Merremia control in Vanuatu
A feasibility study, June 2023

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Abbreviations

AD	Avoided Deforestation
ANR	Assisted Natural Regeneration
ARR	Afforestation, Reforestation and Regeneration
AUD	Australia Dollars
CCA	Community Conservation Area (Vanuatu)
CDM	Clean Development Mechanism
DEPC	Department of Environment, Protection and Conservation (Vanuatu)
FTE	Full Time Equivalent
ha	Hectares
IFM	Improved Forest Management
NGO	Non-Government Organisation
NPR/NPER	Net Project Removals / Net Project Emission Removals
PDD	Project Description Document (Plan Vivo)
PIN	Project Idea Note (Plan Vivo)
REDD+	Reduction of Emissions from Deforestation and Degradation (Plus)
tCO_2e	Tonnes of Carbon Dioxide equivalent
USD	United States Dollars
VAV	Vanuatu Vatu
VCM	Voluntary Carbon Market
VCS	Verra Carbon Standard

Executive summary

The tropical climbing merremia vine (*Merremia peltata*) is widespread and invasive in the Pacific region where it creates significant impacts on forest areas, suppressing regrowth and reducing the carbon uptake and stocks in mature forests. In Vanuatu, it is common in forests degraded by historical commercial logging and is documented as being responsible for widespread tree mortality. Nakau is now seeking to explore the feasibility of managing merremia infestations to generate carbon revenue.

This study finds there is good potential for registering activities in Vanuatu that generate carbon market revenue through management of merremia. Potential activities include the clearing of merremia thicket followed by tree planting, and the manual removal of merremia climbers infesting degraded remnant forest.

This study assumes a baseline scenario of continuation of the pre-project land use of merremia infestation without climber management or tree planting. Future projects should additionally consider the inclusion of the conversion of forest to agriculture as a baseline scenario where applicable to capture a greater pool of Net Project Removals.

When considered over a theoretical 200 hectare (ha) site, the management of merremia climbers in remnant forest yields marginally more net carbon benefits (per ha per year on a 30-year average), than clearing merremia thickets for reforestation. Furthermore, climber management clearly is the most cost-effective activity, requiring less labour, a smaller start-up investment and generating greater returns over a longer period for community benefit sharing. However, its effectiveness over large areas is not tested, and it is limited to remnant forest areas affected by merremia.

A combined set of activities including 10 ha per year of climber management and 6 ha per year of reforestation will require between 2-4 Rangers to implement the activities in establishment years. The upper extent of what is within the real-world capacity of a Ranger group to treat and maintain over a 30-year period is not known, however the findings indicate there is certainly scope to significantly increase the area being managed under the proposed approach beyond the 200 ha assumed in here.

Unlike avoided deforestation projects, both reforestation and climber management activities incur the highest costs in the early years, when clearing, planting activities and climber management activities are the most time consuming. Therefore, start-up investment will be required to support landowners to establish any such activities.

A rough order of priority for site selection for merremia control carbon projects is proposed whereby sites with potential for both climber management and avoided deforestation are given the highest priority and sites with potential for reforestation the lowest priority.

This study finds the following strategies could be pursued to increase financial viability of the proposed activities compared to the scenario considered in the study:

- Increasing the project area to approximately 500ha-800ha over 30 years.
- Increasing the proportion of the project area that implements the relatively more profitable climber management activity (or focusing on climber management only).
- Adding avoided deforestation as a project activity where appropriate.
- Increasing the sale price of carbon credits.
- Subsidising fixed costs (eg: travel costs, audit costs) by grouping regular activities with other projects, or grant-funded project development.

Loru CCA case study

A cost-benefit analysis of these activities at the existing Loru CCA project site shows that all three approaches (reforestation, climber management and combined) are profitable for the Serthiac Family Business over 30 years.

Implementing this activity at Loru would generate the following significant benefits:

- It will provide proof of concept for the approach of generating carbon credits to fund the management of *Merremia peltata* on customary owned land in Vanuatu.
- Increase the profitability of the existing Loru CCA project for all parties.
- Provide significant additional benefits to the Loru landowners (including employment of an additional Ranger position and an increase in community funds available to Serthiac).
- By registering the entire project under Plan Vivo standard v5, Nakau can make use of the grouped project clauses to establish a national forest carbon program for Vanuatu registered with Plan Vivo, making any future sites significantly more straightforward to register.

Our conclusion is that Nakau should seek to pursue the development of a Merremia Control Project at the Loru site by proceeding to project development and securing start-up investment.

Figure 1: Rexly Bune (Live & Learn Vanuatu) showing a Merremia thicket, Lape River, Santo. Photo: Marian Reid/Nakau

Introduction

The Nakau Programme has been working on forest conservation in Vanuatu since 2010, primarily through PES from Avoided Deforestation. As a result of a review of literature on deforestation in Vanuatu in 2022, Nakau is now seeking to explore the feasibility of managing infestations of the invasive Merremia vine (*Merremia peltata*) to generate carbon revenue.

This report will assess the feasibility of the two possible PES options using Merremia control to generate carbon removals in Vanuatu:

1. Conversion of Merremia thickets to forest through clearing and reforestation
2. Conversation of degraded forest to intact forest through removal of Merremia infestation

The report will also test the feasibility of applying these approaches to the existing Loru CCA project, in NE Espirito Santo Island, Vanuatu. Data and findings from the report are intended to support the writing of a Project Idea Note and/or a Project Design Document for any activities (or combination) deemed feasible on this project.

<u>Scope of the study</u>

This study is focussed on Vanuatu in general, and the Loru CCA site in North West Espiritu Santo Island in particular. It is intended to guide the selection of sites for possible project development across Vanuatu. Applicability outside Vanuatu should not be assumed.

This is a desktop level pre-feasibility study. More detailed financial planning will be needed during concept design stage. The study is primarily focussed on the technical and financial feasibility of the proposed project activity from the perspective of a Project Owner under the Nakau Programme. However, some preliminary consideration is also given to the financial feasibility of such an activity from the perspective of Nakau as Program Operator and any local NGO Project Coordinator.

All estimates are deliberately conservative, to ensure that any error in estimates is likely to be in a positive direction. Steps taken to ensure conservative estimates include:

- Carbon sales prices are assumed to be fixed at 2023 rates, despite the high likelihood that sales prices will increase over the short term and stabilise above the estimated sales price over the longer term.
- The preliminary baseline assessment identified the most likely scenario only. Any alternative baseline scenarios have not been assessed, although consideration is given to where these may be relevant and likely impact on the feasibility of the activity.
- It is assumed that project development costs will be covered by grant funds or investment funds (rather than paid for by the income sales only) to ensure minimal financial impact on the project owners.

<u>Research methodology</u>

This feasibility study is essentially a desktop study to quantify potential carbon removals, activity costs and carbon sales revenue.

Carbon accounting is based on published default values (all sources sited), and data sourced from the Loru Forest Carbon Project documentation.

Activity costs are based on Loru Forest Carbon Project documentation, grey literature related to *Merremia peltata* control and interviews with Live & learn Vanuatu field staff and community members.

Carbon Sales revenue is based on a review of carbon credit sale prices during early 2023.

Carbon methodology and technical specifications

In the next phase of project planning, an accurate quantification of PES accounting is required. This study assumes that Nakau will develop a technical specification based on Plan Vivo's PM001 Agriculture and Forestry Carbon Benefit Assessment Methodology (Plan Vivo, 2022) for this purpose.

Other options for methodologies exist with other carbon standards. However, these would require registering any projects with the relevant carbon standard, and the applicability of these methodologies have not been exhaustively assessed at this stage. Possible options include:

- VCS VM0045 Methodology for Improved Forest Management Using Dynamic Matched Baselines From National Forest Inventories (VCS, 2022)
- VCS VM0005 Methodology for Improved Forest Management: Conversion of Low Productive to High Productive Forest (VCS, 2013)
- VCS VM0006 Methodology for Implementation of REDD+ Activities in Landscapes Affected by Mosaic Deforestation and Degradation (VCS, 2017)
- CDM AR-AMS0007: Afforestation and reforestation project activities implemented on lands other than wetlands v3.1 (CDM, 2013)

A technical specification of PES accounting will be developed as part of project design to assess the carbon baseline and carbon benefits. Technical specifications are specific to the intervention type and need to be approved by Plan Vivo as part of the project verification process. The same approach will be required for all project intervention developed based on this feasibility study.

Existing Plan Vivo projects with technical specifications that could be relevant as references for any the technical specification to be written include:

- Khasi Hills Community REDD+ Project, Meghalaya, India (CFI, 2018) – Assisted Natural Regeneration activity includes enclosure of forest areas from fire, grazing and firewood collection (including follow up weed thinning and enrichment planting).
- Gul Gula Food Forest program, West Sumatra Indonesia (CO2Operate, 2022) – Ecosystem restoration activity includes management of invasive grass species to allow for natural regeneration of degraded forests.

