



RESEARCH REPORT / 11 SEPTEMBER 2026

Derisking Carbon–Project Investment

The Mombak Case

Risk assessment, financial scenarios and empirical evidence

Public evidence supports historical carbon-accounting results and early delivery. It does not establish that a specific additional derisking package improves net investor returns. The appropriate conclusion is partial empirical support and a conditional basis for further diligence.

The assessment combines Mombak’s disclosed financing and operating arrangements with a reanalysis of nine public registry exports, including **4,840 measurement records**. Selected uncertainty and prediction summaries reproduce; the verified **21,771.530-tonne** allocation reconciles.^{[DATA][ISO1]}

Safeguards, carbon removal and investor returns require different evidence.

The financial scenarios charge incremental treatment costs and retain residual risks. Their **\$33,389** gain for a hypothetical combined package depends on two assumed effects; it is not a measured Mombak return. Historical measurement simulations are available, while causal treatment effects and their financial probabilities remain unestimated.

Author: Dr. Izzatullah Mustafa. Evidence cutoff: 11 September 2026. Public-source research only; no management interview or private account access. All dollar amounts are US dollars.

Framing the investment decision

Proceed to focused diligence, while withholding a conclusion on new investment. Public evidence supports examining risk allocation, historical quantification and early delivery. It is insufficient to calculate Mombak's project equity value, verify the entire contractual cash waterfall or establish that every proposed treatment is effective.

The case centres on the Mombak reforestation programme associated with the World Bank's 2024 Amazon Reforestation-Linked Outcome Bond. Its Phase I asset is Turmalina in Pará, Brazil. The offering document identifies Mombak Angico-Branco Florestal S.A. as its project company.^[WB4] The Isometric registry separately identifies Turmalina within Reforesting the Brazilian Amazon Project 1.^[ISO1] Independent verification confirms Turmalina as the first project instance.^[SCS1] Specific certificate allocation and contractual eligibility still require reconciliation.

Three investment exposures

A bondholder holds an IBRD obligation, with a fixed component and conditional carbon-linked payments. **A project investor** bears its contractual share of development cost, operating shortfalls and residual cash flows. **A carbon buyer** bears delivery, eligibility and claim-use risks under its purchase agreement. One party's protection can create an obligation for another.

The working decision is whether a prospective investor should fund further Mombak-related project exposure, fund only diligence and milestone-based commitments, or decline. The analysis uses information available at the report cutoff; it does not price a secondary-market purchase of the existing bond.

What would change the decision

The next commitment should depend on a reconciled asset-to-cash record: legal rights and applicable safeguards; parcel and registry identity; buyer acceptance of the relevant methodology and certificates; delivery invoices and collection rights; and an executable budget covering operations and long-term stewardship. These are proposed investor requirements, not findings that Mombak has failed them.

Unresolved eligibility and rights remain conditions for commitment. A numerical haircut does not resolve them. The report moves from existing protection and observed carbon outcomes to the risk register (pages 6–7), then conditional financial consequences, incremental treatments and the evidence needed to assess their effectiveness. Unknowns remain explicit; exhaustive risk discovery is not claimed.

Understanding the existing protection

The 2024 issuance was a **\$225 million IBRD bond**, mobilising approximately **\$36 million** for Mombak's reforestation activities. The bond proceeds support IBRD's wider development activities; the entire principal was not invested in Mombak.^[WB1]

Foregone conventional coupons are converted into project funding through arrangements involving HSBC. The disclosed structure envisages 11 milestone-dependent disbursements through December 2026, with undisbursed amounts returned to bondholders in January 2027. It links carbon-related payments to part of the proceeds from a Microsoft purchase agreement. The issuer's case study describes an agreement for up to 1.5 million units at pre-agreed prices through 2032. These are financing and purchase commitments, not evidence that the full amounts have been disbursed, delivered or collected.^[WB2]

Existing feature	What it addresses	Residual exposure
IBRD principal obligation	Bondholder principal repayment at maturity	IBRD credit, inflation and any loss on an earlier sale; no project-equity guarantee
Milestone funding	Limits release of capital before agreed progress	Poor milestone design, disputed evidence, funding gaps after an unmet condition
Contracted offtake	Reduces price uncertainty for eligible contracted delivery	Quantity, timing, contract termination and counterparty performance
Registry certification	Tests the documented removal claim	Future growth, reversals, commercial acceptance and collection
Carbon buffer	Provides a mechanism for reversal compensation	Restoration expenditure, foregone sales and investor liquidity

Financing features: WB1–WB3. Certification and buffer: ISO1–ISO3. Residual-exposure interpretation: Andi analysis.

