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Tokenomics & Economic Security

A quantitative analysis of the EARTH monetary design and the economic security of Proof of Staked Authority: fixed-supply issuance and its closed-form emission schedule, staking equilibrium and yield dynamics, the fee-burn counterbalance, the cost-of-corruption model, and the governance surface over economic parameters.

MONETARY DESIGN · EMISSION MATHEMATICS · STAKING EQUILIBRIUM · COST OF CORRUPTION · FEE BURN

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Tokenomics & Economic Security

A QUANTITATIVE ANALYSIS OF THE EARTH MONETARY DESIGN AND POSA SECURITY

Abstract

We analyze the monetary design of EARTH, the native utility currency of Earth Blockchain, and the economic security it purchases for Proof of Staked Authority consensus. The design fixes maximum supply at 90×10^9 EARTH and releases the 27×10^9 security allocation under a closed-form exponential schedule calibrated so that two-thirds emits within five years. We derive the emission-rate function and its consequences for staking yield; characterize the self-balancing equilibrium between staked ratio and APY; formalize the fee-burn counterbalance that couples net issuance to network usage; and present the cost-of-corruption model under which violating finality forfeits at least one-third of bonded stake plus all future selection weight. All parameters trace to Whitepaper v2.0 §15 and the Canonical Parameter Registry (EB-SPEC-001 §13); scenario figures are explicitly illustrative and make no market predictions.

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1. Monetary Design Principles

CREDIBLE SCARCITY · SECURITY-FIRST DISTRIBUTION · USAGE-COUPLED ISSUANCE

Three commitments organize the design (Whitepaper §15): a **fixed cap** no mechanism can exceed; **security-first distribution**, with the single largest allocation (30%) reserved to pay for consensus over a decade-plus horizon; and **usage-coupled net issuance**, in which a governed share of real fees is destroyed, tying monetary tightening to demand rather than discretion. EARTH is protocol-native — not a contract asset — and its four utility roles (gas, staking security, governance stake, enterprise settlement; Whitepaper §11) define the demand structure analyzed in §7.

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2. Supply, Allocation, and Vesting

THE STATIC STRUCTURE

Fig. 1 — Allocation of the 90B Maximum Supply

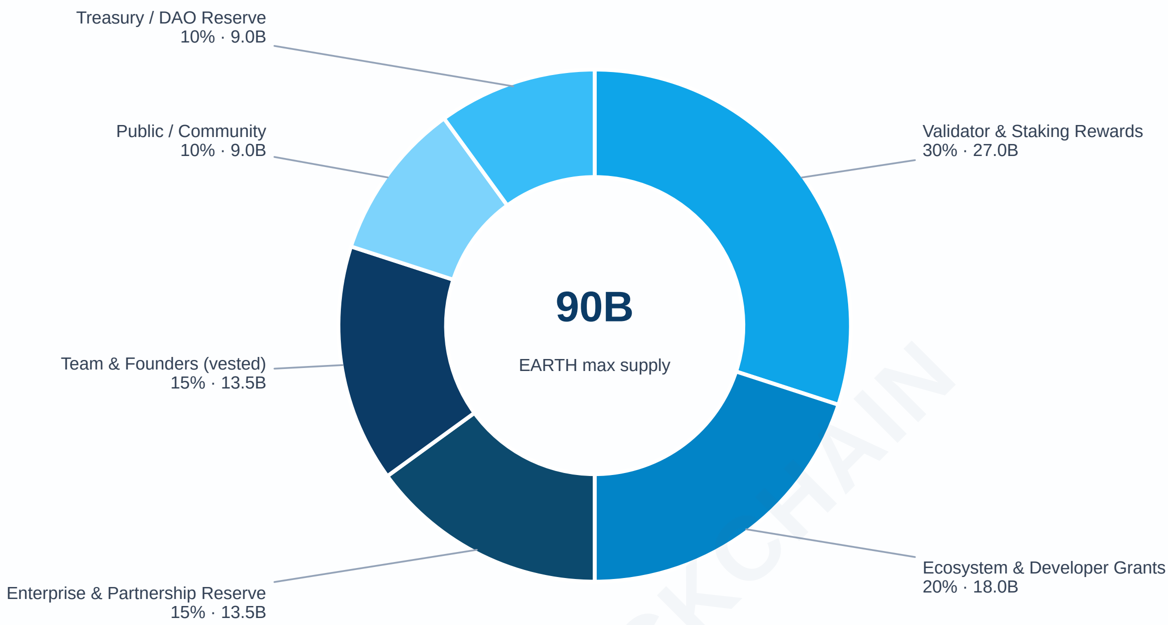

Fig. 1. Six allocation categories (Whitepaper §15.2). Security, builders, and enterprise adoption together hold 65% of supply.

