CARBON FRIENDLY

ANNUAL GREENHOUSE GAS ASSESSMENT

Cherubino Vineyards

For

2022/23

Report prepared in accordance with Section 6.13 of the ISO 14064-2 Standard

PROJECT CODE: CBW-1
DOCUMENT VERSION: 1.1

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We have carried out our best endeavours to ensure the results are accurate and a true reflection of the situation, given that data inputs were not always complete. In cases where we were not provided with data for paddocks, we have made assumptions based on average values for similar paddocks where data was available. Several validations were undertaken on the extraction of input data and the results of the modelling to ensure results are as reliable as possible. To the maximum extent permitted by law, Carbon Friendly® Pty Ltd disclaims all liability for any loss, damage, expense, or cost incurred by any person arising from the use of the information contained in this report.

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ABBREVIATIONS

Abbreviation	Description in full text
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CoV	Coefficient of variation
CF	Carbon Friendly
CH_4	Methane
EF	Emission factor
GHG	Greenhouse gas/es
N_2O	Nitrous oxide
N	Nitrogen
SE	Standard error
SOC	Soil organic carbon
SOM	Soil organic matter
BD	Bulk density
LCA	Life cycle assessment
NIR	National Inventory Report
IPCC	Intergovernmental Panel on Climate Change

REVISION AND MODIFICATION HISTORY

Report version	Rationale for modification	Date	Contact person
1.1	Revision of SOC sequestration value due to additional data being made available	30/08/2024	Dr Majella Mumford majella@carbonfriendly.io

EXECUTIVE SUMMARY

Cherubino vineyards are located in South West Western Australia. The region experiences a Mediterranean climate, with dry summers and wet winters. The vineyards cover a total area of 655 ha, with approximately 160 ha of grape vines included in this assessment.

Cherubino are dedicated to promoting soil health and sustainable farm management practices. They are committed to reducing their carbon footprint and enhancing the carbon storage capacity of their orchards, exemplifying responsible agricultural production.

This report assesses the greenhouse gas (GHG) emissions intensity of the Cherubino vineyards in 2022/23 compared to the base year of 2021/22. The assessment was undertaken using a '*Cradle-to-Farm gate*' system boundary and based on primary inventory data of farm inputs and outputs used for the vineyards.

The methodology and calculations of the net GHG emissions are compliant with Carbon Friendly Standard V1.4 and cover all relevant emission sources and sinks of the orchards.

The emissions intensity (carbon footprint) of the grape production at Cherubino vineyards increased from **186 kg CO_2e per tonne** of grapes in 2021/22 to **198 kg CO_2e per tonne** of grapes in 2022/23. This increase in emissions intensity resulted primarily from an increase in on-farm fuel use compared to the base year. Considering the available carbon sinks, the net GHG emissions intensity decreased from **186 kg CO_2e per tonne** of grapes at the farm gate in 2021/22 to **-10,284 kg CO_2e per tonne** of grapes in 2022/23.

The total net GHG emissions of the Cherubino vineyards were equivalent to **-11,485 t CO_2e** in 2022/23.

