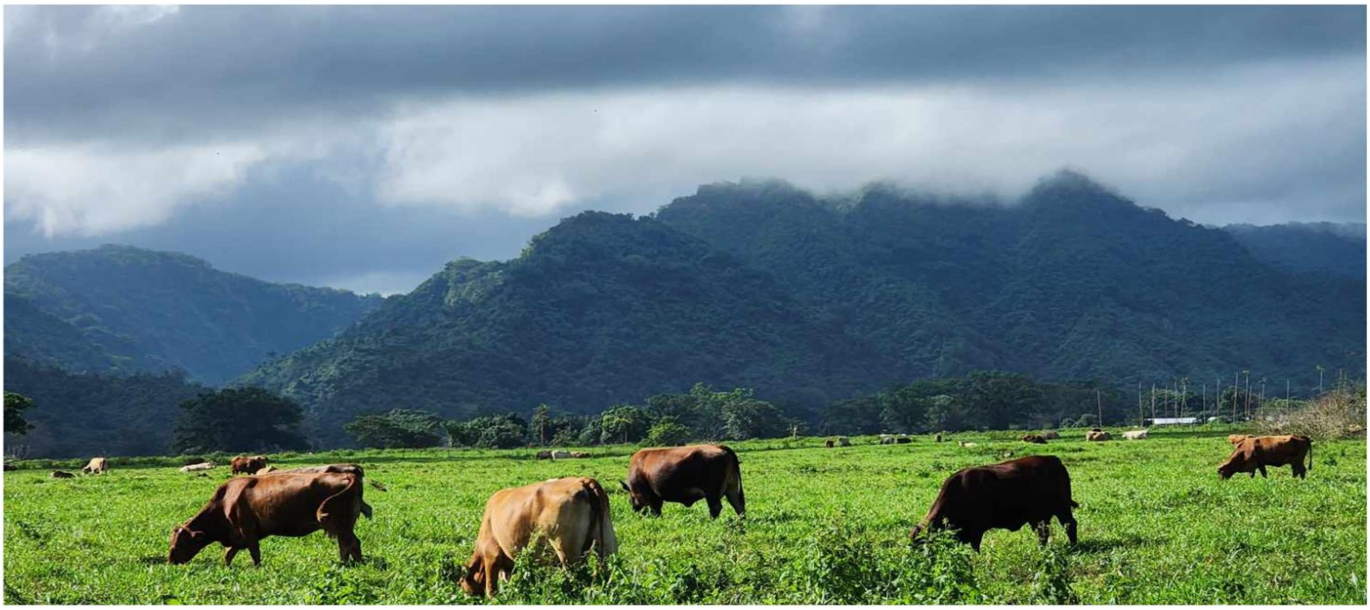

AGRICULTURE POLICY ASSESSMENT FOR VANUATU

March 2025

DISCLAIMER

PREPARED UNDER

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AGRICULTURE POLICY ASSESSMENT

Initiative for Climate Action Transparency – ICAT

Deliverable 2A

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ACRONYMS

C	Carbon
CO_2	Carbon Dioxide
CO_2 e	Carbon Dioxide equivalent
CH_4	Methane
DARD	Department of Agriculture and Rural Development
EF	Emission Factor
FAO	Food and Agriculture Organization
F_I	Input Factor
F_{LU}	Land Use Factor
F_{MG}	Management Factor
GHG	Greenhouse Gas
GHGMI	Greenhouse Gas Management Institute
GWP	Global Warming Potential
HAC	High Activity Clay
ICAT	Initiative for Climate Action Transparency
IE	Intermediate Effect
IPCC	Intergovernmental Panel on Climate Change
IRCCNH	Increasing Resilience Climate Change and Natural Hazard
KPI	Key Policy Indicator
LAC	Low Activity Clay
LULUCF	Land Use, Land-Use Change and Forestry
MALFFB	Ministry of Agriculture, Livestock, Forestry, Fisheries and Biosecurity
MOCC	Ministry of Climate Change
N	Nitrogen
NA	Not Available/Applicable
NGO	Non-Governmental Organization
NLP	National Livestock Policy
N_2O	Nitrous Oxide
OPSP	Overarching Productive Sector Policy
SOC	Soil Organic Carbon
SOC_{REF}	Soil Organic Carbon Reference
SPC	The Pacific Community
UNDP	United Nations Development Programme
VNAC	Vanuatu National Agriculture Census
VOL	Volcanic

INTRODUCTION

The significance of the agriculture sector for national development has become increasingly evident in Vanuatu. Agriculture serves as a cornerstone for social well-being, cultural identity, and livelihoods. It acts as a catalyst for economic growth while also promoting environmental integrity, biodiversity conservation, and risk reduction. The country faces numerous development challenges common among Pacific Island countries, including issues related to climate change, climate variability, natural hazards, population growth, evolving cultural practices, economic inequality, limited market access, geographic disparities, inconsistent technical support, and insufficient access to credit, among others. In Vanuatu, stakeholders in the agriculture sector have been actively addressing these risks, often responding to challenges as they arise and as resources become available. As such, the Vanuatu agricultural policies focus on protecting nation's agricultural resources, which are to be managed in an integrated and sustainable manner, ensuring food security, enhancing incomes, and contributing to environmental and social services that promote the well-being of all citizens in Vanuatu.

Due to the significant role of the agriculture sector in Vanuatu's economy and development, agriculture also contributes to country's greenhouse gas (GHG) emissions. Agriculture sector is the second largest GHG emitter in the country, hence requires policy intervention in order to enhance mitigation efforts of emissions into the atmosphere. Assessing the agricultural policies and their impact on GHG emissions requires a clear understanding of their implementation by the Ministry of Agriculture, Livestock, Forestry, Fisheries, and Biosecurity (MALFFB). Working together with MALFFB also helps align national priorities and activities across ministries and inform future policy development.

The two policies evaluated in this report implemented by the Livestock Department and the Agriculture Department are Commercial Livestock Production and Environmental Protection and Sustainable Farming, respectively. These policies pertain to sources of greenhouse gas (GHG) emissions within the agriculture sector.

Through the Initiative for Climate Action Transparency (ICAT) Project, which focused on building capacity to establish monitoring and reporting systems for the agriculture sector, national experts have collaborated with the Greenhouse Gas Management Institute (GHGMI), the Ministry of Climate Change (MOCC) and MALFFB to implement this assessment. This assessment applies the ICAT Policy Assessment Methodology and aims to provides crucial insights for decision-makers regarding the mitigation effects of these policies. It also offers valuable information to enhance policy design and implementation for improved GHG outcomes.

The purpose of this report is to:

a. Document the selection of two agricultural sector policies for evaluation.
b. Present policy descriptions including causal chains illustrating the effects of these policies within the agricultural sector.
c. Evaluate the impact of these policies on greenhouse gas (GHG) emissions.
d. Identify policy's potential contribution to sustainable development.
e. Establish indicators for measuring policy impacts.

SELECTION OF TWO AGRICULTURE SECTOR POLICIES FOR ASSESSMENT

The selection of two agricultural sector policies for assessment followed a prioritization method provided by the ICAT Agriculture Policy Assessment Methodology to identify policies most relevant in terms of their effect on greenhouse gas emission sources, data availability, and national priorities. Prior to selecting these policies, national experts, with assistance from the Department of Climate Change, consulted with the Agriculture director to ensure the relevance of the chosen policies. The following policies implemented by MALFFB, were reviewed to determine which elements of the policies would be subject to GHG impact assessment:

1. Vanuatu Agriculture Sector Policy (2015-2030)
2. Vanuatu National Livestock Policy (2015-2030)

Vanuatu Agriculture Sector Policy (2015-2030)

In order to maintain a viable agriculture sector in light of changing and increasingly variable climate conditions, the sector ought to employ adaptation and mitigation measures. This includes ensuring that the farming methods employed are able to withstand the likely climate impacts but also that measures are taken to reduce greenhouse gas emissions and promote better agricultural practices. Agriculture is a wide and intertwined sector in Vanuatu and therefore it is necessary to have an all-rounded and all-inclusive strategy for its growth and sustainability.

The Agricultural Policy represents a 15-year strategic plan that sets out to promote economic development, social wellbeing, environmental conservation, and cultural enrichment in Vanuatu. The policy aims at ensuring that food and cash crops as well as farmland of Vanuatu are managed in ways that are both sustainable and profitable. In addition, all efforts are being made so that by 2030, the policy will help attain the planned sustainable development goals.

The design of the policy aims to maintain integrated and sustainable management of the agricultural resources of the country. These strategies are meant to provide food assistance, raise the earnings, and also provide environmental and social services with a particular emphasis on improving the wellbeing of all in Vanuatu. The Vanuatu Agriculture sector policy includes 13 thematic areas:

1. Institutional Setup and Compliance
2. Extension and Training
3. Finance
4. Agriculture Land Use
5. Agriculture Investment
6. Research and Development
7. Planting Materials, Tools and Agricultural Inputs
8. Environmental Protection and Sustainable Farming
9. Production and Market Access
10. Food Security
11. Employment
12. Climate Variability, Climate Change and Disaster Risk Reduction
13. Gender and Vulnerable Groups

Thematic area 8 (Environmental protection and sustainable farming) was selected for analysis as it is expected to have an impact on GHG emissions and removals.

The objectives of thematic area 8 are:

- Environmentally friendly agriculture
- Agriculture soils improved and conserved

The policy aims to integrate environmental aspects in agriculture practices by promoting sustainable approaches to agriculture such as agroforestry and the application of soil management technologies in all agriculture practices. Their focus includes inclusion of practices such as integration of buffer zones and wildlife corridors into all agricultural activities, conducting valuation of native flora and fauna in Agricultural enterprises, and formulation and enforcement of environmental policies that enhance sustainable agriculture. Also, the aim is to protect and promote the sustainable forms of traditional agriculture. Appropriate soil enhancement technologies will be promoted to increase soil quality. Different methods of farming include backyard gardening and the use of agroforestry, such as alley cropping, intercropping, contour farming, compost application, and growing of cover crops.

Backyard gardening practices compose of multiple benefits that contribute to have an effect on GHG emission and removals. Following the pandemic, Vanuatu faced significant challenges regarding food security, prompting the government and local communities to make it a priority to enhance food security measures. Backyard gardening has been recognized as a vital practice that supports food production in Vanuatu. It enables families to grow a variety of vegetables and fruits close to their homes which consequently promotes nutrition, improves soil sequestration, reduction of soil erosion, improve soil health, enhance food security and increase food productivity (Krosofsky, 2021). Agroforestry practices involves planting trees and shrubs into rows alongside crops. It offers multiple benefits including increasing farm productivity, improve soil quality by enhancing soil fertility, reduce soil erosion, conserve biodiversity, improve water circulation and sequester carbon (Akter, Hasan, Kabir, Darr, & Roshni, 2022). In Vanuatu, where many communities rely on subsistence farming, alley cropping and silvopasture also provide a way to diversify food sources and improve resilience against climate change impacts. The addition of organic fertilizer is vital for sustainable agricultural practices due to its impact on improving soil quality and increase production of crop yield. Agroforestry, backyard gardening, and organic fertilizer have been recognized as significant agricultural practices in Vanuatu. As they highly contribute to food security, improving agricultural production, sustainable land use.

Both agroforestry and backyard gardening are integral components of Vanuatu's agricultural policy which both reflect the importance of traditional knowledge that combines innovative approaches to farming. These agriculture practices equally support climate smart agriculture by increasing resilience, and adaptation to challenges posed by climate change within the agriculture sector. For the purpose of this policy assessment, only alley cropping and backyard gardening will be evaluated because they are expected to have significant effects on GHG emissions and removals.

Vanuatu National Livestock Policy (2015-2030)

The National Livestock Policy (NLP) emphasize the importance of integration, whereby livestock development is included as part of broader sustainable development objectives. This promotes a 'No Regrets Development' practice in order to make sure that the policy's directives and strategies do not exacerbate the climate or the environment. It seeks to enhance climate adaptation, lower risks, and maintain ecological health so that livestock development is beneficial to the long-term sustainable development of the nation.

The NLP constitutes a strategic plan with a time frame of 15 years which is designed to further the overall socio-economic development of Vanuatu in an integrated manner. The policy also integrates environmental, climate resilient activities that are most likely to foster sustainable development within the livestock sector. Among the specific targets of the policy is the target to reach a national herd of 500,000 beef cattle head by the year 2025 which demonstrates the government's pledge to improve the productivity and capacity of the sector.

The policy states that the livestock sector's goal is to establish a beneficial policy environment that adopts modern technologies and practices. This will enhance productivity within Vanuatu's livestock sector while at the same time shielding it from multiple threats. The policy calls for balanced delivery of the essential services and products to the people of Vanuatu. It calls for cooperative arrangements among the various sectors to help achieve these objectives which seek the welfare of the whole country in an inclusive and sustainable manner.

The Vanuatu Livestock Policy includes 16 thematic areas:

1. Small Holder Livestock Production
2. Commercial Livestock Production
3. Livestock Industries & Marketing
4. Livestock Genetic Resources
5. Animal Health & Public Health
6. Land Use
7. Livestock Feed, Water & Nutrition
8. Environment, Climate Change & Disaster Risk Management
9. Finance & Planning
10. Institutional Setup & Governance
11. Communication, Extension, Awareness & Training
12. Research
13. Infrastructure & Technology
14. Women & Vulnerable Groups
15. Investment
16. Monitoring & Evaluation.

Thematic area 2 (Commercial livestock production) was selected for assessment.

Commercial livestock production has been the major protein supplier to Vanuatu as well as the export market to other countries. The local beef meat is of quality and taste and ranked the highest in the Pacific region. Constraints in this sector include lack of farmland, lack of proper management and land leases arranged by the government. To improve commercial livestock nationwide, the government encourages collaboration between existing commercial and smallholder livestock farmers to support increased production and growth in this sector. Additional services that support strengthening commercial livestock production is facilitated through trainings and workshops, enabling farmers to learn best practices for livestock management within the sector.

Improved pasture management is also prioritized under the policy.

This thematic area was selected because the activities under this policy has a direct effect on GHG emissions. Development of commercial livestock relies on increasing herd size of cattle and more intensive use of pasture for meat production. Enteric fermentation occurring in cattle's digestive system is a source of methane, a greenhouse gas. The expansion of the livestock sector leads to increases in methane emissions from the enteric fermentation process. The policy aims to manage GHG emissions by improving the cattle productivity (reducing methane emission intensity) and improving pasture quality (increasing soil carbon sequestration).

Quantifying of greenhouse gas emissions from the two key policies in Agriculture and Livestock sector will allow experts in cooperation with policy makers to provide and develop GHG mitigation recommendations to be considered in the Vanuatu's NDC. The policy assessments can help the Livestock Department demonstrate that improving cattle farming may also mitigate GHG emission. Improved understanding of policy impacts can help policy and decision makers to effectively mitigate GHG emissions.

CLIMATE ZONE AND SOIL TYPE

Vanuatu is in a tropical wet climate zone where it experiences hot and humid conditions annually. The temperature typically ranges from 26ºC – 34ºC with annual rainfall of over 4000 millimeters (mm). The climate contributes to the country's vegetation and is suitable for several agricultural activities (WorldBank, 2021).

The climate and the geological location of the country contributes to the different soil types identified in the different provinces such as Cambisol, Andosol, and Ferralsol, all of which categorized under three soil class: Volcanic soils (VOL), High activity clay soils (HAC), and Low activity clay soils (LAC).

Considering Vanuatu's climate and the different soil types, the assessment of the Agriculture and Livestock policy utilizes emission parameters based on climate zone- Tropical Wet, and soil classes – VOL, HAC and LAC. The applicable default values used for calculations in both policies are from the 2019 Refinement to the 2006 IPCC Guidelines (2019 IPCC). Refer to Table A1.1 and A1.2 in Appendix 1.

POLICY 1: VANUATU AGRICULTURE SECTOR POLICY

THEMATIC AREA 8: ENVIRONMENTAL PROTECTION & SUSTAINABLE FARMING

ASSESSMENT OBJECTIVES

The objective of the agriculture policy assessment is to calculate the annual changes in carbon stocks in mineral soil and biomass associated with agroforestry practices, specifically alley cropping and backyard gardening, across the provinces of Vanuatu. This assessment will evaluate the carbon stock variations and associated GHG emissions and removals that occurred as a result of cropland changes from policy start in 2015 to 2024 and for the remainder of the policy implementation period.

The assessment will also contribute to achieve the following goals:

- Track the progress of the policy ensuring it reaches its full purpose.
- Identifying how this policy impacts GHG emissions within the agriculture sector.
- Documenting policy activities
- Identifying the required data to get a more precise estimation and accuracy.
- Gaining understanding of the methodology for evaluation to apply to other policy initiatives.

The intended audience would include farmers and agricultural producers, policymakers, government officials, researchers, non-governmental organizations (NGOs), as well as environmental departments and organizations.

STAKEHOLDER PARTICIPATION

Stakeholder engagement activities conducted during the assessment include:

- Workshop: Organized discussions to gather input and perspectives from various stakeholders and understand policy activities.
- Interviews: One-on-one conversations with key stakeholders to gain in-depth insights and gather available data.

POLICY DESCRIPTION

General Information

Policy Name: Vanuatu Agriculture Sector Policy 2015-2023, Thematic area 8: *Environmental Protection & Sustainable Farming.*

Organization conducting the assessment: Department of Climate Change under the ICAT project scope.

Assessment Date: July 2024 – November 2024

Detailed Description

A comprehensive description of the policy under assessment is crucial for understanding its implications and evaluating its impact on greenhouse gas emissions. The essential elements to consider in this policy description include:

- Key components for policy description
- Description of the policy being assessed
- Identification of the assessment boundary
- Interaction with other policies

Table 1 presented below offers an overview of the policy, in accordance with the ICAT Agriculture Assessment Methodology. This includes critical information such as policy objectives, mitigation measures affecting GHG emissions, corresponding targets, geographic scope, timeline, budgetary considerations, identification of key stakeholders impacted by the policy, and the greenhouse gases targeted for mitigation.

Table 1: Agriculture Policy Description

Name of the policy*	**Vanuatu Agriculture Sector Policy 2015-2023, Thematic area 8: Environmental Protection & Sustainable Farming**
Type of policy instrument*	Voluntary agreements or actions, subsidies and incentives, research, development/information instruments.
Description of specific interventions*	Implement agroforestry practices such as intercropping root crops with perennial crops (alley cropping); and silvopasture. Establish urban gardens in yards to support local food production; Facilitate application of organic fertilizer (purchased or homemade) to increase production in the back yard gardens
Status of the policy*	Adopted, Implementation ongoing
Date of implementation*	Proposed in 2007, in effect starting in 2015
Date of completion (if relevant)	2030
Implementing entity or entities*	Ministry of Agriculture, Livestock, Fisheries, Forestry and Biosecurity (MALFFB), Department of Agriculture and Rural Development (DARD)
Objectives and intended impacts or benefits of the policy*	1. *Environmentally friendly agriculture* 2. *Agriculture soils improved and conserved.* According to the Department of Agriculture and Rural Development (DARD) policy, Sustainable agriculture focuses on ensuring food supply in the face climate change disruptions and includes the following measures: developing and enabling farmers to plant climate resilient varieties of crops (in concert with the Seed strategy that provides local seeds to farmers); diversifying crops, i.e., inter seeding annual with perennial crops, alley cropping; developing urban gardens that provide a localized source of food and reduce barren land in the yards; introducing farmers to the crop calendar; improving soil or reducing soil degradation is focused on research and development, i.e., building capacity to collect and analyze soil samples, developing soil maps, exploring crop rotations and companion planting appropriate for soil types and changing climate conditions. (Vanuatu Agriculture Policy, 2015).
Level of the policy	National
Policy inputs	• Policy Funding from key development partners (UNDP's Pacific Risk Resilience Programme, the SPC – GIZ Coping with Climate Change in the Pacific Islands Region Program, the SPC – USAID Climate Change Food Security Programme, the World Bank IRCCNH project.) • Allocation of Department staffs and funds to provide technical and logistical support for policy implementation

Policy activities	• Activity 1: Increase awareness about climate change vulnerability to make farmers more knowledgeable about risk to agriculture from climate change. • Activity 2: Conduct training on sustainable agriculture practices (Agroforestry) to support farmers' implementation of agroforestry practices. • Activity 3: Conduct training on sustainable agriculture practices (urban gardens) to help residents convert barren land to garden and increase vegetative cover on land. • Activity 4: Conduct training on the application of organic fertilizer to increase productivity.
Geographic coverage	Nation-wide
Sectors affected*	Agriculture, LULUCF
Greenhouse gases affected*	Carbon dioxide (CO_2) from changes in soil and biomass carbon stocks, nitrous oxide (N_2O) from application of fertilizer
Other related policies or actions.	Organic Farming Policy, various sector strategies under the National Agriculture policy – Root Crop strategy, Fruit and Vegetable strategy, Mechanization strategy (in development), also potentially policies from forestry sector as farming is the biggest driver of land clearing and deforestation. Other thematic areas under the National Agriculture Policy such as Agriculture Land Use and Climate Variability, Climate Change and Disaster Risk Reduction.
Intended level of mitigation to be achieved and/or target level of other indicators (if relevant) *	Policy doesn't have emissions reduction targets. However, there are implementation targets aligned to the National Sustainable Development Plan, National Agriculture Policy, Organic Farming Policy, and Sector Strategies. Each program area has targets, mostly focusing on number of farmers trained. There are annual targets in annual business plans and 5-year targets in the Corporate plans. Indicators were developed in 2015, and since then agriculture priorities in the country have shifted (food security, climate adaptation), so some of the indicators are not quite measurable or relevant, or there is no baseline.
Key stakeholders	Farmers, Producers, Processors, Exporters, Government Agencies, Provincial Authorities, the Civil Societies, NGOs
Title of establishing legal framework, or other founding documents	Overarching Productive Sector Policy (OPSP)
Monitoring, reporting and verification procedures	The Department of Agriculture develops 5-yr commercial plans and annual business plans with target indicators for each area of the policy (data available upon request from 2021). Indicators are typically focusing on activities the department staff implements and can easily record (e.g., the number of training workshops conducted) rather than what is actually implemented by farmers and leading to land management practices. The most recent Ag Census (conducted in 2022, released in 2024) provides the most up to date available information on current production in Vanuatu. DARD is currently developing an app for tablets that would allow extension agents to collect information from farmers in real time during their farm visits (to launch in 2025).