Other examples of methodologies and technical specifications that are not applicable, but could be useful examples in development of a technical specification for any projects developed include:

- Australia Clean Energy Regulator Human Induced Regeneration methodology (Australian Clean Energy Regulator, 2022)
- American Carbon Registry Improved Forest Management in Non-Federal U.S. Forestlands Version 2.0 (ACR, 2022)

Threat assessment – *Merremia peltata* in Vanuatu

Merremia peltata in Vanuatu and the region

Merremia peltata (Convolvulacaeae) is a coarse, climbing, woody vine with a large underground tuber, found across the Indian Ocean Islands, throughout South-East Asia, northern Australia and across the Pacific region as far eastwards as Polynesia and the Society Islands (Paynter, Harman, & Waipara, 2006) (Meyer, 2000). It is particularly widespread across the Pacific, ranked eight out of 33 most significant invasive plant taxa in the region for prevalence (Meyer, 2000).

The literature is inconclusive on whether *Merremia* is native to the Pacific or not (Paynter, Harman, & Waipara, 2006), with theories as to its native range including: Malaysia-Indonesia (Paynter, Harman, & Waipara, 2006); Samoa (Kirkham, 2004); Melanesia including Fiji and the Solomon Islands (PIER, 2009); and The Seychelles, now contested (Paynter, Harman, & Waipara, 2006). Anecdotal evidence suggests that it may have been present in the Pacific for hundreds of years at least (GSID, 2023).

All research supports that even in its "native range" it is acting in a highly invasive fashion (Kirkham, 2004) (Paynter, Harman, & Waipara, 2006) (GSID, 2023) (Taylor & Kumar, 2016), with some research proposing that forest disturbance rather than invasiveness may be the primary drivers of its spread (GSID, 2023). It is certainly considered a major weed in forestry plantation areas in the Solomon Islands (GSID, 2023) and a significant environmental weed in Vanuatu (Maturin, 2012) (Live & Learn, 2015). However, some research from Samoa suggests that it naturally plays a role in assisting forest regrowth to transition from pioneer species to climax species over time (GSID, 2023).

Merremia in Vanuatu

In Vanuatu it is often anecdotally said to have been introduced to the country by US military forces during world war II as camouflage (PIER, 2009) (Ser, 2023), however this is difficult to substantiate. Its prevalence has significantly increased across the region since the 1990s due to cyclone damage in forest areas (GSID, 2023) and has also significantly increased across Vanuatu in the same time period particularly in post commercial timber harvesting areas (Ser, 2023) (Sophia Carodenuto, 2017). Anecdotally it is reported to have increased in prevalence in parts of Espiritu Santo Island where feral cattle populations have either been managed or hunted out (Leis, 2023). Climate change will likely increase the land area suitable for merremia's growth in the future (Taylor & Kumar, 2016), including areas of Vanuatu previously considered less suitable such as Western Espiritu Santo, Northern Erromango and Tanna.[1] It has recently been a focus for control in Vanuatu by DEPC at Vatthe CCA and other locations across Vanuatu by Live & Learn Vanuatu. (DEPC, 2014)

Impacts

Merramia vines can be found as dense thickets in non-forest areas (such as unmanaged/abandoned coconut plantations) and in disturbed forest. However it is also increasingly seen invading healthy forest areas from the forest margins (GSID, 2023) where it can smother trees up to 20 metres-high or more (Paynter, Harman, & Waipara, 2006). These forest infestations of merremia are responsible for large numbers of tree deaths in Vanuatu (Maturin, 2012) (Ser, 2023) (Sophia Carodenuto, 2017), a phenomenon seen also in other locations including Fiji (Edwards, 2022) and Sumatra (UNESCO, 2011)

[1] The accuracy of these the results relating to the existing suitability of sites for merremia is likely low, as merremia is difficult to detect with remote sensing and probably already present in some of the locations predicted for future spread by the research cited.

When invading forests in this fashion, lianas (woody vines) such as merremia have been found to "greatly reduce net carbon uptake and storage in this forest by reducing tree growth and recruitment, increasing tree mortality, and shifting forest-level carbon allocation to leaves rather than woody tissue" by up to 76% (van der Heijden, Powers, & Schnitzer, 2015). On flat land it is often used by smallholder farmers to suppress weeds in fallowing periods, but also prevents forest regrowth entirely in abandoned agricultural areas (Maturin, 2012) (Kirkham, 2004).

Management methods

A range of management methods are available and have ben trialled already within Vanuatu by DEPC and a small number of NGO and CBO conservation groups including Live & learn Vanuatu.

Preventing infestation and suppressing regrowth by restricting sunlight can be achieved by minimising disturbance (GSID, 2023) and replanting cleared areas with shade trees and ground covers (Live & Learn, 2015).It is also readily grazed by cattle (GSID, 2023) an approach often used by smallholders to clear garden areas. Thickets can be manually or mechanically slashed and followed up herbicide application (GSID, 2023) (Maturin, 2012).

Canopy climbers can be cut at ground level relatively easily within forest areas (Ser, 2023) (Maturin, 2012). However large mature vines may require follow up herbicide injection, due to merremia's underground tuber. This approach is likely to be a relatively cost-effective management method (Maturin, 2012) a finding supported by research into similar HIR[2] and ANR[3] methods elsewhere (Evans, 2015) (Buchanan, 1989).

The high labour requirement involved in most merremia control methods are a disincentive for voluntary community control efforts and make management expensive to fund through conventional financing (Sophia Carodenuto, 2017). Carbon markets and biodiversity markets could play a useful financing role here and are proposed by a number of sources (SPREP, 2022)(UNESCO, 2011) however no active projects have yet been identified.

Policy context

The debate as to *Merremia peltata's* native range has hampered regional declarations of its status as an "invasive species" (Paynter, Harman, & Waipara, 2006). However, it is currently listed as a priority invasive species for management by the Vanuatu Government Department of Environment Protection and Conservation (DEPC, 2014), primarily due its widespread prevalence, its impact on forests and regrowth areas, and its well documented invasive behaviour.

Figure 2: Merremia invading old coconut plantation, Vunausi, South Santo. Photo: Rexly Bune/Live&Learn Vanuatu

[2] Human Induced Regeneration

[3] Assisted Natural Regeneration

Carbon removals

Baseline description and justification

This study assumes a baseline scenario of continuation of the current land use state. This specifically includes either: closed-canopy forest areas suffering tree mortality as a result of merremia suppression degraded (open-canopy) forest areas being prevented from regrowing by merremia infestation; or cleared areas being unsuitable for natural regeneration due to merremia infestation (merremia thickets).

A preliminary assessment suggests this baseline scenario is credible (in fact it is quite widespread), while the high labour cost involved in removing merremia creates a significant economic barrier without carbon financing, which demonstrates the additionality of project activities. Furthermore, it is not expected that merremia's undecided status as a native/introduced species, or recent research supporting its longer-term role in the transition of regrowth to mature forests would represent a barrier to climber management. This is primarily based on the well-documented suppression and degradation of forests resulting from merremia infestation, and the subsequent reduction in carbon uptake and storage in effected forests (van der Heijden, Powers, & Schnitzer, 2015).

These preliminary observations are most apparent in areas where forest degradation is as a result of anthropogenic causes (eg: historical commercial logging) and would require further testing where the cause is non anthropogenic (eg: cyclone damage).

Table 1: List of Assumptions used in estimating carbon benefits

Baseline activity: Continuation of current (pre-project) land use. Specifically, this is either: complete coverage of non-forest areas by M*erremia peltata* thickets*;* and/or suppression of degraded forest area by *Merremia peltata vines.*
Baseline justification: *Merremia peltata* is a common invasive vine throughout many parts of Vanuatu and is well-documented as suppressing and degrading forested areas and causing tree mortality and preventing regrowth in cleared forest areas.
Legal barriers for baseline activity: none
Economic barriers for baseline activity: none
Institutional constraints for baseline activity: none
Current forest condition: Assumed to be either: mature forest (open or closed canopy); degraded forest because of historical logging; or non-forest covered by merremia thicket.
Carbon Pools included: above and below-ground woody biomass of planted trees; natural forest; merremia thicket and merremia climbers, deadwood caused by merremia suppression.
Carbon pools not included: Organic litter, herb stratum, soil carbon.
Leakage: Potential activity shifting leakage caused by restoration activities will be assessed in PES accounting.

Alternative baseline option – Conversion to agriculture

This study initially considered a second baseline scenario – the conversion of degraded forest into cattle pasture as this is the current baseline scenario for the Loru project considered in the Loru case study (see *Cost Benefit Analysis – Loru CCA* below). It is not yet clear however, if this would also be an applicable baseline scenario more broadly in Vanuatu. To ensure a conservative estimate of carbon benefits and more broadly applicable findings, this study includes only the baseline scenario of continuation of current land use, not conversion to agriculture.

However, when applied to the Loru CCA case study area (see *Cost Benefit Analysis – Loru CCA* below), it was found that the conversion of merremia thicket mixed with remnant forest into pasture for cattle grazing yielded much higher carbon benefits per hectare than either of the merremia management activities (see table 2).

While this is not included in this feasibility study, future projects should consider the inclusion of the conversion to agriculture baseline scenario where applicable to capture a greater quantity of carbon benefits. Considerations of additionality and leakage should be revised accordingly.

