EMJ.LIFE Research Publications

Methodology White Paper Series | MWP02

December 2025

PADV–NTCC – ESG INTEGRATED METHODOLOGY WHITE PAPER V3.0

BEHAVIORAL DATA–DRIVEN ENGAGEMENT INDEX & ESG INTEGRATION FRAMEWORK

Publisher: EMJ LIFE Holdings Pte. Ltd. (Singapore)

DOI Prefix: 10.64969

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METADATA PAGE

TITLE:

- PADV–NTCC – ESG Integrated Methodology White Paper v3.0 — Standardized Engagement Index Protocol for Verified Behavioral Sustainability

PUBLISHER:

- EMJ LIFE Holdings Pte. Ltd. (Singapore)

INSTITUTIONAL OPERATOR:

- NTCC (Non-Tradable Commitment Credit) System under the PADV Behavioral Data Verification Framework

VERSION:

- V3.0 • 02 December 2025

IDENTIFIERS:

- DOI: 10.64969/padv.ntcc.2025.v3
- ORCID (Author): 0009-0002-2161-5808

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PLACE OF PUBLICATION:

- Singapore

Research Program: Evidence Infrastructure Research Series

KEYWORDS:

NTCC • Engagement Index • PADV • ESG • Scope 3 • Behavioral Data • Non-Financial Assurance • Impact Estimation • SDGS PASS • Institutional Governance • Verification Factor (VF) • Recognition Coefficient (RCF) • COSO • IFRS • GRI • ISO • Audit Readiness • Data Integrity • Sustainability

VALUE STATEMENT

At its core, the NTCC (Non-Tradable Commitment Credit) methodology establishes a new standard for how sustainability participation is verified, standardized, and governed rather than traded. It provides the deterministic evidence computation layer that transforms verified behavioral participation into measurable, auditable, and non-financial engagement metrics.

Unlike market-based instruments that derive value from exchange, NTCC derives institutional value from verified human and organizational actions, ensuring that every recognized outcome originates from immutable behavioral evidence. Built upon the PADV (Participation–Action–Data–Value) architecture, the methodology transforms behavioral participation into verified Proof Records, Proof Records into standardized engagement metrics, and standardized engagement metrics into annual governance indicators.

The framework introduces two independent participation systems, Institutional Participation Points (IPP) for public engagement and Enterprise Institutional Participation Points (E-IPP) for enterprise sustainability execution. Although these participation systems represent different engagement densities, both converge through deterministic computation into a unified Non-Tradable Commitment Record (NTCR) and subsequently into the annual Non-Tradable Commitment Credit (NTCC).

By preserving evidence continuity throughout the computational process, NTCC establishes a verifiable bridge between behavioral participation and ESG disclosure while remaining interoperable with internationally recognized assurance frameworks. Rather than replacing existing reporting standards, it provides the computational evidence layer that precedes disclosure and strengthens sustainability governance.

NTCC is neither a currency nor a tradable environmental asset. It is a governance-oriented engagement index founded upon deterministic computation, immutable evidence, and institutional trust, ensuring that sustainability is demonstrated through verified participation rather than purchased through market transactions.

ABSTRACT

The NTCC Methodology White Paper v3.0 defines the conceptual, computational, and governance framework for the Non-Tradable Commitment Credit (NTCC), a deterministic

engagement measurement methodology designed to institutionalize verified behavioral sustainability data within global ESG assurance ecosystems.

Developed under the PADV (Participation–Action–Data–Value) architecture, the methodology establishes a complete evidence processing framework that transforms verified behavioral participation into standardized engagement metrics and subsequently into disclosure-ready governance evidence. The framework distinguishes two independent participation systems: Institutional Participation Points (IPP) for A-Series public participation modules and Enterprise Institutional Participation Points (E-IPP) for B-Series enterprise sustainability execution modules. These participation systems employ different engagement baselines while converging into a unified computational architecture through standardized Non-Tradable Commitment Records (NTCR).

Engagement computation follows a deterministic methodology combining participation normalization, Verification Factors (VF), ESG Weighting ($W_{(ESG)}$), and the Annual Recognition Coefficient (RCF). This architecture ensures that identical verified inputs always generate identical computational outputs while preserving evidence continuity from Proof Records to annual governance indicators.

Unlike market-based mechanisms, NTCC introduces a non-financial governance model in which sustainability performance is measured through verified behavioral reliability rather than exchange value or market liquidity. Every computational result remains entity-bound, traceable, reproducible, and audit-ready, supporting interoperability with GRI, IFRS Sustainability Disclosure Standards, ISO 14064, and the COSO Internal Control Framework.

Field implementation across four sustainability exhibitions conducted between March and October 2025 produced 11,855 verified behavioral activities involving more than 35,000 participants and 72 partner organizations. These implementations generated approximately 5.25 million Institutional Participation Points (IPP) within the A-Series participation framework and demonstrated the practical feasibility of deterministic behavioral evidence computation within institutional sustainability governance.