Policy Key Performance Indicators	**Policy Key Performance Indicators (KPI)** According to DARD, listed are the Policy KPI for sustainable farming and soil improvement for thematic area 8. The KPIs are specifically focused on agroforestry, particularly alley cropping, and backyard gardening. • Number of farmers trained for agroforestry and backyard gardening practices • Number of trainings conducted for agroforestry and backyard gardening practices • Area (hectare) of land converted to alley cropping and backyard gardening • Number of households receiving assistance (equipment/trainings) • Number of farmers receiving assistance (equipment/trainings) • Numbers of pilot sites established for agroforestry and backyard gardening • Soil mapping for potential crops • The proportion of agroforestry types (type and area) such as silvopasture and alley cropping • Carbon flux as a result of practices implemented (tC/yr.) **Additional recommended Indicators** • Number of qualified staff, stakeholders, land owners, industry personnel performing their responsibilities / conducting trainings and workshops • Number of reports submitted to managers and relevant stakeholders • Number of evaluation reports submitted to relevant ministries and stakeholders • Amount of funding allocated
Compliance and enforcement mechanisms	The activities are voluntary but technical support is provided for implementations for farmers.
Reference to relevant documents	• FAO & UN. (2010), "An Assessment of the Impact of and Climate Change on Agriculture and Food Security: A case Study in Vanuatu." • Lebot, V., (2008), "Root Crops Agro-biodiversity in Vanuatu." • Ravo, A. (2013), "An Assessment Study of the Cost of Adaptation of Climate Change Impacts on Agriculture in Vanuatu." • Simeoni, P., and Lebot, V., (2012), "Spatial Representation of Land Use and Population Density: Integrated Layers of Data Contribute to Environmental Planning in Vanuatu. Human Ecology." • Vanuatu Government (2009), National Food Summit Report 2009 • Vanuatu Government (2011), National Adaptation Program for Action
The broader context or significance of the policy	Food security in Vanuatu is a high priority, therefore, many of the agriculture sector policies focus on helping farmers grow better and more resilient crops. This includes activities such as establishing a national seedbank and growing crops that perform better under changing climate conditions within the context of traditional farming practices. Other areas of focus include developing and promoting use of cropping calendars, soil testing, local food production, and bringing back more diverse production systems following the plantation style cultivation prior to Vanuatu independence. Furthermore, there is an effort to help transition farmers to semi-commercial or commercial production (with new certification/license system being developed).
Outline of sustainable development impacts of the policy	SDG 1: POVERTY ERADICATION Activities under the policy support economic empowerment and access to resources. Sustainable farming practices increases agricultural productivity leading to more income. = This policy will enhance livelihood for farmers, and generate more income. SDG 2: FOOD SECURITY

	Crop diversification achieved through intercropping of perennial crops may reduce the risk of food scarcity. Establishment of backyard gardens supports food security in urban areas by allowing urban residents to grow vegetables in their backyards. SDG 8: SUSTAINABLE ECONOMIC GROWTH The policy assessed supports economic growth by increasing crop productivity, encourage diverse crops in an area, and increase soil health that assist in ensuring economic growth. SDG 13: ADDRESS CLIMATE CHANGE IMPACTS The policy will enhance climate resilience and reduce vulnerability by increasing diversity of crops and improving soil health. SDG 15: SUSTAINABLY MANAGE TERRESTRIAL RESOURCES Activities under the policy will enhance soil conservation and biodiversity through sustainable management of terrestrial resources. SDG 17: PARTNERSHIPS FOR DEVELOPMENT The policy improves collaboration with government, NGOs, communities and other sectors to achieve and share knowledge and skills for sustainable agriculture. This policy will help achieve SDG 17 by supporting capacity building and resource allocation for agroforestry and backyard gardening activities that will benefit both environment and local livelihoods.
Other relevant information	Vanuatu is in the early stages of developing and implementing a framework for policy monitoring and evaluation. 5-yr commercial plans and annual business plans establish targets for implementation – they are continuously evolving and being refined. The Department of Agriculture is keen to grow its capacity in this regard and interested in adding relevant data parameters that help evaluate policy implementation from sustainable development side as well as others, such as climate change side.

POLICY IMPACTS

Policy Inputs

For the agriculture policy GHG impacts to be assessed, it is key to identify and describe the inputs, activities and intermediate effects. The inputs, activities and intermediate effects listed in Table 2 lead to GHG impacts (Table 3) of the policy.

Table 2: Policy inputs (I), activities (A), and intermediate effects (IE)

Inputs (I), activities (A), intermediate effects (IE)	Detail/ explanation	Affected parameter	Direction	Magnitude	Geographic location	Timing
(I) Policy funding	The financial resources allocated by governments or international organizations to support and implement agricultural policies.	Budget for policy implementation	NA	10M Vatu + international support	Nation-wide	Annual
(I) Department staff	Staff in the agriculture department are crucial for developing, executing, and assessing the policy	Staff for policy implementation	Increase	96 to 204	Nation-wide	by 2028
(A) Increase awareness about climate change vulnerability	Distribution of information through various communication channels available	Number of farmers learning about climate risk through different channels	Increase	Information Unavailable	Nation-wide	2015-2030
(IE) Farmers are more knowledgeable about risk to agriculture from climate change	Farmers awareness about climate change risks is better aligned with their direct observations regarding changes in rainfall and temperature, crop yields and farm productivity. This knowledge is essential for motivating adoption of adaptive strategies and robust farming practices to cope	Farmers motivated and interested in seeking out more information about climate change and potential mitigation/adaptation practices	Increase	Information Unavailable	Nation-wide	2015-2030

	with ongoing climate challenges.					
(A) Conduct training on sustainable agriculture practices (agroforestry)	Gaining skills to carry out approaches/methods to mitigate climate change impacts on agroforestry practices	Number of farmers applying agroforestry practices	Increase	200 trainings	Nation-wide	Starting in 2021
(IE) Farmers are implementing agroforestry practices - alley cropping	Farmers are adopting agroforestry practices such as alley cropping, where they plant rows of trees or shrubs alongside crops in the same field.	Increase in area of farmland with alley cropping	Increase	Assumption:1% annual increase during policy period (Expert Judgement)	Nation-wide	2015-2030
(IE) Farmers are implementing agroforestry practices - silvopasture	Farmers are incorporating silvopasture into their agricultural practices, which involves integrating trees and livestock grazing within the same area.	Increase in soil carbon, manure deposition on land	Increase	Information Unavailable	Nation-wide	2015-2030
(A) Conduct training to on sustainable agriculture practices (urban gardens)	Gaining skills to convert barren land in the backyard into a garden to produce crops for consumption	Number of households receiving assistance from converting land to backyard gardens	Increase	Total of 1,907 households from 2021-2023 (Taken from 2024 DARD business plans)	Urban households	Starting in 2021
(IE) Farmers convert barren land to garden	Land in backyards is converted from barren to growing crops	Land changing from bare soil to crops	Increase	About 1% increase in area used for backyard gardening annually (Expert judgement)	Urban households	Starting in 2021

(IE) Vegetative cover on land	Vegetative cover on land in the context of urban gardening refers to the growth of plants, including vegetables, herbs, and crops, cultivated in urban setting, typically backyard garden or from small plots	Retained plant residue, reduced soil disturbance	Increase	Information Unavailable	Urban households	Starting in 2021
(A) Conduct training on the application of organic fertilizer for agricultural practices	Gaining skills on the use of organic fertilizers and how to effectively apply natural substances to improve soil fertility and crop growth. This training covers different types of organic fertilizers.	Number of farmers receiving training and effectively applying organic fertilizer to soil and crops	Increase	Total of 646 farmers from 2021-2023 (Taken from 2024 DARD business plan)	Agricultural land with annual crops	Starting in 2021
(IE) Farmers apply fertilizer to crops	Farmers apply fertilizer to crops as a method to supplement essential nutrients in the soil that may be lacking or depleted.	Nitrogen levels increase in soil, plant residue increases, soil structure improves	Increase	All targeted farmers attended the training	Agricultural land with annual crops	Starting in 2021

GHG Impacts

To understand the relationship between the Vanuatu Agriculture Policy and the GHG impacts, the next step identified linkages between the inputs, activities, and intermediate effects (see Table 2) and how they impact GHG emissions. Table 3 below illustrates the relationship between the effects of the activities and GHG impacts.

Table 3: Intermediate effect, subsequent intermediate effects, and their potential GHG impacts.

Intermediate effect	Subsequent intermediate effects			Potential GHG impact
	Effect 1	Effect 2	Effect 3	
Conduct training on sustainable agriculture (agroforestry)	Increase in the number of farmers adopting alley cropping	Increase Biomass		Increase CO_2 sequestration
Conduct training on sustainable agriculture (agroforestry)	Increase in the number of farmers adopting alley cropping	Reduce soil disturbance	Increase in soil carbon stocks	Increase CO_2 sequestration
Conduct training on sustainable agriculture (agroforestry)	Increase in the number of farmers adopting silvopasture	Manure deposition		Increase in N_2O emissions
Conduct training on sustainable agriculture (agroforestry)	Increase in the number of farmers adopting silvopasture	Improved soil health	Increase in soil organic matter	Increase CO_2 sequestration
Conduct training on sustainable agriculture (backyard gardening)	Increase in establishment of urban gardening	Vegetative Soil Cover	Increase in crop residue Reduce soil disturbance	Increase CO_2 sequestration
Conduct training on the application of organic fertilizer in agriculture	Increase Plant Growth	Increase soil structure and quality		Increase CO_2 sequestration
Conduct training on the application of organic fertilizer in agriculture	Increase fertilizer application			Increase in N_2O emissions

Causal Chain

A causal chain approach is used to illustrate how the policy and its corresponding inputs and activities result in intermediate effects and ultimately in GHG impacts. Information in Tables 1, 2 and 3 was used to construct the causal chain. The causal chain shown in Figure 1 shows linkages to intermediate effects established from policy implementation. These intermediate effects link to the subsequent intermediate effects and the potential GHG impact.

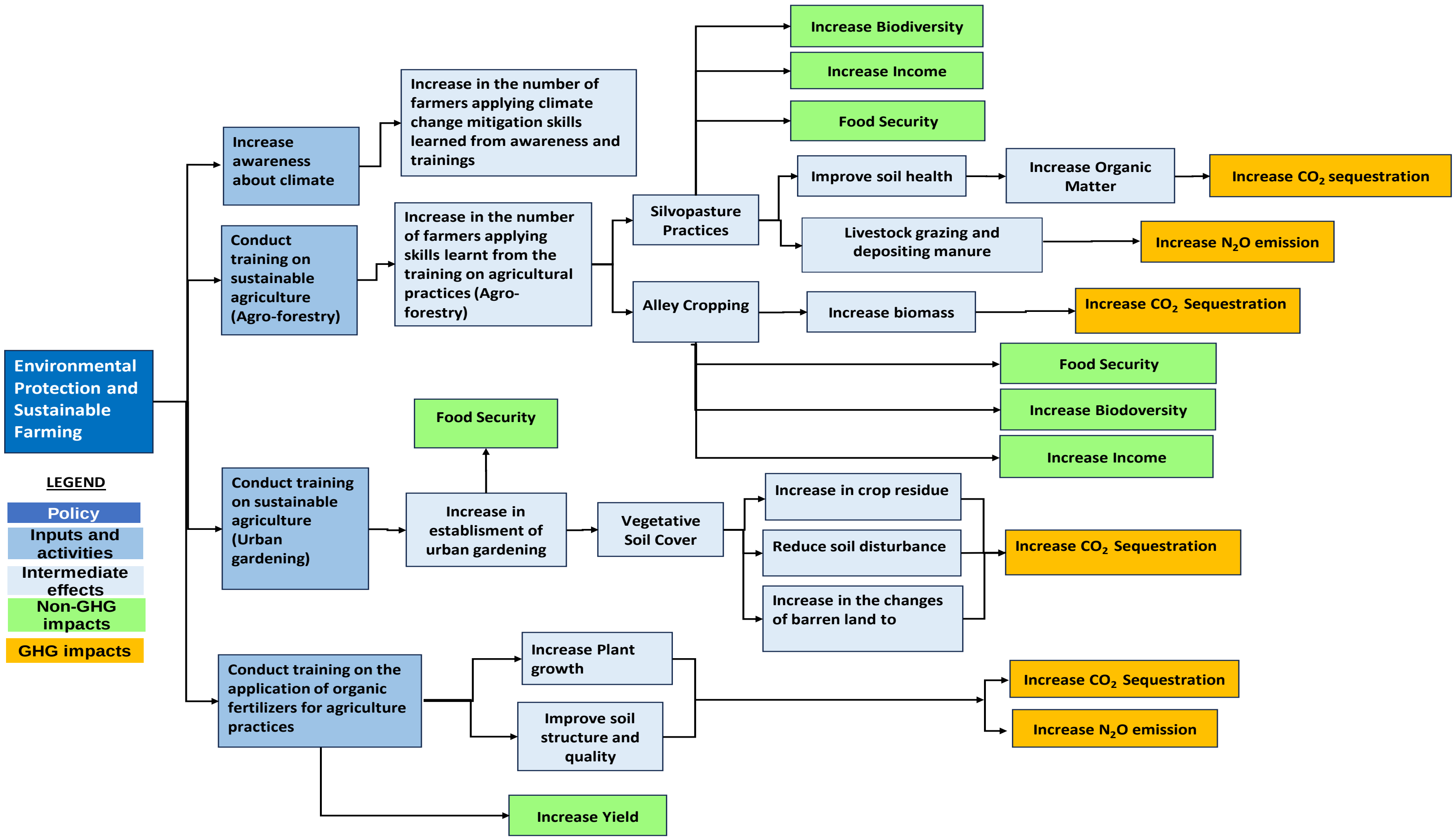

Figure 1:Causal chain representing implementation for of the Vanuatu Agriculture policy

The casual chain illustrates the intermediate effects of policy activities, enhanced training in agroforestry and urban farming. These effects influence the potential GHG impacts of sustainable farming practices.

The causal chain shows that the two farming practices, alley cropping and backyard gardening, are likely to lead to increase in CO_2 sequestration by the soil. In addition, non-GHG impacts resulted from these farming practices include enhanced biodiversity, increased income, and increased in yield.

The primary focus of the policy is environmental protection and sustainability. To implement this policy, specific inputs and activities must be executed. For Vanuatu's policy, essential activities include raising awareness about climate change, providing training in sustainable agriculture (such as agroforestry and urban gardening), and educating on the use of organic fertilizers in agriculture. Each of these activities leads to various intermediate effects, as illustrated in the causal chain figure above.

The intermediate effects in this policy result in both greenhouse gas (GHG) impacts and non-GHG impacts. Common GHG impacts include an increase in CO_2 sequestration and increase in N_2O emission. Furthermore, non-GHG impacts encompass enhanced agricultural yields, which contribute to food security, increase income. Introduction of agroforestry practices boosts biodiversity.

GHG Assessment Boundary

To identify which mitigation measures and GHG impacts are significant, an assessment boundary needs to be determined. The assessment boundary focuses the assessment on the evaluations of mitigation measures and GHG impacts that are expected to have a significant impact on GHG emissions.

The determination of significant GHG sources or carbon pools is based on the likelihood and relative magnitude of each GHG impact. Figure 2 below illustrates the steps conducted to determine significant GHG sources or carbon pools.

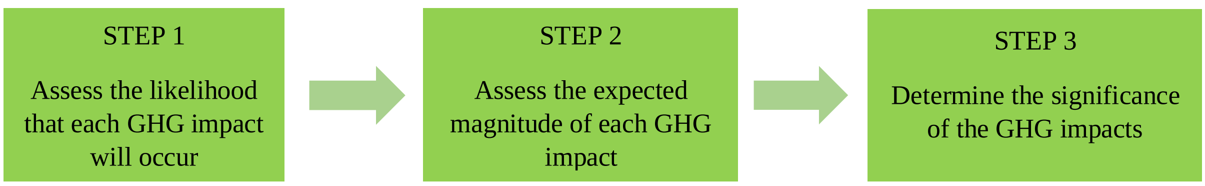

Figure 2: Illustrates the steps used to determine significant GHG sources or carbon pools

Under the environmental protection and sustainable farming policy, as shown in Figure 1, practices such as silvopasture, alley cropping, backyard gardening, and organic fertilizers all contribute to CO_2 sequestration. On the other hand, it is important to account for N_2O emissions that are a result of the application of organic fertilizers and manure deposition. The likelihood and magnitude of each GHG impact needs to be assessed to determine which GHG impact will be included in the assessment boundary. ICAT Agriculture Methodology Table 6.6[1] was employed for determining the assessment boundary.

[1] https://climateactiontransparency.org/our-work/icat-toolbox/assessment-guides/agriculture-sector/

Likelihood of GHG Impact

Expert assessment was employed to evaluate the probability of various greenhouse gas (GHG) impacts associated with different agroforestry practices and urban gardening. Based on expert evaluations, certain GHG impacts are anticipated to have a likelihood of occurrence between 66% and 90%. These include enhanced CO_2 sequestration resulting from practices such as silvopasture, alley cropping, and the use of organic fertilizer. Additionally, emissions of N_2O are expected to arise from manure deposition linked to silvopasture and the application of organic fertilizers (Refer to Table 4 below). On the other hand, GHG impact from Backyard gardening in addition is very likely to occur with a percentage likelihood of 90% or more.

The magnitude of GHG Impact

Next, the magnitude of each GHG impact was classified according to Major, Moderate, and Minor depending on the absolute value of the total change in GHG emissions and removals. In the case of the Vanuatu Agriculture policy, the determination of magnitude was based upon assumptions and the usage of Table 6.7 of the ICAT Agriculture Methodology.

The establishment of backyard gardening has a significant impact on greenhouse gas (GHG) sources and carbon pools, leading to a notable increase in carbon sequestration. As a result, the influence of GHG emissions is crucial in assessing the effectiveness of related policies, which is why this magnitude of the GHG impacts from backyard gardening is categorized as moderate as seen in Table 4 below. The impact of carbon sequestration from alley cropping is anticipated to be moderate, with an estimated relative increase ranging from 1% to 10%. This level of impact slightly affects the overall effectiveness of related policies. Conversely, the greenhouse gas (GHG) effects associated with enhanced carbon sequestration and nitrous oxide (N_2O) emissions from practices like silvopasture and the use of organic fertilizers are considered to have minor impacts of less than 1% magnitude.

Significance of GHG Impact

The significance of the mitigation measures was assessed using the chosen likelihood and magnitude of the GHG impacts. This was accomplished using Figure 6.3 of the ICAT Agriculture Methodology. Additional insights were drawn from Table 6.3[1] to identify the carbon pool that should be incorporated into the assessment boundary.

Following the rubric in the ICAT Agriculture Methodology GHG, impacts that fall into the categories of "very likely" to "likely," with a magnitude level ranging from "major" to "moderate" are significant and should be included in the assessment. The practices identified in this assessment as significant include backyard gardening and alley cropping. On the other hand, the GHG impacts associated with the use of organic fertilizer and silvopasture are classified as minor, which means they are not significant for this evaluation.