Activity description

The two activities considered for this feasibility study include: the clearing of merremia thicket followed by tree planting; and the manual removal of merremia climbers that suppress and kill trees in degraded remnant forest. The study assumed a theoretical 200 ha project site, with each activity being implemented in separate 100 ha areas within this site. The parameters and assumptions for each activity are found in tables 2 and 3 below.

Table 2: Activity Description and Assumptions - Reforestation

Parameters	Assumptions
Project Area	200ha
Area (Reforestation)	100ha
Reforestation area	6ha/yr
Merremia Control method	Cattle fenced into activity area, assumed 50% reduction of merremia biomass. Fencing required for 3 years to protect young seedlings (400m/ha)
Tree Planting	1000 trees/ha (3x3 spacing), mixed native species
Follow up Measures	Manual slashing of planting lines and around planted trees only
Measurement	Measurement of tree increment to improve PES accounting
Monitoring	Close monitoring of tree mortality and replacement of losses over 5yrs, ongoing project monitoring for the life of the project

Table 3: Activity Description and Assumptions - Climber Management

Parameters	Assumptions
Project Area	200ha
Area (Climber Management)	100ha
Climber Management area	10ha/yr
Merremia control method	Manual cutting of climbers invading tree canopy, at ground level, possible use of follow up herbicide as required.
Follow up Measures	Follow up merremia control measures annually for five years, low level ongoing maintenance required for the life of the project
Monitoring	Ongoing project monitoring for the life of the project

Baseline and project emission and removals estimates

Carbon sources and annual Net Carbon Benefits (NCB, in t CO2e) considered for each activity are as follows:

Table 4: Comparative carbon sources and net carbon benefits by project activities

Project Activity	Carbon Sources	NPCB/ T CO2e per yr[4]	NCB T CO2 per ha per yr
Reforestation (A/R)	• Project emissions from clearing of merremia thickets for tree planting (ass. 50%) • Project removals from woody biomass growth from reforestation of cleared merremia thickets	632.8	6.3
Climber Management (IFM)	• Baseline emissions from estimated mortality of 30% of tree biomass from climber suppression • Baseline removals from forest regrowth assumed 0 due to tree suppression as a result of merremia infestation. • Project emissions from clearing of merremia climbers • Project removals from enhanced forest growth through climber management in remnant degraded forest areas	672.7	6.7
Avoided deforestation (AD)	Avoided baseline emissions from conversion of forest to agriculture[5]	(site specific)	5.5
Combined (A/R+IFM)	Reforestation + Climber Management	1305.6	6.5
Combined (AR+IFM+AD)	Reforestation + Climber Management + Avoided Deforestation	2120.1	10.6

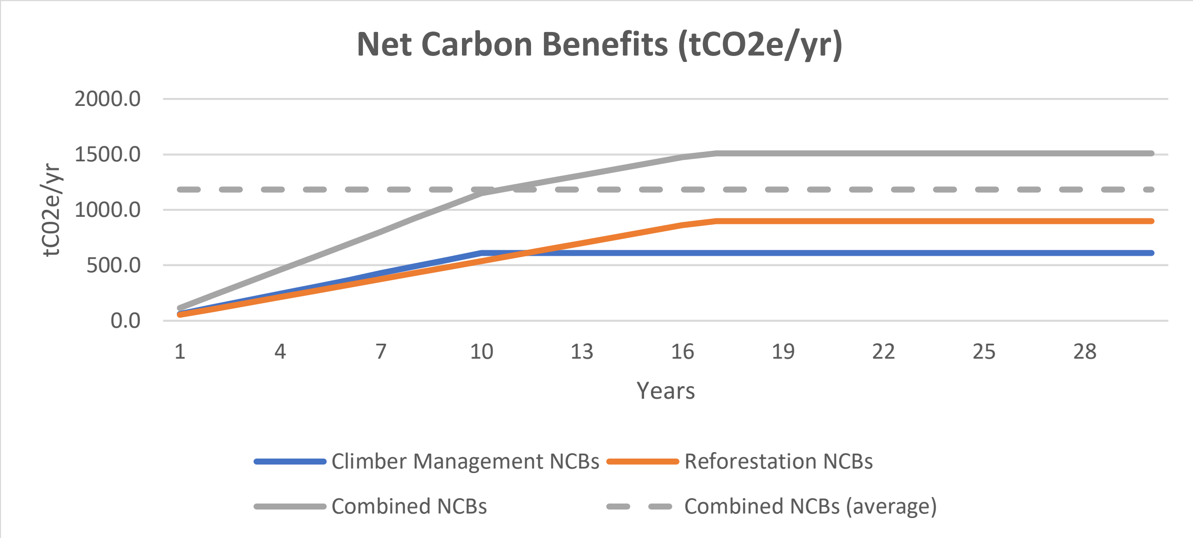
The management of merremia climbers in remnant forest yields marginally more NCB (per hectare per year on a 30-year average), than clearing merremia thickets and reforestation. However, NCB from reforestation are low in the initial 5-10 years while annual tree increment is low. This could possibly be compensated by seeking carbon standard approval to use an annual average of tree growth, or ex-ante (eg: Plan Vivo fPVCs) crediting as a basis for issuance of credits (see table 5).

Both activities combined yield slightly higher NCB per hectare per year (30-year average) than an equivalent avoided deforestation project. However, for sites where conversion to agriculture is a threat in the baseline, avoided deforestation can be added as a project intervention, significantly increasing the overall NCB for the project.

[4] Average annual Net Project Removals over 30 years

[5] Assumes forest carbon stock as per Loru Forest Inventory. See Appendix 1 for details. Note that this NPR/ha is in addition t

Table 5: Growth Curve for NCBs for Reforestation, Climber Management and Combined Activities



Notably the NCBs under an avoided deforestation project scenario remain stable for the life of the project, unlike NCBRs under reforestation and climber management which start low and increase over time as the current annual increment of planted trees increases over time. This makes avoided deforestation activities a good compliment to reforestation and forest regeneration activities, particularly in the early years when ARR NPRs are low. Identifying sites with the potential to combine both A/R and IFM (reforestation or climber management) with AD activities will be more financially viable, particularly in the early years (see below).

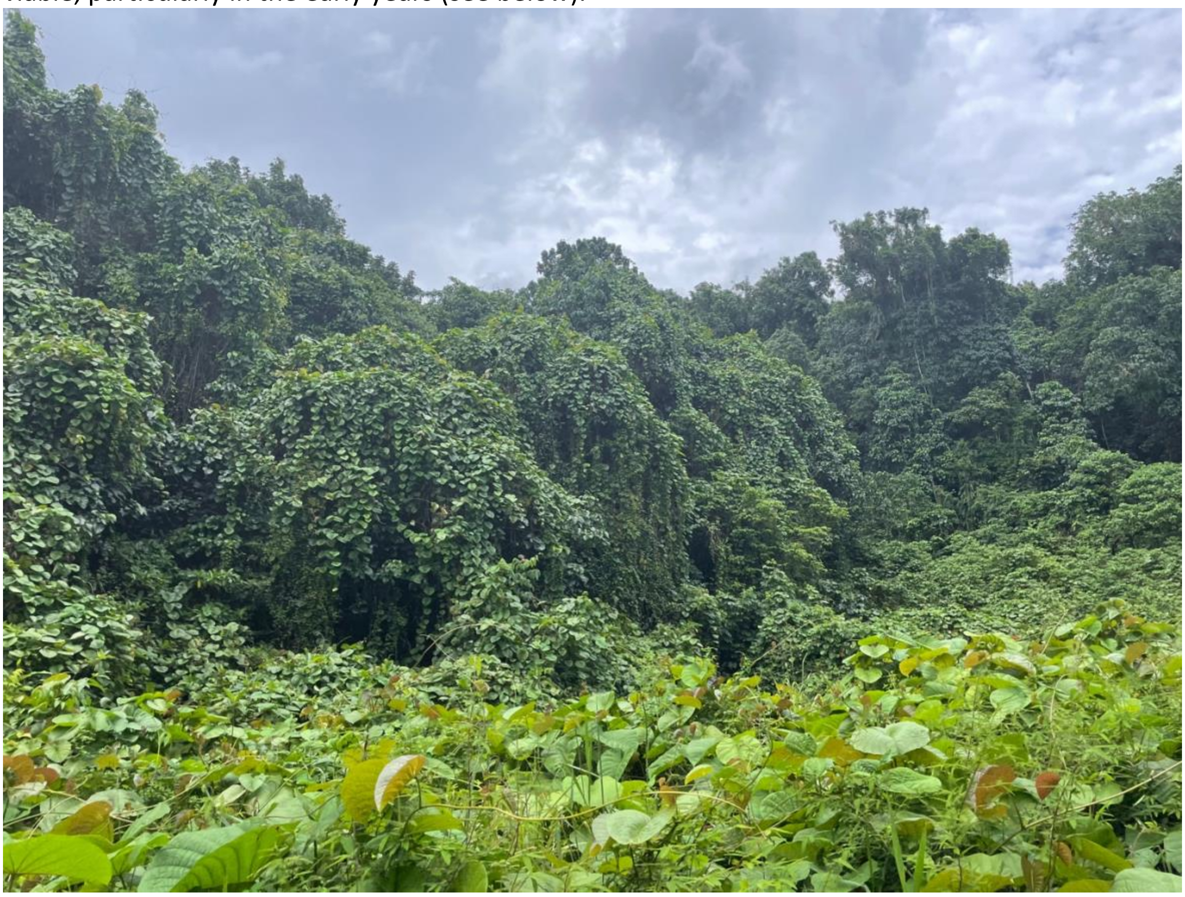


Figure 3: Merremia thicket (front) invading degraded forest (back), Lape River, N Santo. Photo: Marian Reid/Nakau

Generic cost benefit analysis

Activity costs and labour requirement

Both reforestation and climber management activities incur the highest costs in the initial 10-17 years, when clearing, planting activities and climber management activities are the most time consuming. All costings presented are based on the assumptions in table 5, and full costings found in Appendix 3.