QUANTITATIVE SUMMARY

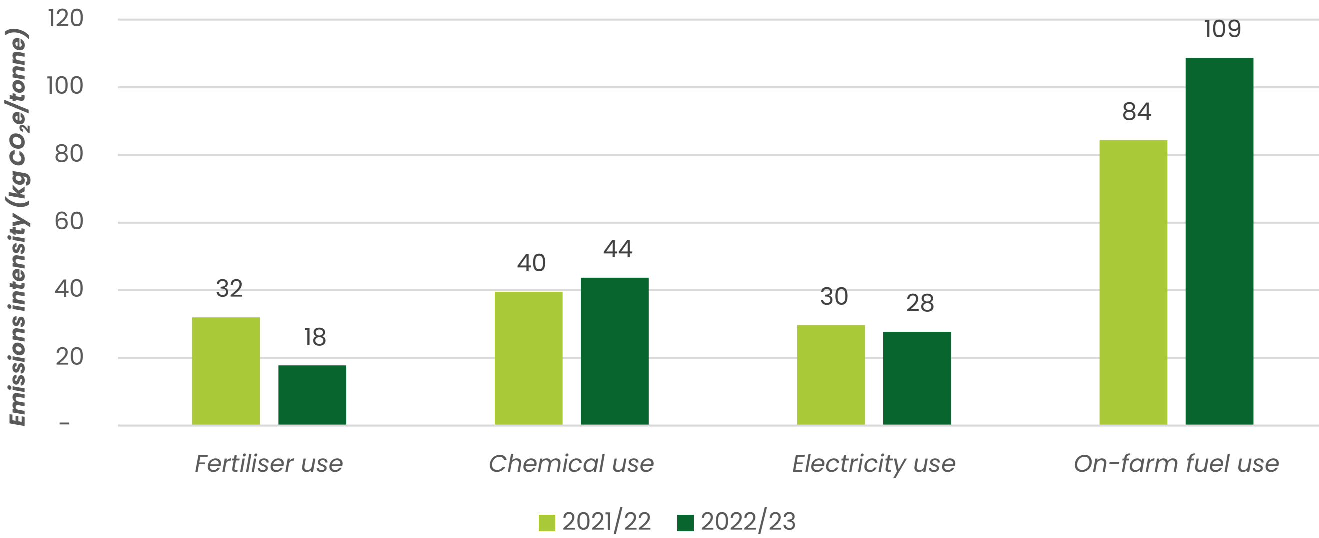


Figure 1. Cherubino vineyards GHG emissions intensity in the base year and reporting year

ASSESSMENT REPORT SUMMARY

PROJECT INFORMATION

Report version	**1.1**
Model version	**1.1**
Project title	ANNUAL GREENHOUSE GAS ASSESSMENT
Client name	Cherubino
Project code	CBW-1
Project proponent	Cherubino 6462 Caves Rd, Wilyabrup WA 6280
Base year/Assessment year	Base Year: 2021/22 Assessment Year: 2022/23
Primary inventory data provided by	Jono Reeve channybearup@larrycherubino.com
Intended user of the report	Cherubino Vineyards and stakeholders

PROJECT OUTCOME

Audit status	Audited by Carbon Friendly *audit@carbonfriendly.com.au*
Report and calculations reviewed by	AUS-QUAL Sofroni Eglezos *sofroni@foodmicrobiologymatters.com.au*
Yield	2021/22 **1,114 tonnes** (7.4 t/ha) 2022/23 **1,117 tonnes** (7.0 t/ha)
GHG emissions intensity per tonne *(Excluding emission sinks)*	2021/22 **186 kg CO_2e per tonne** 2022/23 **198 kg CO_2e per tonne**
Net GHG emissions intensity per tonne *(Including emissions sinks)*	2021/22 **186 kg CO_2e per tonne** 2022/23 **-10,284 kg CO_2e per tonne**
Total GHG emissions *(Excluding emission sinks)*	2021/22 **207 t CO_2e** 2022/23 **221 t CO_2e**
Net emissions *(Including emissions sinks)*	2021/22 **207 t CO_2e** 2022/23 **-11,485 t CO_2e**

THIRD-PARTY VERIFICATION

Application of Program Methodology Verified	
Project Information	
Company	Cherubino Vineyards
Production Year	2022/23
Production system	Wine grapes
AUS-QUAL Remarks	
AUS-QUAL has reviewed the Carbon Friendly Greenhouse Gas Emissions Reduction and Removal Enhancement analysis and report for the company detailed above. The outcome of the desk assessment is that Carbon Friendly methodology appears to have been applied correctly and the outcome is as follows:	
Project Outcome	
Net GHG emissions intensity	-10,284 kg CO_2e per tonne
Total Net emissions	-11,485 t CO_2e
In accordance with the above, the AUS-QUAL logo may be applied to the Carbon Friendly *Certificate of Compliance* for this company for the 12-month period of certification.	
AUS-QUAL Auditor	*Sofroni Eglezos*