Defining the baseline and obligation horizon

Existing offtakes, buffers and documented field controls belong in the baseline. Monitoring, reporting and verification (MRV) expenditure is incremental only to the extent it adds to that baseline.^{[MOM2][SCS1]}

The PDD distinguishes 50-year crediting, a 100-year durability commitment, and financial planning for 150 years including post-crediting monitoring. These source labels do not establish a single reconciled contractual timetable or a verified funded reserve.^[MOM2] An investment exit must leave continuing obligations assigned and financed.

Recomputing the carbon evidence

The July 2026 reforestation issuance is distinct from Mombak's April enhanced-weathering issuance.^{[ISO2][ISO4]} The following outputs cover 31 March 2023 to 23 October 2025, although the hosting GHG entry headline shows only the 2025 vintage.^{[DATA][ISO1]}

Quantity and stage	tCO ₂ e
Mean modeled stock at baseline, T0	4,238.491
Mean modeled stock at monitoring, T2	26,717.671
Mean modeled stock increase, T2 minus T0	22,479.179
Gross removal estimate at the 16th percentile	22,242.880
Benchmark-adjusted estimate at the 16th percentile	22,017.528
Verified total after emissions	21,771.530
Buffer allocation	2,286.012
Supplier allocation	19,485.518

First five rows: public simulation and removal summaries [DATA]. Final three: registry and verified GHG statement [ISO1, MOM1, SCS1]. Stage-specific values; supplier allocation is not sales revenue.

The mean stock difference reproduces the exported gross mean. Moving to the gross 16th percentile subtracts **236.299 tonnes, or 1.051%**. The benchmark then reduces the conservative estimate by a further **225.351 tonnes**. Together, those steps reduce the gross mean by **2.054%**. These are accounting adjustments within the modeled historical estimate, not measured percentage reductions in investment risk.

Separating reconciliation from certification

The final allocation reconciles exactly: $2,286.012 + 19,485.518 = 21,771.530$. The buffer is approximately **10.5%**; it is an allocation to pooled protection, not a calibrated reversal probability.

One small upstream difference remains. Subtracting the GHG statement's displayed emissions of 182.89 and 63.01 tonnes from the exported 22,017.528 gives **21,771.628 tonnes**, approximately **0.098 tonnes above** the verified total. Two-decimal rounding of those two emissions figures alone cannot explain the difference. The complete precise bridge was not reproduced; the verified final total is retained.^{[MOM1][DATA]}

Quantifying uncertainty and model limits

The GHG statement describes **1,000 Monte Carlo draws** for carbon quantification uncertainty. The public regression-diagnostics export contains 1,000 simulation rows; each reports 129 model observations. SCS states that it independently replicated uncertainty distributions and key calculation steps.^{[MOM1][DATA][SCS1]}

A separate public export contains **10,000 simulated counterfactual fractions**. Andi recalculated its mean and percentiles from every row, using linear interpolation between ordered values:

Benchmark fraction statistic	Recomputed
Mean	0.9609%
16th percentile	0.7805%
84th percentile	1.1475%

Matches performance_benchmark_summary.csv to numerical precision. Draws represent simulated uncertainty, not 10,000 independent field observations. ^[DATA]

The gross-removal distribution has a central range of **22,242.880 to 22,720.429 tonnes**; after the benchmark, it is **22,017.528 to 22,505.200 tonnes**. These span the 16th to 84th percentiles, the central 68% of each supplied modeled distribution. They are not 95% confidence intervals, future delivery forecasts, or probabilities that investment proceeds will be received.^[DATA]

Checking independence and prediction error

From 129 public prediction rows, Andi reproduces bias of **−0.407 tCO₂e/ha** and RMSE of **5.368 tCO₂e/ha** for above-ground biomass carbon. The published **95.21% MAPE** reproduces when eight zero-observed rows are excluded. That percentage is sensitive to small denominators and does not measure aggregate credit error.^[DATA]

The PDD uses leave-one-out cross-validation to select a model. Its separate equivalence check did not pass both required one-sided tests: the reported p-values were 0.064 and 0.007 against a 0.05 threshold. It then used a regression fallback.^[MOM2] SCS records that Isometric permitted an exception concerning the independent test dataset.^[SCS1] Arithmetic reproduction therefore supports internal consistency; it cannot establish independent generalisation or eliminate model misspecification.