The empirical implementation validates NTCC as an enterprise-grade evidence computation architecture capable of supporting Scope 3 engagement evidence, sustainability governance, and pre-disclosure assurance. Rather than competing with existing carbon accounting or ESG reporting frameworks, the NTCC methodology provides the missing computational evidence layer that enables organizations, regulators, assurance providers, and software systems to transition from declarative sustainability claims toward standardized, verifiable behavioral evidence.

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CHAPTER 1: ABSTRACT

Note: This document defines a deterministic methodology for transforming verified behavioral participation into standardized engagement metrics within the PADV Evidence Infrastructure. It does not constitute financial advice, carbon credit issuance, emissions accounting, or a prospectus for securities. All engagement metrics are non-financial governance indicators designed to support management accounting, sustainability assurance, and ESG disclosure.

1.1 NTCC AS A STANDARDIZED ENGAGEMENT INDEX

The Non-Tradable Commitment Credit (NTCC) is a standardized engagement index designed to quantify verified sustainability participation through deterministic behavioral evidence rather than market-based transactions.

Unlike carbon credits or financial instruments, NTCC derives its institutional legitimacy from verifiable participation, computational consistency, and evidence continuity. Every NTCC originates from immutable Proof Records and is generated through a deterministic computational process, ensuring that reported engagement outcomes remain traceable, reproducible, and audit-ready.

Within the PADV Evidence Infrastructure, NTCC represents the governance-level engagement index derived from standardized Non-Tradable Commitment Records (NTCRs). Rather than creating tradable environmental assets, NTCC establishes a governance-oriented evidence framework that strengthens sustainability reporting through verified behavioral participation.

1.2 PADV EVIDENCE PROCESSING ARCHITECTURE

The NTCC methodology operates under the PADV (Participation–Action–Data–Value) architecture, which transforms verified behavioral participation into standardized institutional evidence through a deterministic processing sequence.

The architecture consists of five evidence layers.

• **Participation** – Verified behavioral activities performed by individuals or organizations through approved sustainability programs.

• **Proof Record** – Immutable evidence generated from each verified behavioral activity.

• **Engagement Computation** – Standardized computation through Institutional Participation Points (IPP) or Enterprise Institutional Participation Points (E-IPP), Verification Factors (VF), ESG Weighting ($W_{(ESG)}$), and Non-Tradable Commitment Records (NTCR).

• **Recognition** – Annual governance recognition of verified NTCR values through the Recognition Coefficient (RCF), resulting in Non-Tradable Commitment Credits (NTCC).

• **Disclosure-ready Evidence** – Standardized engagement evidence supporting sustainability reporting, institutional governance, and assurance activities.

This architecture preserves evidence continuity throughout the complete computational lifecycle while ensuring deterministic and reproducible governance outcomes.

1.3 INTEGRATION WITH ESG ASSURANCE FRAMEWORKS

The NTCC methodology is designed to complement internationally recognized sustainability reporting and assurance frameworks by providing a standardized computational evidence layer preceding disclosure.

The methodology supports interoperability with GRI Standards, IFRS Sustainability Disclosure Standards (S1 and S2), ISO 14064-1, ISO 19011, ISO 27037, and the COSO Internal Control Framework.

Rather than replacing existing reporting standards, PADV provides the missing behavioral evidence computation layer linking verified participation to disclosure-ready engagement metrics.

Through deterministic computation and immutable Proof Records, organizations can strengthen sustainability governance while enabling auditors, assurance providers, and regulators to reconstruct every reported engagement metric from its originating behavioral evidence.

1.4 DUAL PARTICIPATION SYSTEMS AND ANNUAL RECOGNITION FRAMEWORK

The NTCC methodology distinguishes between participation systems and recognition pathways.

Behavioral participation is represented through two independent participation systems.

Participation System	Applicable Modules	Participation Unit	Computational Baseline
Public Participation	A-Series	Institutional Participation Points (IPP)	10 IPP ≈ 1 Unit Engagement Impact
Enterprise Participation	B-Series	Enterprise Institutional Participation Points (E-IPP)	1 E-IPP ≈ 1 Unit Engagement Impact

Following standardized computation, annual governance recognition is performed through two recognition pathways.

Recognition Pathway	Verification Model	RCF	Recognition Scope
Community Participation	Fixed Verification (VF = 0.95)	0.30	Up to 30% of annual recognized NTCR
Enterprise Task Verification	Dynamic Verification (VF = 0.8–1.2)	1.00	Full annual recognition

The Recognition Coefficient (RCF) aligns verified engagement metrics with annual ESG reporting cycles while preventing duplication across reporting periods.

By separating participation measurement from annual recognition, the methodology enables heterogeneous behavioral participation to converge into a unified, deterministic engagement framework suitable for sustainability governance, assurance, and disclosure.