Table 6: Assumptions for Activity Costs and Labour Requirement

Ranger Group size	2-4 Rangers
Planting rate	6ha/yr, 1000trees/ha
Planting period	Years 1-17
Follow up weeding	2 days/ha/yr manual line and spot weeding
Plantation Monitoring	1 day/ha/yr ongoing (yrs 2-30)
Replacement	Assumes 5% mortality requiring replacement
Climber Management rate	10ha/yr
Climber Management period	Years 1-10
Follow up weeding	6 monthly follow up weeding, 3x visits for each hectare cleared
Ongoing weed management	Est 5% of area cleared ongoing (yrs 2-30)
Climber monitoring	1.33 days/10ha/yr ongoing (yrs 2-30)
Finance Officer costs	Additional 20% of all Ranger hours worked
Overheads	Additional 10% of total activity costs

The combined activities will require between 1.0-1.7 FTE Rangers to implement the activities between years 1-17, with the majority being required for reforestation and clearing activities. Fencing and propagating trees are the most expensive activities due to both high material and labour costs (see appendix 3), and tree planning being the next most time-consuming activity. Climber management using the manual weeding method proposed by the Serthiac Rangers on the Loru Project requires relatively low labour, no material costs and relatively low follow up labour requirements. However its effectiveness being deployed at scale needs to be tested.

Table 7: Project Labour Requirement (FTE)

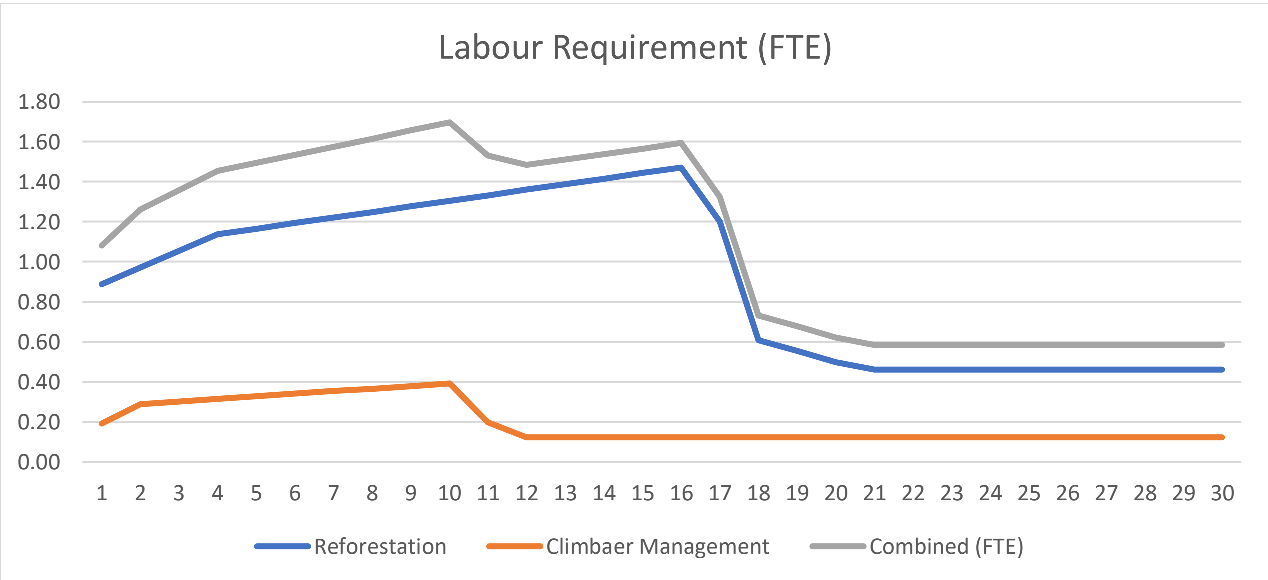


Table 8: Labour Requirement per hectare (establishment period)

Activity	Days/ha	Ha/yr	Days/yr
Reforestation (yrs 1-17)	36.1	6	216.7
Climber Management (yrs 1-10)	9.1	10	91.3
Total			308.1

The approach considered in this feasibility study is currently limited by the size of the site (200ha). Were the Ranger team to continue working at 10ha/yr of climber management and 6ha/yr of reforestation, a total of 480ha could be covered in 30 years (300ha of climber management and 180ha of reforestation). This area could be nearly doubled if the same number of work days/year was applied over 30 years to climber management in forest only.

It is questionable whether 500ha+ is within the real-world capacity of a 4 person Ranger group to treat and maintain over a 30-year period. Similarly, and plantings made in the final 5 years will not derive sufficient carbon income to cover the activity costs of clearing and planting.

However, these figures indicate that there is certainly scope to significantly increase the area being managed under the proposed approach beyond the 200ha assumed in this study.

Sales income

Revenue from carbon credit sales are estimated at USD$16.00/t$CO_2$e (or AUD $22.54/t/$CO_2$e). This figure represents an average sale price of a range of high-quality carbon credits in early 2023. This price is conservatively estimated for the life of the project, despite the likelihood prices will increase over time.

Table 9: Estimated Sales Income and revenue split under the Nakau Methodology

Revenue	%	USD	AUD[6]	VAV[7]
Total sale Price	100%	$ 16.00	$ 22.54	1316
Project Owner	60%	$ 9.60	$ 13.52	790
Project Coordinator	20%	$ 3.20	$ 4.51	263
Nakau	20%	$ 3.20	$ 4.51	263

As per the Nakau Methodology, the cost benefit analysis assumes minimum 60% of carbon sales revenue is distributed to the Project Owner undertaking the activity. 20% is paid to the Project Coordinator, and 20% retained by Nakau.

Cost Benefit Analysis – Project Owner

Cost benefit analysis for the project owner considers all costs of operating the activity in the field, compared to the 60% revenue split to the Project Owner under the Nakau Methodology.

[6] 1 AUD = 0.709863 USD, xe.com, January 2023.
[7] 1 AUD = 82.2581 VUV, xe.com, January 2023.

Climber management is found to be the most profitable activity with 71% of income retained as surplus over 30 years (table 10). This is primarily due to its low costs in relation to carbon revenue earned. The start-up investment required is only AUD $3426.40 to cover losses in the first 4 years of operations. Annual surpluses (essentially the money available for community benefit projects) grows from years 5-11 when they peak at $6923.95/yr for the rest of the project period.

Reforestation is much more costly and labour intensive, returning only a 22% surplus over 30 years. The investment required to cover losses before breaking even in year 15 is also higher $89,173.09. Annual surpluses available for community benefit sharing start from year 16 ($3,759.38), peaking at $11,426.71 in year 24 through to year 30.

It should be noted here that the figures presented define community benefit as the surplus funds available once all project costs have been paid for. However, the salaries paid to locally employed Rangers on the project is also in fact a significant community benefit as well, although currently not accounted as such here.

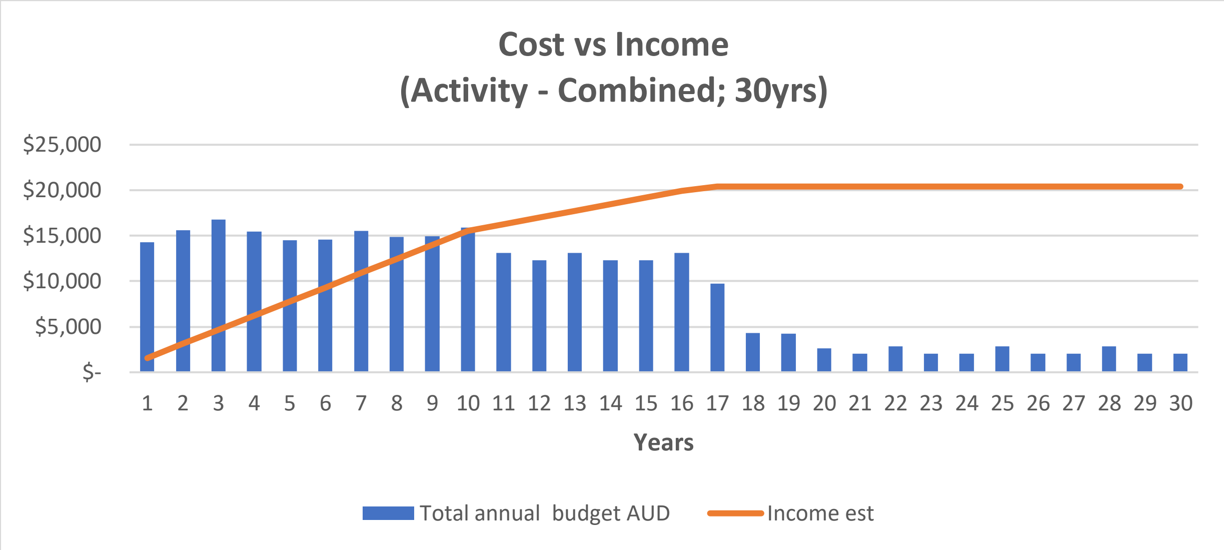
Table 10: Project Owner Profitability Results - Reforestation & Climber Management

