Ketrawe - Vaca Diez

Ecosystem carbon footprint monitoring report by CarbonSpace Ltd.

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1. Executive Summary

This report presents the carbon monitoring results for Ketrawe's Vaca Diez carbon offsetting project in Bolivia, analyzed using the CarbonSpace platform. The project encompasses 29 polygons, totaling 1,056.5 hectares, and includes two primary land cover classes: Grasslands (GRA) and Evergreen Broadleaf Forests (EBF). The monitoring period spans from 2014 to 2024, with 2024 as the reporting year. The project's objective is to quantify carbon sequestration and emissions using Net Ecosystem Exchange (NEE), a key indicator of ecosystem-level carbon balance. Results support high-integrity carbon accounting to inform carbon credit generation and ecosystem performance tracking.

CarbonSpace provides a digital Monitoring, Reporting, and Verification (dMRV) tool that employs artificial intelligence to estimate the net ecosystem exchange (NEE) of CO2 at a field level globally. NEE represents the net exchange of CO2 between the atmosphere and all ecosystem carbon pools during a period of time, reflecting ecosystem carbon sequestration strength.The two key metrics in this report are:

1. **NEE Total** (tCO2) - an absolute value useful for understanding carbon performance overall.
2. **NEE Intensity** (tCO2/ha) - a relative value representing the average NEE *per hectare* over a given project area. NEE Intensity is useful when comparing the hectare-to-hectare performance of project areas of different sizes. Throughout this report, intensity values are italicized.

For both metrics, a **negative** NEE value represents net carbon **sequestration** while a **positive** value represents net carbon **emissions**.

Table 1.1: Overview of the project results (all polygons)

NEE Total in 2024	*NEE Intensity in 2024*
-6611 tCO2	***-6.26 tCO2/ha***

The CarbonSpace approach has a number of unique advantages making it a source of high-quality and accurate carbon data. The tool is fully remote and utilizes robust machine learning algorithms powered with satellite and ground truth data sources, resulting in lower costs by eliminating on-site visits and manual samplings, reduced audit requirements due to system-level certification and the ability to improve accuracy over time. Corporate carbon accounting benefits from the CarbonSpace approach through the incorporation of primary carbon data, a reduction in uncertainties, and access to a third-party verified tool to back publicly-shared data and claims.

Food companies can utilize NEE data to accurately assess and report on the carbon impacts of their agricultural practices, aligning with standards like the GHG Protocol and ISO14000-s. NEE supports carbon insetting projects by providing baselines and measuring benefits from environmental interventions. Additionally, it helps identify sensitive areas for targeted sustainability projects, enhancing ecosystem resilience and improving the company's environmental reputation.

The CarbonSpace dMRV platform has third-party system-level verification in accordance with ISO 14064-3, conducted by Control Union. CarbonSpace monitoring results do not require additional project-level verification and are eligible for carbon accounting across major standards, including ISO14000-s, the GHG Protocol, SBTi's FLAG Guidance, and various carbon crediting schemes.

2. Introduction

About CarbonSpace

CarbonSpace is a digital Monitoring, Reporting, and Verification (dMRV) tool built on a unique machine learning technology and verified methodology. It combines data from various sources, including satellites and eddy covariance stations, to provide accurate, field-level estimations of carbon emissions and sequestration for land areas across the globe remotely, eliminating the need for on-site visits or manual measurement methods.

CarbonSpace has developed a scalable and cost-effective solution that allows customers to benefit from NEE measurements from an extensive existing global eddy covariance network without the need to build, maintain, or operate their own stations.

With CarbonSpace, customers can track the performance of their supply chains, make corporate carbon claims, and communicate about ecosystem health with confidence. CarbonSpace also provides a credible way to disclose land stewardship as part of a corporate social responsibility strategy. Accurate and scalable data empowers customers to make informed decisions, showcase sustainability efforts, and drive positive environmental impact throughout their supply chains.

