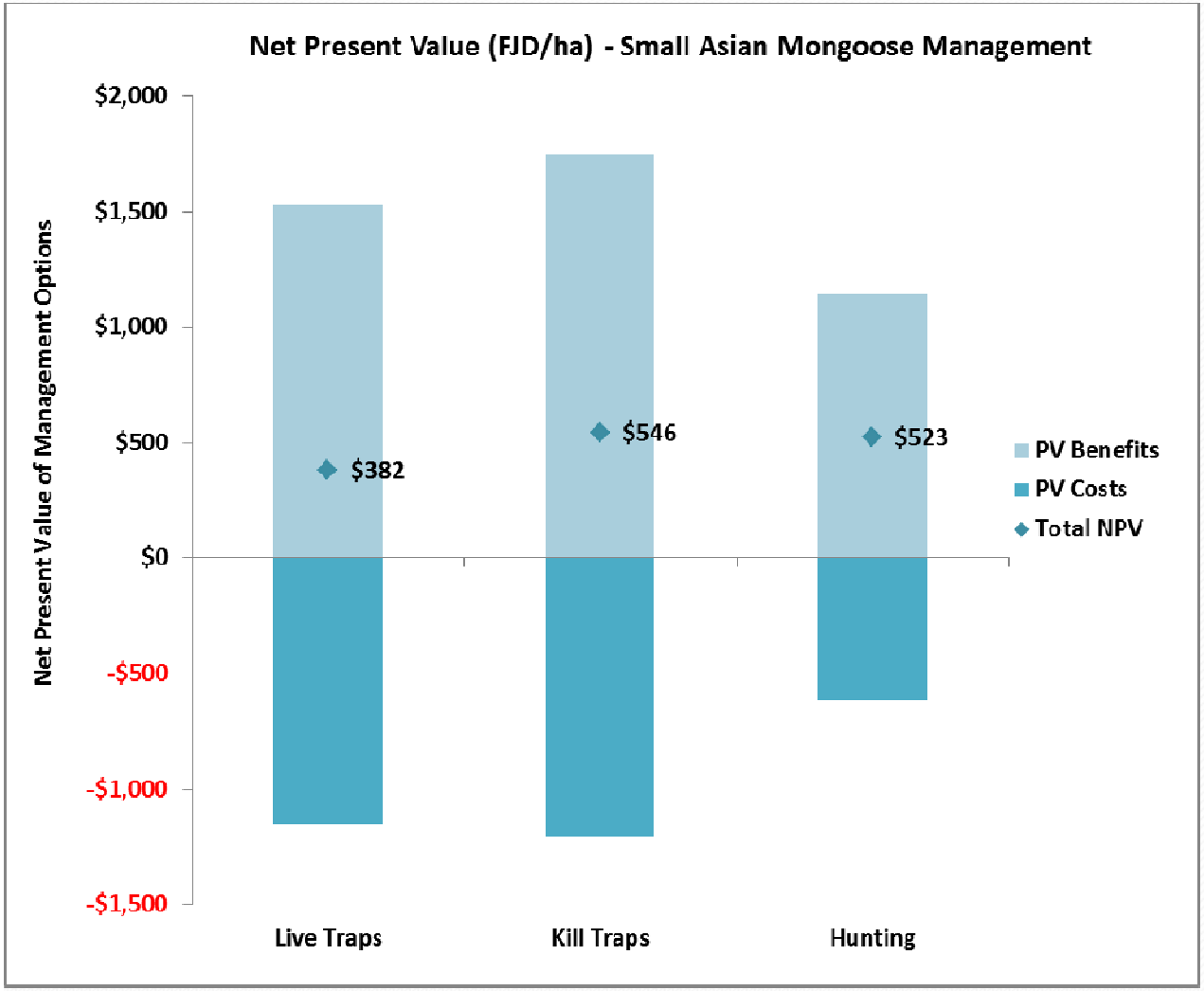
Figure 23 Monetised benefits of avoided damages from management of small Asian mongoose.

4. Aggregate costs and benefit

- Discount rate = 8%
- Time periods = 50 years
- Project area = 1 hectare

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

NPV and BCR



Option	Benefit-Cost Ratio
Do Nothing	1.0
Live Traps	1.3
Kill Traps	1.5
Hunting	1.8

5. Conduct Sensitivity Analysis

1. Initial population (as % of max) – 33% and 66% of carrying capacity
2. Effectiveness of management – 0.5 and 2 times base assumption.
   - This adjusts the pathway of the population growth curves for the 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 – 4% and 12%

Sensitivity Analysis

Net Present Value with Varying Effectiveness and Initial Population

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

All but 1 option preferred over 'do nothing' as NPV > 0
Kill traps typically has highest NPV

Sensitivity Analysis

Net Present Value with Varying Discount Rates

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

All options preferred over 'do nothing'
Kill traps still preferred, when discount rate < 12%

6. Consider Distributional Impacts

- Key stakeholders
  1. Indigenous Fijians
  2. Indian Fijians
  3. Government
- Qualitatively, all stakeholders would see net benefits from management
  - Increased productivity
  - Reduced population (and spread)
  - Costs would be incurred by both villagers (labour and inputs) and government (extension and coordination)

7. Policy Recommendation

- The benefit-cost analysis estimated four options to manage the small Indian mongoose:
- The kill trap approach was estimated to yield the highest net present value of almost all management options investigated in this study
  - estimated NPV of $546/ha with discount rate of 8%
  - Benefit-cost ratio of 1.5
  - scales up to net benefit of more than $16,000/village
  - it is the preferred option, provided that the resources (i.e. money for traps) are available

7. Policy Recommendation

- Both the live traps and hunting approaches also yielded positive net benefits for landowners
  - Live traps: NPV = $382/ha
  - Hunting; NPV = $523/ha
- In a few cases, hunting yielded highest NPV (e.g., high discount rate).
- Live traps typically was third-best option, but still preferred relative to 'do nothing' scenario
- Note: did not value native species protection, which would increase total net benefits of project