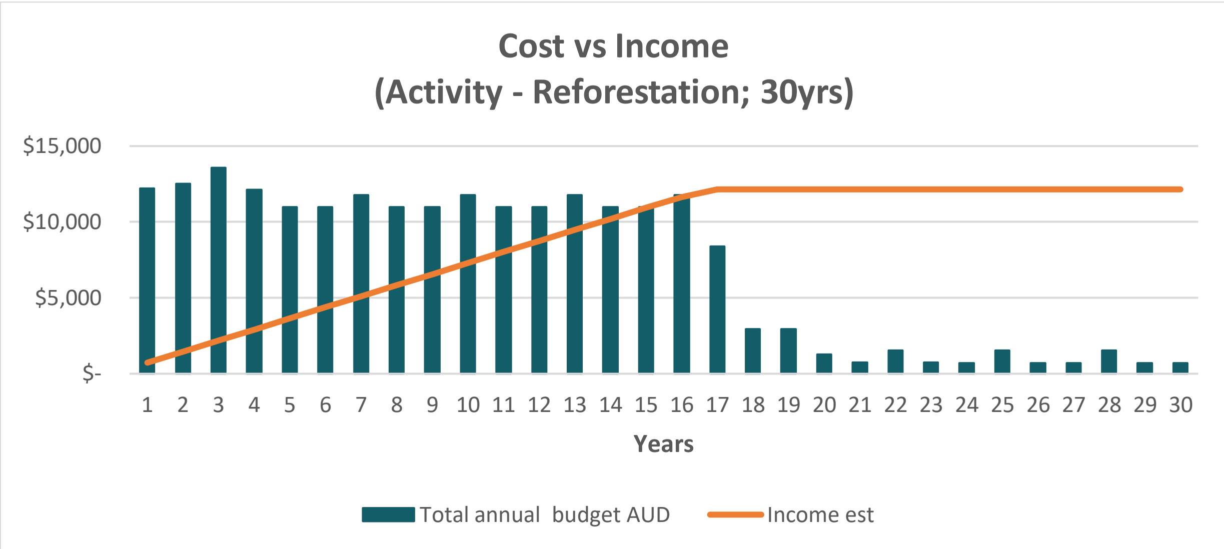
	Reforestation	Climber Management	Combined
Total Cost (30yr)	$213,832.22	$ 62,102.09	$275,934.31
Total Income (30yr)	$269,217.92	$ 210,660.59	$479,878.51
Total Surplus (30yr)	$55,385.70	$ 148,558.50	$203,944.20
% Surplus (30yrs)	22%	71%	43%
Breakeven point	Year 15	Year 4	Year 12
Start-up Investment required	$89,173.09	$ 3,426.40	$68,726.03

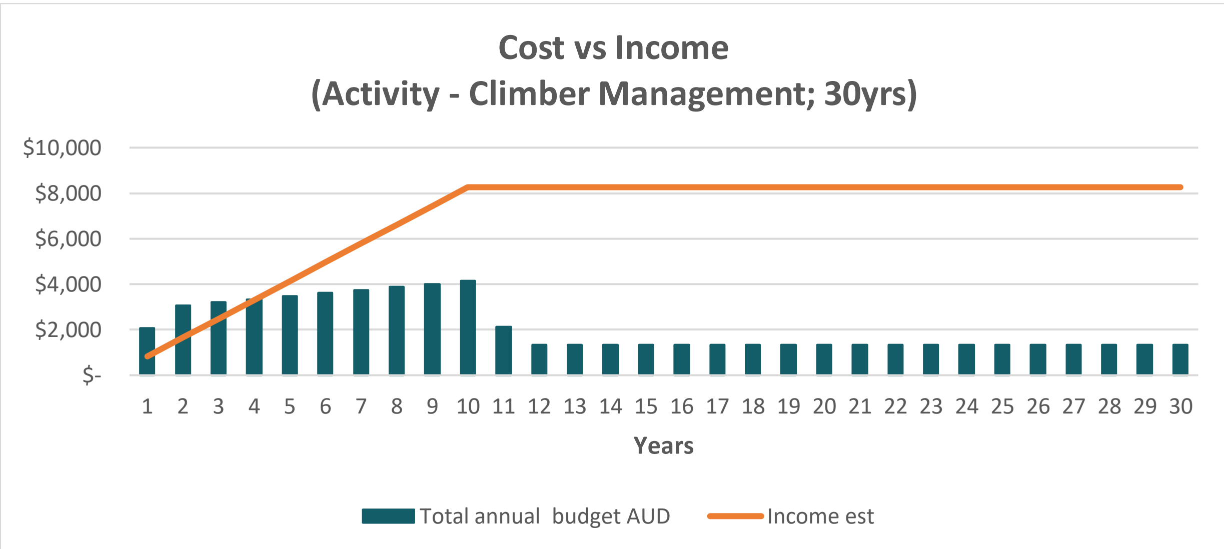
Combining activities makes the reforestation activity more profitable, with the income from climber management offsetting some of the costs of reforestation without greatly adding to costs itself.

Including conversion of the forest and merremia thicket areas to agriculture in the baseline would also increase the profitability of both reforestation and climber management activities. However, when combined this would disproportionately favour climber management compared to reforestation due to the higher loss of carbon stocks in the baseline in merremia affected forest area compared to merremia thicket only.

Figure 4: Project Owner Cost Benefit Charts for Reforestation, Climber Management and Combined







Cost benefit analysis – Nakau and project coordinator

Given current sales prices of USD$16/t$CO_2$ and the standard revenue sharing arrangement used by Nakau, a 200ha project would not be profitable for either Nakau or a local NGO Project Coordinator.

Factors that could increase the profitability of the activity making it viable for Nakau and the Project Coordinator include:

- Increasing the project area to approximately 500ha-800ha over 30 years. Most costs for Nakau and the Project Coordinator are fixed and do not increase if the project area increases. Increasing to 500ha+ roughly lines up with the upper limit of what is possible for a combined set of activities over 30 years with a 4 person Ranger group (see the Labour Requirement section above)
- Increasing the proportion of the project area that implements the relatively more profitable climber management activity (or focussing on climber management only).
- Adding avoided deforestation as an activity (for sites where the baseline scenario includes conversion of forest to agriculture). As shown in the baseline scenario section above, this could nearly double the Net Carbon Benefit and credits generated from a combined activity approach (and likely more than double if applied to climber management only).
- Increasing the sale price of credits (currently conservatively estimated at USD $16/tCO2 for the life of the project.
- Subsidizing fixed costs (eg: travel costs, audit costs) by grouping regular activities with other projects, or grant-funded project development.

Figure 5: Tree mortality in progress from Merremia infestation, NE Santo. Photo: Rexly Bune/Live&Learn Vanuatu

Cost benefit analysis – Loru Community Conservation Area

Loru Forest Carbon Project case study

This feasibility study also seeks to investigate the option of implementing merremia control activities at the existing Loru Forest Carbon Project site. Located in north-east Espiritu Santo Island in Vanuatu, the Serthiac family business already operates a relatively small avoided deforestation project within a community conservation area (CCA) at the Loru site (details below).

Table 11: Loru CCA Project details

Site Name	Loru Community Conservation Area
Project Owner	Serthiac Family Business
Staff	2 Rangers, 1 finance officer, volunteer board.
Activity	Avoided deforestation through forest protection and management. Rehabilitation of degraded forest (natural regrowth, Area B).
Registered	2015 (Plan Vivo)
Project Area	292.7 ha
Annual Net Credits Produced	3029[8]
Eligible Forest Area	201.3 ha (Areas A + B)
Non-Eligible area	91.5 ha (Area C)

A significant proportion of the existing Loru project site is made up of non-forest (Area C, 91.5ha), comprising primarily merremia thicket, with small, scattered fragments of degraded forest and coconut plantations. The proposed approach includes climber management and reforestation activities, based on the assumptions outlined in table 14 below.