INTRODUCTION

PROJECT CONTEXT AND SCOPE

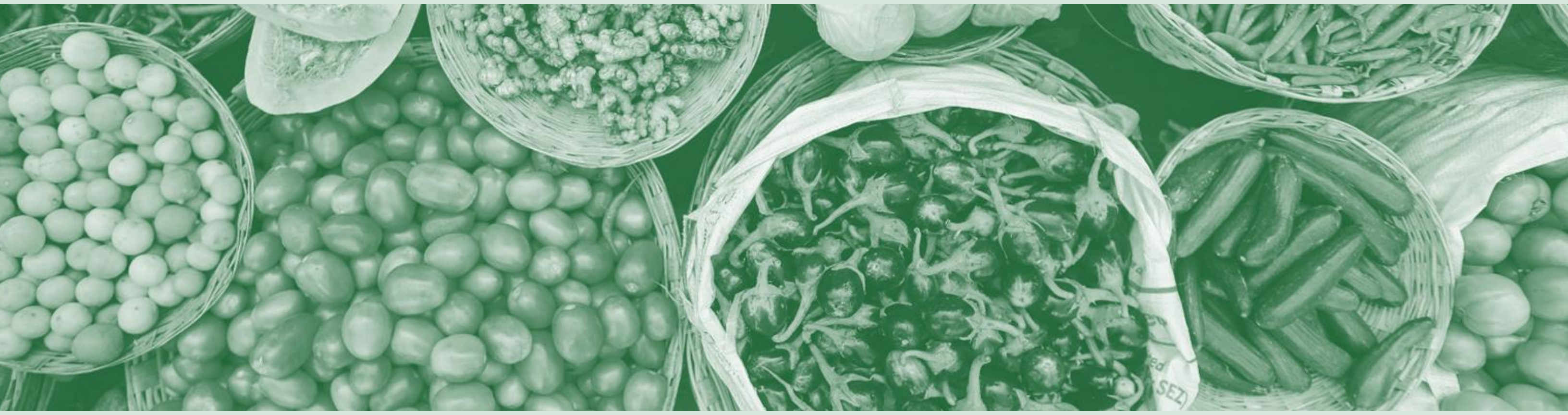
Cherubino vineyards are located in Wilyabrup, Western Australia. The vineyards included in this assessment encompass approximately 160 ha of grape vines. The assessment detailed in this report addresses only emissions of the farming phase, and does not include subsequent phases of the supply chain.

PROJECT AIM

The aim of this report is:

1. to provide a detailed analysis of the baseline GHG emissions inventory for the Cherubino vineyards for the year 2021/22 (1 July 2021 – 30 June 2022)
2. to quantify the GHG emission reduction and removals enhancements of the most recent year, the reporting year of 2022/23 (1 July 2022 – 30 June 2023), in comparison with the base year
3. to identify and/or recognise GHG emission hotspots and mitigation strategies for the orchards to minimise their environmental impact

To satisfy these aims, we employ an attributional life cycle assessment (LCA) method to analyse all GHG emission sources and sinks of the system following the principles and procedures described in Carbon Friendly® Standard V1.4, which is rooted in the GHG Protocol Product Standard and ISO 14064-2: 2019/20.



REGENERATIVE PRACTICE CHANGES

Cherubino has a strong history of sustainable orchard management, taking a wholistic approach to farm production. In recent years they have focused on promoting soil health and sustainable management through the following practices:

- Encouraging groundcover in the interrow area to reduce run-off, improve soil moisture retention, provide habitat for beneficial insect species, and improve SOC.
- Vine prunings and grass clippings are mulched and left to decompose as a source of organic matter to the soil.
- Using organic and biodynamic fertilisers in the place of most synthetic nutrition sources.
- Introduction of biological controls for fungal diseases, and natural predators to control insect pests.