About Ketrawe

Ketrawe has developed and pioneered a unique planting system with native and exotic trees, which is a fusion between windshields and traditional tree plantations. This model allows farmers to add value to their land, while they increase their agricultural yields and on top of that enhance water conditions, fertility and reduce erosion. This system has worked beautifully and is being voluntarily and widely adopted by many farmers. The end product is a higher land value, increased income of farmer families, reduction of forest fires, positive environmental and social impact; the key for success has been to balance out a profitable synergy between farmers, agriculture, trees and environment.

3. Verification Statement

The CarbonSpace dMRV platform has been subjected to independent third-party verification by Control Union in accordance with the ISO 14064-3 standard. The verification process encompassed an in-depth assessment of the methodologies, documentation, and procedures implemented in the latest version of the CarbonSpace dMRV platform, both at system and user levels. The assessment was conducted following a comprehensive framework that included compliance standards, rigorous quality checks, examination of the procedural manual, analysis of historical data, and an assessment of the statements made to clients.

Monitoring results from the CarbonSpace dMRV platform are processed through a thorough quality management approach and do not require additional verification at the project level. The results are suitable for a wide range of carbon accounting frameworks, including:

- Corporate narrative claims
- Corporate carbon accounting and reporting aligned with major standards such as the **GHG Protocol** and **ISO14064**
- Product life cycle assessments (LCA) conducted in accordance with the **GHG Protocol** and **ISO 14040/44**
- Setting carbon emissions and removals targets in line with the **Science Based Targets initiative (SBTi)**
- Nature-based solutions (NBS), insetting, and offsetting projects aligned with various recognized methodologies

The initial assessment using CarbonSpace Technology Version 1.0 was conducted between May and August 2023. The results presented in this report were produced using the latest CarbonSpace Technology Version 2.0, which features enhanced data processing and modeling capabilities. As of April 2025, this version is undergoing re-verification to ensure continued compliance with relevant standards and accuracy of results.

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4. Monitoring Results

4.1 Project-level Results

This section presents the results of monitoring across all 29 polygons included in the Ketrawe – Vaca Diez project. It includes an overview of project-level performance, highlighting Net Ecosystem Exchange (NEE) trends across the full 11-year monitoring period (2014–2024). The analysis compares annual and monthly sequestration patterns in the reporting year (2024), providing insights into both overall carbon dynamics and seasonal fluctuations.

Project Details

Location	Bolivia
Number of polygons	29 polygons
Total area	1056.5 ha
Land cover (IGBP)	Grasslands, Evergreen Broadleaf Forests
Reporting year	2024
Monitoring period	01/01/2014 - 31/12/2024