Identifying the underlying risks

Each row identifies an exposure, its measurement route and the evidence needed to move from a conditional scenario to a project estimate. “Open” means this review has not established the required evidence; it does not allege a defect.

Risk	Cause, event and consequence	Quantification and current limit
R1 Rights and consent	Defective land/carbon rights or unresolved affected-party rights can prevent lawful operation or delivery.	Parcel coverage, disputed area, tenure duration and legal remedy. Prerequisite; no probability or money estimate established.
R2 Eligibility and additional-ity	Ineligible activity or a stronger counterfactual can lower recognized removal or stop issuance.	Additional tonnes by parcel and vintage after baseline adjustment. Project-specific forward sensitivity is open.
R3 Growth and survival	Poor establishment, drought, pests or fire reduce biomass and delay credit generation.	Survival cohorts, annual net removals, replanting cost and correlated loss area. No calibrated hazard or efficacy estimate.
R4 Reversal and stewardship	Stored carbon can be lost after issuance; long obligations outlast an investment exit.	Carbon liability, buffer contribution, restoration cash, future issuance effects and funded stewardship duration. Buffer quantity is observed; cash sufficiency is open.
R5 Accounting and verification	Measurement error, leakage, albedo effects or verification findings reduce or postpone certificates.	Eligible quantity after each deduction; unresolved findings and days to verification. Historical measurement uncertainty is quantified (page 5); future delay and cash effects remain open.
R6 Social and ecological harm	Poor engagement, benefit delivery or ecological outcomes can cause harm, conflict and interruption.	Outstanding grievances, agreed remedies, affected groups and independently assessed outcomes. Serious unresolved harm must be resolved; a price adjustment is insufficient.

Andi risk hypotheses informed by ISO1–ISO3 and IC1. Public protocol and certification evidence establish an assessment framework; they do not close land-title, consent, cash-flow or long-run outcome diligence.

Shared drivers matter. A drought can simultaneously reduce growth, increase fire risk, raise operating expenditure and postpone issuance. The financial model must capture that combined state once, rather than add separate expected losses for overlapping consequences.

Identifying the financing risks

Risk	Cause, event and consequence	Quantification and current limit
R7 Delivery and acceptance	Issued certificates may arrive late or fail the buyer's contractual conditions.	Eligible delivered units divided by contractual target, by observation period. Buyer-specific targets and lot-level matching remain open.
R8 Price and concentration	Uncontracted sales or contract termination expose proceeds to market prices and replacement-buyer terms.	Contracted share, net realized prices, termination and replacement costs. No Mombak price forecast inferred from market averages.
R9 Counter-party and collection	A buyer or intermediary can fail to pay or pass cash through.	Receivable ageing, secured balances, contractual recourse and conditional receipts. Potential loss of the variable coupon is modeled separately from fixed interest.
R10 Funding and execution	Cost overruns, disbursement gaps or currency movements can interrupt planting and maintenance.	Monthly peak funding need; approved budget versus committed cash; BRL costs versus dollar receipts. Public financing envelope is not a verified funding balance.
R11 Allocation and governance	Competing claims, deficient controls or double allocation can prevent investor recovery.	Parcel-to-unit-to-contract reconciliation; cash waterfall, security priority and control exceptions. Equity distributions cannot be inferred from gross credit sales.
R12 Law, tax and exit	Applicable rules, taxes or transfer restrictions can change eligibility, proceeds or recoverability.	Jurisdiction-specific legal/tax review and instrument-specific exit scenarios. Host authorisation and accounting adjustments assessed only where relevant to the intended use.

Andi analytical coverage, informed by the disclosed transaction (WB1–WB4) and registry evidence (ISO1). No finding of default, fraud, rights violation or regulatory non-compliance is made.