CHAPTER 2: BACKGROUND & MOTIVATION

2.1 THE DATA INTEGRITY GAP IN ESG DISCLOSURE

The rapid expansion of ESG reporting frameworks has significantly improved the transparency of sustainability disclosure. However, the quality of the underlying evidence has not advanced at the same pace. A substantial proportion of reported sustainability information continues to rely on estimated data, secondary databases, and aggregated assumptions rather than directly verifiable operational evidence.

This challenge is particularly evident in Scope 3 emissions and value-chain activities. Organizations frequently report environmental performance using expenditure-based estimation models or industry averages. Although these methods support large-scale reporting, they rarely preserve direct evidence connecting reported outcomes with the behavioral activities that generated them.

As a result, regulators, auditors, investors, and other stakeholders often face uncertainty when evaluating whether reported sustainability performance reflects verified implementation or organizational intention.

Current ESG reporting practices primarily measure outcomes while providing limited visibility into the behavioral processes that produced those outcomes. This reduces auditability, weakens traceability, and limits confidence in sustainability disclosures.

These limitations demonstrate the need for an evidence infrastructure capable of transforming verified behavioral participation into standardized, traceable, and audit-ready sustainability evidence.

2.2 LIMITATIONS OF OUTCOME-BASED ESTIMATION MODELS

Existing environmental accounting mechanisms, including voluntary carbon markets, greenhouse gas inventories, and emission-factor databases, were developed primarily to quantify environmental outcomes. Their primary objective is environmental accounting rather than behavioral verification.

Although these systems remain essential for sustainability reporting, they exhibit several structural limitations when behavioral evidence is required.

• **Limited Behavioral Traceability.** Aggregated datasets cannot be reconstructed into verified individual or organizational activities.

• **Methodological Fragmentation.** Different estimation methodologies reduce comparability across organizations, industries, and jurisdictions.

• **Greenwashing Exposure.** Sustainability claims may rely on estimated performance without corresponding implementation evidence.

• **Incomplete Audit Trails.** Existing reporting systems rarely preserve immutable evidence linking reported indicators with verified behavioral activities.

These limitations affect the ability of assurance providers to evaluate implementation quality, participation integrity, accountability, and governance effectiveness.

The challenge therefore extends beyond reporting methodology. It reflects the absence of a standardized evidence architecture capable of preserving behavioral traceability throughout the sustainability data lifecycle.

2.3 THE NEED FOR A NON-TRADABLE DATA ARCHITECTURE

The PADV framework introduces the Non-Tradable Commitment Credit (NTCC) to address this structural evidence gap through a governance-oriented behavioral verification methodology.

NTCC does not function as a tradable asset, investment product, emissions offset, or financial instrument.

Its purpose is to establish a standardized methodology that converts verified behavioral participation into structured engagement evidence supporting sustainability governance and ESG disclosure.

The non-tradable architecture provides three fundamental governance safeguards.

• **Evidence Stability.** Engagement metrics remain permanently associated with verified participation and cannot be exchanged or transferred.

• **Evidence Uniqueness.** Every recognized engagement outcome originates from a unique Proof Record, preventing duplication and double counting.

• **Evidence Transparency.** Verified records remain available for assurance review, governance oversight, and regulatory examination through a complete evidence trail.

These governance safeguards strengthen the integrity of sustainability information by preserving evidence continuity from behavioral participation to institutional reporting.

2.4 EVOLUTION FROM PADV TO ESG-INTEGRATED METHODOLOGY V3

The original PADV methodology established the conceptual foundation for recording, verifying, and structuring behavioral participation as digital evidence.

Its primary contribution was the introduction of Proof Records as standardized representations of verified sustainability participation.

Building upon this foundation, NTCC Methodology v3 extends PADV into a governance-oriented methodology designed to support institutional interoperability and ESG assurance.

Three methodological advancements characterize this evolution.

• **Verification Factor Framework (VF_0, VF_n, VF_s).** A multi-dimensional verification framework supporting behavioral, regional, and sector-specific evidence quality.

• **ESG Weighting Model ($W_{(}ESG_{)}$).** A standardized governance weighting methodology integrating Carbon Effect (CEF), Social Effect (SEF), and Institutional Reliability (IRF).

• **Annual Recognition Coefficient (RCF).** A governance mechanism aligning verified engagement metrics with annual ESG reporting cycles while preventing recognition duplication across reporting periods.

These methodological components enable NTCC Methodology v3 to operate as a governance-ready behavioral evidence methodology compatible with internationally recognized sustainability reporting and assurance frameworks, including GRI, IFRS Sustainability Disclosure Standards, ISO standards, COSO, and QS sustainability metrics.

The methodology strengthens the traceability, comparability, and auditability of behavioral participation while providing an institutional evidence foundation for sustainability disclosure.

CHAPTER 3: THEORETICAL FOUNDATION OF PADV

3.1 THE PADV FOUR-RING MODEL: FROM BEHAVIOR TO VERIFIABLE EVIDENCE

The **PADV Framework**: standing for **Participation, Action, Data, and Value**, defines the structural evolution of behavioral events into verifiable data assets recognized within ESG assurance systems.