Two allocations are time-locked by formula. Team & Founders (13.5B) vests as

$$\text{Vested}(t) = 0 \text{ for } t < 12 \text{ mo}; \quad \text{Vested}(t) = 13.5\text{B} \times \min(1, (t-12)/36) \text{ thereafter}$$

— zero insider float in year one, full vesting only at month 48 (Whitepaper §15.3). The 27.0B security pool never pre-circulates; it exists only as the emission source analyzed next. Remaining categories (Ecosystem 18B, Enterprise Reserve 13.5B, Public 9B, Treasury 9B) release under milestone- and program-gating (Whitepaper §15.2), with the Treasury additionally receiving slashed stake and forfeited governance deposits (EB-SPEC-001 §8.3–§8.4) — attacks fund the ecosystem.

3. The Emission Schedule: Derivations

CLOSED FORM, CALIBRATION, AND RATE FUNCTION

Cumulative emission from the security pool follows (Whitepaper §15.4):

$$\text{Emitted}(t) = E_{pool}\,(1 - e^{-kt}),\quad E_{pool} = 27.0\text{B}$$

Calibration. The design constraint “two-thirds within five years” fixes k exactly: $1 - e^{-5k} = 2/3 \Longrightarrow e^{-5k} = 1/3 \Longrightarrow$ **$k = \ln 3 / 5 \approx 0.2197\ \text{yr}^{-1}$**. Differentiating gives the gross emission rate,

$$\varepsilon(t) = d\text{Emitted}/dt = E_{pool} \cdot k \cdot e^{-kt} \approx 5.93\, e^{-0.2197t}\ \ \text{B EARTH / yr}$$

so security spending opens at ≈5.93B/yr, halves every ln 2/k ≈ 3.15 years, and falls to ≈0.66B/yr by year 10. Discretization to epochs is exact by evaluating the closed form at boundaries (EB-SPEC-001 §7.2); no rounding drift accumulates.

Fig. 2 — Gross Emission Rate ε(t)

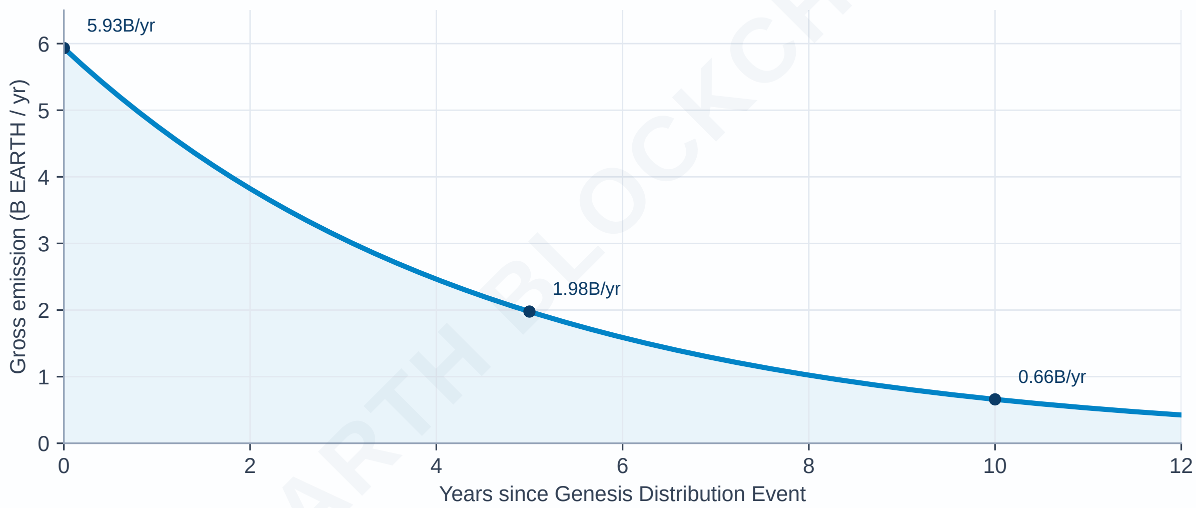

Fig. 2. The rate function front-loads security incentives when the network most needs to attract stake, tapering as fee revenue matures (Whitepaper §15.4).