Preserving the uncertainty

These risks are quantified through observed balances, contractual sensitivities, conditional cash-flow tests or explicit unresolved conditions. No calibrated basis was established for forward probabilities of fire, default, non-issuance or incremental treatment success. A numerical score would not supply that missing evidence.

Testing the bond's residual exposure

The bond offers an observable example of protection at one layer alongside retained exposure at another. The following conditional calculation uses the published full-disbursement coupon schedule. It assumes all 11 disbursements occur, no catch-up or excess-collection uplift, and full intermediary receipts unless the failure branch is selected. It describes annual payments per \$100,000 face value, not annualized investment yield.^[WB4]

Payment year	Target variable	Full delivery	Half delivery	Receipt fails
2028	921	2,666	2,205.5	1,745
2029	2,871	4,616	3,180.5	1,745
2030–2033	5,476	7,221	4,483.0	1,745

Dollar payments. The last three columns include \$1,745 fixed annual interest; the variable amount is conditional. Last row applies in each year 2030–2033. Inputs: WB4, final terms PT-46 and PT-49. Recomputed in the report model.

What the contract does and does not protect

For 2030, full realization produces \$5,476 variable interest; half produces \$2,738. If the corresponding intermediary receipt fails, IBRD need not pay the carbon-linked amount. Deferred shortfalls earn no interest and remaining amounts are cancelled at maturity.^[WB4] The principal obligation is a different exposure.

This is why better forest performance and improved credit accounting cannot alone eliminate financial risk. The required protection must reach the collection account and contractual recipient. Conversely, paying for operational treatments cannot create value for a bondholder beyond the applicable payout rules. A project-level improvement and a bond-level improvement are not interchangeable.

Keeping expected payments separate from observations

The first carbon-linked coupon is scheduled for **July 2028**, beyond this report's cutoff.^[WB2] Its absence in September 2026 is not a default signal. Earlier fixed interest is a separate obligation.

Actual draw completion, eligible Microsoft deliveries and intermediary collections are not established here. The early deliveries discussed on page 9 cannot be assigned to the bond without certificate, contract and receipt matching. The 2024 documents anticipated standards including Verra; reconcile later Isometric certificates with buyer acceptance and governing confirmations.^{[WB3][ISO1]} This table neither values the bond today nor estimates project equity returns.

Assessing derisking evidence

Public evidence supports several steps along the proposed causal chain. It does not identify which intervention produced how much of the observed improvement.

Risk treatment	Observable evidence	Validation status
Measurement and verification	Public measurements, uncertainty outputs, audit findings and issued certificates.	Historical implementation and selected arithmetic supported; incremental benefit versus existing practice unestimated.
Field resilience	PDD describes species diversity, mortality monitoring, replanting thresholds and pest management.	Controls documented. No linked treatment assignment, comparator outcomes and incremental cost series obtained.
Permanence buffer	Final credited allocation includes 2,286.012 tonnes in the buffer.	Allocation verified. Future adequacy and reduction in a particular investor's loss are unresolved.
Commercial execution	Developer announcement and buyer acknowledgement support early delivery.	Delivery progress corroborated; causal acceleration and net collected proceeds unmeasured.
Financing and payment protection	Published bond terms allocate principal, coupon and collection risks.	Contractual design documented. Realised protection and project net returns are not yet quantified here.

Evidence: [DATA, ISO1, MOM2, MOM3, BUY1, WB2, WB4]. Status judgments are Andi's assessment of the evidence reviewed, not a new assurance opinion.

Interpreting the early deliveries

Mombak reports deliveries to Google, McKinsey and McLaren Racing more than two years ahead of expectations. Climeworks separately acknowledges receiving early credits.^{[MOM3][BUY1]} Both are transaction participants; buyer quantities, collected prices and bond allocation remain unverified.

The first reporting period ended on 23 October 2025; the SCS opinion followed **245 days** later and issuance another **six days** later, a **251-day** interval.^{[SCS1][ISO1]} This measures elapsed time, not avoidable processing delay. Conservative initial schedules, favourable conditions or cohort selection could explain early delivery; the evidence does not isolate a causal MRV effect.

Designing additional derisking

The proposed treatments follow the scoped risk register and consequence assessment. The public estimates above provide a baseline; unresolved risks remain conditions for commitment. The assessment returns to risk identification whenever diligence reveals a new dependency or a treatment creates a new exposure.