- **Participation (P):** The decision or intent to engage in a sustainability-related behavior. This marks the entry point of human agency into the data ecosystem.
- **Action (A):** The execution of a measurable, context-specific task. Each action corresponds to a **"Proof Record"** that captures immutable evidence of completion.
- **Data (D):** The conversion of verified behavioral evidence into structured digital information. At this stage, the action becomes traceable and auditable through the **V-Layer Registry**.
- **Value (V):** The recognized outcome of verified participation, expressed as **NTCR (Non-Tradable Commitment Records)** or **NTCC Engagement Indices**. Here, "value" signifies **Trust and Accountability**, representing a quantifiable metric of sustainability performance rather than economic exchange.

The Four-Ring Model ensures that every sustainability act can be quantified as a **Performance Indicator** without commodification, transforming sustainability from narrative into measurable, auditable impact.

3.2 INSTITUTIONAL LOGIC OF BEHAVIORAL DATA GOVERNANCE

PADV redefines data governance as a process of **institutionalizing trust** through verified participation. In contrast to traditional financial auditing, which validates monetary transactions, PADV validates **behavioral interactions**, the foundational layer of ESG impact.

The model operates on three governance logics:

1. **Transparency:** Every Proof Record is publicly traceable within the PADV Registry.
2. **Accountability:** Each verified act links directly to an identifiable actor (Individual UID or Enterprise UID).

3. **Non-Transferability:** Data cannot be resold, transferred, or traded. This restriction preserves the **authenticity of the behavioral origin**, ensuring that the credit remains permanently attached to the actor who performed the action.

Through these principles, PADV extends governance from organizational disclosure to **citizen-level accountability**, forming a multi-actor data assurance ecosystem.

3.3 RELATIONSHIP BETWEEN PADV AND DATA ASSURANCE THEORY

Data assurance, in the context of ESG, refers to the verification of data quality, origin, and reliability prior to disclosure[14]. PADV complements existing assurance frameworks (ISAE 3000, AA1000AS, and COSO) by introducing a **Behavioral Data Layer**, a foundational source for non-financial assurance[15].

Conventional Assurance Layer	**PADV Behavioral Assurance Layer**	**Integration Outcome**
Financial Data Auditing	**Behavioral Data Verification**	Extended Assurance Scope
Corporate Governance Controls	**Proof Record Registry Governance**	Real-Time Accountability
ESG Reporting Verification	**NTCC Engagement Data Model**	Enhanced Data Traceability

Thus, PADV bridges the gap between behavior (micro) and institutional assurance (macro), enabling verifiers, auditors, and policymakers to trace sustainability outcomes back to the **verified actions** that generated them.

3.4 RELATED WORKS AND METHODOLOGICAL LINEAGE

The theoretical design of PADV draws from multiple interdisciplinary traditions:

- **Behavioral Economics:** Recognizing that real sustainability impact arises from collective micro-decisions.

- **Information Assurance Theory:** Ensuring verifiable provenance and non-repudiation in digital systems.
- **ESG Reporting Frameworks:** Aligning with GRI, IFRS, and ISO methodologies to emphasize **verifiability** over mere disclosure.
- **COSO Control Environment:** Aligning behavioral verification with internal control and risk management.
- **QS Sustainability Metrics:** Reinforcing educational and social participation as measurable sustainability outcomes.

PADV therefore represents an **institutional synthesis**, linking human behavior, digital verification, and organizational accountability into a unified assurance architecture.

3.5 SUPPLEMENTARY NOTE ON ILLUSTRATIVE CALCULATION LOGIC (PROXY)

Disclaimer

The following calculation model is provided as an illustrative representation of the logical mechanism underlying the NTCC framework.

It is designed as a Management Accounting Tool for estimating behavioral engagement impact and does not replace, replicate, or supersede any certified carbon accounting methodology, including ISO 14064, the GHG Protocol, or the IPCC Guidelines.

The purpose of this section is to demonstrate the traceability, consistency, and verification logic through which behavioral participation can be translated into standardized engagement impact proxies within the PADV–NTCC system.

1. BASELINE SCENARIO DEFINITION (PROXY LOGIC)

Each NTCC task defines:

- **EF_0 (Baseline Emission Factor):** the estimated emission factor prior to behavioral change.
- **EF_1 (Post-Action Emission Factor):** the estimated emission factor after the sustainable behavior has been adopted.

The difference between EF_0 and EF_1 represents the estimated behavioral impact proxy generated by a verified action.

The estimated impact proxy is expressed as:

$$\Delta CO_2e_{(proxy)} = (EF_0 - EF_1) \times n$$

where:

- **EF_0** = baseline emission factor before behavioral change
- **EF_1** = post-action emission factor after behavioral change
- **n** = number of verified task completions

This proxy represents an estimated behavioral contribution rather than a certified emissions reduction claim.