Table 4: Significant mitigation measures to be included in the assessment boundary

Mitigation measure	GHG impact	Likelihood	Relative magnitude	Significance
		(Very likely, Likely, Possible, Unlikely, Very unlikely)	(Major, Moderate, Minor, Unknown)	(Significant – include in the assessment, Not significant – may exclude from the assessment, Not estimated – exclude from the assessment when magnitude is unknown or impact is outside the Agriculture sector)
Silvopasture practices				
Improve soil health	Increase soil CO_2 sequestration	Likely	Minor	Not significant
Manure deposition	Increase N_2O	Likely	Minor	Not significant
Alley cropping	Increase CO_2 sequestration due to soil and biomass C stock increase	Likely	Moderate	Significant
Establishment of urban gardening	Increase in soil CO_2 sequestration	Very Likely	Moderate	Significant
Application of organic fertilizer	Increase in N_2O	Likely	Minor	Not significant
Application of organic fertilizer	Increase soil CO_2 sequestration	Likely	Minor	Not significant

The temporal boundary for the policy assessment is to evaluate achieved impact to date (2015-2024: ex-post assessment) and the expected effects of the policy following its implementation by 2030 (2025-2030: ex-ante assessment).

METHODOLOGY

To calculate the GHG emissions and removals, the following equations for aboveground biomass and soil carbon stocks are applied.

The formula for calculating aboveground biomass in alley cropping systems[2].

EQUATION 2.7
ANNUAL CHANGE IN CARBON STOCKS IN BIOMASS IN LAND REMAINING IN A PARTICULAR LAND-USE CATEGORY (GAIN-LOSS METHOD)

$$\Delta C_B = \Delta C_G - \Delta C_L$$

[2] 2006 IPCC Guidelines for National Greenhouse Gas Inventories

Where:

ΔC_B = annual change in carbon stocks in biomass (the sum of above-ground and below-ground biomass terms in Equation 2.3) for each land sub-category, considering the total area, tonnes C yr^{-1}

ΔC_G = annual increase in carbon stocks due to biomass growth for each land sub-category, considering the total area, tonnes C yr^{-1}

ΔC_L = Annual decrease in carbon stocks due to biomass loss for each land sub-category, considering the total area, tonnes C yr^{-1}

The formula for calculating change in soil carbon stocks in mineral soil applies to both alley cropping and backyard gardening as follows:

EQUATION 2.25
ANNUAL CHANGE IN ORGANIC CARBON STOCKS IN MINERAL SOILS

$$\Delta C_{Mineral} = \frac{(SOC_0 - SOC_{(0-T)})}{D}$$

$$SOC_{Mineral} = \sum_{c,s,i} \left(SOC_{REF_{c,s,i}} \bullet F_{LU_{c,s,i}} \bullet F_{MG_{c,s,i}} \bullet F_{I_{c,s,i}} \bullet A_{c,s,i} \right)$$

(Note: T is used in place of D in the $\Delta C_{Mineral}$ equation if T is ≥ 20 years, see note below associated with the parameter D)

Where:

$\Delta C_{Mineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr^{-1}

SOC_0 = soil organic carbon stock in the last year of an inventory time period, tonnes C

$SOC_{(0-T)}$ = soil organic carbon stock at the beginning of the inventory time period, tonnes C

SOC_0 and $SOC_{(0-T)}$ are calculated using the SOC equation in the box where the reference carbon stocks and stock change factors are assigned according to the land-use and management activities and corresponding areas at each of the points in time (time = 0 and time = 0-T)

T = number of years over a single inventory time period, yr.

D = Time dependence of stock change factors which is the default time period for transition between equilibrium SOC values, yr. Commonly 20 years, but depends on assumptions made in computing the factors F_{LU}, F_{MG}, and F_I. If T exceeds D, use the value for T to obtain an annual rate of change over the inventory time period (0-T years).

c = represents the climate zones, s the soil types, and i the set of management systems that are present in a country.

SOC_{REF} = the reference carbon stock, tonnes C ha^{-1}

F_{LU} = stock change factor for land-use systems or sub-systems for a particular land-use, dimensionless

F_{MG} = stock change factor for management regime, dimensionless

F_I = stock change factor for input of organic matter, dimensionless

A = land area of the stratum being estimated, ha. All land in the stratum should have a common biophysical condition (i.e., climate and soil type) and management history over the inventory time period to be treated together for analytical purposes.

To convert the total change in soil carbon stock into CO_2-e emissions measured in tonnes, the net change in soil carbon is multiplied by 44/12 and then by -1. This calculation gives the total cumulative CO_2e emissions (positive) or removals (negative) for the baseline period, reflecting the overall CO_2e emissions and removals that occurred during this time.

The average annual emissions and removals are calculated by dividing the cumulative CO_2-e emission or removals by the time interval of the assessment period of 20 years.

We calculated the average annual emissions and removals for both the ex-post (2015-2024) and ex-ante (2025-2030) periods. The sections below describe baseline and policy carbon flux calculations for assessing GHG impact. For alley cropping activities, carbon fluxes in the following carbon pools were estimated: Aboveground biomass and SOC in mineral soils. For backyard gardening, carbon fluxes were estimated for SOC in mineral soils.

As discussed, conclusions from defining the assessment boundary indicate that alley cropping and backyard gardening are expected to significantly reduce atmospheric CO_2 emissions by enhancing the carbon stocks in both the soil and biomass.

The diagram below shows the steps needed to estimate GHG emissions.

The steps for estimating the baseline emissions of soil carbon are shown in figure 3

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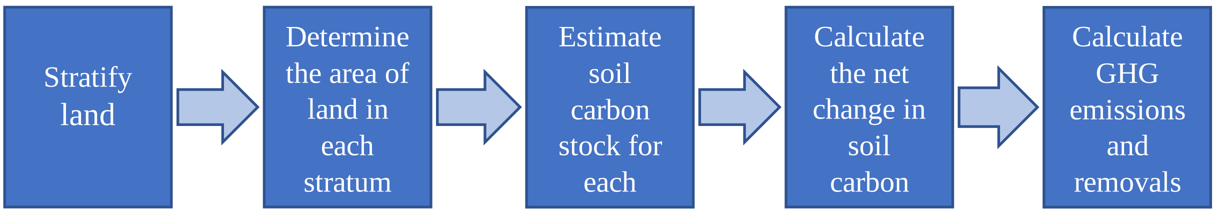

Figure 3: Estimation of the baseline emissions of soil carbon

Stratifying land

To successfully assess the decrease or increase in soil carbon stocks and thereby GHG emissions or removals, the changes in land use and/or management must be evaluated, hence the key parameters are areas of land in relevant land categories and associated reference soil carbon stocks, stratified by relevant soil types. Soil types for each province and corresponding Carbon reference values are provided in Appendix 1. (Refer to Table A1.1 and A1.2).

The constant baseline scenario assumes that area of land used for alley cropping and backyard gardens remains unchanged throughout the baseline scenario.

The workshops and training sessions implemented under the policy lead to farmer's adoption of these practices. Data was not available on how much land was converted to alley cropping or backyard gardens since the start of the policy. For the assessment, it is assumed based on expert judgement that trainings may lead to a 1% annual increase in alley cropping practices. Similarly, it is assumed that backyard garden area is expected to increase by 1% annually under the policy scenario. If data is collected in the future years on area of land where alley cropping and backyard gardens are implemented, the parameters and associated estimates can be refined to improve the accuracy.

To estimate area used for alley cropping and backyard gardens, Vanuatu agricultural census from 2022 was used. Values were aggregated at the province level. The area for alley cropping was determined by multiplying the median parcel size (in hectares) by the percentage of parcels with temporary crops and the primary planting method, which is intercropping. The backyard garden area was calculated by multiplying the median parcel size (in hectares) by the proportion of parcels designated as home gardens. The areas for 2015 were calculated by reversing the policy assumption, i.e., 1% annual decrease. The estimated areas in 2015 for alley cropping and backyard gardens in Vanuatu are shown in Table 5 and Table 6 below.

Table 5: Area (ha) used for alley cropping under the baseline scenario

YEAR	ALLEY CROPPING AREA (ha)						TOTAL AREA (ha)
	Torba	Sanma	Penama	Malampa	Shefa	Tafea	
2015	937.9	3051.6	3555.3	848.7	638.4	802.3	9,834.0

Table 6: Area (ha) used for Backyard Gardening under the baseline scenario

YEAR	BACKYARD GARDENING AREA (ha)						TOTAL AREA (ha)
	Torba	Sanma	Penama	Malampa	Shefa	Tafea	
2015	131.6	1434.2	974.8	381.0	100.2	16.8	3,038.6

Identifying carbon stock change parameters for each land category

The soil carbon stocks (tC/ha) were determined using the IPCC Tier 1 as Vanuatu lacks country-specific parameters. Table 7 provides an overview of the soil stock change factors used in the assessment. The stock change factors used to estimate SOC for Backyard Gardening and Alley Cropping are based on Tier 1 default values from 2019 Refinement to 2006 IPCC Guidelines (Vol 4, Ch. 5, Table 5.5).

Table 7: Stock change factors utilized for estimating policy GHG impact

Stock change factor	Type	2019 IPCC Default Value		
		Temperature Regime	Moisture Regime	IPCC Default Value
F_{LU}	Perennial crops	Tropical	Moist / Wet	1.01
F_{LU}	Annual Permanent Crop	Tropical	Dry and Moist / Wet	0.83

F_{MG}	Full Tillage	All	Dry and Moist / Wet	1
F_{MG}	Reduced Tillage	Tropical	Moist / Wet	1.04
F_{I}	Medium	All	Dry and Moist / Wet	1
F_{I}	Low	Tropical	Moist / Wet	0.92

BACKYARD GARDENING F_{LU}, F_{MG}, F_{I}

Before conversion, it is likely that the land is barren or has very little cover. There is no factor that represents such conditions, therefore parameter for long-term cultivated conditions was selected.

For land before it is converted to a garden, the following values are used:

- F_{LU} – 0.83
- F_{MG} – 1
- F_{I} – 0.92

Additionally, when land is converted to garden, F_{MG} and F_{I} parameters are adjusted because soil disturbance and plant residue changes on land where gardens are implemented. The following values are used:

- F_{LU} – 0.83
- F_{MG} – 1.04
- F_{I} – 1

ALLEY CROPPING F_{LU}, F_{MG}, F_{I}

Land before implementation of alley cropping is assumed to be used for growing annual crops, therefore, the parameter for long term cultivated is used. The following stock change factors are applicable when calculating SOC before adoption of alley cropping:

- F_{LU} – 0.83
- F_{MG} – 1.04
- F_{I} – 1

When alley cropping is implemented, the parameters F_{MG} F_{LU} remain the same. However, F_{LU} changes to 1.01, representative of perennial cops. The following parameters are used in the calculations:

- F_{LU} – 1.01
- F_{MG} – 1.04
- F_{I} – 1

BASELINE SCENARIO AND GHG EMISSIONS

The baseline emissions and removals are calculated utilizing the baseline scenario, which incorporates assumptions regarding land use, changes in land use and soil management practices in the absence of policy. Establishing a baseline is essential for the evaluation process. The GHG impacts are determined by comparing emissions in the baseline scenario with the policy scenario. The constant baseline approach assumes that there will be no changes in farming practices, technology, or land use in the baseline scenario compared to the scenario if the policy was implemented. This approach is applicable in this assessment due to two factors. It is valid to assume that no changes would be expected to occur in land management in the absence of the policy. Secondly, data is simply not available to be able to discern reliable trends that could be applied in the baseline.

Baseline SOC Calculation for Backyard Gardening

Since the baseline assumes no change in area for backyard gardening in Vanuatu in the absence of policy intervention, for the ex-post and ex-ante periods, there is no change SOC levels and therefore, no emissions or removals of CO_2. Table A2.1 in Appendix 2 shows the unchanged land area for Backyard Gardening. Table 8 below shows the land area gained during the ex-post and ex- ante periods.

Table 8: Land Area (ha) gained from Backyard Gardening

Provinces	Area of backyard gardens (ha)					
	2015	2024	Gain in BYG	2025	2030	Gain in BYG
Torba	131.6	144.1	12.4	145.5	152.9	7.4
Sanma	1434.2	1569.7	135.5	1585.4	1666.2	80.9
Penama	974.8	1066.9	92.1	1077.5	1132.5	55.0
Malampa	381.0	417.0	36.0	421.1	442.6	21.5
Shefa	100.2	109.7	9.5	110.8	116.4	5.7
Tafea	16.8	18.4	1.6	18.5	19.5	0.9

BASELINE SOC CALCULATION FOR ALLEY CROPPING

Similarly, with the assumption that area of alley cropping practices remains unchanged, there is no change SOC levels and therefore, no emissions or removals of CO_2. Table A2.2 in Appendix 2 shows the unchanged land area for Alley Cropping. Nevertheless, the accumulation of carbon does occur in the existing alley cropping area due to the continuous growth of trees. Changes in biomass also factor into the analysis of carbon sequestration alongside soil.

Table 9 below shows the land area gained during the ex-post and ex- ante periods.

Table 9: Land Area (ha) gained from Alley Cropping

Provinces	Area of Alley Cropping (ha)					
	2015	2024	Gain in AC	2025	2030	Gain in AC
Torba	937.9	1,026.4	88.6	1,036.7	1,089.6	52.9
Sanma	3,051.6	3,339.8	288.2	3,373.2	3,545.3	172.1
Penama	3,555.3	3,891.1	335.8	3,930.0	4,130.4	200.5
Malampa	848.7	928.8	80.2	938.1	986.0	47.9

Shefa	638.4	698.7	60.3	705.7	741.7	36.0
Tafea	802.3	878.0	75.8	886.8	932.1	45.2

BASELINE BIOMASS CALCULATION FOR ALLEY CROPPING

Aboveground biomass carbon stocks were not calculated for the baseline scenario because existing vegetation used in alley cropping would increase by the same amount in baseline and policy scenarios. Therefore, only increase in aboveground biomass carbon stock from new alley cropping practices are estimated in the policy scenario section.

POLICY SCENARIO AND GHG EMISSIONS

Policy SOC Stock Calculation for Backyard Gardening

As stated previously, the assessment assumes that area increased by 1% annually as a result of policy activities. The 'gain' in backyard garden area were estimated for ex-post (2015 – 2024) and ex-ante (2025-2030) assessment periods (Table 8 and Table 9). Then, the area was multiplied by soil SOC_{REF} (Table A1.1) and the corresponding stock change factors ($F_{MG,}$ F_{I}, and F_{LU}) before and after conversion (Table 7) to estimate SOC at the beginning and end of the period following equation 2.25. The values are summarized in Table 10, disaggregated by province. The table presents data on the Soil Organic Carbon (SOC) levels for different provinces, showing both the ex-post and ex-ante periods. Within the ex-post period, the total $SOC_{(0\text{-}T)}$ amounted to 14,036.6 tonnes of carbon (C), with SOC $_{(0)}$ estimated at 15,867.5 tonnes of C. On the other hand, the ex-ante period estimates suggest that SOC (0) has a value of 9,427.7 tonnes of C, while $SOC_{(0\text{-}T)}$ is anticipated to be around 8,379.7 tonnes of C.

Table 10: Policy SOC calculation for backyard gardening

Province	**Backyard Gardening SOC (tonnes of carbon (C))**			
	Ex-post		**Ex-ante**	
	SOC_0	**$SOC_{(0\text{-}T)}$**	**SOC_0**	**$SOC_{(0\text{-}T)}$**
Torba	826.4	731.1	493.4	436.4
Sanma	7015.9	6206.4	4188.4	3705.1
Penama	5444.0	4815.9	3250.0	2875.0
Malampa	1863.7	1648.7	1112.6	984.2
Shefa	629.1	556.5	375.6	332.3
Tafea	88.2	78.0	52.7	46.6
Total	**15867.5**	**14036.6**	**9472.7**	**8379.7**

Policy Annual Change in SOC Stock Calculation for Backyard Gardening

Changes in SOC were calculated using Equation 2.25 from the 2016 IPCC Guideline, which determines annual SOC changes for backyard gardening by subtracting initial SOC from final SOC. As shown in Table 10, during the Ex-post period, the final SOC was 15,868 tonnes C and the initial SOC was 14,037 tonnes C. Dividing the difference by 20 years yielded an annual change of 92 tonnes C yr^{-1}. For the Ex-ante period, a similar calculation resulted in an annual change of 55 tonnes C yr^{-1}. Detailed calculations for annual changes in organic carbon in mineral soil for Ex-post and Ex-ante are illustrated in Appendix 2, Table A2.3 and Table A2.4 respectively.

Emissions Calculation for Backyard Gardening

To calculate the emissions sequestered from changes in annual Soil Organic Carbon (SOC) stock in backyard gardening, the change in SOC is multiplied by -44/12. This factor represents the molar mass of CO_2, with the negative sign indicating that CO_2 is being sequestered, thus contributing to atmospheric removals. The total atmospheric removals during the ex-post period amount to -335 tonnes of CO_2, while it is estimated that -200 tonnes of CO_2 will be sequestered during the Ex-Ante period. Refer to Table A2.3 and Table A2.4 in Appendix 2

Carbon flux and CO_2 emission calculations

Table 11 illustrates the emissions associated with backyard gardening derived from changes in SOC stocks in mineral soil.

Table 11: CO_2 emissions from SOC change due to increase in backyard gardening

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
SOC CO_2 Emissions (tonnes)	-336	-336	-336	-336	-336	-336	-336	-336	-336	-336	-536	-536	-536	-536	-536	-536

Figure 4 illustrates the removal of CO_2 via organic carbon stocks in mineral soil resulting from backyard gardening practices.

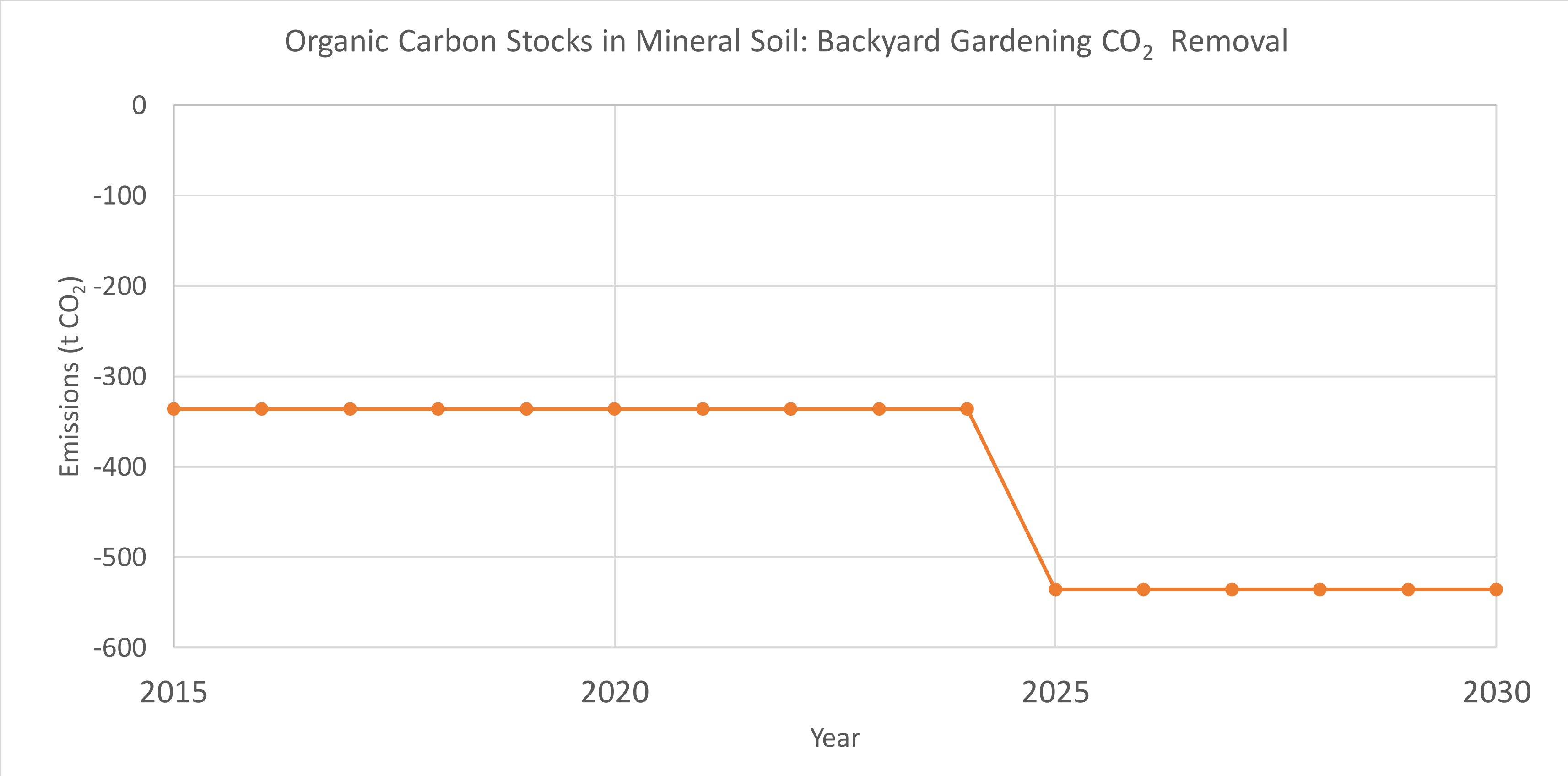

Figure 4: CO_2 Removal through Organic Carbon Stocks in Mineral Soil from Backyard Gardening

At the onset of the policy, the amount of CO_2 sequestered was recorded at -336 tonnes per year. This level remained constant throughout the ex-ante period. However, during the ex-post period, the sequestered CO_2 increased to -536 tonnes per year.