Proposed action	Mechanism and risk linkage	Cost and residual risk
Resolve commitment conditions	Counsel and safeguards leads reconcile rights, asset identity, buyer eligibility and any additionality effect of cheaper capital; stop release on unresolved material issues (R1, R2, R6, R7, R11).	Obtain actual diligence quotes. Information may improve a decision without improving the asset; sunk diligence cost remains.
Strengthen MRV readiness	Agree evidence formats, quality controls and verification capacity before the reporting cycle (R5, R7).	Test \$25,000 incremental cost per normalized case. External review time may remain unchanged.
Strengthen field resilience	Use locally supported establishment, maintenance and fire-response measures linked to diagnosed causes (R3, R4).	Test \$50,000 incremental cost. Drought and shared hazards may defeat the intervention.
Protect funding and collections	Set draw conditions, reporting, reserve rules and enforceable collection arrangements (R9–R11).	Quote legal, reserve, financing and hedge costs. Reserves tie up cash; security can constrain other creditors.
Match liabilities and exit	Allocate restoration obligations, replacement delivery, insurance exclusions and long-term funding before exit (R4, R7, R12).	No assumed insurance cover or price. Legal transfer does not prove that the successor can perform.

Evaluating treatment alternatives

Evaluate avoidance, reduction, transfer and retention separately. A guarantee changes who bears loss; a reserve funds loss; an information exercise reduces uncertainty; none necessarily prevents the physical event. Require a quote and a defined beneficiary before crediting insurance or a guarantee with financial value.

The normalized tests on pages 11–12 examine only MRV readiness and field resilience. Other treatments remain conditional proposals pending scope, cost and enforceability evidence. Any financing improvement must also preserve credit eligibility, including additionality reassessment where required by the applied Isometric Reforestation v1.1 protocol.^[ISO3]

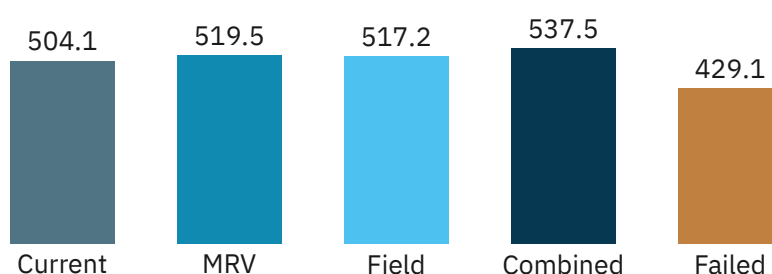
Comparing treatment packages

To compare treatment packages without assuming Mombak's undisclosed finances, normalize a prospective investor's planned net receipt to **\$1 million in year 4**. This is cash after existing operating and contractual obligations, not gross credit revenue. Use an illustrative 8% discount rate, an 80% receipt realization and a two-year delay: the unchanged-course present value is **\$504,136**.

Assume MRV readiness brings collection forward one year at a \$25,000 cost. Assume field resilience recovers 10 percentage points of the planned net receipt at a \$50,000 cost. Combining them costs \$75,000. These are hypothetical effects and budgets. The empirical evidence on pages 4–5 and 9 does not calibrate them.

Package	Cost now	PV after cost	Change in PV
Current course	0.0	504.1	0.0
MRV readiness	25.0	519.5	15.3
Field resilience	50.0	517.2	13.0
Combined	75.0	537.5	33.4
Combined fails	75.0	429.1	-75.0

USD thousands. Same starting exposure, horizon and discount rate in every row. "Combined fails" pays the full cost and achieves neither assumed improvement. Results: report model, unweighted conditional scenarios.



Present value after incremental cost, USD thousands.

The combined package adds **\$33,389** in this state, yet leaves a **\$197,505** gap to the untreated full, on-time receipt benchmark. The gap includes remaining volume and delay effects plus the cost of treatment. Derisking improves this conditional outcome; it does not restore the original proposition.

Testing conditions and treatment failure

The combined package is sensitive both to the starting exposure and to whether its assumed effects occur. These are unweighted conditional scenarios, not samples from a probability distribution.