Table 12: Loru CCA - Assumptions for Activity Costs and Labour Requirement

Ranger Group size	2 Rangers
Planting rate	3 ha/yr, 1000trees/ha
Planting area	57.12 ha of Merremia thicket located in Loru Area C[9]
Planting period	Years 1-13
Follow up weeding	2 days/ha/yr manual spot and line weeding
Planting Monitoring	1 day/ha/yr ongoing (yrs 2-30)
Climber Management rate	5 ha/yr
Climber Management Area	15.1 ha of Merremia infested remnant forest located in Loru Area C
Climber Management period	Years 1-4
Follow up weeding	6 monthly follow up weeding, 3x visits for each hectare cleared
Ongoing weed management	Est 5% of area cleared ongoing (yrs 2-30)
Climber monitoring	1.33 days/10ha/yr ongoing (yrs 2-30)
Finance Officer costs	Additional 20% of all Ranger hours worked
Overheads	Additional 10% of total activity costs

Under this scenario, the Serthiac Rangers could achieve the following activity level outcomes:

- Reforestation method:

[8] Nakau (2020) Loru Forest Project - Monitoring Report 2, internal.

[9] Any areas of Area C containing no Merremia thicket (eg: coconut plantation or remnant forest areas) have been excluded from this area calculation. 80% of remaining assumed available for reforestation (due to existing Serthiac plans for non-carbon agroforestry)

- 57.12 ha of merremia thicket cleared and reforested with native species over 13 years (at a rate of 3 ha per year),
    - Carbon removals would peak at 513.1 t/CO_2/yr in year 20.
    - Total area available for reforestation activity is assumed to be lower than the total 86.5ha in zone C, as some area has been identified remnant forest (15.1ha) and an additional estimated 20% is being used for livelihood activities by the landowners (agro plot style reforestation). Final areas need to be determined through a Land Use Planning process.
- Climber Management Activity
    - 15.1ha of remnant degraded forest located in Area C cleared of merremia vines in 4 years (at a rate of 5ha/yr)
    - Carbon removal yield would peak at 92.2t/CO_2/yr after vines have been cleared in year 4.
    - Total area for the climber management activity is likely much higher that 15ha, as large sections of secondary regrowth forest in Areas A and B are known to be infested with merremia. The final area would need to be determined through a weed mapping survey on site.

Cost benefit analysis – Serthiac Family Business

A cost-benefit analysis of these activities at Loru shows that all three approaches (reforestation, climber management and combined) are profitable for the Serthiac Family Business over 30 years. The actual financial benefits to Serthiac on an annual basis however are small (eg: $2861.08/yr in surplus for a combined set of activities), due to the limited area available on-site to implement these activities.

However, despite its small scale, there are a number of factors that could make this an attractive activity for the Serthiac Family Business:

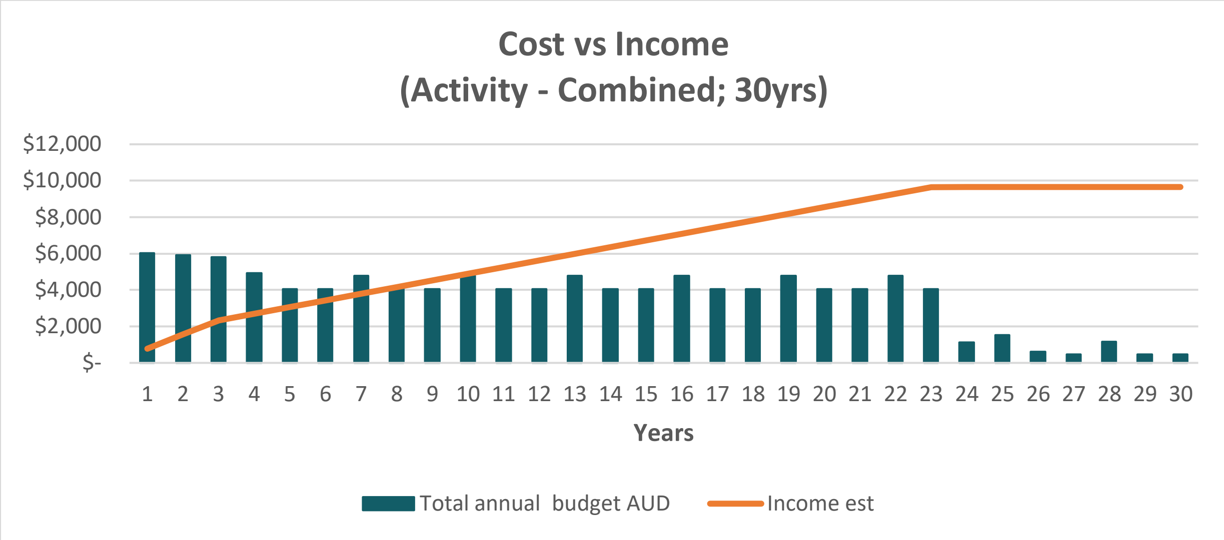
- The new activity could support the business to employ an additional Ranger position (0.6FTE), as the combined activity workload costed into this assessment averages 154 work days per year (30 year average) is equivalent to one part time position (3days/wk). As mentioned above, Ranger salaries should also be considered a community benefit from the project.
- Serthiac Rangers are already being employed using carbon sales revenue to undertake very similar activities on site but are not currently deriving any additional carbon benefits from these activities.[10]
- The project is already financially and socially beneficial to the Loru landowners and enjoys high levels of support within the community. Many of the governance and admin costs of running these new activities are already covered by the existing Loru Project. Adding these activities will increase the benefits of the project for the landowners.

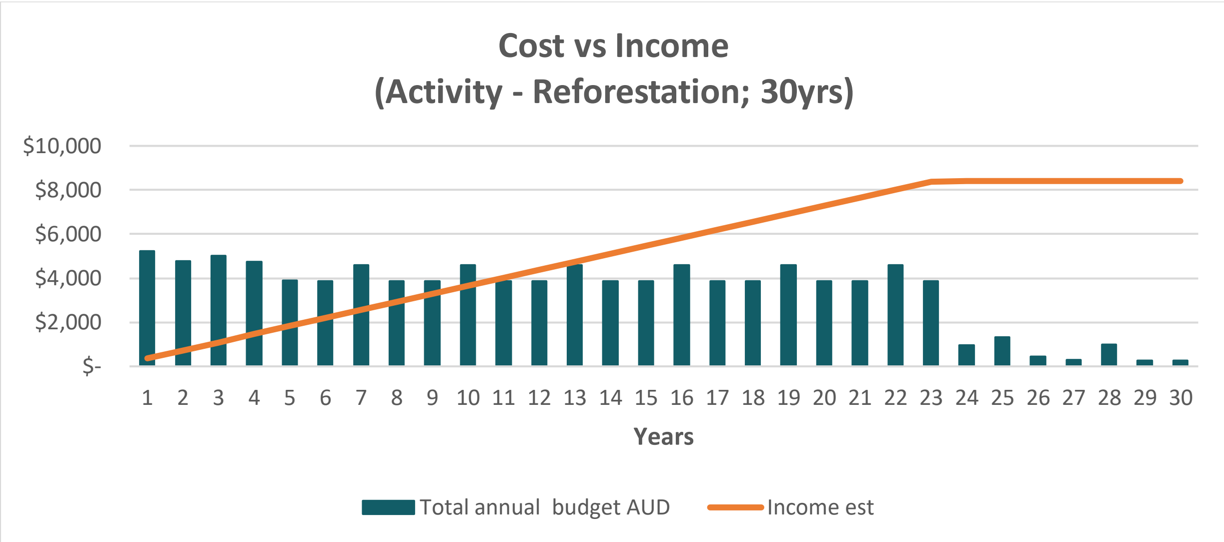
Table 13: Loru CCA site - Project Owner Profitability Results

	Reforestation only	Climber Management only	Combined
Total Cost (30yr)	$104,363.43	$ 7,489.69	$111,853.12
Total Income (30yr)	$145,581.78	$ 36,159.27	$181,741.05
Total Profit (30yr)	$41,218.34	$ 28,669.58	$69,887.93
% Profit (30yrs)	36%	79%	44%
Breakeven point	Year 11	Year 3	Year 8
Start-up Investment req	$25,226.18	$ 705.92	$18,429.14

[10] These activities (small-scale climber management in Area A and agro-plots in Area C) are not considered an issue for meeting additionality requirements, as they would not be taking place without the funding provided by carbon credit sales from the existing project.