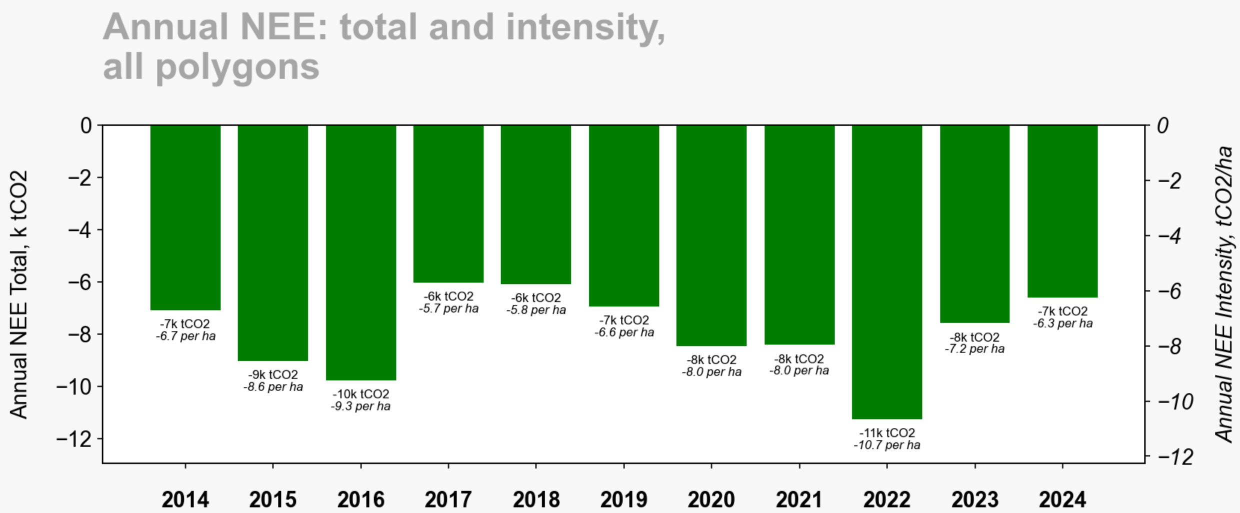
Overview of Project Results

	NEE Total (tCO2)	*NEE Intensity (tCO2/ha)*
Average Annual Value, 2014-2024	**-7935**	***-7.51***
2024	**-6611**	***-6.26***

Annual Performance and Long-Term Trend

In 2024, total NEE reached -6611 tCO_2, with an intensity of -6.3 tCO_2/ha. Over the full monitoring period from 2014 to 2024, annual NEE values reveal fluctuating sequestration rates, with a peak in 2022 (-11255 tCO_2) followed by a weakening trend in the two most recent years.

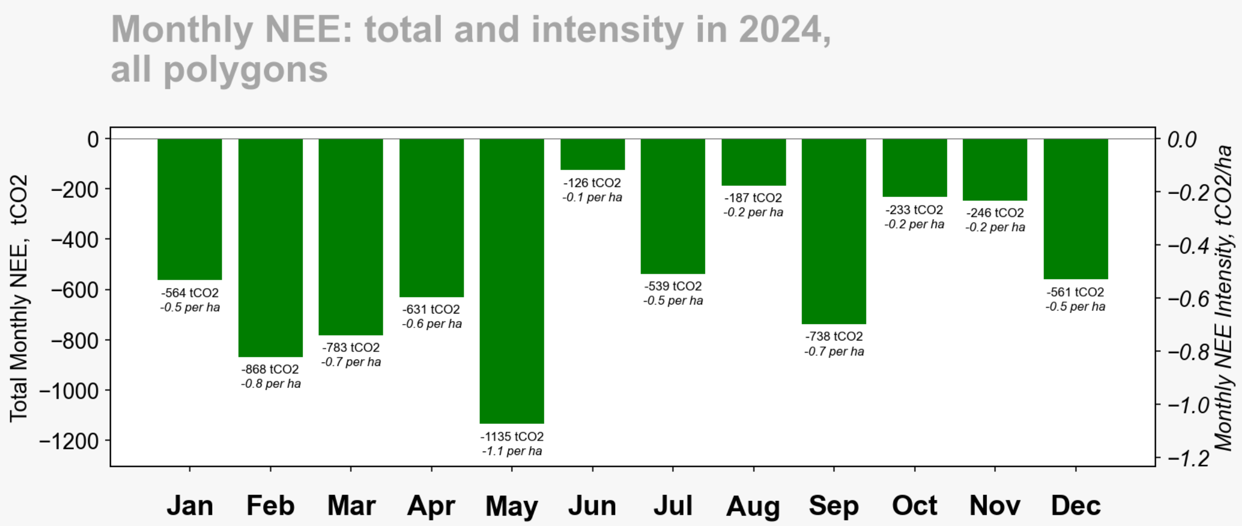
In 2023, nearly all polygons, except for Vaca Diez 1-1 and Vaca Diez 1-2, experienced a change from forest to grassland, which explains, in part, the overall decreased sequestration observed across the project.



Year	NEE Total (tCO2)	*NEE Intensity (tCO2/ha)*
2014	-7081.43	*-6.70*
2015	-9040.27	*-8.56*
2016	-9775.75	*-9.25*
2017	-6024.86	*-5.70*
2018	-6084.10	*-5.76*
2019	-6947.19	*-6.58*
2020	-8464.97	*-8.01*
2021	-8414.73	*-7.97*
2022	-11254.75	*-10.65*
2023	-7590.12	*-7.18*
2024	-6611.05	*-6.26*

2024 Monthly NEE Dynamics

Monthly NEE values in 2024 followed the typical seasonal curve, with the strongest sequestration occurring in May (-1135 tCO_2), closely aligned with the historical seasonal peak. However, spring and early summer months (April–July) underperformed compared to the baseline, especially in June, which showed minimal sequestration (-126 tCO_2). The driest months (August to October) maintained low but consistent carbon uptake, while December showed a modest rebound (-561 tCO_2). Overall, sequestration in 2024 was more evenly distributed across the year but remained below average in intensity, especially during the mid-year period.