All emission factors are derived from recognized reference databases, including IPCC Guidelines, national emission factor databases, environmental agency publications, and other publicly available sustainability datasets.

2. EMISSION FACTOR STANDARDIZATION (REFERENCE DATA)

To maintain consistency across different activity categories, emission factors are standardized into kg CO_2e per activity unit.

Activity Type	EF_0 (kg CO_2e/unit)	EF_1 (kg CO_2e/unit)	Reference Source
Private Vehicle (Gasoline)	0.271	—	IPCC 2006 Guidelines
Public Transport (MRT / Bus)	—	0.071	Local EPA Database
Paper Document Delivery	0.013	—	GRI 305 Reference Data

Activity Type	EF_0 (kg CO_2e/unit)	EF_1 (kg CO_2e/unit)	Reference Source
Electronic Document Delivery	—	0.004	IFRS S2 Supporting Reference

Example

A participant shifts from private vehicle commuting to MRT transportation.

(0.271 – 0.071) = 0.20

If the behavior is verified twenty times:

0.20 × 20 = 4.0

The estimated behavioral impact proxy equals:

4.0 kg $CO_2e_{(proxy)}$

3. UNCERTAINTY AND ERROR MARGIN

Consistent with the principles of ISO 14064-3, the NTCC framework recognizes that behavior-based estimations contain inherent uncertainty.

Typical uncertainty ranges are expected to remain within ±10–15%, depending on activity type, verification density, and source data quality.

For each generated proxy value, the system records:

- Emission Factor Database Version
- Verification Timestamp
- User UID or Enterprise UID
- SDGS Activity ID
- Verification Factor (VF)
- ESG Weighting Value ($W_{(ESG)}$)

This evidence chain allows auditors and reviewers to reconstruct the logic behind each calculated proxy.

4. AGGREGATION AND AUDIT LOGIC

Each verified behavioral action generates an estimated behavioral impact proxy:

$\Delta CO_2e_{(proxy,i)}$

The framework aggregates all verified proxy values to form a total engagement impact estimate:

$NTCC_{(total)} = \Sigma(\Delta CO_2e_{(proxy,i)})$

The resulting value represents a cumulative behavioral engagement impact estimate and serves as the quantitative basis for NTCR and NTCC calculations.

Weekly, quarterly, and annual summaries can be exported for management review, internal control procedures, ESG reporting preparation, and assurance activities.

All exported datasets retain:

- Verification identifiers
- Calculation assumptions
- Uncertainty ranges
- Audit trail references

5. ILLUSTRATIVE EXAMPLES

Task Name	**Category**	**Frequency (n)**	**Estimated ΔCO_2e Proxy**	**NTCC Proxy Value**
Green Commuting Challenge	Transportation	20	4.0 kg $CO_2e_{(proxy)}$	4.0 ± 0.5 Units
Paperless Report Submission	Digitalization	10	0.09 kg $CO_2e_{(proxy)}$	0.09 ± 0.01 Units

These examples are provided solely to illustrate the logical relationship between behavioral verification and engagement impact estimation.

6. CONCLUSION AND CLARIFICATION

The proxy model demonstrates how verified behavioral participation can be translated into standardized engagement impact estimates through a transparent and auditable methodology.

Within the NTCC framework, these values function as management-accounting and sustainability-governance indicators rather than regulatory carbon accounting outputs.

NTCC therefore remains a non-tradable, verification-based mechanism designed to complement existing ESG disclosure and assurance systems.

It does not constitute a carbon credit, emissions offset, financial instrument, or certified emissions reduction program.

Its primary purpose is to strengthen the traceability, consistency, and auditability of behavioral sustainability data within institutional ESG governance frameworks.

CHAPTER 4: DEFINITION OF NTCC

4.1 NTCC AS A STANDARDIZED ENGAGEMENT INDEX

The Non-Tradable Commitment Credit (NTCC) is a standardized engagement index designed to quantify verified sustainability participation through deterministic behavioral evidence rather than market-based transactions.

Unlike carbon credits, emissions offsets, or financial instruments, NTCC functions as a governance-oriented measurement framework that transforms verified participation into auditable engagement metrics supporting sustainability management, institutional accountability, and ESG reporting.

Within the PADV Evidence Infrastructure, NTCC represents the highest governance-level engagement metric generated through a structured evidence-processing architecture.

Its objective is not to monetize sustainability performance but to preserve evidence continuity from participation through verification to disclosure.

Every NTCC therefore represents verified institutional trust rather than a tradable environmental asset.

4.2 INSTITUTIONAL CHARACTERISTICS OF NTCC

NTCC possesses six defining characteristics.

NON-TRADABLE

NTCC cannot be transferred, exchanged, sold, pledged, retired, or traded.

It exists solely as a governance metric.

ENTITY-BOUND

Every NTCC remains permanently linked to the individual, institution, or enterprise that generated the underlying behavioral evidence.

Ownership is irreversible.