GHG EMISSION SOURCES AND SINKS

GHG INVENTORY INCLUSIONS

The following emission sources were assessed:

- Fertiliser use: including direct in-field and indirect fertiliser-N_2O emissions and upstream emissions for the production of fertilisers.
- Chemical use: upstream manufacturing of chemicals (e.g., insecticide, herbicide, growth regulator, adjuvant, and fertiliser).
- Energy use: diesel, petrol, and AvGas used in field operations, and electricity for irrigation activities.
- Transport: fuel used in the delivery of fertiliser, chemicals, and fuel to the farm.
- Crop residue management: direct and indirect emissions associated with the treatment of crop residues.
- Soil carbon emissions: Emissions arising from soil due to loss of carbon.
- Soil carbon sequestration: Annual soil carbon improvement.

GHG INVENTORY EXCLUSIONS

Emissions associated with the manufacture of capital goods, including infrastructure and equipment have been excluded from this analysis. These emission sources are not considered material to stakeholders, not material in the context of the inventory, and not technically feasible nor cost-effective to be quantified at present.

Background Data

Background data referenced scientific literature and qualified assumptions were applied to support data that was not available from the farm records and/or measurements. For the transport of farm inputs, we assumed that trucks used diesel rather than petrol and noted that there is a small difference in emission factors between diesel and petrol. Emission factors for diesel, electricity, fertilisers, and all chemicals were taken from scientific literature, AusLCI, NIR, and expert opinion when data was not available. The details of emissions, default values, and assumptions used in the model are given in the appendices.

THE BASE YEAR

SELECTION OF THE BASE YEAR

The assessment aimed to determine the impact of practice changes introduced in 2021/22. Therefore, 2021/22 FY was selected as the base year, and subsequent annual assessments will track the improvements against this year.

GHG EMISSION SOURCES & SINKS OF THE BASE YEAR

The emissions intensity of grape production was **186 kg CO_2e per tonne** of grape in 2021/22 (Table 1). On-farm fuel use was the dominant source of emissions, accounting for 45% of emissions. Emissions from chemical use, fertilsier use, and electricity use were also key sources of GHG emissions contributing 21%, 17%, and 16% of the total carbon footprint, respectively. Emissions associated with the transport of inputs to the vineyard were negligible (<1%).

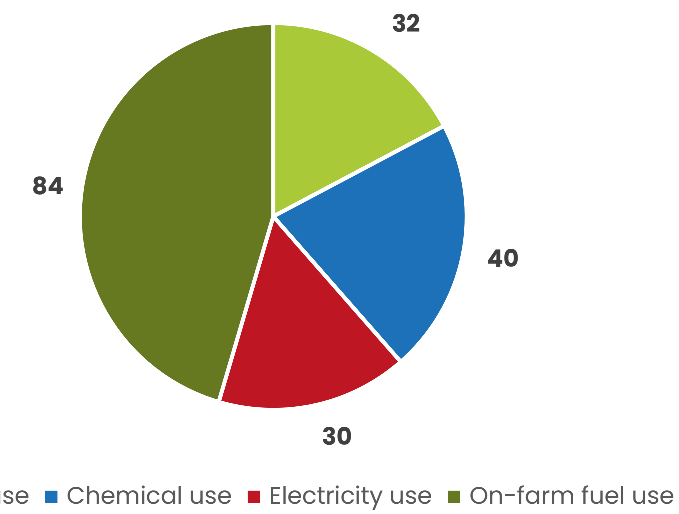


Figure 2. Contribution of individual sources to total GHG emissions in 2021/22

Considering the entire vineyard area, the total GHG emissions of the base year were **207 t CO_2e.**

Table 1. Greenhouse gas emission sources and sinks of Cherubino vineyards in the base year (2021/22) and assessment year (2022/23)

Sources & sinks	Emissions intensity (kg CO_2e per tonne)		Total GHG emissions (t CO_2e)	
	Base year	Assessment year	Base year	Assessment year
Total GHG emissions	**186**	**198**	**207**	**221**
Fertiliser use	32	18	36	20
Chemical use	40	44	44	49
Electricity use	30	28	33	31
On-farm fuel use	84	109	94	121
Transport of inputs	0	0	0	0
Total C sinks	**-**	**-10,482**	**-**	**-11,706**
Soil carbon sequestration	-	-10,482	-	-11,706
Native vegetation credit	-	-	-	-
Net GHG emissions	**186**	**-10,284**	**207**	**-11,485**