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Fig. 3 — Cumulative Emission and Team Vesting

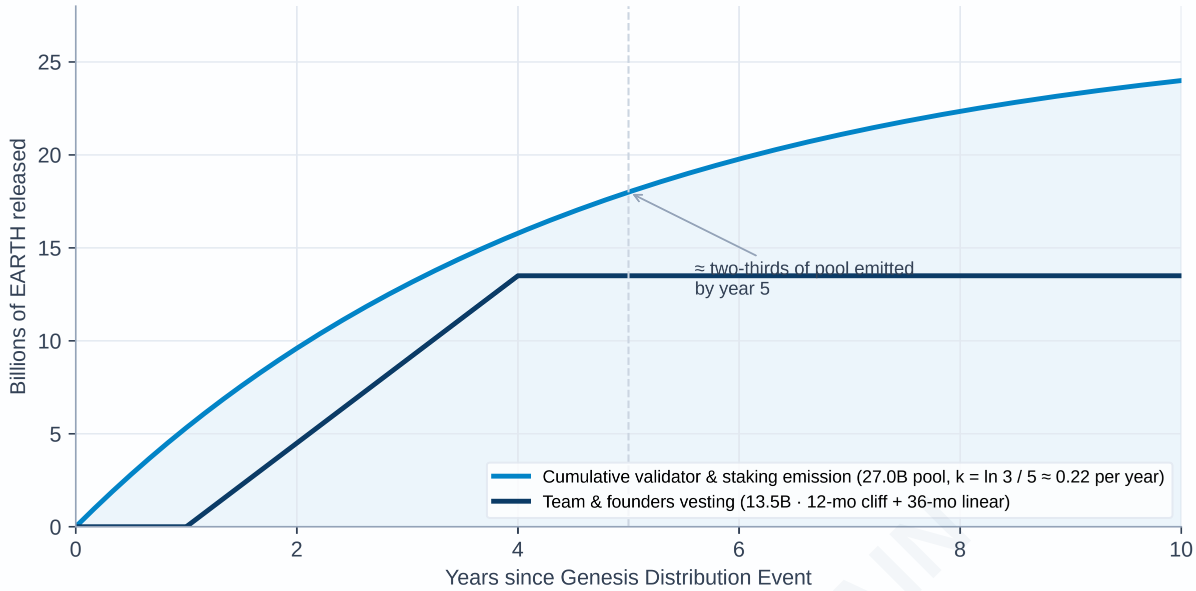

Fig. 3. The two largest time-locked supplies enter circulation on transparent, formula-defined schedules (Whitepaper §15.3–§15.4).

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4. Staking Yield and Equilibrium Dynamics

SELF-BALANCING PARTICIPATION

Let $\sigma \in (0,1]$ be the staked share of maximum supply. Emission-funded yield is

$$\mathrm{APY}(t, \sigma) = \varepsilon(t) \,/\, (\sigma \cdot 90\mathrm{B}) \times 100\% \quad (+\ \text{fee component } (1-\beta)\cdot \text{fees}/\sigma\cdot 90\mathrm{B})$$

Yield is decreasing in both arguments: over time (ε decays) and in participation (dilution across more stake). The equilibrium logic is standard and intentional (Whitepaper §15.5): low $\sigma \Longrightarrow$ high APY $\Longrightarrow$ stake inflows restore the security margin; high σ compresses APY toward the fee-funded floor. Because $\varepsilon(t)$ is closed-form, participants can compute forward yields exactly for any assumed σ — an unusual degree of predictability among staking systems.

