

ARTICLE | SUSTAINABILITY

THE FARM THAT BREATHES IN REVERSE



PHOTO_THIAGO DE JESUS

A photograph of a herd of white Zebu cows in a green field. The cows are in the foreground, looking towards the camera. In the background, there is a line of trees and a clear sky.

THE EXPERIENCE OF A RURAL PROPERTY THAT BECAME A CARBON SINK
SHOWS, IN PRACTICE, THAT SUSTAINABILITY IS INDEED SYNONYMOUS WITH
PRODUCTIVITY GAINS AND INCREASED INCOME

By **PELERSON PENIDO DALLA VECCHIA**, from Pindamonhangaba (SP)

EVERY FARM EMITS greenhouse gases. The tractor burns diesel, the herd digests grass and releases methane, the nitrogen fertilizer returns nitrous oxide to the air. The question climate science asks is not whether a property emits – it is whether, at the end of the day, it returns more carbon to the atmosphere than it removes from it. At Fazenda São Pedro da Mantiqueira, in Pindamonhangaba (SP), the answer defies intuition: the math closes in the negative. The property sequesters more than it emits.

This article is organized into three parts. First, the verified inventory – what the farm emits and removes, calculated by researcher Susan Christian Martins, Master in Soil Science and Plant Nutrition and PhD in Sciences, and audited by KPMG. Then, the ephemeral carbon: what it is and how it fits into the reading of the property's gas flow. Finally, a reflection on the 30-centimeter depth rule – where it comes from and what we find when we investigate in greater detail.

PART 1

THE VERIFIED INVENTORY

What the farm emits and what it removes

Imagine a scale. On one side, everything the farm emits: fuel, livestock fermentation, fertilizers, electricity. On the other, everything it pulls from the air and stores – especially the carbon that plant roots push into the soil, where it can remain stocked for decades. The GHG balance is the difference between the two sides of the scale.

When emission exceeds removal, the number is positive: the farm is a source. When removal exceeds emission, the number is negative – and the property functions as a sink, a drain that helps clean the atmosphere. This balance was calculated by Susian Martins according to the GHG Protocol Agricultural Guidance and independently verified by KPMG.

Measuring emissions is relatively simple – you count the diesel, the herd, the fertilizer. Measuring carbon removal in the soil is harder, and that is where the so-called tiers of the IPCC, the UN’s climate science panel, come in. Each tier is a ruler with increasing precision:

Tier 2 — National Factors. Uses standardized removal

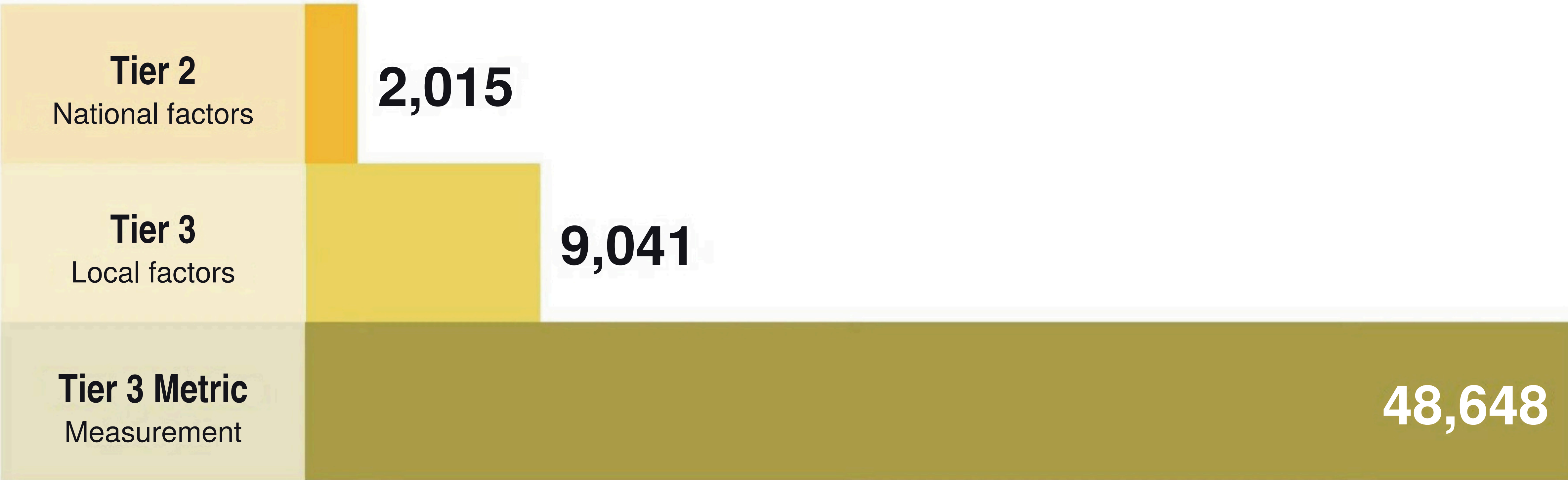
factors adjusted for Brazil’s biome and conditions. It is the most conservative approach: it applies table values without measuring that specific farm’s soil.