THE REPORTING YEAR

RELEVANT C SINKS

Soil Organic Carbon

The weighted average SOC content of the upper soil layer of 30 cm was 4.07% ± 1.12 in 2023, an increase from 2020 levels in which SOC was 2.21% ± 0.36% (Figure 3). Analysing the trend between 2020 and 2023, a regression equation of $Y = 0.6363X-1283.1$ was obtained, where Y is the estimated SOC% and X is the year. This increase in SOC content corresponds to an increase in C stock of 29.09 t C per hectare per annum, equivalent to 17,026 t CO_2e of carbon sequestered annually between 2020 and 2023 based on an assumed BD of 1.52 g/cm^3 for the assessed cropping area (Supplementary Table 4).

Accounting for uncertainty, the total soil carbon sequestration in 2022/23 was **11,706 t CO_2e**.

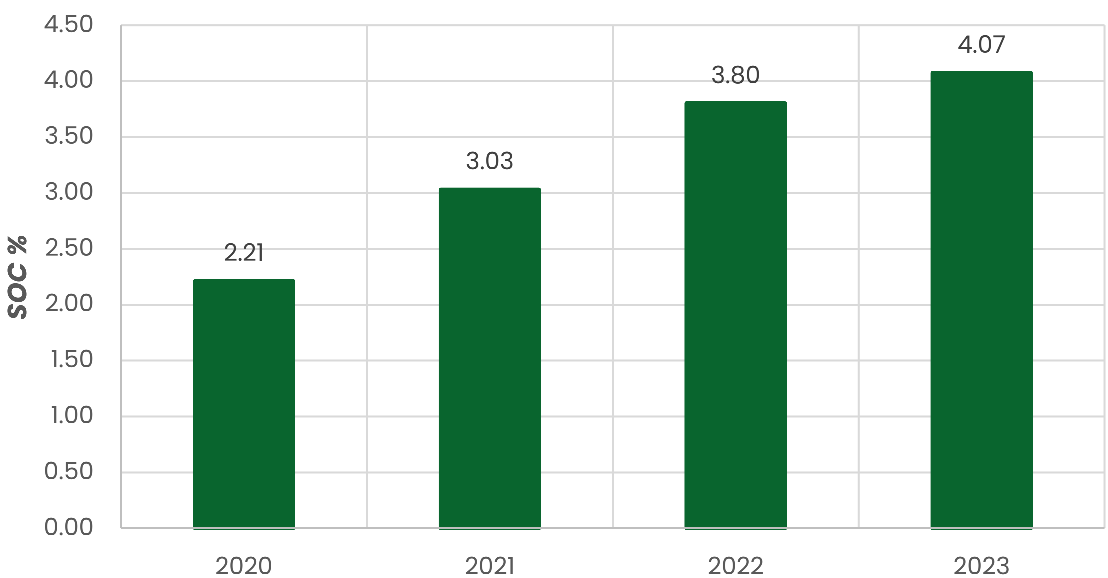


Figure 3. Weighted average SOC of Cherubino vineyards between 2020 and 2023

Native Vegetation

No native vegetation carbon sequestration was accounted for at the Cherubino vineyards as part of this assessment.

GHG EMISSION SOURCES & SINKS OF THE REPORTING YEAR

The GHG emissions intensity of grape production in the assessment year was 198 kg CO_2e per tonne of grape at the farm gate, a 6% increase compared to the base year (Table 1). This increase was primarily due to a 29% increase in on-farm fuel use.

On-farm fuel use was a dominant source of emissions, contributing 55% of the total carbon footprint (Figure 4). Chemical use (22%), electricity use (14%), and fertiliser use (9%) were also key sources of emissions, while GHG emissions from the transport of inputs were negligible (<1%).