Policy SOC Calculation for Alley Cropping

Similar calculation was conducted for area of farmland converted from annual cropping to implementing alley cropping. The values are summarized in Table 12, disaggregated by province.

Table 12: Policy SOC Calculation for Alley Cropping

Province	Alley Cropping SOC (tonnes C)			
	Ex-post		Ex-ante	
	SOC_0	$SOC_{(0-T)}$	SOC_0	$SOC_{(0-T)}$
Torba	7,164.5	5,887.7	4,277.1	3,514.9
Sanma	18,165.3	14,927.9	10,844.5	8,911.8
Penama	24,161.5	19,855.5	14,424.1	11,853.5
Malampa	5,051.8	4,151.5	3,015.9	2,478.4
Shefa	4,876.8	4,007.7	2,911.4	2,392.5
Tafea	5,133.8	4,218.9	3,064.8	2,518.6
Total	**64,553.8**	**53,049.2**	**38,537.9**	**31,669.8**

Table 12 presents data on the ex-post and ex-ante Soil Organic Carbon (SOC) values, specifically $SOC_{(0)}$ and $SOC_{(0-T)}$, for each province in Vanuatu, along with the overall SOC figures for alley cropping. In the ex-post period, the total $SOC_{(0-T)}$ amounted to 53,049.2 tonnes of C, while the $SOC_{(0)}$ was estimated at 64,553.8 tonnes of C. In contrast for the ex-ante period, $SOC_{(0-T)}$ was noted at 31,666.9 tonnes of C, with $SOC_{(0)}$ estimated to be 38,537.9 tonnes of C.

Policy Annual Change in SOC Stock Calculation for Alley Cropping

Changes in SOC were calculated using Equation 2.25 from the 2016 IPCC Guideline, which determines annual SOC changes for alley cropping by subtracting initial SOC from final SOC. As shown in Table 12, during the Ex-post period, the final SOC was 64,554 tonnes C and the initial SOC was 53,049 tonnes C. Dividing the difference by 20 years yielded an annual change of 575 tonnes C yr^{-1}. For the Ex-ante period, a similar calculation resulted in an annual change of 343 tonnes C yr^{-1}. Detailed calculations for annual changes in organic carbon in mineral soil for Ex-post and Ex-ante are illustrated in Appendix 2, Table A2.5 and Table A2.6 respectively.

Emissions Calculation for Alley cropping

To calculate the emissions sequestered from changes in annual Soil Organic Carbon (SOC) stock in Alley cropping, the change in SOC is multiplied by -44/12. This factor represents the molar mass of CO_2, with the negative sign indicating that CO_2 is being sequestered, thus contributing to atmospheric removals. The total atmospheric removals during the ex-post period amount to -2,109 tonnes of CO_2, while it is estimated that -1,259 tonnes of CO_2 will be sequestered during the Ex-Ante period. Refer to Table A2.5 and Table A2.6 in Appendix 2.

Timeseries

Table 13 illustrates the emissions associated with Alley cropping derived from organic carbon stocks in mineral soil.

Table 13: CO_2 emissions from Organic Carbon Stocks in Alley Cropping

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
SOC CO_2 Emissions (tonnes)	-2,109	-2,109	-2,109	-2,109	-2,109	-2,109	-2,109	-2,109	-2,109	-2,109	-3,368	-3,368	-3,368	-3,368	-3,368	-3,368

The table presents a time series analysis from 2015 to 2030, focusing on the atmospheric carbon removals achieved through alley cropping and its impact on organic carbon in mineral soil. From the inception of the policy until 2024, the sequestered emissions remain stable at -2,109 tonnes of CO_2. However, it is projected that between 2025 and 2030, the amount of CO_2 removed from the atmosphere will increase to an estimated total of -3,368 tonnes of CO_2.

Figure 5 illustrates the removal of CO_2 via organic carbon stocks in mineral soil resulting from alley cropping.

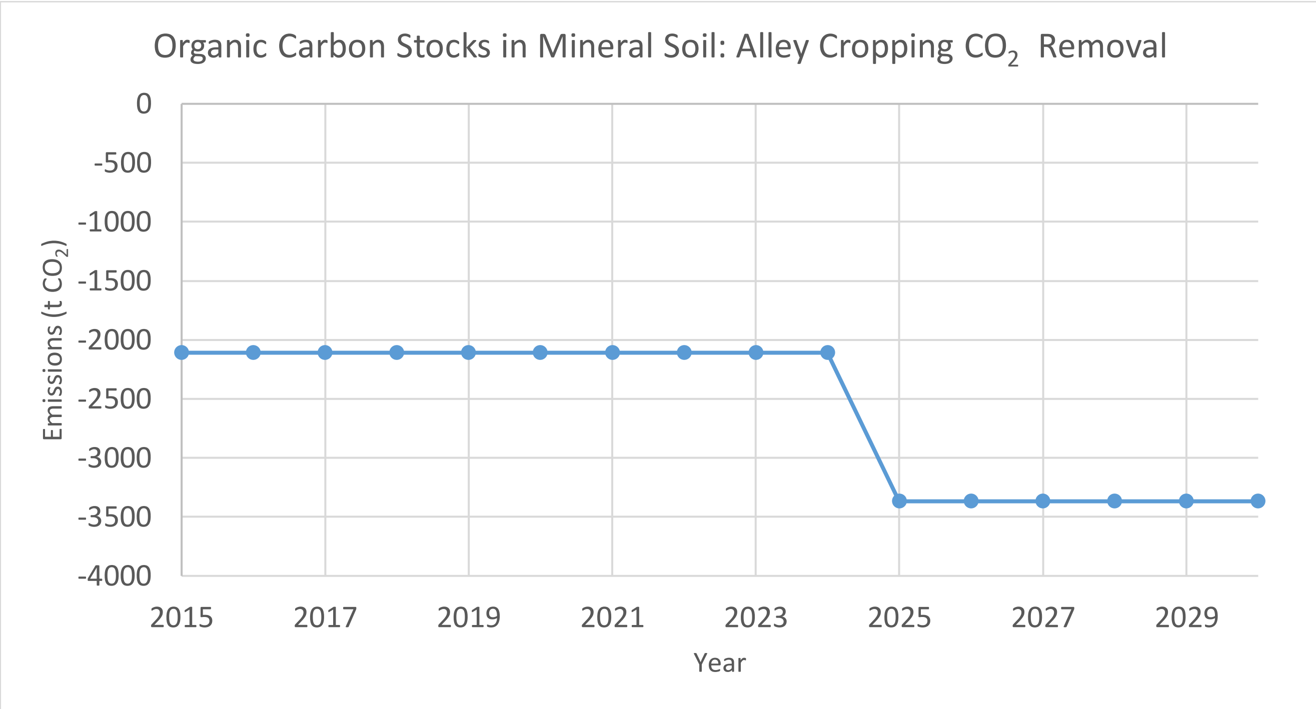

Figure 5: CO_2 Removal through Organic Carbon Stocks in Mineral Soil from Alley Cropping

Policy Aboveground Biomass Calculation For Alley Cropping

Carbon accumulates in biomass through growth absorbing carbon dioxide from the atmosphere. To calculate the amount of atmospheric CO_2 absorbed by the aboveground biomass, Tier 1 values for alley cropping aboveground biomass accumulation rate from the 2019 Refinement to the 2006 IPCC Guidelines – 2.37 tonnes C ha $^{-1}$ yr^{-1}. Belowground biomass accumulation was not estimated in this assessment as Tier 1 methods assume no change. Change in aboveground biomass carbon stock was estimated by multiplying cumulative area increases each year by the biomass accumulation rate. Increase in C stock from growth occurring in existing alley cropping areas was not estimated because it is equal to the growth that would occur in the baseline. Only additional growth from newly converted alley cropped areas is due to the policy. We assume losses to be 0 because the default value for maturity cycle is 20 years for alley cropping systems in tropical climate while the policy assessment period covers only 15 years.

Annual CO_2 emissions are calculated by multiplying the annual change in carbon stock (ΔC_B) by (-44/12). The calculations indicate that under the policy scenario, the change in carbon stock in aboveground biomass increases each year as more land is converted to alley cropping. In 2030, the total area utilizing alley cropping is projected to remove -13,825.5 tonnes of atmospheric CO_2. Full estimates of C fluxes and associated removals are shown in Table A2.7 in Appendix 2.

POLICY GHG IMPACT

Both carbon pools, soil organic carbon and aboveground biomass contribute to GHG emissions and removals.

Soil Sequestration Equation CO_2 Removals

Backyard gardening and alley cropping contributes to soil organic carbon sequestration hence promoting atmospheric CO_2 removals. The SOC $_{(0)}$ and $SOC_{(0-T)}$ were calculated for each of the provinces as previously discussed.

Above ground Biomass CO_2 Removals

Implementation of agricultural practices such as alley cropping and backyard gardening under the policy leads to an increase in CO_2 removals as illustrated in the graph below (Figure 6).

Table 14: Time series showing alley cropping biomass emissions from 2015 to 2030

Aboveground biomass CO_2 emission (tonnes/yr^{-1})	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
	0	-863	-1,735	-2,616	-3,506	-4,404	-5,312	-6,229	-7,146	-8,072	-9,007	-9,952	-10,906	-11,869	-12,843	-13,826

Table 14 presents a time series analysis from 2015 to 2030, focusing on the atmospheric carbon removals achieved through alley cropping and its impact below ground biomass. From the inception of the policy until 2024, the sequestered emissions initially begin at 0 (tonnes CO_2) this increases to -13,826 tonnes by the end of the policy period. An illustration is provided below showing the emissions (t CO_2) produced from the Biomass alley cropping in Vanuatu.

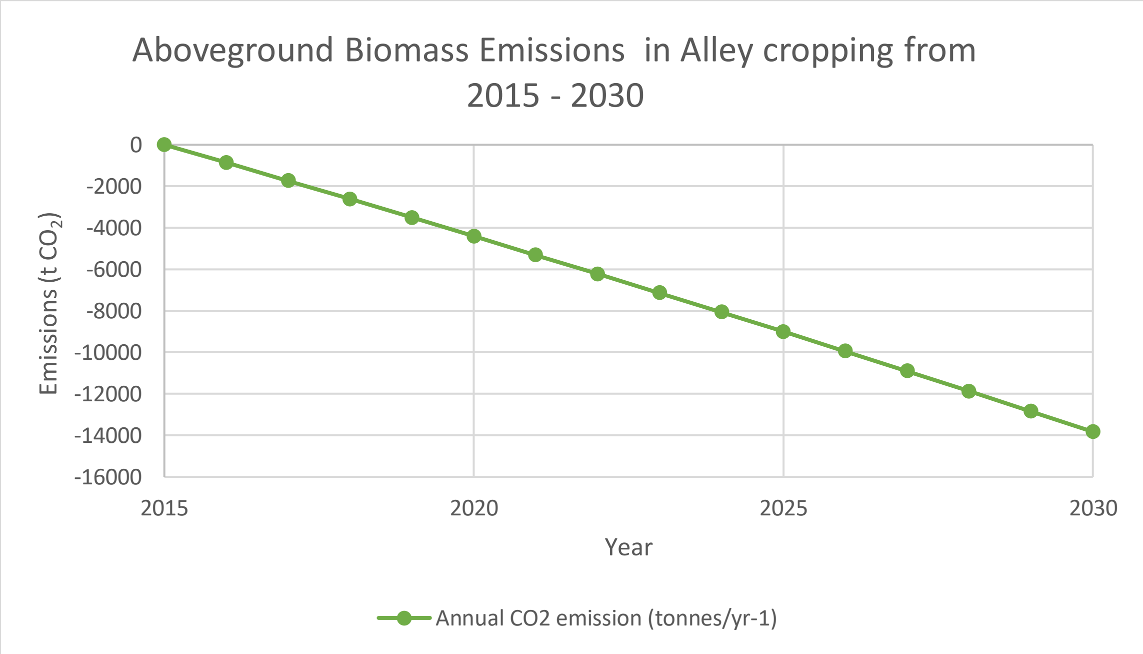

Figure 6: The Annual Emissions for aboveground biomass in alley cropping

Graph depicts how CO_2 removals from the atmosphere increase from 2015 to 2030. The beginning of the policy the emissions are 0 tonnes of CO_2, by the end of the policy 2030 the removals are estimated to be a total of -13,826 tonnes of CO_2.

Overall Emissions under the Policy scenario for alley cropping and Back yard gardening

In the context of the policy scenario, the adoption of alley cropping and backyard gardening plays a significant role in sequestering CO_2. As depicted in the graph below, it is anticipated that the total CO_2 emissions linked to these land uses will increase from -2,445 tonnes of CO_2 to -18,139 tonnes of CO_2 by the end of the policy period.

Figure 7 shows the total emissions generated from various land use practices, including alley cropping and backyard gardening, during the policy period 2015 to 2030.

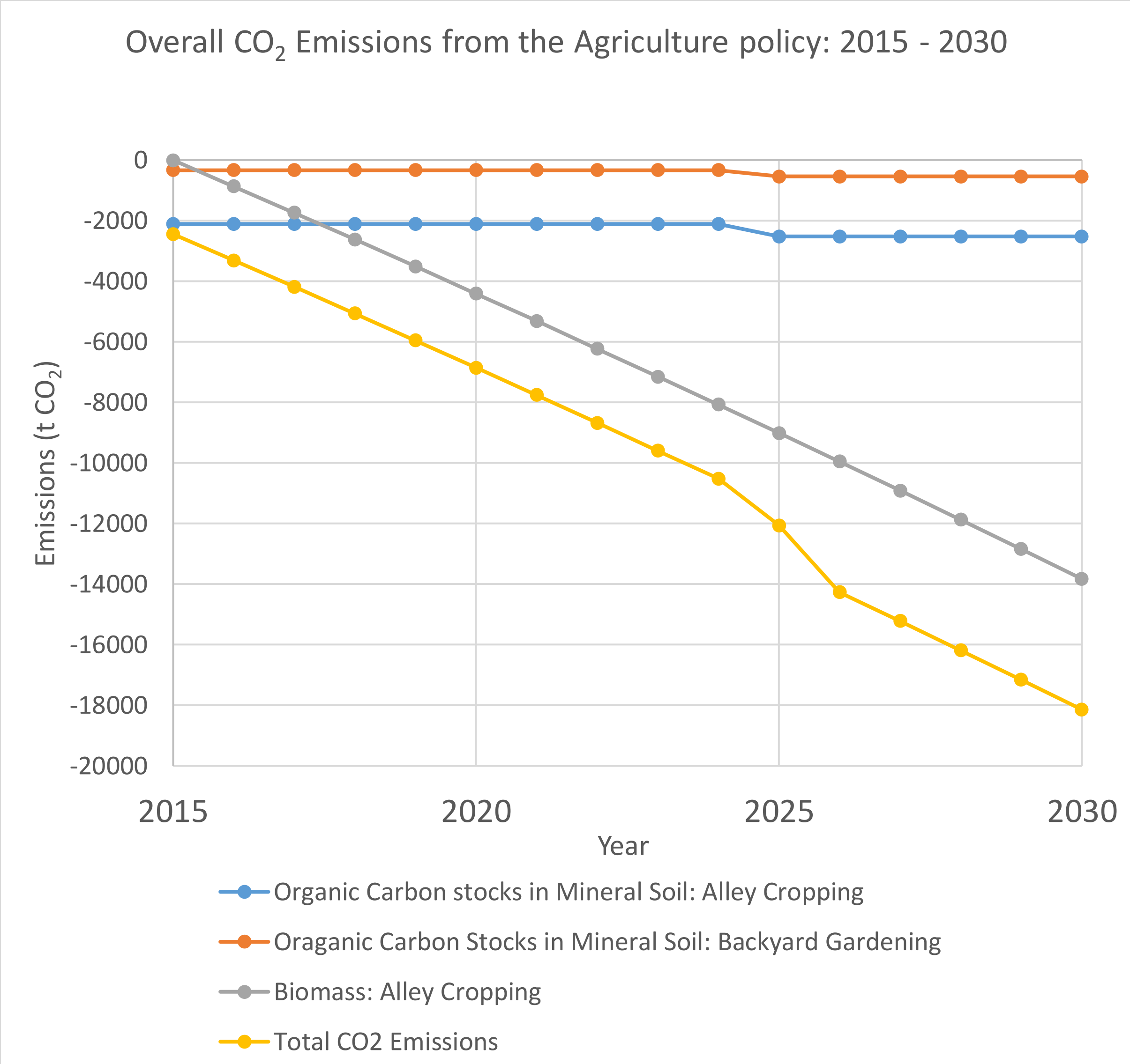

Figure 7: Removal of CO_2 tonnes resulting from implementation of backyard gardens and alley cropping under the Agriculture policy.

MONITORING PERFORMANCE OVER TIME

Key Performance Indicators (KPIs) are used to track the performance activities under thematic area 8 of the Vanuatu Agriculture Sector Policy evaluated in this policy assessment. They are introduced to monitor the progress and efficiency of training programs, sustainable agriculture practices and soil management, and impact on GHG emissions and removals.

Key performance indicator target

The KPIs were identified to be monitored over time for the performance of the assessed agriculture policy, in regard to monitoring policy implementation and the targeted impacts. The KPIs help track policy activities such as technical support provided to farmers and policy impacts, such as annual change in carbon stocks and annual CO_2 emission.

Monitoring Frequency

Monitoring frequency is the period where process performance is checked. The policy implementation period is between 2015 and 2030. Because of the ongoing effects, the assessment runs from 2015 to 2024 and ends in 2030. Table 15 shows the KPIs proposed.

Identifying responsible entity

These entities are responsible for holding and managing KPI data. They act as the stewards of this data, ensuring its accuracy, integrity, and availability for reporting and analysis.

Table 15: Monitoring Plan and KPIs for the Vanuatu Agriculture Sector Policy, thematic area 8.

KPI	Potential Sources for Data	Monitoring Frequency	Responsible Entity
Number of farmers trained in agroforestry and backyard gardening practices	DARD	Annual	DARD
Number of trainings conducted for agroforestry and backyard gardening practices	DARD	Annual	DARD
Number of farmers receiving assistance (equipment/trainings)	Vanuatu National Census / DARD	Annual	DARD, Vanuatu Bureau of Statistics
Number of households receiving assistance (equipment/trainings)	Vanuatu National Census / DARD	Annual	DARD, Vanuatu Bureau of Statistics
Area (hectare) of land converted to/applying alley cropping and backyard gardening	Vanuatu National Census / DARD	Annual	DARD, Vanuatu Bureau of Statistics
Number of pilot sites established for agroforestry and backyard gardening	Vanuatu National Census / DARD	Annual	DARD, Vanuatu Bureau of Statistics
Soil mapping for potential crops	DARD	Periodically	DARD
The proportion of agroforestry types (type and area) such as silvopasture and alley cropping	Vanuatu National Census / DARD	Annual	DARD, Vanuatu Bureau of Statistics
Carbon flux as a result of practices implemented (tC/yr.)	DARD	Annual	Department of Climate Change

The relevant KPIs were identified specifically for alley cropping and backyard gardening to be monitored over time for the performance of the assessed agriculture policy, in regards to monitoring policy implementation and its impacts.

POLICY 2: VANUATU NATIONAL LIVESTOCK SECTOR POLICY 2015-2030

Thematic Area 2: Commercial Livestock Production

ASSESSMENT OBJECTIVES

The objectives of the livestock policy assessment are to estimate changes in GHG emissions due to policy activities, specifically the changes in carbon stocks in mineral soil focusing on pasture management and emissions from enteric fermentation, across the provinces of Vanuatu. The objectives will help achieve the following:

- Identify how policy impacts GHG emissions
- Document policy activities and assess policy effectiveness
- Track policy progress towards national goals
- Improve policy implementation

The intended audience include livestock farmers, Government Agencies, policy makers, environmental departments and organizations, research institutions, and non-governmental organizations (NGOs).

STAKEHOLDER PARTICIPATION

Stakeholder engagement activities conducted during the assessment include:

- Workshops: Organized discussions to gather input on policy activities and perspectives from various stakeholders.
- Interviews: One-on-one conversations with key stakeholders to gain in-depth insights about policy implementation.

POLICY DESCRIPTION

General Information

Policy Name: Vanuatu National Livestock Sector Policy 2015-2023, Thematic area 2: ***Commercial Livestock Production.***

Organization conducting the assessment: Department of Climate Change under the ICAT project scope.

Assessment Date: July 2024 – October 2024

Detailed Description

Table 16 provides a detailed overview of the **Vanuatu National Livestock Policy (2015–2030)**, thematic area 2: **Commercial livestock production**. The policy focuses on increasing cattle productivity, supporting rural livelihoods, promoting environmental sustainability, and ensuring food security. The policy encourages partnerships between smallholders and large-scale farmers, facilitates access to resources, and supports infrastructure for cattle welfare. Implemented nationwide by the Ministry of Agriculture and Department of Livestock, it relies on voluntary actions, subsidies, and training programs. Key performance indicators track improvements in pasture management, partnerships, and greenhouse gas emissions/removals, aiming for increases in productivity by 2030.