EVIDENCE-BASED

Every NTCC originates exclusively from verified Proof Records.

No declaration, questionnaire, manual estimation, or self-reported statement can directly generate NTCC.

DETERMINISTIC

All calculations follow deterministic algorithms defined by the PADV methodology.

Identical inputs always produce identical outputs.

TRACEABLE

Every NTCC can be reconstructed from its originating behavioral evidence through immutable processing records.

AUDIT-READY

Every computational step is independently reviewable by auditors, assurance providers, regulators, or authorized reviewers.

4.3 HIERARCHICAL RELATIONSHIP OF PADV EVIDENCE

The PADV framework transforms behavioral participation into governance-ready evidence through a structured hierarchical architecture.

Each processing layer performs a unique governance function while maintaining complete traceability throughout the data lifecycle.

The hierarchy consists of five layers.

LAYER 1

Proof Record (PR)

Proof Record is the smallest immutable evidence unit within PADV.

Each Proof Record represents one verified behavioral activity.

Typical metadata include

• UID or Enterprise UID

• SDGS Activity ID

• Timestamp

• Verification Metadata

• Task Metadata

• MME Mapping

• Evidence Hash

Proof Records contain no engagement calculations.

They function solely as immutable behavioral evidence.

LAYER 2

INSTITUTIONAL PARTICIPATION POINTS

Behavioral participation is quantified using two independent participation systems.

PUBLIC PARTICIPATION

Institutional Participation Points (IPP)

Applicable to

A-Series modules

Community participation

Educational participation

Public sustainability engagement

Baseline

10 IPP ≈ 1 Unit Engagement Impact

ENTERPRISE PARTICIPATION

Enterprise Institutional Participation Points (E-IPP)

Applicable to

B-Series modules

Corporate ESG execution

Operational sustainability workflows

Enterprise behavioral verification

Baseline

1 E-IPP ≈ 1 Unit Engagement Impact

IPP and E-IPP are different participation units designed for environments with different engagement densities.

They should not be converted directly into each other.

LAYER 3

Non-Tradable Commitment Record (NTCR)

NTCR represents standardized engagement impact generated from verified participation.

The PADV framework applies separate normalization rules for different participation environments.

For A-Series modules

NTCR = (IPP ÷ 10) × $VF_{(total)}$ × $W_{(ESG)}$

For B-Series modules

NTCR = E-IPP × $VF_{(total)}$ × $W_{(ESG)}$

Although different participation units are used, both pathways generate the same standardized NTCR output.

NTCR functions as a management-accounting engagement metric rather than an emissions inventory or carbon accounting result.

LAYER 4

Non-Tradable Commitment Credit (NTCC)

NTCC represents the annual governance recognition of verified NTCR.

Recognition is performed through the Annual Recognition Coefficient (RCF).

The annual recognition formula is

NTCC = Σ(NTCR × RCF)

The resulting value serves as

• Annual Engagement Index

• Governance KPI

• ESG Management Indicator

• Sustainability Performance Metric

• Disclosure Support Metric

NTCC remains a non-financial governance indicator and does not constitute a carbon credit, emissions offset, financial instrument, or tradable asset.

LAYER 5

Disclosure-Ready Evidence

The final NTCC dataset is transformed into disclosure-ready evidence suitable for

• ESG reporting

• Sustainability assurance

• Internal governance

• Corporate management

• Regulatory review

• Cross-standard interoperability

At this stage, every reported engagement metric remains fully traceable to its originating Proof Records.

4.4 SYSTEM BOUNDARY

To preserve conceptual integrity, PADV separates five distinct governance layers.

Layer	**Primary Function**	**Governance Boundary**
Proof Record	Immutable behavioral evidence	Evidence generation
IPP / E-IPP	Participation quantification	Behavioral normalization
NTCR	Standardized engagement calculation	Management accounting
NTCC	Annual governance recognition	Institutional governance
Disclosure Output	ESG reporting support	Reporting interoperability

Each layer performs an independent governance function.

No layer replaces another.

Instead, every layer progressively transforms behavioral participation into structured institutional evidence while maintaining deterministic traceability throughout the entire processing chain.

CHAPTER 5: PADV–ESG INTEGRATION FRAMEWORK

5.1 LINKING PADV TO ESG DISCLOSURE STANDARDS

The increasing adoption of ESG reporting frameworks has improved transparency across sustainability disclosures. However, most reporting systems remain primarily focused on outcomes, governance statements, and performance indicators, while the underlying behavioral activities that contribute to those outcomes often remain fragmented or difficult to verify.

The PADV–NTCC framework addresses this challenge by introducing a structured behavioral verification methodology that enables sustainability-related participation to be captured, verified, and transformed into auditable datasets.

Under the PADV framework, every verified participation activity generates a Proof Record containing standardized metadata, verification information, and participation attributes. These records are subsequently aggregated into Non-Tradable Commitment Records (NTCRs) and ultimately recognized as Non-Tradable Commitment Credits (NTCCs) within annual reporting cycles.