Soil carbon sequestration was a significant carbon sink for the production system, equating to -10,482 kg CO_2e per tonne of grape, resulting in a net GHG emissions intensity of -10,284 t CO_2e per tonne of grape. The net GHG emissions of the total assessed area were -11,485 t CO_2e for the 2022/23 season.

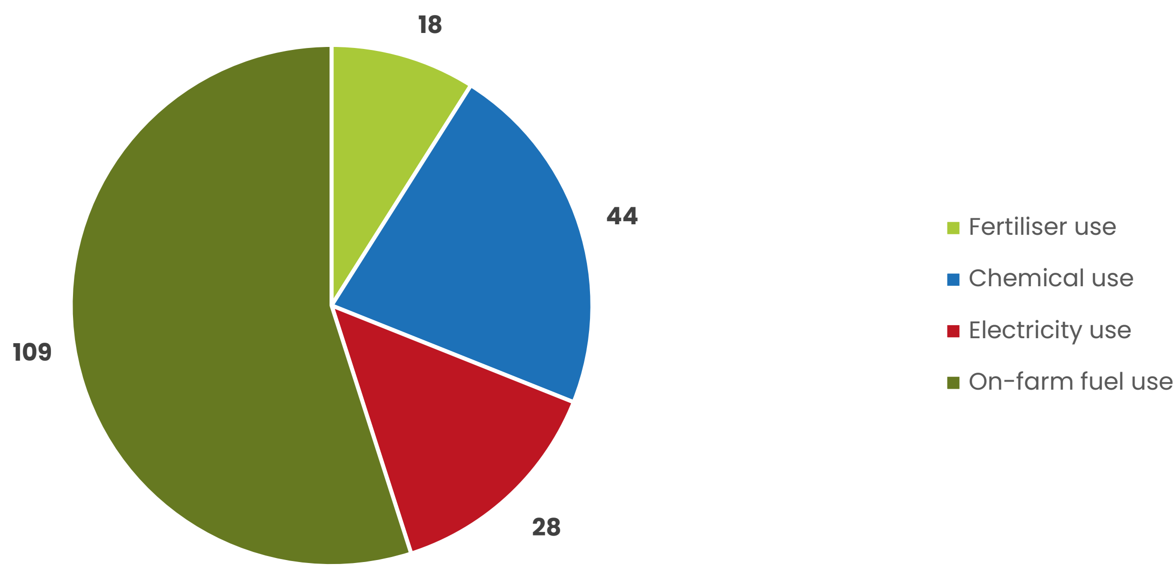


Figure 4. Contribution of individual sources to total GHG emissions in 2022/23

IMPACT OF UNCERTAINTY

The uncertainty in the primary input data and the SOC improvement was evaluated using a quantitative risk assessment matrix (Supplementary Table 5) and quantitative analyses of standard error (SE) of annual SOC data. The uncertainty in each dataset was calculated in a manner that avoids the underestimation of GHG emissions and the overestimation of GHG removals.

The uncertainty in SOC improvement was calculated as a weighted confidence score derived from both quantitative and qualitative parameters such as the variation (standard error) in SOC test results between blocks and farms, the source of bulk density values and the number of soil samples taken per hectare. Accounting for these factors is crucial to avoid overestimating soil carbon sequestration and underestimating GHG emissions.

The uncertainty in the primary SOC data was found to be 31% in the base and the reporting year. The uncertainty in the base year was due primarily to the absence of site-specific bulk density, in the absence of which, a state average bulk density factor was utilised. In the base year there was a very low degree of variation between individual samples, reflected by a coefficient of variation of only 16%. In the assessment year, variation between samples was higher, a CoV of 27%, adding to the uncertainty in the dataset. This was however, offset by the high sampling resolution (Supplementary table 5).

CONCLUSION

This analysis assessed the GHG emissions intensity and total carbon footprint of the Cherubino vineyards in compliance with the ISO 14064-2: 2019/20 Standard. The base year was selected as 01 July 2021 to 30 June 2022, and the reporting year selected as 01 July 2022 to 30 June 2023. Primary inventory data for crop area, inputs, outputs, and measured SOC data were used to calculate the net GHG emission reductions and removals enhancements of the orchards. The analyses were performed following the Carbon Friendly® Standard V1.4, which provides the methodology, requirements, and procedures for quantifying GHG emission reductions or removal enhancements.