Fig. 4 — Illustrative APY versus Staked Share

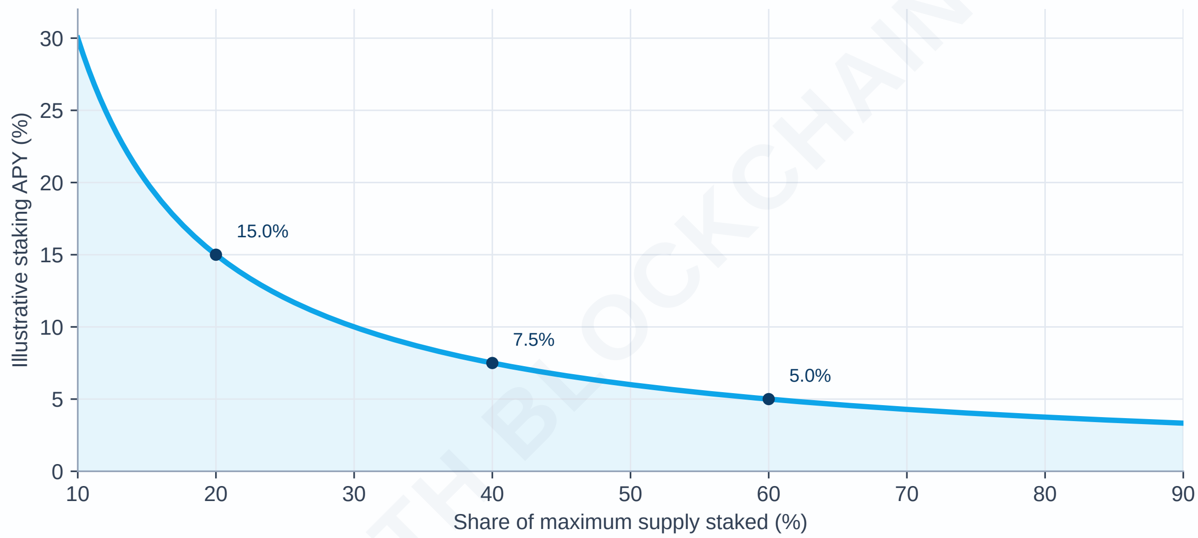

Fig. 4. Illustrative steady-state relationship at a 3%-of-max-supply annual emission (Whitepaper §15.5). Actual yield varies with t, σ, and fees.

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Delegation propagation. Delegators receive $(1-c_i)$ of pro-rata rewards and share slashing risk (EB-SPEC-001 §7.3), so the yield curve disciplines operator commissions: c_i prices operator quality (reputation R, uptime, green attestation) in a transparent market (EB-VAL-004 §3).

5. The Fee-Burn Counterbalance

COUPLING NET ISSUANCE TO USAGE

$$\mathrm{NetEmission}(t) = \varepsilon(t) - \beta \cdot \mathrm{GasFees}(t), \quad \beta = 0.30 \text{ at genesis}$$

Burning a governed share of base fees (EB-SPEC-001 §6.3) makes monetary policy respond to demand mechanically: as usage grows, net issuance falls, crossing into net deflation when β·fees exceeds $\varepsilon(t)$ — increasingly attainable as ε decays. The cap is never at risk in either direction: emission cannot exceed the pool, and burn only destroys.

Fig. 5 — Net Emission under Illustrative Burn Levels

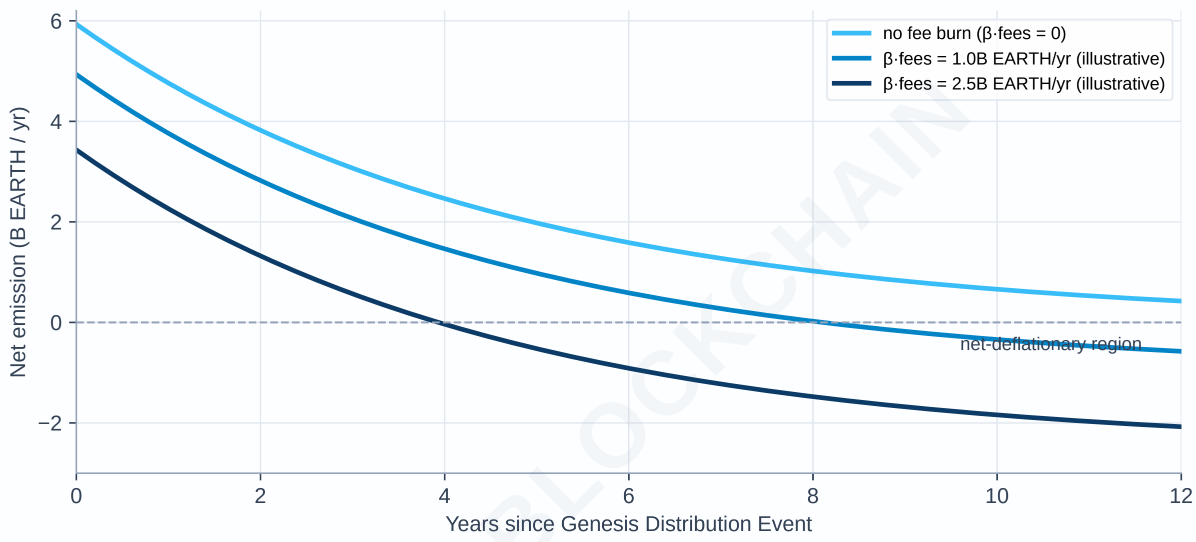

Fig. 5. Net issuance for three illustrative, constant fee-burn levels. These are scenario curves, not forecasts; realized fees depend on adoption.

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Reading the figure honestly. The curves answer "what would net issuance be *if* burn ran at level X," isolating the mechanism. No claim is made about which curve materializes; that is an adoption outcome, not a protocol property.