Table 16: Vanuatu Livestock Policy Description

Name of Policy	**Vanuatu National Livestock Policy, 2015 – 2030, Thematic area 2: Commercial Livestock Production**
Type of policy instrument	Voluntary agreements or actions, subsidies and incentives, research, developments/ information instruments.
Description of specific interventions	• Increase cattle production and grow semi-commercial operations in Vanuatu by: ○ promoting joint partnership between smallholder farmers and large commercial cattle farmers to provide wider access to machinery and pasture. ○ increasing investment in commercial cattle farming ○ reducing unproductive cattle population through improved reporting requirements incorporated into land leases • Improve cattle productivity by improving pasture • Improve cattle welfare through establishment of holding yards and other infrastructure
Status of the policy	Adopted, implementation ongoing
Date of implementation start	2015
Date of completion (if relevant)	2030
Implementing entity or entities	Ministry of Agriculture, Department of Livestock
Objectives and intended impacts or benefits of the policy	**Economic Development:** One of the primary goals of the policy is to stimulate economic development within the country. By promoting and supporting the growth of the livestock industry, the government aims to create employment opportunities, generate income for farmers, and contribute to overall economic growth. **Food Security**: Another important objective of the policy is to enhance food security within Vanuatu. By investing in and improving the livestock sector, the government seeks to increase domestic production of meat, dairy, and other animal products. This helps reduce reliance on imports and ensures a stable food supply for the population. **Livelihood Improvement**: The policy also aims to improve the livelihoods of rural communities engaged in livestock farming. By providing support, training, and resources to small-scale farmers, the government intends to enhance their productivity, income levels, and overall quality of life. **Environmental Sustainability:** Sustainable practices in commercial livestock production are another key focus of the policy. By promoting environmentally friendly farming methods, such as rotational grazing, waste management systems, and conservation practices, the government aims to minimize the environmental impact of livestock farming and preserve natural resources for future generations. **Quality Standards:** Ensuring high standards of animal health, welfare, and product quality is a crucial aspect of the policy. By implementing

	regulations and guidelines for commercial livestock producers, the government aims to safeguard consumer health, promote ethical farming practices, and maintain Vanuatu's reputation for producing safe and high-quality animal products
Level of the policy	National
Policy inputs	Funding support for a) technical staff, b) communication/promotion, c) administrative support staff, and d) supplies.
Policy activities	1. Land preparation for pasture implementation. 2. Establishment of new pasture and rehabilitation of degraded pasture. 3. Establishment of machine centers. 4. Smallholder farmers and commercial farmers participate in programs (borrowing/lending equipment, etc.) 5. Training on pasture establishment and management. 6. Development and distribution of promotional materials for training. 7. Cattle fencing and equipment support. 8. Nurseries established and species distributed to commercial farmers to improved pasture. 9. Explore and develop markets for specific livestock products to facilitate better market access for farmers. 10. Restock cattle with improve breeds. 11. Provide support to build holding yards. 12. Implement business support programs that will help forge closer working relationship between commercial livestock and smallholder livestock farmers
Geographic coverage	Nation-wide
Sectors affected	Agriculture, LULUCF
Greenhouse gases affected	Methane (CH_4) from livestock enteric fermentation; CO_2 from soil carbon changes of pasture
Other related policies or actions	1. Environmental Policies, 1.a Land Use Policies, 1.b Water Resource Management 1.c Climate Change Mitigation 2. Agricultural Policies, 2.a Livestock Health Regulations, 2.b Feed and Nutrition Standards: 2.c Market Access Policies 3. Socio-Economic Policies: 3.a Rural Development Programs, 3.b Employment Regulations, 3.c Education and Training Initiatives 4. International Agreements: 4.a Trade Agreements, 4.b Environmental Convention
Intended level of mitigation to be achieved and/or target level of other indicators (if relevant)	Intended level of mitigation not specified, only qualitative objectives provided regarding growing markets for commercial livestock, improving livestock productivity and health, and improving pastures
Key stakeholders	Livestock farmers Government Agencies

	Consumers Industry Association Environmental groups Research institutions Local communities Exporters and Importers Animal welfare Organization Financial institutions
Title of establishing legal framework, or other founding documents	1. Agricultural Quarantine (Cap 200) 2. Animal Health Act (Cap 205) 3. Livestock Development Act (Cap 215)
Monitoring, reporting and verification procedures	Information is collected through survey, one-to-one basis where individual farmers are interviewed and asked a series of questions relating to animal husbandry, cattle stock, farm capacity and management, and the information's are captured in a software known as Kobo Toolkit. Each farmer is assigned a survey form in the toolkit and a tablet is used to log all data collected from the farmers. The data is available at the Livestock Department.
Policy Key Performance Indicators. (KPIs)	Indicator 1: Number of extension agent delivering pasture management trainings Indicator 2: Training to improve pasture management (number of trainings, number of farmers attending training) Indicator 3: Improve pasture management on commercial farms number of farms adopting improved pasture management (area of pasture under improved management). Indicator 4: Registered commercial farmers providing support to smallholder farmers (number of registered commercial farmers). Indicator 5: Increased number of commercial farms (number of commercial farms). Indicator 6: Number of animals using improved pasture. Indicator 7: Number of farmers receiving fencing support. Indicator 8: Allocated funding to the department (internal budget, donor support) Indicator 9: Number of holding yards developed, number of farms with stockyards Indicator 10: Partnerships (number of partnerships between commercial and small holder farmers) Indicator 11: Farmer access to machinery (number of farmers borrowing machinery, number of farmers lending machinery) Indicator 12: % reduction of CH_4 emissions relative 2015 Indicator 13: % increase in soil organic carbon relative 2015
Compliance and enforcement mechanisms	Farmer participation is voluntary
Reference to relevant documents	National Livestock Sector Policy Action Plan, Monitoring and Evaluation Framework 2015 – 2030
The broader context or	The policy on commercial livestock production in Vanuatu is essential for ensuring economic development, food security, environmental sustainability, and cultural preservation. By promoting sustainable

significance of the policy	practices and supporting farmers with appropriate resources and infrastructure, Vanuatu aims to strengthen its livestock sector for the benefit of both present and future generations.
Outline of sustainable development impacts of the policy	1. SDG 8: DECENT WORK AND ECONOMIC GROWTH & SDG 9: INDUSTRY, INNOVATION, AND INFRASTRUCTURE Economic Development - market access for livestock products 2. SDG 2: ZERO HUNGER Food Security and Nutrition - increased production of livestock 3. SDG 15: LIFE ON LAND & SDG 13: CLIMATE ACTION Environmental sustainability - resilient pasture for livestock 4. SDG 1: NO POVERTY & SDG 8: DECENT WORK AND ECONOMIC GROWTH Improve the livelihood or wellbeing of local and commercial farmers 5. SDG 9: INDUSTRY, INNOVATION, AND INFRASTRUCTURE Technology Adoption - installation of holding yards to monitor livestock health 6. SDG 1: NO POVERTY & SDG 10: REDUCED INEQUALITIES Rural Development - enables access for smallholder farmers to grow their production 7. SDG 13: CLIMATE ACTION Climate Resilience - pasture and livestock breeds more resilient to climate change effects

POLICY IMPACTS

Policy Inputs

Assessing the Vanuatu National Livestock Policy is vital because it provides a structured approach to evaluating the policy's impact on greenhouse gas (GHG) emissions and sustainable agricultural practices. The table below (table 17) outlines the policy inputs, activities, and intermediate effects. Key effects that contribute to GHG impacts include improved pasture, livestock productivity and reduced overgrazing.

Table 17: Policy inputs (I), activities (A), and intermediate effects (IE)

Inputs, activities, intermediate effects	Detail/ explanation	Affected parameter	Direction	Magnitude	Geographic location	Timing
(I) Funding support for a) technical staff, b) communication/promotion, c) administrative support staff, d) supplies	Budget allocation by the government to support implementation of the policy	Development of materials need to promote activities, availability of technical staff to carry out activities, availability of staff to manage documents (applications, contracts, agreements, etc.)	N/A	384,303,973vt (2023 budget from annual report)	National	Annually
(A) Develop and distribute promotional materials to support professional development on cattle and pasture management	Marketing information on market access, practices to improve pasture, livestock productivity and animal health, solicitations for farmers to collaborate and utilize services	Farmers participate in trainings on improving pasture, livestock productivity and animal health, attend informational meetings, seek out information and participate in programs (leases, etc.)	Increase	Up to 84% farmers were reached. (2023 annual report)	National	Ongoing

(A) Smallholder farmers and commercial farmers participate in programs (borrowing/lending equipment, etc.)	Programs that facilitate collaboration between smallholder and commercial farmers by providing access to shared equipment and livestock. These initiatives enable farmers to lend and exchange livestock breeds, such as cattle, pigs, etc... to enhance breed quality and productivity, particularly benefiting smallholder farmers.	Number of farmers lending/borrowing equipment, # of farmers access to livestock exchange	Increase		National	Ongoing
(A) Establish machine centers	Mechanism to allow small holder farmers to borrow equipment from commercial farmers to grow their operation	Ability to clear land for pasture access	Increase		National	4-9 years
(IE) Clearing of land for pasture	Ability to clear overgrowth and paths for livestock to reach different parts of the land to graze on	Land available for grazing more animals	Increase	Up to 6% increase in pasture land. (2023 annual report)	National	Ongoing
(IE) Loss of biomass from land clearing	Removal of shrubs and overgrown grasses	Decreased carbon stock in biomass	Decrease		National	Ongoing
(A) Training on pasture establishment and management	Provide training/supplies to farmers to implement improved pasture management practices	# of trainings conducted, # of farmers receiving support	Increase	350 farmers trained. (2023 annual report)	National	Ongoing

(A) Implement business support programs that will help forge closer working relationship between commercial livestock and smallholder livestock farmers	Improved collaborations between commercial and smallholder farmers	# of contracts between government and livestock farmers	Increase		National	4-9 years
(A) Explore and develop other markets for specific livestock products to facilitate better market access for farmers	Helps to increase markets for livestock products	Farmers access to new market openings for livestock products	Increase		National	10-15 years
(IE) Farmers change pasture management	Improved pasture management on commercial farms	Improved forage quality and quantity which therefore improve productivity. Note: this affects GHG emissions	Increase	Up to 84% of farmers trained (2023 annual report)	National	4-9 years
(IE) Improved pasture management	Farmers adopt sustainable pasture management practices such as rotational grazing and stocking rate (ration of cattle inside a paddock) which reduces overgrazing	Area of land with improved pasture growth. Note: this affects carbon stocks in soil and associated GHG emissions/removals	Increase		National	Ongoing
(IE) Increased pasture growth	Farmers adopt strategies in improving pasture growth to	# of commercial farmers adapt strategies	Increase		National	Ongoing

	support sustainable cattle farming	in pasture improvement and species distribution				
(IE) Improved forage quality and quantity	Farmers adapt to improving pasture management on commercial farms	Improved forage quality and quantity which therefore improve productivity. Note: this affects GHG emissions	N/A		National	4-9 years
(IE) Improved digestibility	Cattle consume higher quality forage that leads to improved digestibility	Improved forage quality and quantity improves cattle digestibility. Note: this affects GHG emissions	N/A		National	Ongoing
(IE) Improved production efficiency	improved pasture management on commercial farms	Commercial farms with improved pasture	N/A		National	Ongoing
(A) Cattle fencing and equipment support.	Commercial farmers provided with fencing materials	Ability to have better grazing management which can lead to pasture productivity # of cattle farmers receiving fencing support	Increase	350 farmers provided with fencing materials	National	1-3 years
(A) Land preparation for pasture establishment-land being prepared for over 3 years for pasture establishment.	Commercial farm land prepared for pasture implementation. Note: For pasture implementation, although it is said to take 1-3 years, it will ultimately be an ongoing activity.	# of farm land prepared over 3 years for pasture growth	Increase	up to 12% of farmland. (2023 annual report)	National	1-3 years (Ongoing)
(A) Establishment of new pasture and rehabilitation of degraded pasture	Rehabilitation of pasture	Area of improved pasture	Increase	up 33% of farms (110) achieved	National	1-3 years

				(2023 annual report)		
(A) Nurseries established and species distributed to commercial farmers to improve pasture	Cattle farms with nurseries established and species distribution for better pasture.	# of nurseries established	Increase			(Ongoing)
(A) Restock cattle with improve breeds	Distribution of cattle. (improve cattle breeds)	# of contracts between government and cattle farmers	Increase	up to 23% of cattle distributed. (2023 annual report)	National	4-9 years
(A) Provide support to build holding yards	Cattle farms with holding grounds constructed and distribution.	# of cattle farmers with stockyards.	Increase	up to 23% of cattle distributed. (2023 annual report)	National	4-9 years

Policy GHG Impacts

It is essential to identify policy intermediate effects (IE) and link them to potential GHG impacts for a thorough assessment. The inputs and activities outlined in the table above (table 17) result in the following intermediate effects. Table 18 illustrates the potential GHG impacts related to the activities of the Vanuatu National Livestock Policy, detailing how each intermediate effect contributes to greenhouse gas (GHG) impacts. For example, actions like improving forage quality, enhancing pasture management collectively boost soil carbon sequestration and reduce methane emissions. Enhanced digestibility from improved feed quality further reduces methane production, as livestock convert feed to energy more efficiently, reducing waste emissions. Land clearing for expanded pastures, however, can lead to increases in carbon emissions due to biomass loss.

Table 18: The table below shows the potential Greenhouse Gas (GHG) impacts from intermediate and subsequent effects of the Commercial Livestock Policy.

Intermediate effect*	Subsequent intermediate effects			Potential GHG impact
	Effect 1	Effect 2	Effect 3	
Farmers change management to improve pasture	Increase pasture growth			Increase soil CO_2 sequestration
	Improve forage quality & quantity	Increase N content of manure		Increase N_2O emissions from manure
	Improve forage quality & quantity	Digestibility improved	Improve production efficiency	Decrease CH_4 emissions per unit of production
Clearing land for pasture	Loss of aboveground biomass			Release of CO_2 from biomass removal

Causal Chain

Figure 8 shows a chain of events that can occur as a result of the Commercial Livestock Policy. It demonstrates how inputs and activities result in intermediate effects and impacts. Impacts may be related to GHG emissions/removals or other factors affected by the policy.

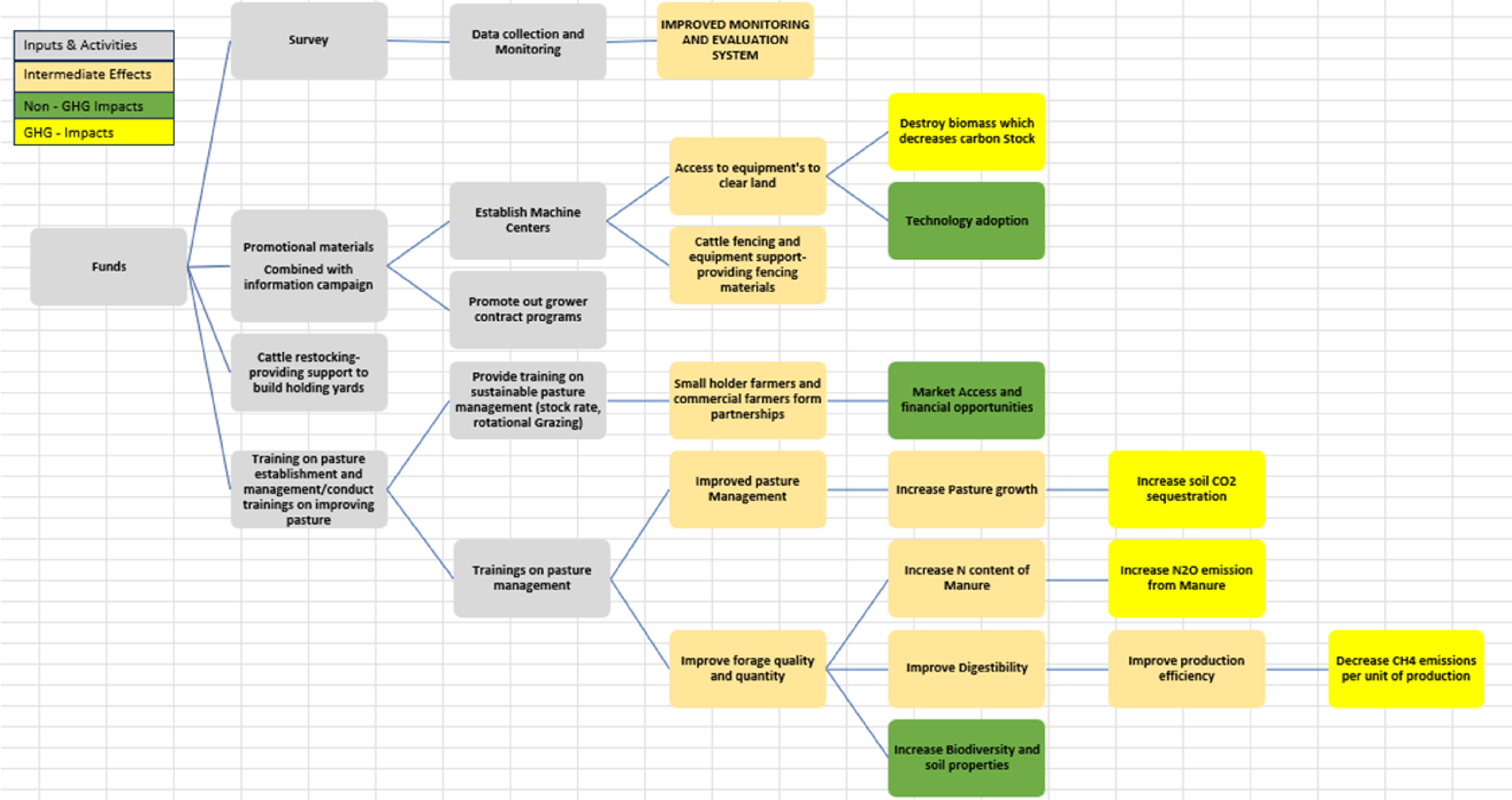

Figure 8: Casual chain for the livestock policy assessed

GHG Assessment Boundary

The GHG assessment boundary defines the scope of greenhouse gas emissions and carbon pools considered relevant for evaluating the impact of the Vanuatu National Livestock Policy. It includes considering emissions from sources affected by the policy such as livestock enteric fermentation, pasture management, and soil carbon changes due to land-use activities like land clearing and pasture rehabilitation. The boundary ensures that significant sources and sinks directly influenced by policy activities are included.

The steps shown in Figure 9 were taken to identify significant GHG sources and sinks for analysis:

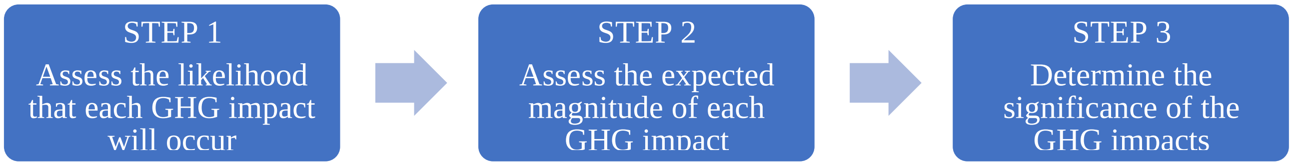

Figure 9: Steps used to define GHG assessment boundary

Before defining the GHG assessment boundary, we identified potential GHG impacts and sources/sinks from the policy description.

1. Methane (CH_4) – Emitted through livestock enteric fermentation and manure management.
2. Carbon Dioxide (CO_2) – Emitted during land clearing and biomass removal for pasture expansion; removed as a result of improved pasture management.
3. Nitrous Oxide (N_2O) – Emitted from soils, when nitrogen content increases due to manure deposition on pasture and improved pasture practices.

To assess the significance of GHG impacts, a likelihood-magnitude matrix, as outlined in ICAT Agriculture Policy Assessment Guides[3] (Table 5.4), was employed to evaluate both the likelihood and magnitude of potential impacts.

Table 19: Likelihood, magnitude, and significance of GHG impacts

Mitigation measure	GHG impact	Likelihood	Relative magnitude	Significance
		(Very likely, Likely, Possible, Unlikely, very unlikely)	(Major, Moderate, Minor, Unknown)	(Significant – include in the assessment, not significant – may exclude from the assessment, Not estimated – exclude from the assessment when magnitude is unknown or impact is outside the agriculture sector)
Improve pasture management	Increase soil CO_2 sequestration	Likely	Moderate	Significant

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[3] https://climateactiontransparency.org/our-work/icat-toolbox/assessment-guides/agriculture-sector/

Improve forage quality and quantity	Increase N_2O emissions from manure	Possible	Unknown	Not significant
	Decreased CH_4 emissions	Likely	Moderate	Significant
Clearing land for pasture	Release of CO_2 from biomass removal	Likely	Minor	Not significant

Table 19 categorizes the mitigation measures outlined in the Vanuatu National Livestock Policy, evaluating their expected GHG impacts, likelihood, magnitude, and overall significance in regard to changing GHG emissions. Each mitigation measure targets a specific GHG source. For example, improved pasture management are expected to increase soil carbon sequestration, removing carbon dioxide (CO_2). Other measures, such as enhanced forage quality and quantity, aim to decrease methane (CH_4) emissions by optimizing livestock feeding efficiency. There may be trade-offs as some effects of the policy may lead to increases in nitrous oxide (N_2O) emissions, as improved digestibility may lead to higher levels of N in manure deposited on pasture.