The GHG emissions intensity of production at Cherubino vineyards increased from **186 kg CO_2e per tonne** to **198 kg CO_2e per tonne** of grapes at the farm gate between 2021/22 and 2022/23. Accounting for the available carbon sinks for the orchard, soil carbon sequestration equivalent to **-10,482 kg CO_2e per tonne**, the net GHG emissions intensity of production in 2022/23 was **-10,284 kg CO_2e per tonne**, equivalent to **-11,485 t CO_2e** for the total vineyard area.

Acknowledgements

We sincerely thank Jono Reeve and the Cherubino team for all their assistance in providing the data that enabled us to make a detailed assessment.

APPENDIX 1 – PRIMARY INVENTORY DATASET

Supplementary Table 1. Key input data of Cherubino vineyards in the base year (2021/22) and assessment year (2022/23)

Parameter	Unit	Base year	Assessment year
1. Crop productivity			
Assessment area	ha	151	160
Yield	tonnes	1,114	1,117
Average yield	tonnes/ha	7.4	7.0
2. Fertiliser use			
Fertiliser application rate	t/ha	0.5	0.2
Nitrogen application rate	kg N/ha	17.5	7.0
3. Chemical use			
Insecticide	L	9	122
Herbicide	L	355	277
Fungicide	L	5,215	5,760
Adjuvants and other	L	97	45
4. Energy			
Diesel use	L	27,830	35,945
Petrol use	L	0	0
LPG use	L	0	0
Electricity use	kWh	60,217	56,284
5. Transport distances			
Fuel depot	km	55	55
Fertiliser depot	km	55	55
Chemical depot	km	55	55
Compost/OA depot	km	0	0
Lime/gypsum depot	km	170	170

Supplementary Table 2. Fertiliser use (tonnes) in the base year (2021/22) and assessment year (2022/23)

Fertiliser product	2021/22	2022/23
Algen Ultra	-	0.3
Amion Acid	1.2	-
Bioguano	-	0.1
Boron	-	0.0
Cal nitrate	4.0	-
Ferticoat	0.7	-
Foliar NRG	-	0.4
Fulic Max	-	0.1
Green raft Cal	-	0.2
Gusto NPK	-	8.2
Gypsum	40.0	2.4
Humate Plus	-	0.6
Hydro Fish	4.3	-
K Systemics	-	0.1
Khumic 100	-	0.0
Liquid Kelp	-	0.4
Magnesium Sulphate	0.8	-
Manga Mate	0.5	0.2
MAP	2.0	-
Mega Kel P	1.1	0.4
Micro Foilar	-	2.1
Microlife	-	2.8
Multimate	0.6	-
Natural Potassium Granule	-	4.4
No Frill Granual Blend	-	9.5
No Frills Regenrate	-	2.1
Omni Bor	0.2	0.1
Omni Gold	10.0	-
Organosul s 20	-	0.2
Potassium Humate	3.2	-
Potassium Sulphate	1.8	-
Seaweed Extract	2.34	0.1
Soil NRG	-	0.5
Solfo Urea	-	0.0
Supr-N	-	0.1
SW Trace	-	0.4
Triumphilis 20l	-	0.1
Vibrocalcite	-	0.2
Zinc Mate	0.10	-

Supplementary Table 3. Chemical use (L or kg) in the base year (2021/22) and assessment year (2022/23)

Chemical product	2021/22	2022/23
Amistar	-	82
Avatar	9	4
Botector	35	-
Bravo/Barrack	374	317
Cabrio	28	-
Digger	23	47
Dragon	14	14
Duwet	44	-
Endorse	19	-
Intervene	-	36
Microthiol	3792	4506
Miravis	6	6
Nail	1	-
Polyram	200	211
Polyram	-	-
Prolectus	63	-
Prosper	16	-
Reglone	-	30
Round up	170	170
Round up	-	-
Serenade	63	-
Sprayseed	183	77
Stifle	375	383
Switch	120	128
Talendo	14	10
Teldor	88	96
Trivor	-	15
Vitiwet	34	45
Vivando	6	8
Voliam tago	-	21