This structure establishes a traceable chain of custody:

Participation → Proof Record → NTCR → NTCC → ESG Disclosure

By linking behavioral evidence to sustainability reporting processes, PADV strengthens the transparency, consistency, and auditability of ESG-related information without replacing existing disclosure standards.

The framework therefore functions as a behavioral verification methodology that complements sustainability reporting systems by providing structured evidence capable of supporting governance, assurance, and disclosure activities.

5.2 THE ESG WEIGHTING MODEL ($W_{(ESG)}$)

To ensure consistency and comparability across diverse sustainability activities, PADV introduces a standardized ESG Weighting Model ($W_{(ESG)}$).

The purpose of $W_{(ESG)}$ is to evaluate the relative sustainability relevance of verified participation activities through three complementary dimensions:

CARBON EFFECT FACTOR (CEF)

CEF evaluates the estimated environmental relevance of an activity, including potential contributions to resource efficiency, environmental stewardship, sustainable consumption, or emission avoidance behaviors.

Score Range:

0–5

SOCIAL EFFECT FACTOR (SEF)

SEF measures the social contribution generated through participation activities.

Assessment criteria may include community benefit, inclusiveness, public engagement, educational value, and stakeholder participation.

Score Range:

0–5

INSTITUTIONAL RELIABILITY FACTOR (IRF)

IRF evaluates the reliability of governance, verification, documentation, and internal control processes associated with the activity.

Assessment criteria may include data quality, verification procedures, audit readiness, and institutional governance practices.

Score Range:

0–5

The ESG Weighting Model is defined as:

$W_{(}ESG_{)}$ = (CEF + SEF + IRF) ÷ 15

Resulting values are normalized between:

0.00 and 1.00

This weighting mechanism ensures that NTCR calculations reflect not only participation volume but also environmental relevance, social contribution, and institutional reliability.

By integrating these dimensions into a single coefficient, $W_{(}ESG_{)}$ enables behavioral participation to be evaluated through a balanced ESG perspective while maintaining consistency across different sectors and activity types.

5.3 MAPPING TO GLOBAL STANDARDS: GRI / IFRS / ISO / COSO / QS

The PADV–NTCC framework is designed to support interoperability with internationally recognized sustainability, governance, assurance, and educational frameworks.

Rather than introducing a new disclosure standard, PADV provides a structured behavioral verification methodology that can be referenced alongside existing reporting and governance systems.

The relationship between PADV data layers and international frameworks can be summarized as follows:

PADV Data Layer	Representative Alignment	Primary Purpose
Proof Record (Behavioral Evidence)	GRI, QS	Participation Documentation
NTCR (Engagement Impact Proxy)	GRI 305, IFRS S2	Sustainability Performance Estimation
NTCC (Annualized Engagement Index)	IFRS S1, GRI Management Approach	Governance and Reporting Support

PADV Data Layer	Representative Alignment	Primary Purpose
V-Layer Audit Trail	ISO 19011, ISO 27001	Verification and Assurance Support
Governance Controls	COSO Internal Control Framework	Data Integrity and Oversight

Through this mapping structure, organizations may associate verified participation data with existing sustainability reporting processes while preserving compatibility with established frameworks.

The framework therefore serves as a behavioral verification layer that supports data traceability and governance readiness without altering the requirements of existing reporting standards.

This interoperability enables sustainability participation data to be consistently referenced across disclosure, assurance, governance, and educational environments.

5.4 GOVERNANCE IMPLICATIONS OF CROSS-STANDARD INTEGRATION

The integration of behavioral verification data with sustainability reporting frameworks introduces several governance benefits.

First, it enhances data traceability by linking reported sustainability metrics to underlying verified participation activities. This enables organizations to demonstrate how sustainability-related actions were performed, verified, and incorporated into reporting processes.

Second, it strengthens internal control environments by establishing structured verification procedures, standardized data records, and documented evidence chains that support sustainability governance activities.

Third, it improves audit readiness by organizing participation data into consistent and reviewable datasets. Auditors, assurance providers, and internal reviewers can evaluate verification procedures, supporting documentation, and data lineage through standardized records.

Fourth, it supports stakeholder confidence by providing additional transparency regarding sustainability participation activities. Regulators, investors, educational institutions, employees, customers, and community stakeholders increasingly expect sustainability disclosures to be supported by verifiable evidence.

Finally, cross-standard interoperability improves organizational efficiency by enabling participation data to be referenced across multiple governance and reporting contexts without requiring separate verification mechanisms for each framework.

By integrating behavioral verification with ESG reporting logic, PADV–NTCC establishes a structured governance approach in which sustainability participation, data integrity, and disclosure readiness operate within a consistent and auditable framework.

This approach strengthens the relationship between verified actions and institutional reporting, helping organizations move from activity reporting toward evidence-supported sustainability governance.