The likelihood of these impacts refers to the expected probability that each measure will achieve its intended GHG effect. Measures like pasture improvement are deemed "likely" to reduce CO_2 emissions through enhanced carbon sequestration, while forage quality and quantity improvements are also considered likely to lower methane emissions. The magnitude of each measure represents the scale of the emissions reduction, classified as minor, moderate, or major. For instance, methane reductions through feed quality improvements are assessed as moderate, given that better digestion can significantly reduce emissions per animal. Meanwhile, CO_2 release from land clearing is viewed as minor. Finally, significance assesses whether the GHG impact justifies inclusion in the policy's overall assessment. Measures with "significant" impacts, like enteric fermentation, methane reduction from cattle due to improved forage quality and quantity, are prioritized in the GHG assessment, while those with minor or unknown impacts, such as soil N_2O emissions, are excluded from the assessment.

Policy Assessment Period

The assessment period refers to the timeframe during which the impacts of a policy are evaluated. The Vanuatu National Livestock Policy started implementation in 2015 and is set to complete in the year 2030. There are two assessment periods utilized in this assessment: ex-post assessment and ex-ante assessment. The ex-post (2015-2024) assessment period refers to evaluating the actual outcomes of the policy that have occurred. The ex-ante (2025 – 2030) assessment period estimates potential future impacts of policy activities.

LIVESTOCK POLICY BASELINE SCENARIO AND GHG EMISSIONS

When estimating baseline scenario, it is essential to establish a clear reference point that represents the expected greenhouse gas GHG emissions and other relevant factors in the absence of policy intervention. This baseline serves as a foundation for comparing the actual impact of the Vanuatu National Livestock Policy on emissions. By accurately modeling the baseline, policymakers can identify the benefits achieved through the policy and evaluate its effectiveness in mitigating climate impacts. The baseline scenario is constructed using historical data, observed trends, and expert judgement to ensure it reflects realistic and credible characteristics for livestock practices and their associated GHG emissions.

The baseline type selected for this assessment is constant baseline. This approach assumes that pasture management practices remain unchanged over the assessment period, providing a straightforward reference for comparison. This assumption is reasonable because farmers are unlikely to change their practices without government intervention. Further, data is not available to construct a baseline based on historic trends. Data from the 2022 Vanuatu Agriculture Census is the most recent and comprehensive dataset covering agricultural production in Vanuatu and was the main source of data for this assessment. It is important to note that other livestock animals such as sheep and goats also graze on the pasture, however, enteric fermentation were estimated for cattle only due to data limitations. For the assessment baseline, it is assumed that cattle population does increase at the same rate as prior 10 years. FAO data was used to derive trend in livestock population increase in Vanuatu.

Description of the Baseline Scenario

The baseline scenario reflects the continuation of existing livestock practices without intervention from the Vanuatu National Livestock Policy. It is considered the most likely scenario because it assumes no additional improvements in pasture management or livestock productivity beyond current practice. This assumption is based on expert judgement. The conditions include:

- Total area of pasture remains the same
- Proportion of improved pasture (relative to total pasture area) remains the same
- Livestock population grows at the same rate as previous 10 years

The emissions estimation employed in this analysis follow the 2019 Refinement to the 2006 IPCC Guidelines, Tier 1 Methodology, utilizing default factors for soil organic carbon (SOC) stocks and emission factors suited to tropical climates. Soil organic carbon reference values for Vanuatu are provided in Appendix 1 (Table A1.1). Baseline values for key parameters were derived by data from the 2022 Vanuatu Agriculture Census.

Baseline Activity Data

The total pasture area was estimated by consolidating data from the 2022 Vanuatu Agriculture Census, specifically from parcels designated for permanent crops with pastures, temporary meadows and pastures, and permanent meadows and pastures. This aggregated pasture area was then multiplied by the median parcel size for each province to calculate the total hectares available for pasture management. Based on this methodology, there is 5,174.65 hectares of pasture in Vanuatu. Area of pasture by province are available in Table A3.1 and Table A3.2 in Appendix 3.

The baseline improved pasture area was estimated using expert judgment and data from the 2022 Vanuatu Agriculture Census. The percentage of improved pasture in 2022 varied across provinces, ranging from 0.5% in Torba to 5.9% in Tafea, with a total of 197.93 hectares of improved pasture nationwide. (See Table A3.2 in Appendix 3)

To estimate cattle population growth, the cattle population data from FAO was used. (See Table A3.4 in Appendix 3) A regression analysis was performed to estimate the growth rate of the population for years 2005-2014. The cattle population growth from 2005-2014 was annualized, resulting in a 1.9% annual growth rate. This percentage was then used to back cast and project the cattle population based on 2022 Vanuatu Agricultural Census livestock population data from 2015 to 2021 and 2023 to 2030, respectively.

Methodology and Sources for Key Parameters

Soil types were determined using the IPCC Tier 1 guidelines in conjunction with data from the FAO Harmonized Soil Map. Default stock change factors (Table 20) were applied for land use, land management, and land inputs. Analysis also assumes the default 20-year period to reach equilibrium.

The enteric fermentation emission factor for cattle (beef cattle) were determined using the IPCC Tier 1 guidelines and default factor for Oceania is 63 kg CH_4 head-1 yr-1. For cattle on improved pasture, the EF is reduced 12% from the default.[4]. To convert methane emissions to carbon dioxide equivalent (CO_2e), this assessment uses the Global Warming Potential (GWP) values from the IPCC Guidelines where methane has a GWP of 28 over a 100-year timeframe

Table 20: Stock change factors from the 2019 IPCC default values

Stock change factor	Type	Temperature Regime	Moisture Regime	IPCC Default Value
F_{LU}	All	All	All	1
F_{MG}	Nominally Managed	All	Dry and Moist / Wet	1
F_{MG}	Improved pasture	Tropical	Moist / Wet	1.04
F_I	Medium	All	Dry and Moist / Wet	1

Emissions and Removals

CO_2 sequestration and CH_4 emissions resulting from enteric fermentation will be calculated under the livestock policy focused on pasture enhancement. The equation for SOC carbon flux is described in the section on policy

The formula for calculating CH_4 emissions from enteric fermentation is:

$$Emissions = EF \bullet \frac{N_T}{10^6}$$

Where:

Emissions = methane emissions from Enteric Fermentation, Gg CH_4 yr-1

EF = emission factor for the defined livestock population, kg CH_4 head-1 yr-1

N_T = the number of heads of livestock species/category T in the country

T = species/category of livestock

The emissions due to change in soil carbon stocks are calculated using equation 2.25 from IPCC Guidelines (see policy 1 assessment). Given the assumption that no changes in land management (i.e., improved pasture) occur, carbon flux and therefore CO_2 emissions/removals from soils under the baseline is 0.

For enteric fermentation, baseline scenario emissions are summarized in Table 21. While the area of improved pasture remains unchanged, the cattle population increases (refer to Table A3.4 in Appendix 3). This pasture area, combined with varying cattle numbers, leads to increased methane emissions.

[4] Arndt, C., Hristov, A.N., Price, W.J., McClelland, S.C., Pelaez, A.M., Cueva, S.F., Oh, J., Dijkstra, J., Bannink, A., Bayat, A.R. and Crompton, L.A., 2022. Full adoption of the most effective strategies to mitigate methane emissions by ruminants can help meet the 1.5 C target by 2030 but not 2050. Proceedings of the National Academy of Sciences, 119(20),

Table 21: Baseline Scenario enteric fermentation emissions for both improved and unimproved pasture for cattle.

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cattle on Improved pasture	CH_4 Emission (Gg CH_4/yr.)	0.169	0.172	0.175	0.178	0.182	0.185	0.189	0.192	0.196	0.2	0.203	0.207	0.211	0.215	0.219	0.223
	CH_4 Emission (Gg CO_2 Eq)	4.721	4.81	4.901	4.994	5.088	5.185	5.283	5.383	5.485	5.589	5.696	5.804	5.914	6.026	6.141	6.258
Cattle on Regular pasture (Unimproved)	CH_4 Emission (Gg CH_4/yr.)	4.733	4.822	4.914	5.007	5.102	5.198	5.297	5.397	5.499	5.604	5.71	5.819	5.929	6.042	6.157	6.274
	CH_4 Emission (Gg CO_2 Eq)	132.52	135.029	137.585	140.19	142.843	145.548	148.303	151.11	153.981	156.907	159.888	162.926	166.022	169.176	172.39	175.666
Total emission Gg CO_2e		137.241	139.839	142.486	145.183	147.932	150.732	153.586	156.493	159.466	162.496	165.584	168.73	171.936	175.202	178.531	181.923

POLICY SCENARIO AND GHG EMISSIONS

Assumptions

The emissions estimation methods were based on the IPCC Tier 1 guidelines, incorporating default stock change factors for soil organic carbon (SOC) and the emission factor for methane (CH_4) decreases by 12% from the default value. It is also assumed:

- higher levels of improved pasture management will occur incrementally throughout the policy implementation period starting in 2022.
- 1% annual increase in the total pasture area under improved management
- Livestock population increases at the same rate as baseline; however, more cattle have access to improved pasture as area of improved pasture increases staring in 2022

The reason for assuming changes starting in 2022 is that policy implementation activities in reality began following the COVID-19 pandemic which revealed significant challenges in ensuring food security in Vanuatu. Area of improved pasture by province is provided in Table A3.6 in Appendix 3.

Values for Key Parameters and Their Sources

Emission factors include soil organic carbon (SOC) stock change factors from IPCC Tier 1 guidelines for tropical mineral soils. Under the policy scenario, F_{MG} changes from 1 to 1.04 representing a change from nominally managed to improved pasture (Table 20). It was assumed that livestock population is expected to grow at the same rate as in the baseline.[5]

[5] Arndt, C., Hristov, A.N., Price, W.J., McClelland, S.C., Pelaez, A.M., Cueva, S.F., Oh, J., Dijkstra, J., Bannink, A., Bayat, A.R. and Crompton, L.A., 2022. Full adoption of the most effective strategies to mitigate methane emissions by ruminants can help meet the 1.5 C target by 2030 but not 2050. Proceedings of the National Academy of Sciences, 119(20),

Policy Scenario

Area of improved pasture

The policy period runs from 2015 to 2030, totaling 15 years. The Vanuatu Agriculture Census of 2022 is the only source that provides data on pasture areas for cattle grazing. Policy activities provide training and technical support to farmers to adopt improved pasture management practices, however, no consistent data on land management changes and area affected across the assessment period is available. As a result, expert estimates of a 1% increase in improved pasture area starting in 2022. The estimated pasture improvement areas can be found in Table A3.6 in Appendix 3.

With the assumption that there will be a 1% increase in the improved pasture area annually under the policy period is assumed to have gained by 4 hectares of improved pasture from 2015 – 2024 and from 2025 to 2030 the gain in improved pasture will be 10 hectares of pasture (see Table A3.7 in Appendix 3).

Stock change values used for SOC calculation under the Ex-Post and Ex-Ante period

The stock change factors for pasture at the start of the assessment period are as follows: 1 for F_{LU}, 1 for F_{MG}, and 1 for F_{I}. These values apply to both ex-post and ex-ante periods. At the beginning of the assessment period, the pasture is native; therefore, a value of 1 will be used for F_{MG}, since native pasture management practices are expected to be minimal.

By the end of the assessment period, the values for F_{LU}, F_{MG}, and F_{I} are adjusted to 1, 1.04, and 1 respectively for the area of pasture that has been converted to improved pasture; thus, a value only F_{MG} changes to 1.04 while other stock changes factors remain the same.

Soil Organic Carbon (SOC)

The amount of Soil Organic Carbon stored has been quantified for each province, as detailed in Table 22. At the start of the ex-post assessment period $SOC_{(0-T)}$, a total of 248.307 tonnes of carbon was estimated. At the end of the ex-post assessment period in 2024, the SOC increases to 258.239 tonnes. During the ex-ante period, the SOC is estimated to be 649.250 tonnes of carbon at the start, and 675.220 tonnes in - 2030.

Table 22: SOC values for Ex-Post and Ex-Ante period under the policy scenario

Province	SOC (tonnes C)			
	Ex-post		Ex-ante	
	SOC_0	$SOC_{(0-T)}$	SOC_0	$SOC_{(0-T)}$
Torba	0.122	0.117	0.319	0.307
Sanma	149.474	143.725	390.832	375.800
Penama	50.711	48.760	132.594	127.494
Malampa	21.789	20.951	56.972	54.781
Shefa	7.553	7.262	19.748	18.989
Tafea	28.590	27.491	74.755	71.880
TOTAL	258.239	248.307	675.220	649.250

Emissions

The emissions associated with carbon sequestration under the policy scenario (table 23) indicate that during the ex-post period, there was a removal of -1.82 tonnes/yr. of CO_2. During the ex-ante policy assessment period, atmospheric removals had increased by an additional 4.76 tonnes of CO_2 detailed calculations shown in Table A3.8 and Table A3.9 in Appendix 3. Due to the 20-year time period for reaching equilibrium, changes in pasture management that occurred in years 2023-2024 continue to remove CO_2 at the rate of 1.82 tonnes/yr. for 18 more years.

Table 23: CO2 emissions from the establishment of improved pasture

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Improved Pasture Soil Organic Carbon																
Removals from Improved pasture Soil Organic Carbon (CO_2 tonnes)	0	0	0	0	0	0	0	0	-1.82	-1.82	-6.58	-6.58	-6.58	-6.58	-6.58	-6.58

As illustrated in Figure 10, the ongoing development of enhanced pasture is projected to lead to in CO_2 removals under the specified policy scenario.

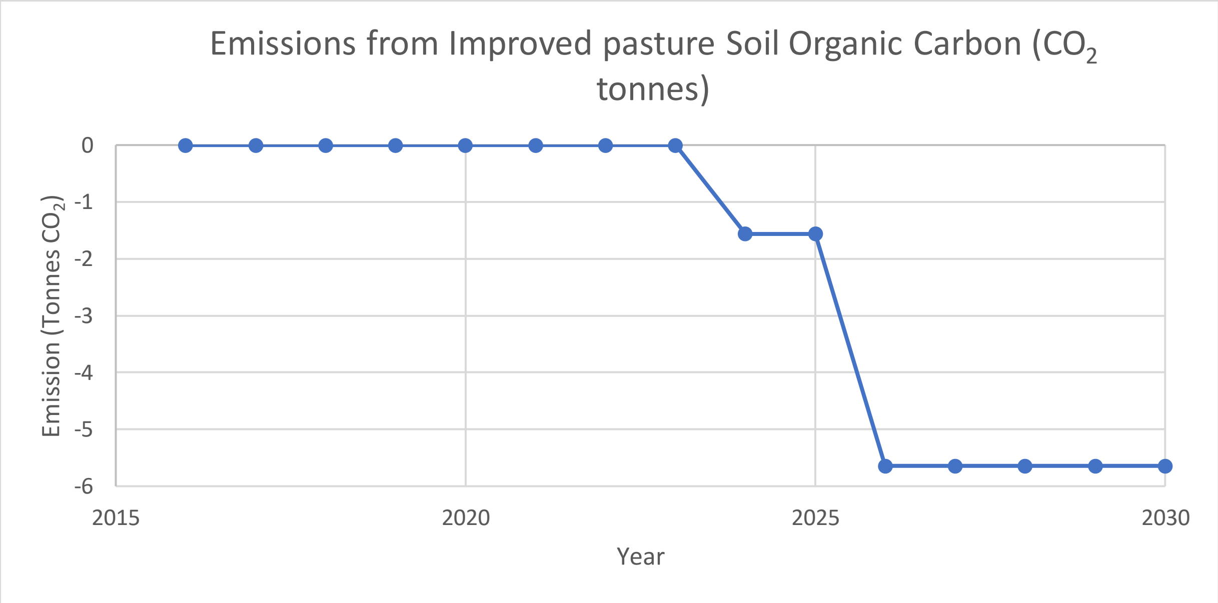

Figure 10: Emission from the establishment of Improved pasture 2015-2030

ENTERIC FERMENTATION EMISSIONS UNDER THE POLICY SCENARIO

Enteric fermentation emissions were calculated for both improved and unimproved pastures across Vanuatu's provinces using the specified equation. Emissions from cattle on improved pastures were estimated using an emission factor reduced by 12%. Emission data is detailed in Table A3.10 of Appendix 3.

Table 24: CO_2Eq emissions from enteric fermentation due to enhanced pasture quality

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Enteric Fermentation Emission from Improved pasture (Gg CO_2Eq)	4.721	4.810	4.901	4.994	5.088	5.185	5.283	5.383	5.538	5.697	5.861	6.029	6.203	6.381	6.565	6.754
Enteric Fermentation Emission from Regular Pasture (Gg CO_2Eq)	132.520	135.029	137.585	140.190	142.843	145.548	148.303	151.110	153.855	156.650	159.494	162.389	165.337	168.337	171.390	174.498
Total Emission (Gg CO_2Eq)	137.241	139.839	142.486	145.183	147.932	150.732	153.586	156.493	159.393	162.347	165.355	168.419	171.539	174.718	177.955	181.252

Table 24 presents a time-series analysis (2015–2030) of enteric fermentation emissions for livestock on both improved and unimproved pastures, and total emissions. Despite an increase in the overall cattle population, transition of more livestock to improved pasture has led to a relative decrease in enteric fermentation emissions intensity (emissions per head). By 2030, enteric fermentation emissions from improved pastures are projected to reach 6.754 Gg CO_2e, whereas emissions from regular pasture are expected to rise to 174.498 Gg CO_2e. The total enteric fermentation emissions, combining both pasture types, will reach 181.252 Gg CO_2e.

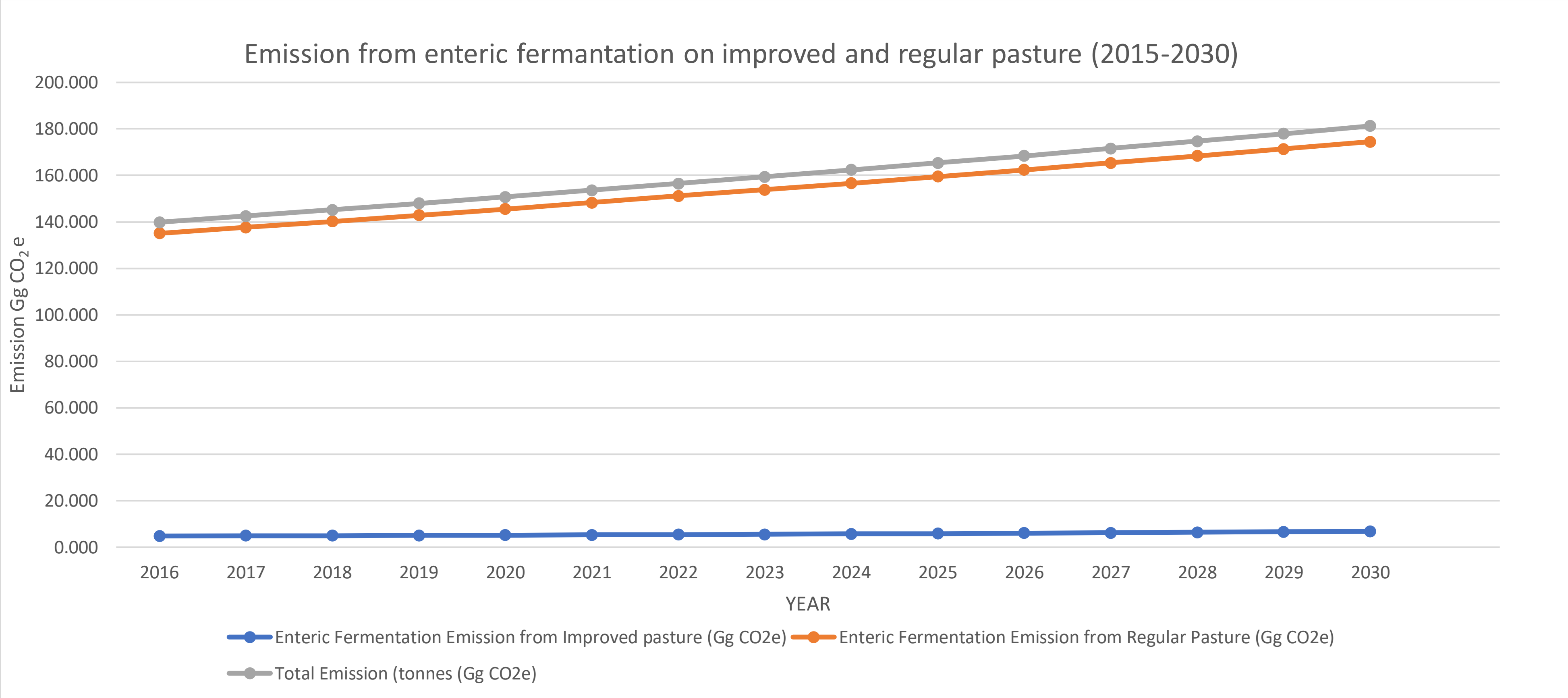

Figure 11: Emissions from Enteric Fermentation due to the establishment of improved pastures, non-improved pastures, and the total emissions from both pasture types from 2015 to 2030.