Figure 6: Loru CCA Site - Project Owner Cost Benefit Charts for Reforestation, Climber Management and Combined Activities





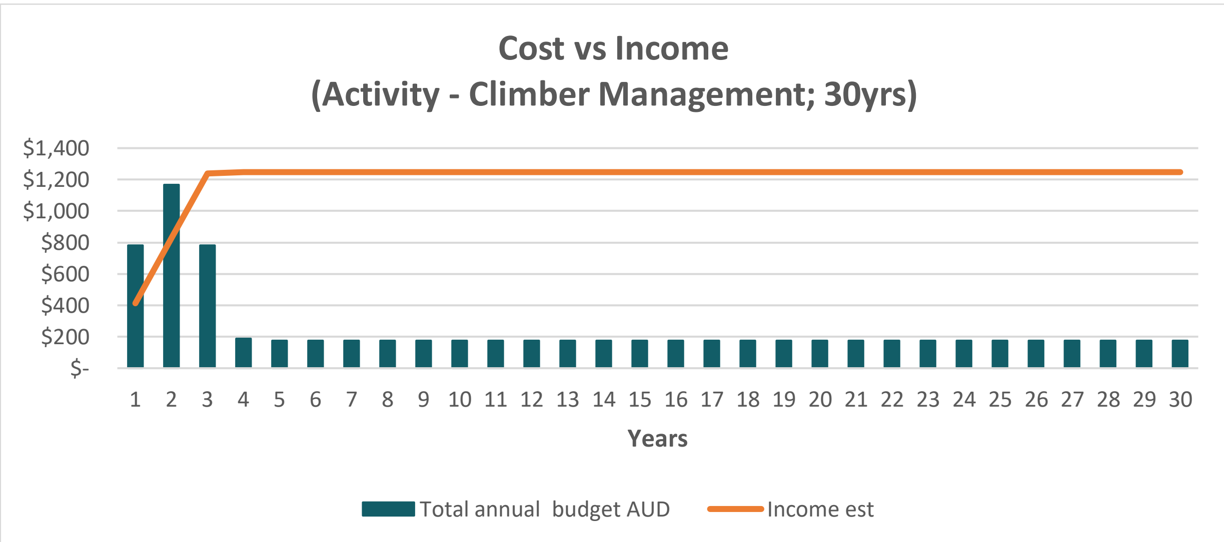


Figure 7: Chief Steven Ser planting "waetwud" in cleared Merremia thicket, Loru CCA, NE Santo. Photo: Diana Wrangham/Plan Vivo

Cost benefit analysis – Nakau and Live & Learn Vanuatu

As the Loru Forest Carbon Project is already a registered project selling carbon credits, the addition of the reforestation and climber management activities would not substantially increase Nakau or LLV's operating costs which are largely fixed. Therefore cost benefit is not calculated in the same fashion as above for a new project.

The Loru project is already not profitable for Nakau due to its small size and low credit sales, but is highly valuable for Nakau and the REDD+ sector in Vanuatu and the Pacific as the first indigenous-owned REDD+ project registered in the Pacific.

Adding the following activities to the project provides an opportunity to reduce the annual losses incurred by Nakau on the project:

- Begin both reforestation and climber management activities as a combined approach.
- Investigating the possibility of inclusions of conversion to agriculture in the baseline scenario for these new activities, in line with the existing project.
- Potentially expanding the overall project area into adjacent forest areas owned by the Serakar family to increase the conservation and eligible forest area.

Furthermore, adding the combined merremia control activities to the Loru project will provide the following strategic benefits:

- It will provide proof of concept for the approach of generating carbon credits to fund the management of *Merremia peltata* on customary owned land in Vanutau.
- By registering the entire project under Plan Vivo standard v5, Nakau can make use of the grouped project clauses to establish a national forest carbon program for Vanuatu registered with Plan Vivo, making any future sites significantly more straightforward to register.

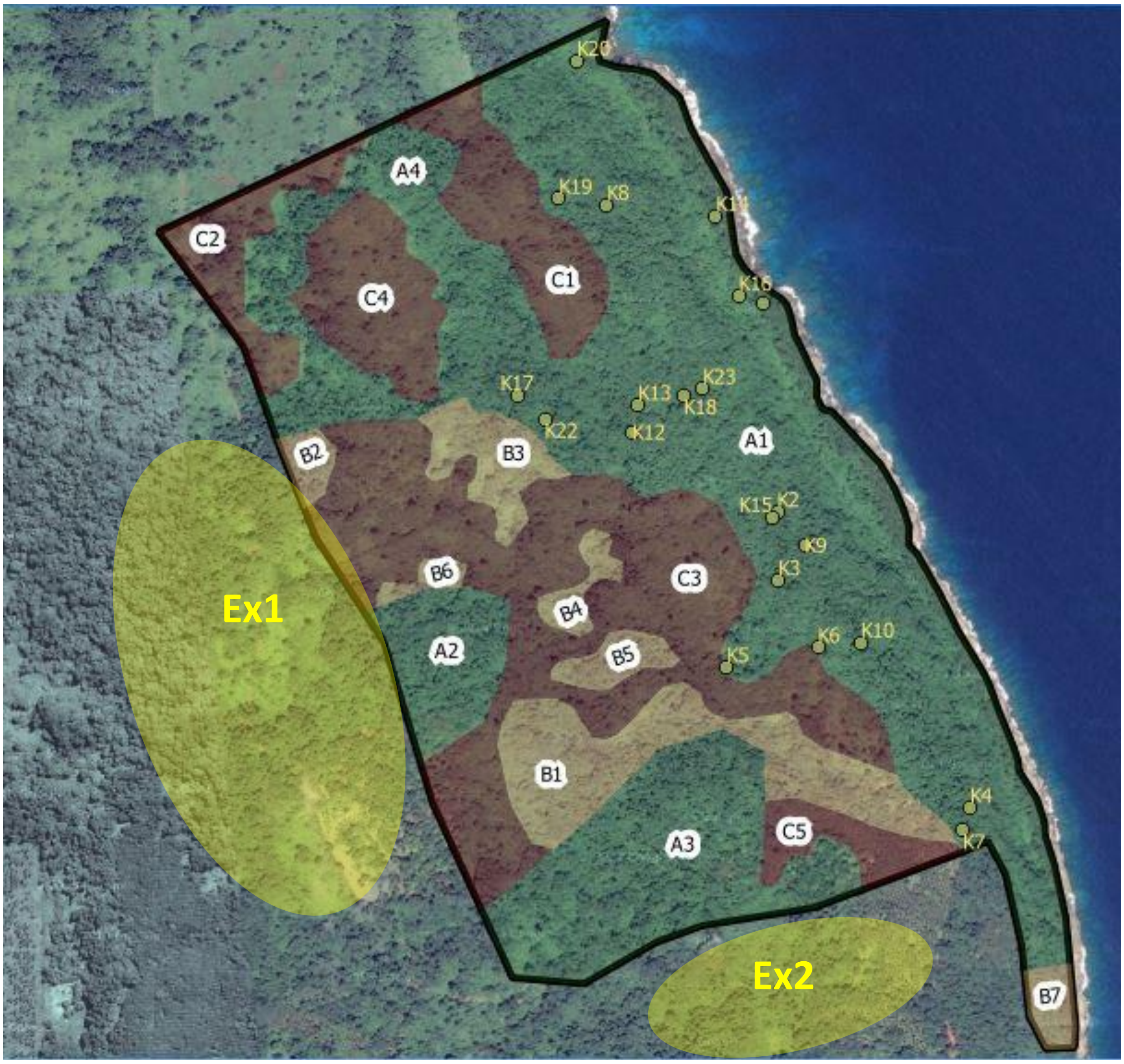


Figure 8: Loru CCA Site, NE Santo

Key

▬▬▬	Existing Community Conservation Area Boundary
Area A	Area A – Intact Forest Area (EFA)
Area B	Area B – Degraded Forest Area (EFA)
Area C	Area C – Non forest area (merremia thicket and agro-forestry plots)
Ex 1 Ex 2	Potential Expansion areas (extent not yet defined)
A1, A2, B6, etc	Stratification area labels
K1, K2	Forest Inventory sample plot locations

Conclusion and recommendations

This study finds that there is good potential for registering activities in Vanuatu that generate carbon market revenue through management of the invasive vine species *Merremia peltata*. Potential activities include the clearing of merremia thicket followed by tree planting; and the manual cutting of merremia suppressing degraded remnant forest.

This study assumes a baseline scenario of continuation of the current land use, without climber management or reforestation. However future projects should also consider the inclusion of the conversion to agriculture as an additional baseline scenario where applicable to increase carbon benefits.

A preliminary consideration of additionality suggests that there are no barriers to prevent the baseline scenario, while the high labour cost involved in removing merremia creates a significant economic barrier to the proposed set of project activities, without carbon finance.

When comparing the activities on a theoretical 200 ha site, the management of merremia climbers in remnant forest yields marginally more carbon benefits (NCB) per hectare per year on a 30 year average (6.7t/Co_2/ha/yr), than clearing merremia thicket for reforestation (6.3t/Co_2/ha/yr). However, for sites where avoided deforestation can be added as a project intervention, the overall NCB for the project will significantly increase (up to 10.6t/Co_2/ha/yr for combined activities with avoided deforestation in the baseline).

Both reforestation and climber management activities incur the highest costs in the initial 10-17 years, when clearing, planting and climber management activities are the most time consuming, but credits sales are still low. Therefore, start-up investment will be required to support landowners to establish any such activities.

The combined activities will require between 2-4 part time Rangers (1.0-1.7 FTE) to implement the activities in early establishment years. Were the Ranger team to continue working at 10 ha/yr of climber management and 6ha/yr of reforestation, a total of 480ha could be covered in 30 years. It is questionable whether 480 ha is within the real-world capacity of a small Ranger group to manage and maintain over a 30-year period. However, these figures indicate that there is certainly scope to significantly increase the area being managed under the proposed approach beyond the 200ha assumed in this study.

Climber management clearly is the most cost-effective activity, requiring less labour, a smaller start-up investment and generating greater returns over a longer period for community benefit sharing. It is far more profitable over 30 years (71% surplus) than reforestation (22%). However, its effectiveness over large areas is not tested, and it is limited to areas where existing degraded forest is suppressed by merremia.