4.2 All Polygons, 2024

Polygon Name	**Polygon Area (ha)**	**Land Cover** (Evergreen broadleaf forest = EBF; Grassland = GRA)	**NEE Total in 2024 (tCO2)**	***NEE Intensity in 2024 (tCO2/ha)***
Vaca Diez 1-1	611.1	EBF	-4243	*-6.9*
Vaca Diez 1-2	79.0	EBF	-601	*-7.6*
Vaca Diez 1-3	18.0	GRA	-124	*-6.9*
Vaca Diez 1-4	5.9	GRA	-48	*-8.1*
Vaca Diez 1-5	27.8	GRA	-192	*-6.9*
Vaca Diez 1-6	24.2	GRA	-113	*-4.7*
Vaca Diez 1-7	3.4	GRA	-24	*-7.0*
Vaca Diez 1-8	2.0	GRA	-12	*-6.0*
Vaca Diez 1-9	3.4	GRA	-2	*-0.6*
Vaca Diez 1-10	26.2	GRA	-85	*-3.3*
Vaca Diez 1-11	30.6	GRA	-156	*-5.1*
Vaca Diez 1-12	11.9	GRA	-23	*-1.9*
Vaca Diez 1-13	37.4	GRA	-195	*-5.2*
Vaca Diez 1-14	18.4	GRA	-94	*-5.1*
Vaca Diez 1-15	24.2	GRA	-110	*-4.5*
Vaca Diez 1-16	15.3	GRA	-86	*-5.7*
Vaca Diez 1-17	23.2	GRA	-84	*-3.6*
Vaca Diez 1-18	9.1	GRA	-40	*-4.4*
Vaca Diez 1-19	14.9	GRA	-50	*-3.3*
Vaca Diez 1-20	19.2	GRA	-120	*-6.2*
Vaca Diez 1-21	10.4	GRA	-23	*-2.2*
Vaca Diez 1-22	5.9	GRA	-29	*-5.0*
Vaca Diez 1-23	5.5	GRA	-18	*-3.3*

Polygon Name	**Polygon Area (ha)**	**Land Cover** (Evergreen broadleaf forest = EBF; Grassland = GRA)	**NEE Total in 2024 (tCO_2)**	***NEE Intensity in 2024 (tCO_2/ha)***
Vaca Diez 1-24	2.3	GRA	-4	*-1.6*
Vaca Diez 1-25	7.3	GRA	-58	*-8.0*
Vaca Diez 1-26	7.2	GRA	-10	*-1.4*
Vaca Diez 1-27	7.9	GRA	-42	*-5.3*
Vaca Diez 1-28	1.2	GRA	-14	*-12.1*
Vaca Diez 1-29	3.6	GRA	-11	*-3.1*

5. Possible Claims and Narratives

General Claims

We are proud to collaborate with CarbonSpace's digital carbon MRV platform to enhance the credibility and accuracy of our carbon offsetting efforts. This partnership supports transparent and science-based monitoring of ecosystem carbon dynamics in Bolivia, enabling us to quantify climate benefits with confidence and align with international standards for nature-based solutions.

The CarbonSpace platform was applied to 29 land polygons in the Vaca Diez region, covering a total area of 1,056.5 hectares across grasslands and evergreen broadleaf forests. The monitoring period spanned from 2014 to 2024.

Over the full monitoring period, 11 years from 2014 to 2024, the project achieved a total estimated sequestration of approximately 83,616 tCO_2, corresponding to an average annual sequestration of about 7,602 tCO_2. This translates to an average NEE intensity of -7.2 tCO_2/ha per year, reflecting consistent carbon removal from the atmosphere into ecosystem carbon pools.