Overall policy results

The assessment of SOC and enteric fermentation emissions provides critical insights into the impact of pasture management on greenhouse gas (GHG) dynamics in Vanuatu. The calculations reflect both historical (ex-post) and projected (ex-ante) changes in SOC and methane (CH_4) emissions from livestock, highlighting the effectiveness of improved pasture management.

Table 25: Overall policy results 2015-2030

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Soil Organic Carbon (SOC)																
Emission from Improved pasture Soil Organic Carbon (tonnes CO_2)	0	0	0	0	0	0	0	0	-1.82	-1.82	-6.58	-6.58	-6.58	-6.58	-6.58	-6.58
Enteric Fermentation																
Total Enteric Fermentation (tonnes CO_2e)	137.241	139.839	142.486	145.183	147.932	150.732	153.586	156.493	159.393	162.347	165.355	168.419	171.539	174.718	177.955	181252
Total Emissions (tonnes CO_2e)	137.241	139.839	142.486	145.183	147.932	150.732	153.586	156.493	157.572	160.526	158.773	161.837	164.957	168.136	171.373	174.670

Table 25 provides an overview of the policy's impact on greenhouse gas (GHG) emissions, including soil organic carbon (SOC) removals and enteric fermentation emissions over the policy period. It confirms that improved pasture management contributes to increased carbon sequestration in soils while simultaneously reducing enteric methane emissions per unit of livestock.

- Soil Organic Carbon (SOC) removals: The policy scenario demonstrates increased SOC sequestration, with notable removals of -1.82 t CO_2e annually from 2023 to 2024, and a projected -6.58 t CO_2e removal annually from 2025 onwards
- Enteric Fermentation Emissions: The emissions from enteric fermentation continue to rise due to cattle population growth, but emissions per animal are lower under improved pasture conditions compared to the baseline scenario

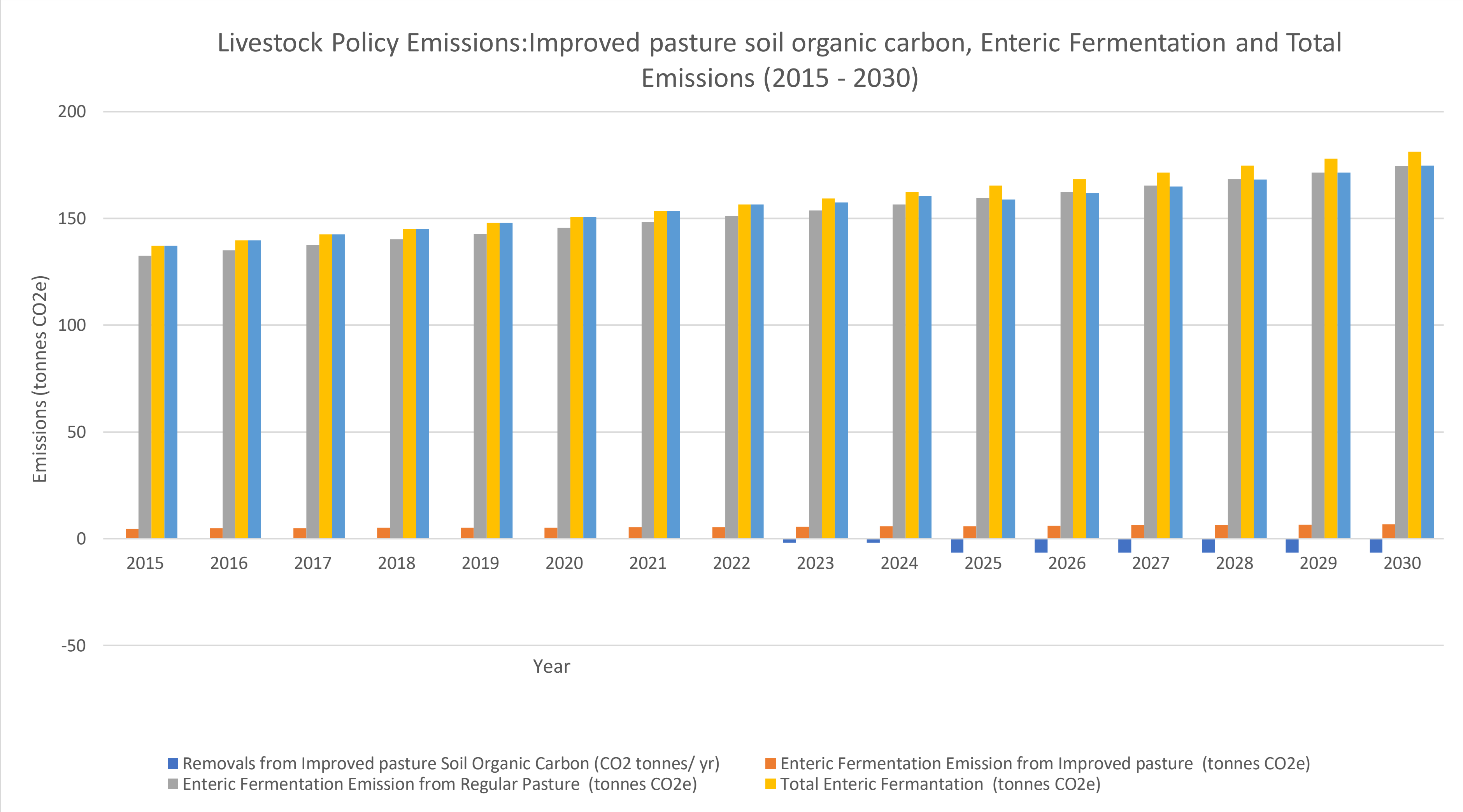

Figure 12: Livestock Policy Emissions: Improved pasture soil organic carbon, Enteric Fermentation and Total Emissions, 2015 - 2030

Figure 12 depicts the total emissions resulting from improved pasture establishment, total enteric fermentation, and the combined emissions from both factors under the policy scenario, spanning from the start of the policy in 2015 to the end of the policy period 2030.

MONITORING PERFORMANCE OVERTIME

The monitoring of the Vanuatu National Livestock Policy (2015-2030) is designed to ensure that its objectives are effectively implemented and continuously assessed. This process relies on structured data collection and evaluation methods that track livestock productivity, pasture management practices, stakeholder engagement, and environmental sustainability. By measuring key performance indicators (KPIs), policymakers can evaluate the progress of the sector and make informed decisions to enhance its impact.

Key Performance Indicator (KPI)

The KPIs outlines measurable targets used to assess the effectiveness of policy implementation over time. These indicators cover several critical areas, including livestock productivity, pasture management, training and capacity building, infrastructure development. Table 26 provides a structured framework for monitoring and evaluating policy outcomes, ensuring that interventions remain effective in promoting food security and economic growth in Vanuatu. Regular assessments based on these KPIs help guide decision-making and policy adjustments to enhance the sector's long-term performance.

Table 26: Monitoring plan and KPIs for the Vanuatu Livestock Sector Policy, thematic area 2

KPI	Potential sources for data	Monitoring frequency	Responsible entity
Number of extension agent delivering pasture management trainings	DARD	Periodically	DARD
Training to improve pasture management (number of trainings, number of farmers attending training)	DARD	Annual	DARD
Improve pasture management on commercial farms (number of farms adopting improved pasture management, area of pasture under improved management).	DARD	Annual	DARD, Vanuatu Bureau of Statistics
Registered commercial farmers providing support to smallholder farmers. (number of registered commercial farmers).	DARD/Vanuatu National Census	Annual	DARD, Vanuatu Bureau of Statistics
Increased number of commercial farms (number of commercial farms).	Vanuatu National Census/ DARD	Annual	DARD, Vanuatu Bureau of Statistics
Number of animals using improved pasture	Vanuatu National Census/ DARD	Annual	DARD, Vanuatu Bureau of Statistics
Number of farmers receiving fencing support	DARD	Annual	DARD, Vanuatu Bureau of Statistics
Allocated funding to the department (internal budget, donor support)	DARD	Annual	DARD, Vanuatu Bureau of Statistics
Number of holding yards developed, number of farms with stockyards	DARD	Annual	DARD, Vanuatu Bureau of Statistics
Partnerships (number of partnerships between commercial and small holder farmers)	DARD	Annual	DARD, Vanuatu Bureau of Statistics
Farmer access to machinery (number of farmers borrowing machinery, number of farmers lending machinery).	DARD	Annual	DARD, Vanuatu Bureau of Statistics

The relevant KPIs were identified specifically for the assessed livestock policy to be monitored over time for the performance of the Livestock policy, in regards to monitoring policy implementation and its impacts.

CONCLUSION

POLICY 1: AGRICULTURE POLICY

The implementation of backyard gardening and alley cropping in agricultural cropland has evidently shown to be a vital approach to reduce atmospheric CO_2 emissions in Vanuatu. This is proven by increasing biomass and soil carbon stocks. Alley cropping is projected to remove about -2,109.18 tonnes of CO_2 annually, while backyard gardening contributes to remove about -335.66 tonnes of CO_2. Furthermore, with the growth of above ground biomass, it is projected to have a total removal of -13,825.5 tonnes of CO_2 by 2030. This shows the effectiveness of strengthening the policy.

Alley cropping and backyard gardening practices not only contribute to mitigation of emission by enhancing soil sequestration but to also support climate resilience and increase food security. The agricultural policy which spans from 2015-2030 and the department of agriculture has fostered the implementation of these practices through trainings, workshops, and an increase in participation. This results in a gradual increase in areas dedicated to alley cropping and backyard gardening.

The ex-post and ex-ante assessment for both backyard gardening and alley cropping shows promising results. The annual CO_2 removals continues to increase over time beginning from the policy period (2015-2030). The estimated CO_2 removals have shown that these agricultural practices have the potential to remove GHG from the atmosphere, hence mitigate climate change. The projected increase in carbon sequestration from 2025-2030 showcase the advantage of integrating these practices into innovative farming approaches in the future.

POLICY 2: LIVESTOCK POLICY

The assessment of the Vanuatu National Livestock Policy (2015–2030) underscores its pivotal role in advancing sustainable livestock practices, enhancing economic development, and contributing to environmental sustainability. Implementation of improved pasture management, the policy is estimated to result in removals of CO_2 from the atmosphere and reductions in methane (CH_4) emissions intensity.

The ex-post analysis reveals an annual reduction of -1.82 t CO_2e over the period 2012–2024. Projected outcomes for 2025–2030 indicate even greater potential, with an estimated annual reduction of -4.76 tCO_2e. Enteric fermentation emissions have shown a decline under the policy scenario. The emission intensity, measured as total livestock emissions per total livestock population, has improved significantly. Under the baseline scenario, enteric fermentation emissions reached 181.252 Gg CO_2e by 2030, while the policy scenario demonstrates a reduction due to enhanced pasture quality, bringing emissions from enteric fermentation to a lower rate relative to cattle population growth. This reduction is attributed to a 12% decrease in methane emissions per head of cattle on improved pastures, reinforcing the effectiveness of better forage quality and pasture management in reducing overall CH_4 output. These figures highlight the effectiveness of targeted interventions and the importance of sustained policy implementation.

As Vanuatu progresses toward its 2030 goals, the findings emphasize the need for continued investment in training, infrastructure, and research to maximize the policy's benefits. Policy implementation will help Vanuatu in adapting to emerging challenges, ensuring long-term resilience and sustainability for the agriculture sector.

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APPENDIX 1

Table A1.1: Soil Type and Class for each Province in Vanuatu

SOC (ref)					
Soil Organic Carbon Stock for Mineral Soil (Tonnes C ha^{-1} in 30cm depth					
Province	**Soil Type**	**Soil Class** (IPCC default soil classes derived from the Harmonized World Soil Data Base (Ver. 1.1))	**2019 IPCC Default Value** (Vol. 4, Ch. 2, Table 2.3)	**Specific Parameters used in this assessment**	**Reference / Note**
Torba	Mollic Andosol	VOL	77	77	Not all islands possess a single predominant soil type; instead, there is a variety of common soil types found across the islands in Tafea Province and Penama Province. The average soil organic carbon (SOC) values for each soil type were estimated to be used in the analysis for the mentioned provinces
Sanma	Ferralic Cambisol	HAC	60	60	
Penama	Umbric Andosol	VOL	77	68.5	
	Ferralic Cambisol	HAC	60		
	Mollic Andosol	VOL	77		
	Eutric Cambisol	HAC	60		
Malampa	Eutric Cambisol	HAC	60	60	
Shefa	Vitric Andosol	VOL	77	77	

Tafea	Rhodic Ferralsol	LAC	52	64.5	
	Mollic Andosol	VOL	77		
	Vitric Andosol	VOL	77		
	Xanthic Ferralsol	LAC	52		

Table A1.2: Vanuatu Climate Region for all Provinces in Vanuatu

PARAMETER			**Note**
Climate Region			Provinces ranging from the northern to the southern regions experience similar temperature and moisture conditions
Province	**Temperature Regime**	**Moisture Regime**	
Torba	Tropical	Moist/Wet	
Sanma			
Penama			
Malampa			
Shefa			
Tafea			

APPENDIX 2

Table A2.1: Backyard Gardening land area (ha)

Year	Backyard Gardening Area (ha)						Total Area (ha)
	Torba	Sanma	Penama	Malampa	Shefa	Tafea	
2015	131.6	1434.2	974.8	381	100.2	16.8	3038.6
2016	131.6	1434.2	974.8	381	100.2	16.8	3038.6
2017	131.6	1434.2	974.8	381	100.2	16.8	3038.6
2018	131.6	1434.2	974.8	381	100.2	16.8	3038.6
2019	131.6	1434.2	974.8	381	100.2	16.8	3038.6
2020	131.6	1434.2	974.8	381	100.2	16.8	3038.6
2021	131.6	1434.2	974.8	381	100.2	16.8	3038.6
2022	131.6	1434.2	974.8	381	100.2	16.8	3038.6
2023	131.6	1434.2	974.8	381	100.2	16.8	3038.6
2024	144.1	1569.7	1066.9	417	109.7	18.4	3325.8
Gain ex-post	12.5	135.5	92.1	36	9.5	1.6	287.2
2025	145.5	1585.4	1077.5	421.1	110.8	18.5	3358.8
2026	131.6	1434.2	974.8	381	100.2	16.8	3038.6
2027	131.6	1434.2	974.8	381	100.2	16.8	3038.6
2028	131.6	1434.2	974.8	381	100.2	16.8	3038.6
2029	131.6	1434.2	974.8	381	100.2	16.8	3038.6
2030	152.9	1666.2	1132.5	442.6	116.4	19.5	3530.1
Gain ex-ante	7.4	80.8	55	21.5	5.6	1	171.3

Table A2.2: Alley Cropping land area (ha)

Year	Alley Cropping Area (ha)						Total Area (ha)
	Torba	Sanma	Penama	Malampa	Shefa	Tafea	
2015	937.9	3051.6	3555.3	848.7	638.4	802.3	9834.2
2016	937.9	3051.6	3555.3	848.7	638.4	802.3	9834.2
2017	937.9	3051.6	3555.3	848.7	638.4	802.3	9834.2
2018	937.9	3051.6	3555.3	848.7	638.4	802.3	9834.2
2019	937.9	3051.6	3555.3	848.7	638.4	802.3	9834.2
2020	937.9	3051.6	3555.3	848.7	638.4	802.3	9834.2
2021	937.9	3051.6	3555.3	848.7	638.4	802.3	9834.2
2022	937.9	3051.6	3555.3	848.7	638.4	802.3	9834.2
2023	937.9	3051.6	3555.3	848.7	638.4	802.3	9834.2
2024	1,026.40	3,339.80	3,891.10	928.8	698.7	878	10,762.80
Gain ex-post	88.6	288.2	335.80	80.10	60.30	75.70	928.70
2025	1,036.70	3,373.20	3,930.00	938.1	705.7	886.8	10,870.50
2026	937.9	3051.6	3555.3	848.7	638.4	802.3	9834.2
2027	937.9	3051.6	3555.3	848.7	638.4	802.3	9834.2
2028	937.9	3051.6	3555.3	848.7	638.4	802.3	9834.2
2029	937.9	3051.6	3555.3	848.7	638.4	802.3	9834.2
2030	1,089.60	3,545.30	4,130.40	986	741.7	932.1	11,425.10
Gain ex-ante	52.9	172.1	200.40	47.90	36.00	45.30	554.60

Table A2.3: Backyard Gardening 2015-2024 (Ex- Post) Assessment- CO_2 Emissions

BACKYARD GARDENING: ASSESSMENT OF CHANGE IN ORGANIC CARBON IN MINERAL SOIL FROM YEAR 2015 TO 2024						
	Total Soil organic carbon stock in the last year of an inventory time period, tonnes C	**Soil organic carbon stock at the beginning of the inventory time period (Tonnes C)**	**Time dependence of stock change factors (years)**	**Annual change in carbon stocks in mineral soils, (Tonnes C yr-1)**	**CO_2 Emissions**	**Reference / Note**
	SOC_O	$SOC_{(O-T)}$	D	ΔCMineral = (SOCo - SOC (O - T) / D	ΔCMineral * (-44/12)	IPCC 2019 Equation 2.25
	15867.5	14036.6	20	91.54	-335.66	Default Value of Time dependance of stock change factor extracted from ICAT/19R_V4_Ch05_Cropland

Table A2.4: Backyard Gardening 2025-2030 (Ex-Ante) Assessment- CO_2 Emissions

BACKYARD GARDENING: – ASSESSMENT OF CHANGE IN ORGANIC CARBON IN MINERAL SOIL FROM YEAR 2025 TO 2030						
	Total Soil organic carbon stock in the last year of an inventory time period, tonnes C	**Soil organic carbon stock at the beginning of the inventory time period (Tonnes C)**	**Time dependence of stock change factors (years)**	**Annual change in carbon stocks in mineral soils, (Tonnes C yr-1)**	**CO_2 Emissions**	**Reference / Note**
	SOC_O	$SOC_{(O - T)}$	D	ΔCMineral = (SOCo - SOC (o - T) / D	ΔCMineral * (-44/12)	IPCC 2019 Equation 2.25
	9472.7	8379.7	20	54.65	-200.38	Default Value of Time dependance of stock change factor extracted from ICAT/19R_V4_Ch05_Cropland

Table A2.5: Alley cropping 2015-2024 (Ex-Post) Assessment- CO_2 Emissions

ALLEY CROPPING: ASSESSMENT OF CHANGE IN ORGANIC CARBON IN MINERAL SOIL FROM YEAR 2015 TO 2024					
Total Soil organic carbon stock in the last year of an inventory time period, tonnes C	**Soil organic carbon stock at the beginning of the inventory time period (Tonnes C)**	**Time dependence of stock change factors (years)**	**Annual change in carbon stocks in mineral soils, (Tonnes C yr-1)**	**CO_2 Emissions**	**REFERENCE / NOTE**
SOC_O	$SOC_{(O-T)}$	D	ΔCMineral = (SOCo - SOC (o - T) / D	ΔCMineral * (-44/12)	IPCC 2019 Equation 2.25
64553.8	53049.2	20	575.2317948	-2109.183248	Default Value of Time dependance of stock change factor extracted from ICAT/19R_V4_Ch05_Cropland

Table A2.6: Alley cropping 2025-2030 (Ex-Ante) Assessment- CO_2 Emissions

ALLEY CROPPING: ASSESSMENT OF CHANGE IN ORGANIC CARBON IN MINERAL SOIL FROM YEAR 2025 TO 2030						
	Total Soil organic carbon stock in the last year of an inventory time period, tonnes C	**Soil organic carbon stock at the beginning of the inventory time period (Tonnes C)**	**Time dependence of stock change factors (years)**	**Annual change in carbon stocks in mineral soils, (Tonnes C yr-1)**	**Annual Change in CO_2 stocks in mineral soils**	**Reference / Note**
	SOC_O	$SOC_{(O-T)}$	D	ΔCMineral = (SOCo - SOC (o - T) / D	ΔCMineral * (-44/12)	IPCC 2019 Equation 2.25
	38537.9	31669.8	20	343.4069671	-1259.158879	Default Value of Time dependance of stock change factor extracted from ICAT/19R_V4_Ch05_Cropland