Tier 3 — Local Factors. Replaces the table with parameters calibrated for the region and the property, with detailed modeling of the carbon stock. It better captures the real effect of soil management.

Tier 3 Metric — Direct Measurement. The gold standard: instead of any estimated factor, carbon is physically measured in soil samples collected in the field, via laboratory analysis (CHN). It is the most faithful picture of what is actually in the ground.

The pattern repeats itself: the more the data comes from the farm’s own measurements, and the less from generic factors, the higher the recognized sequestration. Standard table parameters are conservative and fail to account for the Roncador Integrated Regenerative System – which, due to its positive impact on the ecosystem, ends up capturing more carbon in the soil than expected under conventional management.

GHG Balance Method (tCO₂e)



GHG balance of Fazenda São Pedro da Mantiqueira, by calculation method. Negative values indicate net sequestration
Crop year 2023/2024, verified by KPMG
The math already closes in the negative across all three methods – the farm is a sink even by the most conservative ruler

HOW THIS BALANCE WAS MADE

The greenhouse gas inventory of Agropecuária São Pedro da Mantiqueira Ltda. (Grupo Roncador), 2023/2024 crop year, was prepared according to the GHG Protocol Agricultural Guidance, considering the gases CO₂, CH₄ and N₂O converted into CO₂ equivalent by the IPCC (AR5) global warming potentials. Soil carbon was calculated using three approaches (Tier 2, Tier 3 and Tier 3 Metric), the latter via CHN laboratory analysis of

field samples. The technical analysis was conducted by researcher Susian Christian Martins, and the independent verification of the balance by KPMG. The GHG balance is expressed in tCO₂e (annual flow); carbon stocks by depth, in tCO₂eq/ha. Ephemeral carbon represents the annual flow of temporary carbon, not permanent stock. The ephemeral carbon fraction retained in livestock was estimated from

a herd carbon mass balance (ingested carbon partitioned between respiration, methane, feces, urine and body tissue). This balance relies on NASEM – Nutrient Requirements of Beef Cattle (2016) and Dairy Cattle (2021); IPCC (2006) for enteric methane; the CNCPS system (Tedeschi, Fox & Tylutki) for nutrient partitioning; Johnson & Johnson (1995) for methane emission; and works by Ungerfeld on ruminal fermentation.



PART 2 THE GAS FLOW

Ephemeral carbon: counting what comes in and what goes out

So far we have looked at the stock that remains. But there is a second, complementary view: the flow of carbon that passes through the farm over a year – the carbon that plants fix and that, to a large extent, returns relatively quickly to the atmosphere. This is called ephemeral carbon. It is not permanent stock; it is a snapshot of how much carbon the property moves and temporarily retains each

crop year. Because it is temporary, this carbon must be accounted for rigorously: only what actually becomes a real temporary stock is counted, and the rest is discounted – what is respired back by microorganisms, by the animal itself, or what already appears elsewhere in the balance (such as methane). There are two sources:

PHOTOS_HANDOUT



In livestock, the reasoning is as follows: out of every portion of carbon the animal ingests, most is respired back or becomes methane (already accounted for separately). Only a fraction – what becomes animal tissue, soil microorganism biomass, and the portion of manure that effectively stabilizes – remains as stored carbon. It is this fraction, and only this fraction, that enters the

equation. The size of this flow becomes clear when we place it side by side with the farm’s emissions. The ephemeral carbon fixed in a single year – just in grain and biomass – is in the same order of magnitude as the direct and energy emissions for the same period:



The distinction is worth making: ephemeral carbon is an annual flow of temporary carbon – it is not part of the verified GHG balance from Part 1, and it should not be read as permanent sequestration. It is presented separately precisely to make clear what is stock measurement and what is flow reading. One observation on the scope of this calculation – and it reinforces the conservative nature of the number. Only two things were included in the ephemeral carbon: what becomes a product and leaves the farm (the soy-

bean grain and the cattle’s body mass) and what humifies in the soil, tending to become very long-lasting carbon. Excluded was all the carbon retained in feed reserves stored on the farm itself – corn grain, silage, sorghum and snaplage –, which can remain stored for up to two years as a food security strategy for the herd, regardless of the climate. In other words: the temporary carbon flow effectively managed on the property is larger than what is accounted for here.

PART 3

AN OPEN QUESTION

The 30-centimeter rule

What follows in this section is a reflection by the author, based on field observation and a personal reading of the carbon balance. It is not part of the verified inventory in parts 1 and 2 – it is presented as a hypothesis and an invitation for investigation, not as audited data.

The GHG Protocol – and practically all carbon inventories in the world – accounts for soil carbon down to only 30 centimeters of depth. This ruler is not arbitrary: it was born from the soil science of temperate climates, where organic matter is concentrated in a shallow surface layer and little carbon descends beyond that. For those soils, 30 centimeters capture almost the whole story.

Deep tropical soils, like those in Brazil, do not necessarily follow this pattern. For this reason, at Fazenda São Pedro da Mantiqueira, the soil was measured down to 2 meters. We present the numbers below without

closed conclusions – the reader can draw their own.

I also speak from the experience of someone who digs. Every year I climb into trenches on the farm and see, with my own eyes, live roots reaching past 2 meters in depth. I see the earth darken from the top down, gradually – what appears to me to be organic matter accumulating and carbon descending through the profile. Measuring has been a routine for me since I was 14, and what the trench shows is hard to ignore: there is life and carbon far below the line where we usually stop counting.

Soil carbon stock by depth range (tCO₂eq/ha)



Soil carbon stock by depth range — Plot 20B, Fazenda São Pedro da Mantiqueira. Direct measurement (CHN)
These values are carbon stock per area (tCO₂eq/ha), a distinct metric from the annual flow balance (tCO₂e) presented in parts 1 and 2

SYSTEMIC VIEW

“Accounting for all the production and the carbon that descends and accumulates in the soil profile is perhaps the most honest way to measure the true role of the field in the climate,” says producer Pelerson Penido Dalla Vecchia





In this plot, the layer between 30 centimeters and 2 meters holds 330.67 tCO₂eq/ha – more than the 267.08 in the first 30 centimeters. In other words: the standard ruler would see just under half of the carbon present in the measured profile.

What the numbers raise is a legitimate question: if there is so much carbon below the line we usually mea-

sure, how much of the soil's role in the climate might be left out of the equation? Confirming whether this deep carbon is also increasing under good management is the next step of the investigation.

The 30-centimeter ruler was made for a different type of soil. In deep tropical earth, perhaps it is time to dig deeper before closing the math.

WHY THIS MATTERS*

Two readings emerge from this work. The first is about Fazenda São Pedro da Mantiqueira: even by the world's most conservative and standardized ruler, and without counting deep carbon, the farm is already carbon-negative. It is part of the solution, not the problem.

The second is an invitation to investigation. The way we measure soil carbon – stopping at 30 centimeters – was a convention inherited from shallow temperate soils. The Mantiqueira data suggest that, in deep tropical soils, this convention might be leaving a relevant part of the story out of the frame. We do not claim to have the final answer; we present the measurement and the question.

There is also a third, more personal reading. If we view

a farm as a greenhouse – a closed geographical space –, everything it pulls from the atmosphere should enter the equation, even if temporarily. In this sense, limiting the footprint of a property by its emissions, especially those from cattle, is looking at only one side of the scale: the more food a farm produces, the more carbon it has pulled from the air to produce it. Accounting for all the production – and all the carbon that descends and accumulates in the soil profile – is perhaps the most honest way to measure the true role of the field in the climate.

**Reflection by Pelerson Penido Dalla Vecchia. The technical work (sample extraction and compilation of CHN analysis results) was conducted by researcher Susian Christian Martins, and the balance verification by KPMG*