In 2024, total sequestration reached -6,611 tCO_2 (or -6.3 tCO_2/ha), representing a 13.0% decrease compared to the long-term annual average.

6. Annex: Scope and Methodology Overview

The CarbonSpace tool can be used to monitor, report, and verify the biogenic carbon removals of any land system globally, including agricultural systems and nature-based carbon removal projects.

CarbonSpace's dMRV technology provides estimates of land NEE, a net carbon flux corresponding to carbon removals or emissions on the ecosystem level. NEE represents aggregated total carbon stock change in all natural carbon pools (Table 7.1).

Table 7.1. Natural carbon pools

Carbon pool	Included/Excluded
Aboveground Tree Biomass	Included as a component of NEE
Aboveground Non-Tree Biomass	Included as a component of NEE
Belowground Biomass	Included as a component of NEE
Litter	Included as a component of NEE
Deadwood	Included as a component of NEE
Soil Organic Carbon	Included as a component of NEE
Harvested Biomass and Residues	Included as a component of NEE

NEE can be used for the assessment and reporting of several accounting categories within major carbon standards, including ISO14000-s, GHG Protocol, SBTi's FLAG Guidance, and various carbon crediting schemes (Table 7.2).

Table 7.2. NEE within major accounting standards

Accounting category	Definition	Standard	Applicability
Gross Biogenic Land CO_2 Removals	Gross CO_2 removals from atmospheric CO_2 transferred via biogenic sinks to land-based carbon pools	→ ISO14064-1, -2 → GHG Protocol Land Sector and Removal Guidance - flow accounting approach	NEE value corresponds to Gross Biogenic Land CO_2 Removals
Land Management Net Removals	Net increases to storage in land carbon pools	→ ISO14064-1, -2	NEE minus carbon contained in the harvested biomass

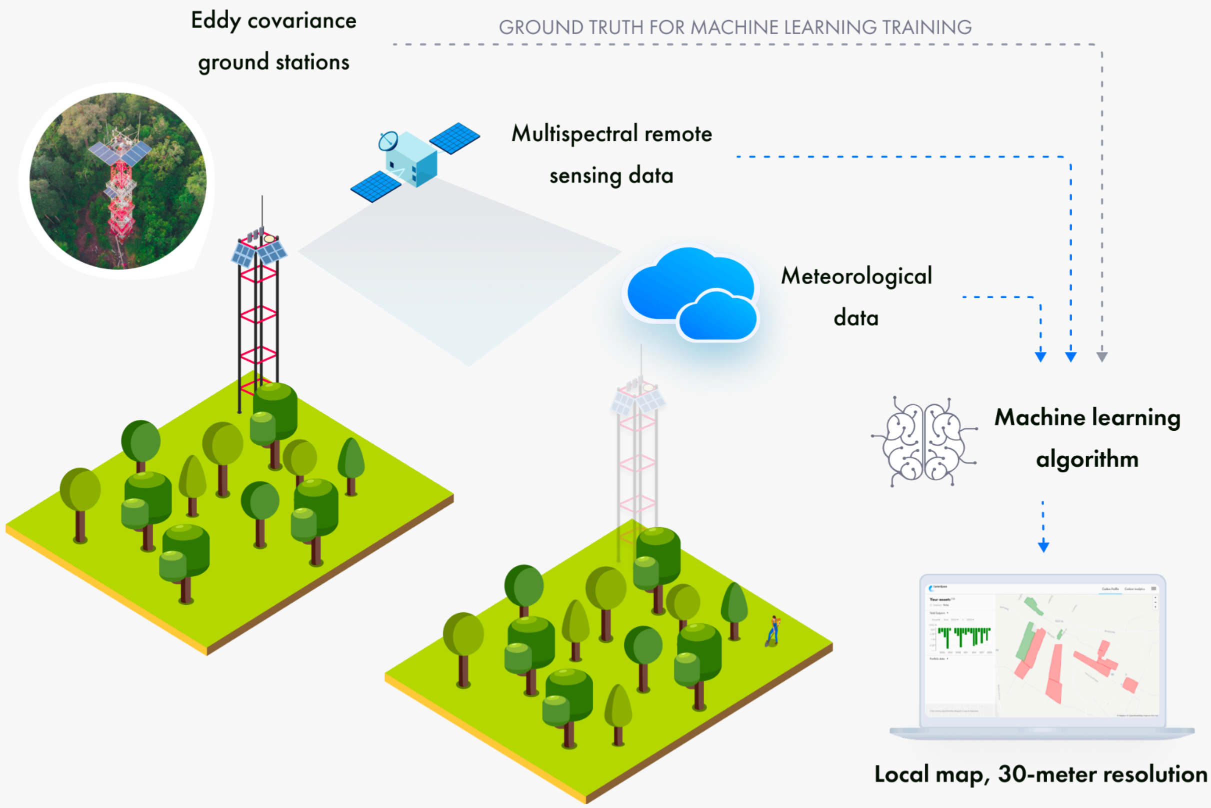
	due to ongoing land management practices	→ GHG Protocol Land Sector and Removal Guidance - stock-change accounting approach	corresponds to Land Management Net Removals
Biogenic Product CO2 Removals	Uptake of CO2 by biogenic materials within the boundaries of the LCA	→ ISO14040 / 14044 / 14067 → GHG Protocol Product Life Cycle Accounting and Reporting Standard	NEE per kg of final product corresponds to Biogenic Product CO2 Removals
Removals Into Natural Carbon Pools	Changes in storage in land carbon pools due to land management practices	→ Carbon insetting and offsetting methodologies	NEE value corresponds to Gross Biogenic Land CO2 Removals and could be used for ongoing monitoring and modeling baseline scenario