Table A2.7: Above ground biomass Emissions

Cropland		Provinces	Land Area of reporting year	gain in alley cropping area	Biomass accumulation rate	Biomass carbon loss (L)	Annual growth of perennial woody biomass[2]	Annual carbon stock in biomass removed (removal or harvest)[3]	Annual change in carbon stocks in biomass[4]	Annual CO_2 emission
Land Use Reporting Year	Agroforestry System (Area of land converted)		(Hectare)	Hectare	(tonnes C ha-1 yr-1) (G)	(tonnes C ha-1 yr-1)	(tonnes C yr^{-1})	(tonnes C yr^{-1})	(tonnes C yr^{-1})	(tonnes yr^{-1})
			Vanuatu Agriculture Census (2022)	Area gained = Land area in reporting year - Land area in 2015	Default Value from Table 5.1. 2019 IPCC Guideline Chapt. 5	Assume there is no loss because maturity cycle is assumed to be 20 years, so all the plants are still growing during the assessment period and haven't been removed/harvested			$\Delta C_B = \Delta C_G - \Delta C_L$	CO_2 emission $= \Delta C_B *(-44/12)$
					2.37	0	ΔC_G	ΔC_L	ΔC_B	ΔCO_2
2015	Alley Cropping	Torba	937.9	0.0	2.4	0.0	0.0	0.0	0.0	**0.0**
		Sanma	3051.6	0.0	2.4	0.0	0.0	0.0	0.0	**0.0**
		Penama	3555.3	0.0	2.4	0.0	0.0	0.0	0.0	**0.0**
		Malampa	848.7	0.0	2.4	0.0	0.0	0.0	0.0	**0.0**
		Shefa	638.4	0.0	2.4	0.0	0.0	0.0	0.0	**0.0**
		Tafea	802.3	0.0	2.4	0.0	0.0	0.0	0.0	**0.0**
Total										**0.0**
2016	Alley Cropping	Torba	947.3	9.5	2.4	0.0	22.5	0.0	22.5	**-82.3**
		Sanma	3082.4	30.8	2.4	0.0	73.1	0.0	73.1	**-267.9**
		Penama	3591.2	35.9	2.4	0.0	85.1	0.0	85.1	**-312.1**
		Malampa	857.2	8.6	2.4	0.0	20.3	0.0	20.3	**-74.5**
		Shefa	644.8	6.4	2.4	0.0	15.3	0.0	15.3	**-56.0**

		Tafea	810.4	8.1	2.4	0.0	19.2	0.0	19.2	**-70.4**
Total										**-863.2**
2017	Alley Cropping	Torba	956.9	19.0	2.4	0.0	45.1	0.0	45.1	**-165.5**
		Sanma	3113.6	62.0	2.4	0.0	146.8	0.0	146.8	**-538.4**
		Penama	3627.4	72.2	2.4	0.0	171.1	0.0	171.1	**-627.3**
		Malampa	865.9	17.2	2.4	0.0	40.8	0.0	40.8	**-149.7**
		Shefa	651.3	13.0	2.4	0.0	30.7	0.0	30.7	**-112.6**
		Tafea	818.6	16.3	2.4	0.0	38.6	0.0	38.6	**-141.6**
Total										**-1735.1**
2018	Alley Cropping	Torba	966.6	28.7	2.4	0.0	68.0	0.0	68.0	**-249.5**
		Sanma	3145.0	93.4	2.4	0.0	221.4	0.0	221.4	**-811.7**
		Penama	3664.1	108.8	2.4	0.0	257.9	0.0	257.9	**-945.7**
		Malampa	874.6	26.0	2.4	0.0	61.6	0.0	61.6	**-225.7**
		Shefa	657.9	19.5	2.4	0.0	46.3	0.0	46.3	**-169.8**
		Tafea	826.8	24.6	2.4	0.0	58.2	0.0	58.2	**-213.4**
Total										**-2615.9**
2019	Alley Cropping	Torba	976.3	38.5	2.4	0.0	91.2	0.0	91.2	**-334.3**
		Sanma	3176.8	125.2	2.4	0.0	296.7	0.0	296.7	**-1087.8**
		Penama	3701.1	145.8	2.4	0.0	345.6	0.0	345.6	**-1267.3**
		Malampa	883.5	34.8	2.4	0.0	82.5	0.0	82.5	**-302.5**
		Shefa	664.6	26.2	2.4	0.0	62.1	0.0	62.1	**-227.6**
		Tafea	835.2	32.9	2.4	0.0	78.0	0.0	78.0	**-286.0**
Total										**-3505.5**
2020	Alley Cropping	Torba	986.2	48.3	2.4	0.0	114.5	0.0	114.5	**-420.0**
		Sanma	3208.9	157.3	2.4	0.0	372.7	0.0	372.7	**-1366.6**
		Penama	3738.5	183.2	2.4	0.0	434.2	0.0	434.2	**-1592.2**
		Malampa	892.4	43.7	2.4	0.0	103.7	0.0	103.7	**-380.1**
		Shefa	671.3	32.9	2.4	0.0	78.0	0.0	78.0	**-285.9**

		Tafea	843.6	41.3	2.4	0.0	98.0	0.0	98.0	**-359.3**
Total										**-4404.1**
2021	Alley Cropping	Torba	996.1	58.3	2.4	0.0	138.2	0.0	138.2	**-506.6**
		Sanma	3241.3	189.7	2.4	0.0	449.5	0.0	449.5	**-1648.3**
		Penama	3776.2	221.0	2.4	0.0	523.7	0.0	523.7	**-1920.4**
		Malampa	901.4	52.8	2.4	0.0	125.0	0.0	125.0	**-458.4**
		Shefa	678.1	39.7	2.4	0.0	94.0	0.0	94.0	**-344.8**
		Tafea	852.1	49.9	2.4	0.0	118.2	0.0	118.2	**-433.3**
Total										**-5311.8**
2022	Alley Cropping	Torba	1006.2	68.4	2.4	0.0	162.0	0.0	162.0	**-594.0**
		Sanma	3274.0	222.4	2.4	0.0	527.1	0.0	527.1	**-1932.8**
		Penama	3814.4	259.1	2.4	0.0	614.1	0.0	614.1	**-2251.8**
		Malampa	910.5	61.9	2.4	0.0	146.6	0.0	146.6	**-537.5**
		Shefa	684.9	46.5	2.4	0.0	110.3	0.0	110.3	**-404.3**
		Tafea	860.7	58.5	2.4	0.0	138.6	0.0	138.6	**-508.1**
Total										**-6228.7**
2023	Alley Cropping	Torba	1016.3	78.4	2.4	0.0	185.9	0.0	185.9	**-681.5**
		Sanma	3306.8	255.2	2.4	0.0	604.7	0.0	604.7	**-2217.3**
		Penama	3852.5	297.3	2.4	0.0	704.5	0.0	704.5	**-2583.3**
		Malampa	919.6	71.0	2.4	0.0	168.2	0.0	168.2	**-616.7**
		Shefa	691.8	53.4	2.4	0.0	126.5	0.0	126.5	**-463.9**
		Tafea	869.4	67.1	2.4	0.0	159.0	0.0	159.0	**-582.9**
Total										**-7145.6**
2024	Alley Cropping	Torba	1026.4	88.6	2.4	0.0	209.9	0.0	209.9	**-769.8**
		Sanma	3339.8	288.2	2.4	0.0	683.1	0.0	683.1	**-2504.7**
		Penama	3891.1	335.8	2.4	0.0	795.8	0.0	795.8	**-2918.1**
		Malampa	928.8	80.2	2.4	0.0	190.0	0.0	190.0	**-696.6**
		Shefa	698.7	60.3	2.4	0.0	142.9	0.0	142.9	**-524.0**

		Tafea	878.0	75.8	2.4	0.0	179.6	0.0	179.6	**-658.5**
Total										**-8071.6**
2025	Alley Cropping	Torba	1036.7	98.8	2.4	0.0	234.3	0.0	234.3	**-859.0**
		Sanma	3373.2	321.6	2.4	0.0	762.3	0.0	762.3	**-2794.9**
		Penama	3930.0	374.7	2.4	0.0	888.1	0.0	888.1	**-3256.2**
		Malampa	938.1	89.4	2.4	0.0	212.0	0.0	212.0	**-777.3**
		Shefa	705.7	67.3	2.4	0.0	159.5	0.0	159.5	**-584.7**
		Tafea	886.8	84.6	2.4	0.0	200.4	0.0	200.4	**-734.8**
Total										**-9006.9**
2026	Alley Cropping	Torba	1047.1	109.2	2.4	0.0	258.8	0.0	258.8	**-949.1**
		Sanma	3407.0	355.4	2.4	0.0	842.2	0.0	842.2	**-3088.1**
		Penama	3969.3	414.0	2.4	0.0	981.2	0.0	981.2	**-3597.7**
		Malampa	947.5	98.8	2.4	0.0	234.2	0.0	234.2	**-858.8**
		Shefa	712.7	74.3	2.4	0.0	176.2	0.0	176.2	**-646.0**
		Tafea	895.7	93.4	2.4	0.0	221.4	0.0	221.4	**-811.9**
Total										**-9951.5**
2027	Alley Cropping	Torba	1057.5	119.7	2.4	0.0	283.6	0.0	283.6	**-1040.0**
		Sanma	3441.0	389.4	2.4	0.0	922.9	0.0	922.9	**-3384.1**
		Penama	4009.0	453.7	2.4	0.0	1075.3	0.0	1075.3	**-3942.7**
		Malampa	957.0	108.3	2.4	0.0	256.7	0.0	256.7	**-941.1**
		Shefa	719.9	81.5	2.4	0.0	193.1	0.0	193.1	**-707.9**
		Tafea	904.7	102.4	2.4	0.0	242.6	0.0	242.6	**-889.7**
Total										**-10905.6**
2028	Alley Cropping	Torba	1068.1	130.3	2.4	0.0	308.7	0.0	308.7	**-1131.9**
		Sanma	3475.5	423.8	2.4	0.0	1004.5	0.0	1004.5	**-3683.2**
		Penama	4049.0	493.8	2.4	0.0	1170.3	0.0	1170.3	**-4291.0**
		Malampa	966.5	117.9	2.4	0.0	279.4	0.0	279.4	**-1024.3**
		Shefa	727.1	88.7	2.4	0.0	210.1	0.0	210.1	**-770.5**

		Tafea	913.7	111.4	2.4	0.0	264.1	0.0	264.1	**-968.3**
Total										**-11869.3**
2029	Alley Cropping	Torba	1078.8	140.9	2.4	0.0	334.0	0.0	334.0	**-1224.8**
		Sanma	3510.2	458.6	2.4	0.0	1086.9	0.0	1086.9	**-3985.2**
		Penama	4089.5	534.3	2.4	0.0	1266.2	0.0	1266.2	**-4642.9**
		Malampa	976.2	127.5	2.4	0.0	302.3	0.0	302.3	**-1108.3**
		Shefa	734.3	95.9	2.4	0.0	227.4	0.0	227.4	**-833.7**
		Tafea	922.8	120.6	2.4	0.0	285.7	0.0	285.7	**-1047.7**
Total										**-12842.5**
2030	Alley Cropping	Torba	1089.6	151.7	2.4	0.0	359.6	0.0	359.6	**-1318.5**
		Sanma	3545.3	493.7	2.4	0.0	1170.1	0.0	1170.1	**-4290.2**
		Penama	4130.4	575.2	2.4	0.0	1363.2	0.0	1363.2	**-4998.3**
		Malampa	986.0	137.3	2.4	0.0	325.4	0.0	325.4	**-1193.1**
		Shefa	741.7	103.3	2.4	0.0	244.8	0.0	244.8	**-897.5**
		Tafea	932.1	129.8	2.4	0.0	307.6	0.0	307.6	**-1127.9**
Total										**-13825.5**

APPENDIX 3

BASELINE SCENERIO TABLE

Table A3.1: Area of Land (in hectares) for meadows and pastures

Activity Data	Province	Land Area (in hectare)
Median parcel size (ha)	Torba	0.66
	Sanma	1.25
	Penama	1.36
	Malampa	0.75
	Shefa	0.21
	Tafea	0.6
Parcels w/permanent crops with pastures	Torba	21
	Sanma	2222
	Penama	732
	Malampa	1069
	Shefa	547
	Tafea	586
Parcels w/ temp meadows and pastures	Torba	0
	Sanma	27
	Penama	6
	Malampa	20
	Shefa	36
	Tafea	12
Parcels w/perm meadows and pastures	Torba	2
	Sanma	21
	Penama	6
	Malampa	14
	Shefa	5
	Tafea	1

Table A3.2: Land area of normal pasture and improved pasture (in hectare)

Activity Data	Province	Land Area (in hectare)
2022 area of pasture (ha)	Torba	15.18
	Sanma	2837.5
	Penama	1011.84
	Malampa	827.25
	Shefa	123.48
	Tafea	359.4
	Total	**5174.65**
% Of improved pasture	Torba	0.50%
	Sanma	4.20%
	Penama	3.50%
	Malampa	2.10%
	Shefa	3.80%
	Tafea	5.90%
2022 area of improved pasture (ha)	Torba	0.0759
	Sanma	119.18
	Penama	35.41
	Malampa	17.37
	Shefa	4.69
	Tafea	21.20
	Total	**197.93**

Table A3.3: Area of improved pasture acquired from 2015 to 2024 and from 2050 to 2030 under the baseline scenario.

Province	Area of Pasture					
	2015	2024	Gain in area of pasture	2025	2030	gain in area of pasture
Torba	8.2	8.2	0.0	8.2	8.2	0.0

Sanma	1684.8	1684.8	0.0	1684.8	1684.8	0.0
Penama	381.0	381.0	0.0	381.0	381.0	0.0
Malampa	181.0	181.0	0.0	181.0	181.0	0.0
Shefa	382.8	382.8	0.0	382.8	382.8	0.0
Tafea	403.2	403.2	0.0	403.2	403.2	0.0
Total Sum	*3041.0*	*3041.0*	*0.0*	*3041.0*	*3041.0*	*0.0*

Table A3.4: Cattle population growth from years 2005-2014 under the baseline scenario.

Year	Cattle Population
1990	125000
1991	130000
1992	140000
1993	150000
1994	151000
1995	151000
1996	151000
1997	151000
1998	151000
1999	151000
2000	140000
2001	130000
2002	130000
2003	135000
2004	138000
2005	140000
2006	142915
2007	174137
2008	175000
2009	160000

2010	165000
2011	170000
2012	172000
2013	173000
2014	175000
2015	152403
2016	115540
2017	100000
2018	101535
2019	102100
2020	102776
2021	103635
2022	103825

Table A3.5: Cattle population and Enteric Fermentation CH4 emissions on improved and non-improved pasture

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cattle on Improved pasture	TORBA	8	8	9	9	9	9	9	9	10	10	10	10	10	10	11	11
	SANMA	1685	1717	1749	1782	1816	1850	1885	1921	1958	1995	2033	2071	2111	2151	2192	2233
	PENAMA	381	388	396	403	411	418	426	434	443	451	460	468	477	486	496	505
	MALAMPA	181	184	188	191	195	199	203	206	210	214	218	223	227	231	235	240
	SHEFA	383	390	397	405	413	420	428	437	445	453	462	471	480	489	498	507
	TAFEA	403	411	419	427	435	443	451	460	468	477	486	496	505	515	524	534
Cattle on Regular Pasture (Unimproved)	TORBA	1630	1661	1692	1724	1757	1790	1824	1859	1894	1930	1967	2004	2042	2081	2120	2161
	SANMA	38429	39157	39898	40653	41423	42207	43006	43820	44652	45501	46365	47246	48144	49059	49991	50941
	PENAMA	10505	10704	10906	11113	11323	11538	11756	11979	12206	12438	12674	12915	13161	13411	13665	13925

	MALAMPA	8439	8599	8761	8927	9096	9268	9444	9623	9805	9992	10182	10375	10572	10773	10978	11186
	SHEFA	9692	9875	10062	10253	10447	10645	10846	11051	11261	11475	11693	11916	12142	12373	12608	12847
	TAFEA	6430	6552	6676	6802	6931	7062	7196	7332	7472	7614	7758	7906	8056	8209	8365	8524

POLICY SCENARIO TABLES

Table A3.6: Area of improved pasture with an expert assumption of 1% increase in the area annually.

	Province	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Area of Improved Pasture (ha)	Torba	0.0759	0.0759	0.0759	0.0759	0.0759	0.0759	0.0759	0.0759	0.076	0.0774	0.0781	0.0789	0.0797	0.0804	0.0813	0.0821
	Sanma	119.17	119.17	119.17	119.17	119.17	119.17	119.17	119.17	120.36	121.57	122.78	124.013	125.25	126.50	127.77	129.049
	Penama	35.41	35.41	35.41	35.41	35.41	35.41	35.41	35.41	35.76	36.12	36.48	36.85	37.22	37.59	37.96	38.34
	Malampa	17.37	17.37	17.37	17.37	17.37	17.37	17.37	17.37	17.54	17.72	17.89	18.077	18.25	18.44	18.62	18.81
	Shefa	4.69	4.69	4.69	4.69	4.69	4.69	4.69	4.69	4.73	4.78	4.83	4.88	4.93	4.98	5.030	5.081
	Tafea	21.20	21.20	21.20	21.20	21.20	21.20	21.20	21.20	21.41	21.63	21.84	22.065	22.28	22.50	22.73	22.96

Table A3.7: Gain in Pasture area under the policy scenario

Province	Area of Pasture (ha)					
	2015	**2024**	**Gain in improved pasture**	**2025**	**2030**	**Gain in improved pasture**
Torba	0.076	0.077	0.002	0.078	0.082	0.004
Sanma	119.175	121.570	2.395	122.786	129.049	6.263
Penama	35.414	36.126	0.712	36.487	38.349	1.861
Malampa	17.372	17.721	0.349	17.899	18.812	0.913
Shefa	4.692	4.787	0.094	4.834	5.081	0.247
Tafea	21.205	21.631	0.426	21.847	22.962	1.114
Total	197.934	201.913	3.978	203.932	214.335	10.403

Table A3.8: Ex - post Assessment of Change in Organic Carbon in mineral Soil from the year 2015 to 2024

Ex - post Assessment of Change in Organic Carbon in mineral Soil from the year 2015 to 2024					
Land Use Category	Total Soil organic carbon stock in the last year of an inventory time period, tonnes C	Soil organic carbon stock at the beginning of the inventory time period (Tonnes C)	Time dependence of stock change factors (years)	Annual change in carbon stocks in mineral soils, (Tonnes C yr-1)	CO2 Emissions
Improved pasture	SOC_O	$SOC_{(O-T)}$	D	ΔCMineral = (SOCo – SOC (o - T) / D	ΔCMineral * (-44/12)
	258.2	248.3	20	0.496613308	-1.820915463

Table A3.9: Ex - Ante Assessment of Change in Organic Carbon in Mineral Soil from the year 2025 to 2030

Ex - Ante Assessment of Change in Organic Carbon in Mineral Soil from the year 2025 to 2030					
Land Use Category	Total Soil organic carbon stock in the last year of an inventory time period, tonnes C	Soil organic carbon stock at the beginning of the inventory time period (Tonnes C)	Time dependence of stock change factors (years)	Annual change in carbon stocks in mineral soils, (Tonnes C yr-1)	Annual Change in CO2 stocks in mineral soils
Improved Pasture	SOC_O	$SOC_{(O-T)}$	D	ΔCMineral = (SOCo – SOC (o - T) / D	ΔCMineral * (-44/12)
	675.2	649.3	20	1.298500639	-4.761169008

Table A3.10: Number of cattle on improved and non-Improved pasture

		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Number of Cattle on Improved pasture	Torba	8	8	9	9	9	9	9	9	10	10	10	10	11	11	11	12
	Sanma	1685	1717	1749	1782	1816	1850	1885	1921	1976	2033	2092	2152	2214	2277	2343	2410
	Penama	381	388	396	403	411	418	426	434	447	460	473	487	501	515	530	545
	Malampa	181	184	188	191	195	199	203	206	212	218	225	231	238	245	252	259
	Shefa	383	390	397	405	413	420	428	437	449	462	475	489	503	518	532	548
	Tafea	403	411	419	427	435	443	451	460	473	487	501	515	530	545	561	577
Number of Cattle on Unimproved Pasture	Torba	1630	1661	1692	1724	1757	1790	1824	1859	1893	1928	1964	2000	2037	2075	2114	2153
	Sanma	38429	39157	39898	40653	41423	42207	43006	43820	44614	45423	46246	47084	47937	48805	49689	50588
	Penama	10505	10704	10906	11113	11323	11538	11756	11979	12197	12419	12645	12875	13109	13348	13590	13837
	Malampa	8439	8599	8761	8927	9096	9268	9444	9623	9799	9979	10162	10349	10539	10732	10929	11130
	Shefa	9692	9875	10062	10253	10447	10645	10846	11051	11252	11457	11665	11877	12093	12312	12536	12763
	Tafea	6430	6552	6676	6802	6931	7062	7196	7332	7464	7598	7734	7872	8013	8157	8303	8451