EXHIBIT 1

Varying the untreated starting conditions

Untreated receipt fraction	No delay	1-year delay	2-year delay
60%	-1.5	31.2	23.3
80%	-1.5	42.1	33.4
100%	-75.0	-20.6	-24.6

Change in PV, USD thousands, after the \$75,000 combined package. Its nominal effects remain ten receipt percentage points and one year of acceleration, capped at full, on-time receipts. These nine states do not supply a success probability.

EXHIBIT 2

Paying for the full package when an effect fails

Effects achieved after paying \$75,000	Change in PV
Neither effect	−\$75,000
One-year acceleration only	−\$34,669
Ten-point receipt improvement only	−\$11,983
Both assumed effects	+\$33,389

Worked state: 80% receipt realisation, two-year starting delay, 8% discount rate. USD, rounded. Same initial exposure as page 11.

Purchasing MRV alone costs \$25,000 and adds \$15,331; paying \$75,000 but obtaining only its timing effect loses \$34,669. The \$50,000 difference is the extra cost paid. Likewise, field-only purchase adds \$13,017 at a \$50,000 cost; that effect alone loses \$11,983 at the full \$75,000 cost. The two comparisons therefore use consistent benefits and different cost commitments.

With both effects, the maximum total upfront cost is **\$108,389**; a further \$25,000 implementation burden reduces the net gain to **\$8,389**. At a \$75,000 cost, break-even needs a **5.094-point** receipt gain with one-year acceleration, or **11.902 points** without acceleration. Actual effectiveness and cost evidence must support these thresholds before they inform commitment.

Assigning responsibility for investment decisions

The following governance plan assigns responsibility for an investor's diligence and any subsequent commitment. Its evidence requirements and responses are proposals, not observed Mombak practices.

Proposed owner	Evidence, cadence and trigger	Required response
Investor counsel and safeguards lead	Before commitment and each new parcel: title, carbon rights, agreements, grievances and buyer eligibility. Any unresolved material constraint.	Withhold affected commitment; define remedy and authority to reopen.
Investment analyst and project finance lead	Before each draw, then monthly: as-set/contract map, bank evidence, budget and funding runway. A forecast cash shortfall before the next funded milestone.	Update funding plan; escalate before release or new obligation.
Technical and MRV leads	Monthly field review and each reporting cycle: survival cohorts, incident logs and verification findings. Milestone drift or evidence inconsistent with the approved case.	Reforecast net units and delivery; investigate cause before selecting treatment.
Commercial and treasury leads	Each delivery and collection: serials, buyer acceptance, invoices and balances. Any unmatched allocation, overdue amount or eligibility change.	Reconcile or pursue contractual remedy; reassess the next draw.
Risk owner and investment committee	Before every commitment and after material incidents: costed residual scenarios, treatment status and remaining obligations. Risk exceeds expressly agreed capacity.	Record accept, reduce, transfer or decline, with a named accountable owner.

Converting the case into an investment decision

Before an investment decision, require the governing project confirmations, permitted standards, actual disbursements, delivery targets, ownership and payment records, reconciled accounts and funded stewardship plan. This public-only research has not obtained the complete set. Establish the investor's hurdle, liquidity limit and loss capacity before ranking alternatives.

A rights or eligibility failure can make declining the exposure rational even when a spreadsheet shows positive value. An attractive conditional treatment result can justify obtaining a quote or running a bounded test. It cannot by itself authorize an investment.

Assessing effectiveness and future evidence

The integrated assessment supports partial empirical validation. Selected historical accounting outputs reproduce and delivery is corroborated. The causal risk reduction and net investor benefit of additional treatments remain unresolved. This is an evidence limit, not a finding that those treatments fail.

The assessment connects public evidence to potential causes of loss, financial consequences and proposed treatments. It compares incremental costs with conditional benefits, retains residual exposure and identifies the observations needed to inform an investment decision.

Assessment question	Conclusion
Implementation and accounting	Documented controls, verified issuance, reproducible selected output summaries and corroborated delivery provide partial empirical support. Full spatial reconstruction was not performed.
Analytical comparison	Conditional comparison is possible with declared inputs and common financial assumptions. This establishes scenario consistency.
Causal effectiveness	No linked incremental intervention, comparable untreated outcome and confounder record identifies the assumed treatment effects.
Financial effectiveness	Actual incremental costs and investor-linked net receipts are missing. Positive net benefit and its probability remain unestimated.
Commitment decision	The evidence supports further diligence. This assessment does not establish a basis for committing new capital to Mombak.