6. Economic Security: Cost of Corruption

WHAT AN ATTACK MUST PAY

Violating finality requires certificates from ≥ ⌈2n/3⌉ validators on conflicting blocks, forcing more than n/3 of the active set into equivocation — slashable at α up to 1.0 with evidence anyone can submit (EB-SPEC-001 §5.5–§5.7). The minimum attack budget is therefore bounded below by:

$$CoC(t) \geq (1/3) \cdot S_{bonded}(t) \cdot \alpha_{S2} + V_{reputation} + V_{future\ rewards}$$

where S_{bonded} grows with the emission-attracted stake of §4, $V_{reputation}$ is the destroyed selection weight ($R \to 0$ excludes the keys from future sets), and $V_{future\ rewards}$ is the discounted reward stream forfeited. Three structural properties reinforce the bound:

- **No exit before consequences.** The 21-day slashable unbonding window means evidence discovered post-hoc still binds (EB-SPEC-001 §7.4) — "slash-and-run" is closed.
- **Capital cannot buy authority alone.** Selection weights S·R require earned reputation; acquiring one-third of *effective* weight requires sustained honest operation before betrayal, raising the time-cost of attack (Whitepaper §6.2–§6.3).
- **Attacks are self-defeating economically.** Slashed stake routes to the Treasury (EB-SPEC-001 §8.3), and reputation-weighted rotation plus community-tier admission keeps marginal honest capacity cheap to add relative to the cost of corrupting incumbents (Whitepaper §5, §6.7).

Cartels and censorship. Sustained censorship needs ≥ Q collusion, which is visible in participation bitmaps (public per block) and governance-punishable through the validator framework; sub-quorum censorship only delays inclusion by seconds via backup proposers (EB-SPEC-001 §5.4, §12).

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7. Demand Structure of a Utility Currency

WHERE DEMAND FOR EARTH COMES FROM, MECHANICALLY

Channel	Mechanism	Supply-Side Interaction
Gas	Every transaction pays base fee + tip in EARTH (EB-SPEC-001 §6.2).	β share of base fee burned — demand directly tightens supply.
Security stake	Bonding/delegation locks EARTH for selection weight; 21-day exit.	Reduces liquid float; scales the CoC bound of §6.
Governance stake	Voting power with up-to-24-month lock multiplier (Whitepaper §10.1).	Long-duration locking by construction.
Enterprise settlement	BaaS metering, product subscriptions, verification and marketplace fees settle in EARTH (Whitepaper §11–§12).	Recurring transactional demand tied to product adoption, recirculating to validators and Treasury (Whitepaper Fig. 9).

The analytical point is not a price claim but a structure claim: every demand channel is a *usage* channel. The currency's monetary tightening (burn), its security budget (stake), and its cash flows (settlement) all scale with the same underlying variable — network utility — which is the design intent stated in Whitepaper §11.

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8. Governance Surface and Risk Discussion

WHAT CAN CHANGE, WHAT CANNOT, WHAT COULD GO WRONG

- **Governable:** β, emission calibration within the pool, slashing coefficients, governance thresholds, validator-set size — each only via supermajority-class proposals through the 48 h Timelock (EB-SPEC-001 §9, §13). **Fixed:** the 90B cap.
- **Parameter-capture risk.** Time-locked voting power (λ multiplier) weights long-horizon holders, and upgrade-class thresholds (≥66.7%) raise the bar for economic changes; the public queue gives markets and operators reaction time. Residual risk is inherent to on-chain governance and is disclosed rather than dismissed.
- **Low-fee regime risk.** If usage lags, burn is small and validator income leans on decaying emission; the mitigation is the same lever set the design anticipates — EarthDAO can recalibrate within the pool, and enterprise settlement demand (§7) is the strategic answer, not monetary tinkering.
- **Concentration risk.** Stake concentration metrics are public on-chain (Whitepaper §6.7); community-tier admission and reputation weighting are the structural counters, monitored through the explorer and `earth_` telemetry.
- **Scope of this paper.** No price forecasts, no TPS or revenue projections; every quantitative figure is either a protocol constant or labeled illustrative.

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References

SOURCES

[1] Earth Blockchain Whitepaper v2.0 — §6 (consensus economics), §10 (governance), §11 (utility roles), §15 (economic model).

[2] EB-SPEC-001 Technical Protocol Specification — emission discretization (§7.2), fee rule and burn (§6), slashing (§5.7), parameter registry (§13).

[3] EB-VAL-004 Validator Handbook — operator-level reward and commission mechanics.

[4] Public design literature on fee-burn mechanisms and staking-equilibrium analysis in EIP-1559-style fee markets — informative context for §4–§5.

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