Given current sales prices in early 2023 and the standard revenue sharing arrangement used by Nakau, a 200ha project would not be profitable for either Nakau or a local Project Coordinator. However, this study recommends that Nakau pursues *Merremia* control projects in Vanuatu, adjusted as follows to increase financial viability for Nakau:

- Increasing the project area to approximately 500ha-800ha over 30 years.
- Increasing the proportion of the project area that implements the relatively more profitable climber management activity (or focussing on climber management only).
- Adding avoided deforestation into the baseline scenario where appropriate

- Increasing the sale price of credits
- Subsidizing fixed costs (eg: travel costs, audit costs) by grouping regular activities with other projects, or grant-funded project development.

Loru CCA Case Study

A cost-benefit analysis of these activities at Loru shows that any of the 3 approaches (reforestation, climber management or combined) are profitable for the Serthiac Family Business over 30 years.

Even though this activity would not be profitable for Nakau when applied to a site of such a small scale as the Loru CCA site, it brings significant other benefits:

- Reduce existing financial losses on the Loru CCA project
- Provide significant additional benefits to the Loru landowners (including employment of an additional Ranger position and an increase in community benefit funds available to Serthiac).
- It will provide proof of concept for the approach of generating carbon credits to fund the management on *Merremia peltata* on customary owned land in Vanutau.
- By registering the entire project under Plan Vivo standard v5, Nakau can make use of the grouped project clauses to establish a national forest carbon programme for Vanuatu registered with Plan Vivo, making any future sites significantly more straightforward to register.

Nakau should seek to pursue the development of a Merremia Control Project at the Loru site through climber management and reafforestation activities combined.

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Appendixes

Appendix 1: Emissions Removals Estimates

General Parameters	Value	Unit	Assumptions/Data Source
Area Zone C (ha)	200	ha	Default Site estimate
Remnant Forest (degraded forest)	100	ha	Default Site estimate
Merremia thicket	100	ha	Default Site estimate
Carbon Stock AG+BG Woody Biomass Forest	365.7	t CO2 ha-1	Loru Forest Inventory (Area B)
Carbon Stock AG+BG Woody Biomass Forest	36567.0	t CO2	
Carbon Stock AG+BG Merremia thicket	7082.9	t CO2	IPCC 2006 Chapter 4 biomass in tropical shrubland Asia table 4.8
Project Period	30	years	
Forest AG biomass growth (Natural Forest)	3.4	t d.m. ha-1 yr-1	IPCC 2006 Chapter 4 Table 4.9
Forest AG biomass growth (Tropical Plantation)	5	t d.m. ha-1 yr-1	IPCC 2006 Chapter 4 Table 4.10
Biomass Merremia	30	t.d.m. ha-1	IPCC 2006 Chapter 4 biomass in tropical shrubland Asia table 4.8
Carbon Fraction Woody Biomass	0.49	dimensionless	IPCC 2006 Chapter 4 Table 4.3
Carbon Fraction Woody Foliage	0.47	dimensionless	IPCC 2006 Chapter 4 Table 4.3
C to CO2 conversion	3.67	dimensionless	
Factor Below Ground Biomass	1.37	dimensionless	IPCC 2006 Chapter 4 Table 4.4
Carbon Parameters	**Value**	**Unit**	**Assumptions/Data Source**
Baseline Emissions (AG+BG Deadwood)	365.7	t CO2 yr-1	Estimated mortality of 30% of tree biomass from climber suppression
Baseline Removals (Woody Biomass)	0.0	t CO2 yr-1	Forest Regrowth in baseline scenario is assumed to be zero due to climber suppression
Project Removals (Natural Forest biomass growth)	711.4	t CO2 yr-1	Enhanced AG+BG woody biomass growth through climber management in forest fragments
Project Removals (Planted trees biomass growth)	909.1	t CO2 yr-1	AG+BG biomass growth from reforestation of Merremia thickets
Project Emissions (Merremia Clearing)	-118.0	t CO2 yr-1	AG+BG Project emissions from clearing of Merremia thickets for tree planting (ass. 50%)
Project Emissions (Merremia Clearing)	-236.1	t CO2 yr-1	AG+BG Project emissions from clearing of Merremia through climber management
Net Baseline Emissions	365.7	t CO2 yr-1	
Net Project Benefits	1266.3	t CO2 yr-1	
Net Carbon Benefits	1632.0	t CO2 yr-1	
Risk Buffer	326.4	t CO2 yr-1	20% under Plan Vivo
Potential PVCs	1305.6	t CO2 yr-1	

Appendix 2: Carbon Emission and Removal Estimates Loru CCA

General Parameters	Value	Unit	Assumptions/Data Source
Total Area Zone C (ha)	86.5	ha	Loru GIS
Remnant Forest	15.1	ha	Loru GIS
Merremia thicket	69.2	ha	Loru GIS
Carbon Stock AG+BG Woody Biomass Forest	365.7	t CO2 ha-1	Loru Forest Inventory
Carbon Stock AG+BG Woody Biomass Forest	5521.6	t CO2	
Carbon Stock AG+BG Biomass Merremia thicket	4901.4	t CO2	IPCC 2006 Chapter 4 biomass in tropical shrubland Asia table 4.8
Project Period	30	years	
Forest AG biomass growth (Natural Forest)	3.4	t d.m. ha-1 yr-1	IPCC 2006 Chapter 4 Table 4.9
Forest AG biomass growth (Tropical Plantation)	5	t d.m. ha-1 yr-1	IPCC 2006 Chapter 4 Table 4.10
Biomass Merremia	30	t.d.m. ha-1	IPCC 2006 Chapter 4 biomass in tropical shrubland Asia table 4.8
Carbon Fraction Woody Biomass	0.49	dimensionless	IPCC 2006 Chapter 4 Table 4.3
Carbon Fraction Woody Foliage	0.47	dimensionless	IPCC 2006 Chapter 4 Table 4.3
C to CO2 conversion	3.67	dimensionless	
Factor Below Ground Biomass	0.37	dimensionless	IPCC 2006 Chapter 4 Table 4.4
Carbon Parameters	**Value**	**Unit**	**Assumptions/Data Source**
Baseline Emissions (AG+BG Deadwood)	55.2	t CO2 yr-1	Estimated mortality of 30% of tree biomass from climber suppression
Baseline Removals (Woody Biomass)	0.0	t CO2 yr-1	Forest Regrowth in baseline scenario is assumed to be zero due to climber suppression
Project Removals (Natural Forest biomass growth)	122.1	t CO2 yr-1	Enhanced AG+BG woody biomass growth through climber management in forest fragments
Project Removals (Planted trees biomass growth)	538.4	t CO2 yr-1	AG+BG biomass growth from reforestation of Merremia thickets
Project Emissions (Merremia Clearing)	-81.7	t CO2 yr-1	AG+BG Project emissions from clearing of Merremia thickets for tree planting (assumed 50%)
Project Emissions (Merremia Clearing)	-35.7	t CO2 yr-1	AG+BG Project emissions from clearing of Merremia through climber management
Net Baseline Emissions	55.2	t CO2 yr-1	
Net Project Benefits	543.2	t CO2 yr-1	
Net Carbon Benefits	598.4	t CO2 yr-1	
Risk Buffer	119.7	t CO2 yr-1	20% under Plan Vivo
Potential PVCs	478.7	t CO2 yr-1	

Appendix 3: Cost Estimate Generic (per Hectare)

Costs	Unit Type	# of units	Unit rate	Hectare costs	Hectare Costs
			VAV	VAV	AUD
Reforestation Activity					
temp fencing	m rate fencing, 1 ha	400	96	38,400	$ 466.82
temp fencing install	Ranger work days	12.1212121	2500	30,303	$ 368.39
Slashers x2 (replacement cost)	Units	1.0	60,000	60,000	$ 729.41
Running Costs per ha, slashers	VAV/ha	1.0	4,424	4,424	$ 53.78
Labour Propagate trees, per hecatre	Ranger work days	12	2500	30,000	$ 364.71
Ranger labour planting, one hectare	Ranger work days	8	2500	20,000	$ 243.14
Labour ongoing weeding	Work days to spot slash 1ha trees	2	2500	5,000	$ 60.78
Labour monitoring	work days/ha	1	2500	2,500	$ 30.39
Finance Officer costs	est 20% of all labour costs	20%		25,241	$ 306.85
Admin overheads costs	est 10% of all costs	10%		21,587	$ 262.43
Total project reforestation budget/hectare				**237,454**	**$ 2,104.89**
Climber Management Activity					
Ranger work – Merremia clearing	Ranger work days/ha	4	2500	10,000	$ 121.57
Ranger work - follow up weeding	Ranger work days/ha	1	2500	2,500	$ 30.39
Ongoing weed control	Ranger work days/ha	4	2500	10,000	$ 121.57
Labour monitoring	work days/ha	0.13333333	2500	333	$ 4.05
Finance Officer costs	est 20% of all labour costs	20%		4,567	$ 55.52
Admin overheads costs	est 10% of all costs	10%		2,740	$ 33.31
Total annual climber management budget/hectare				**30,140**	**$ 366.41**

Front cover and back cover Merremia on Santo. Photos: Marian Reid/Nakau

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