Learning within the public-evidence constraint

The next public update can record new monitoring and issuance events, retain forecasts before outcomes arrive, and test performance against later cohorts. Treatment evaluation additionally needs assignment and timing, comparable baseline conditions, all-in cost and net cash attributable to the same investor. An untouched holdout or later independent cohort would strengthen generalisation testing.

This exploratory assessment is informed by evidence already seen. It does not demonstrate superior investment performance from the analytical approach. Conditional treatment comparisons are possible, but empirical evidence of incremental effectiveness remains insufficient. A useful scenario result and a demonstrated investment benefit require different evidence.

Appendix: reproducing the financial tests

Inputs and interpretation

The normalized model assumes a \$1 million net receipt scheduled in year 4 from a hypothetical future commitment; an 8% discount rate; receipt realization of 60%, 80% or 100%; and delay of zero, one or two years. No probability weights are assigned. Dollar values share a constant purchasing-power basis, with no additional inflation, tax or financing layer introduced.

The receipt is defined after all existing claims, costs, reserves and stewardship provisions. This definition is necessary for comparison; its level and sufficiency are not established for Mombak. An actual valuation must model annual BRL and dollar cash flows, taxes, financing, existing pledges, delivery obligations and continuing stewardship explicitly.

Equations

Let R be the planned net receipt, f the realized fraction, d the delay, r the discount rate, g the recovery in receipt fraction, a the acceleration in years and C total upfront incremental cost:

$$\begin{aligned} PV_0 &= \frac{Rf}{(1+r)^{4+d}}, \\ PV_1 &= \frac{R \min(1, f+g)}{(1+r)^{4+\max(0, d-a)}} - C, \\ \Delta PV &= PV_1 - PV_0, \\ C_{\max} &= \frac{R \min(1, f+g)}{(1+r)^{4+\max(0, d-a)}} - PV_0. \end{aligned}$$

MRV readiness uses $(g, a, C) = (0, 1, 25,000)$; field resilience uses $(0.1, 0, 50,000)$; combined uses $(0.1, 1, 75,000)$. Full-cost failure cases retain $C = 75,000$ while setting either or both effects to zero. No benefit is allowed above full realization or before the original scheduled receipt.

Limits on transfer to Mombak

The recovery parameter represents improvement in *investor net receipts*, not a directly assumed percentage improvement in tree survival or gross tonnes. Field and MRV evidence must first be translated through applicable credit accounting and contracts. The shared discount rate avoids counting the same risk reduction again through a lower hurdle rate. These are scenario present values, not Mombak's project NPV or an expected return. In the worked state, the timing-only gross benefit is \$40,331 and the volume-only gross benefit \$63,017; accelerating recovered volume adds an interaction.

Appendix: interpreting the empirical data

The carbon additionality benchmark compares restoration with continued pasture. A treatment-effect comparison instead asks what the *same restoration activity* would achieve with and without a defined extra safeguard. The biomass-model equivalence check on page 5 addresses a third question: agreement between prediction and inventory. None of these comparisons can substitute for another.

Public export records	Count	Interpretation
Tree measurements	4,840	Prepared measurement rows; not treatment experiments.
Inventory plot-periods	124	63 baseline (T0), 61 monitoring (T2).
Predicted/observed plots	129	One exported prediction set, with residuals.
Regression diagnostics	1,000	Carbon-model simulation rows.
Counterfactual fractions	10,000	Simulated benchmark draws.

Nine exports from official calculation run `mlr_1KPTWWH361S0QX4M`; source [DATA](#). Mean and percentile removal summaries are exported outputs; they were not reconstructed from raw joint carbon draws.

The measurement IDs are unique and have no blank cells. The file flags 4,379 records inside the area and 461 outside. No unsupported filter was imposed. The inventory and prediction sets differ; their unmatched IDs remain explicit. T0 and T2 labels do not overlap, and the PDD states that nonpermanent, randomized plot locations prevent direct repeated-measure growth analysis. [\[DATA\]](#)[\[MOM2\]](#)

The raw exports lack coordinates and incremental treatment assignments, costs and receipts. Control-parcel matching, spatial inputs and the complete emissions bridge were not reproduced. Publicly printed financial links failed to resolve as transcribed; that does not establish that their contents are private or absent. [\[SCS1\]](#)

Maintaining reproducibility and boundaries

Source files, hashes, two numerical models and shared-input checks underpin the calculations. The financial model has 53 arithmetic/boundary checks and the empirical reanalysis 29 checks; these counts are not independent empirical tests. Consistency checks reconcile inputs, allocations and full-cost versus individual-package comparisons.