Technology

CarbonSpace's core technology involves machine learning algorithms trained on multispectral satellite imagery and CO2 flux data from ground stations which estimate CO2 flux based on the eddy covariance method. CarbonSpace has created global models for each land cover type to produce reliable GHG estimates for areas down to 1 ha in size.

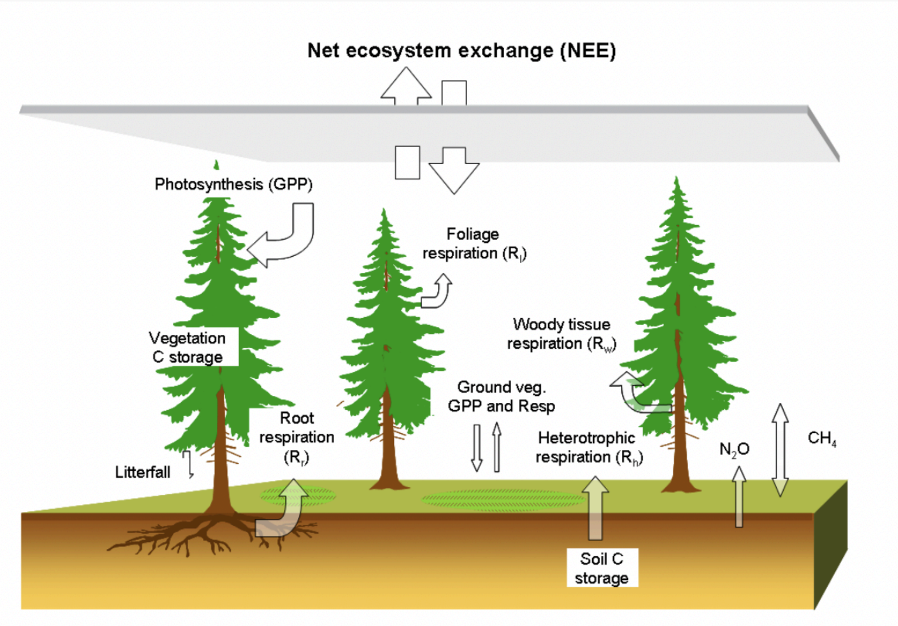
The tool is intended to provide a holistic view of CO2 exchange between the ecosystem and the atmosphere and reduce uncertainties in estimating the carbon benefits of ecosystem restoration projects and sustainable land management practices. This is possible due to the use of a globally distributed network of ground stations that consistently measure carbon fluxes. Tracking carbon fluxes on a monthly basis, CarbonSpace can provide data faster and more consistently than traditional methods, with an added layer of historical context and change. On-site calibration of the model is not required.