Supplementary Table 4. Weighted annual SOC, SOC stock, and SOC increase rate

Year	Weighted SOC (%)	Derived SOC (%)	C stock (t C/ha)	SOC sequestration (t C/ha)
2020	2.21	2.33	101.1	-
2021	3.03	2.96	138.6	29.1
2022	3.80	3.60	173.8	29.1
2023	4.07	4.23	186.3	29.1

Supplementary Table 5. Cherubino vineyards uncertainty assessment matrix

Relevant Parameters	Discount applied	Comment/Note
Soil Organic Carbon (2021/22)	**31%**	
Historic soil data trend of >3 years		Soil history from 2020-2023 available
Sampling density		Sampling density of 9 ha per sample
Soil bulk density		Assumed BD of 1.52 g/cm^3
Data variance		Standard deviation of 0.36%. CoV of 16%.
Soil Organic Carbon (2022/23)	**31%**	
Historic soil data trend >3 years		Soil history from 2020-2023 available
Sampling density		Sampling density of 6 ha per sample
Soil bulk density		Assumed BD of 1.52 g/cm^3
Data variance		Standard deviation of 1.12%. CoV of 27%
Farm Inputs	**0%**	
Fertiliser use		Farm record was provided
N% content of fertilisers		Common fertilisers
Energy use (fuel and electricity)		Farm record was provided
Chemical use		Farm record was provided
Farm Outputs	**0%**	
Yield of main product		Farm records provided
Yield of co-product		N/A

APPENDIX 2 – ISO 14064-2 REPORTING INDEX

ISO 14064-2	Requirement	Section in this report
Section 6.13 (b1)	The name of the project proponent	INTRODUCTION
Section 6.13 (b2)	A brief description of the GHG project, including size, location, duration, and types of activities;	INTRODUCTION
Section 6.13 (b3)	A GHG statement, including a statement of GHG emissions reductions and removal enhancements stated in units of CO_2e, e.g., tonnes of CO_2e	THE REPORTING YEAR CONCLUSION
Section 6.13 (b4)	A statement describing whether the GHG statement has been verified and/or validated, including the type of verification or validation and level of assurance achieved;	ASSESSMENT REPORT SUMMARY
Section 6.13 (b5)	A list of all relevant GHG sources and sinks controlled by the project, as well as those related to or affected by the project, including the defined criteria for their selection for inclusion in quantification	GHG EMISSION SOURCES AND SINKS
Section 6.13 (b6)	A statement of the aggregate GHG emissions and/or removals by GHG SSRS for the GHG project that are controlled by the project proponent, stated in unit of CO2e, e.g., tonnes of CO_2e, for the relevant period (e.g., annual, cumulative to date, total);	THE REPORTING YEAR CONCLUSION
Section 6.13 (b7)	A statement of the aggregate GHG emissions and/or removals by GHG SSRs for the GHG baseline, stated in units of CO_2e, e.g., tonnes of CO_2e, for the relevant time period;	THE REPORTING YEAR CONCLUSION
Section 6.13 (b8)	A description of the GHG baseline and demonstration that the GHG emission reductions or removal enhancements are not over-estimated;	THE BASE YEAR
Section 6.13 (b9)	A general description of the criteria, procedures or good practice guidance used as a basis for the calculation of project GHG emission reductions and removal enhancements;	CARBON FRIENDLY METHODOLOGY
Section 6.13 (b10)	A statement on uncertainty, how it affects the GHG statement and how it has been addressed to minimize misrepresentation	IMPACT OF UNCERTAINTY
Section 6.13 (b11)	The date of the report and the period covered	PROJECT INFORMATION
Section 6.13 (b12)	As applicable, an assessment of permanence	GHG EMISSION REDUCTIONS & REMOVALS PERFORMANCE