The PDD development sensitivity table is distinct from the final official export. Andi uses the official export for the historical totals and does not mix parameter labels or uncertainty discounts across versions. [\[MOM2\]](#)[\[SCS1\]](#) Selected calculations are reproducible, while a complete spatial/model rerun and independent human domain review remain outside this assessment.

Sources: financing and certification

Primary evidence checked 11 September 2026. Multiple documents from the same producer are one source family; announcements are not independent performance audits. Source labels are used consistently throughout.

WB1 / World Bank

Amazon Reforestation-Linked Outcome Bond issuance. 20 August 2024; transaction size and financing structure. Issuer announcement; no current disbursement or performance confirmation.

WB2 / World Bank Treasury

Amazon Reforestation-Linked Outcome Bond: case study. September 2024, pp. 1–2. Financing design and scheduled first carbon-linked coupon in July 2028. No current disbursement or collection statement.

WB3 / World Bank Treasury

Amazon Reforestation-Linked Bond: questions and answers. 2024; pp. 2-4, price exposure, risks and funding. Explanatory summary; complete applicable documents govern.

WB4 / IBRD

Prospectus supplement and final terms, XS2884011011. 15 August 2024; PT-1, PT-15–17, PT-41–44, PT-46 and PT-49. Full-disbursement rate row and fixed rate support the coupon calculations; actual collections are unverified.

ISO1 / Isometric Registry

Reforesting the Brazilian Amazon Project 1. Project 84R7; issuance and allocation, 1 July 2026. Registry balances do not identify invoice collections or investor distributions.

ISO2 / Isometric

First nature-based carbon removal certificates. 1 July 2026; first reforestation issuance. Issuer announcement; broader portfolio marketing figures are not carried into this case.

ISO3 / Isometric

Reforestation Protocol v1.1. Section 7.4 and section 10.4.1. Applied historical version; treatment-related financing changes can require additionality reassessment. Buffer rules do not estimate an investor's loss probability.

ISO4 / Isometric

Mombak first credits and reforestation registration. 1 April 2026; enhanced-weathering issuance. Different carbon activity; not evidence of reforestation issuance that April.

Sources: operating evidence and validation

DATA / Isometric registry / Mombak

Public calculation exports. GHG entry rmv_1KKAC5BT01S0QSRX; calculation run mlr_1KPTWWH361S0QX4M. Nine CSV exports retrieved 11 September 2026. Whole-period outputs are distinct from the entry's 2025 vintage. Measurements, simulations and predictions are different data types.

SCS1 / SCS Global Services

Validation and Verification Report, version 1-0. 25 June 2026; pp. 5, 12, 19–27, 28–33, 37–39 and 50–51. Historical assurance, financial-link references, model-version and independent-test exception.

MOM1 / Mombak

GHG Statement Report. 24 June 2026; pp. 4–5. Measurement uncertainty and final allocations. Displayed emissions do not close the precise upstream bridge.

MOM2 / Mombak

Project Design Document, Project 1. Published 1 July 2026; pp. 6–10, 43, 55–60, 83–97 and 110–117. Entity, horizon, control and model definitions; several fields are redacted.

MOM3 / Mombak

First reforestation delivery announcement. Company post beginning “Mombak is proud to announce its first deliveries”; accessed 11 September 2026. Relative post timestamp only; quantities by buyer and cash receipts are undisclosed.

BUY1 / Climeworks

Buyer acknowledgement of Mombak deliveries. Company post beginning “A major milestone for MOMBAK”; accessed 11 September 2026. Buyer-side corroboration of receipt; commercial participant, not an independent financial audit.

IC1 / ICVCM

Assessment Framework, Part 4, v1.1. January 2024 version; criteria 8-11. Background integrity taxonomy; not the project methodology or a cash-flow guarantee.