Figure 7.3: CarbonSpace technology overview



CarbonSpace provides Net Ecosystem Exchange (NEE) estimates as an output. NEE is a measure of the net exchange of carbon between an ecosystem and the atmosphere and is a primary gauge of ecosystem carbon sink strength. It is the difference between photosynthesis, plants drawing CO2 out of the atmosphere, and respiration, the ecosystem “breathing” and releasing CO2 into the atmosphere. Negative NEE indicates the amount of CO2 that was accumulated in the ecosystem. Positive NEE indicates emission of CO2 into the atmosphere.

Figure 7.4: Carbon fluxes in the ecosystem



NEE is a crucial metric for assessing ecosystem health. It measures the rate at which plants convert solar energy into organic matter, providing essential habitat and resources for other organisms. It also serves as an indicator of biodiversity and environmental disturbance.

Strong NEE values indicate robust primary biomass production, supporting biodiverse and stable ecosystems. The opposite trend can signal ecosystem degradation, highlighting potential threats and emphasizing the need for conservation efforts.

Utilizing NEE as a metric reduces the complexity and uncertainty inherent in the individual measurement of each carbon pool and offers an accurate, holistic perspective on ecosystem carbon fluxes.

In contrast to measuring carbon pools individually, focusing on NEE allows for an efficient and effective assessment of the overall effect of actions on an ecosystem's carbon balance. This enables the effective prioritization of carbon sequestration activities.

7. Annex: Quality Assurance Process

Quality Assurance Process Overview

The CarbonSpace data delivery process involves a rigorous quality assurance process consisting of several steps. Output net ecosystem exchange (NEE) estimates are compared against reference NEE values collected from eddy covariance stations for the relevant land Covers.

Metrics and charts resulting from this comparison are reviewed by the science staff and any irregularities are flagged for follow-up investigation. Anomalies may be characterized by unusual
statistics (e.g., NEE efficiencies outside of the standard deviation of the reference NEE values), or by values or behavior that do not conform with scientific domain knowledge or physical/biological dynamics.

Where available and practical, science staff check that the produced NEE results are in line with international literature.

Finally, NEE estimates are reviewed to check consistency with the known attributes of the project, such as crop type, climatic conditions, and seasonal dynamics.
This quality assurance process ensures data are accurate, consistent, and reliable.

Data Quality and Integrity at CarbonSpace

At CarbonSpace, we are committed to providing high-quality data using methods that are both peer-reviewed and certified. Our data delivery adheres to the highest scientific standards, ensuring reliability and accuracy. Our process includes a multi-stage quality control that validates the Net Ecosystem Exchange (NEE) fluxes produced with our models against eddy-covariance ground measurements relevant to the specific land cover in question. We also compare our data to published values for similar ecosystems or crop types, monitoring trends in vegetation activity (e.g., NDVI time series), changes in land cover, and shifts in agricultural practices.

As a general principle, we accept the output of our methodology “as is” and our quality assurance process is not oriented towards correction but rather towards identification of problematic results. In most cases our data remain within the acceptable error margins and closely aligns with the standard deviations from databases of ground-measured data fluxes. Data that deviates from expected patterns is thoroughly investigated for potential errors in the input information, such as misclassification of land cover, but other sources of error are merely noted and the original results retained.

Anomalies are generally the result of limitations in the production version of our technology, such as restricted satellite data availability or the absence of comparable flux tower data in certain ecosystems or crop types. In such instances, we still deliver these data to our customers but provide clear communication regarding any potential issues associated with these specific Datasets.

We are continually performing research and development aimed at improving our methodology by incorporating imagery from new satellite missions, adding ground data from new stations, and refining our machine learning techniques. From this perspective, quality assurance results provide lessons learned that help inform the direction and prioritization of algorithm improvements.