CHAPTER 6: DETERMINISTIC ENGAGEMENT COMPUTATION FRAMEWORK

6.1 PURPOSE OF THE COMPUTATIONAL FRAMEWORK

The PADV computational framework establishes a deterministic methodology for transforming verified behavioral participation into standardized engagement metrics.

Rather than estimating sustainability outcomes through statistical inference or subjective evaluation, the framework computes engagement using predefined institutional rules, ensuring that identical inputs always produce identical outputs.

This deterministic architecture enables behavioral evidence originating from heterogeneous participation environments to converge into a unified governance metric while preserving auditability, traceability, and institutional comparability.

The framework is designed exclusively for engagement measurement within the PADV Evidence Infrastructure and does not replace carbon accounting methodologies, life-cycle assessment models, or financial reporting standards.

6.2 DUAL PARTICIPATION SYSTEMS

Behavioral participation within PADV is represented through two independent participation systems.

Each participation system reflects a different operational environment while maintaining identical governance principles.

A-SERIES PARTICIPATION

Participation Unit

Institutional Participation Points (IPP)

Applicable Scope

Public participation

Community engagement

Educational participation

Volunteer activities

Behavioral Baseline

10 IPP ≈ 1 Unit Engagement Impact

B-SERIES PARTICIPATION

Participation Unit

Enterprise Institutional Participation Points (E-IPP)

Applicable Scope

Corporate ESG execution

Operational sustainability workflows

Supply-chain behavioral verification

Behavioral Baseline

1 E-IPP ≈ 1 Unit Engagement Impact

IPP and E-IPP are independent participation units.

They represent different engagement densities and shall not be converted directly into one another.

Following baseline normalization, both pathways produce standardized engagement outputs through the same deterministic computational process.

6.3 DETERMINISTIC VERIFICATION FRAMEWORK

Every verified behavioral activity is evaluated through the PADV Verification Framework.

The framework measures verification quality rather than sustainability performance.

Three verification dimensions are applied.

Component	**Function**
VF_0	Behavioral Verification
VF_n	Regional Calibration
VF_s	Sector Calibration

The composite verification coefficient is defined as

$VFtotal = (VF_0 + VF_n + VF_s) \div 3$

For Community Interaction (Type A), the Verification Factor remains fixed according to MWP01.

For Direct Task Verification (Type B), dynamic verification coefficients are applied.

This architecture preserves computational consistency while accommodating different verification complexities.

6.4 ESG WEIGHTING FRAMEWORK

Behavioral participation is subsequently weighted according to governance significance.

The ESG weighting model evaluates three institutional dimensions.

Carbon Effect (CEF)

Social Effect (SEF)

Institutional Reliability (IRF)

The weighting equation is

WESG = (CEF + SEF + IRF) ÷ 15

The weighting model evaluates governance relevance rather than environmental performance alone.

It therefore functions as an institutional weighting mechanism rather than a carbon quantification methodology.

6.5 UNIFIED NTCR COMPUTATION

Following verification and ESG weighting, standardized engagement impact is generated through the Non-Tradable Commitment Record (NTCR).

To preserve comparability across heterogeneous participation environments, PADV applies pathway-specific participation normalization while maintaining a unified engagement output.

Public Participation

NTCR = (IPP ÷ 10) × VFtotal × WESG

Enterprise Participation

NTCR = E-IPP × VFtotal × WESG

Although different participation baselines are applied, both pathways generate identical NTCR structures.

NTCR therefore serves as the standardized engagement metric throughout the PADV ecosystem.

6.6 ANNUAL RECOGNITION FRAMEWORK

Verified NTCR values are recognized through the Annual Recognition Coefficient (RCF).

The Recognition Framework aligns behavioral evidence with annual ESG reporting cycles while preventing duplication across reporting periods.

The annual calculation is

NTCC = Σ(NTCR × RCF)

Recognition coefficients are defined as

Recognition Pathway	RCF
Community Interaction	0.30
Direct Task Verification	1.00

RCF governs reporting recognition only.

It does not modify verification quality or engagement significance.

6.7 DETERMINISTIC PROCESSING PIPELINE

Every engagement metric follows the same computational sequence.

Behavioral Participation → Proof Record → IPP / E-IPP → Verification Factor → ESG Weighting → NTCR → Annual Recognition → NTCC → Disclosure-ready Evidence

Each computational step is deterministic, reproducible, and independently auditable.

No manual intervention is permitted once a Proof Record has been verified.

6.8 ILLUSTRATIVE COMPUTATIONAL EXAMPLES

EXAMPLE A

Public Sustainability Exhibition

Participation

20 IPP

VFtotal

0.95

WESG

0.80

Calculation

NTCR = (20 ÷ 10) × 0.95 × 0.80

= 1.52

EXAMPLE B

Corporate Operational Task

Participation

6 E-IPP

VFtotal

1.05

WESG

0.92

Calculation

NTCR = 6 × 1.05 × 0.92

= 5.796

These examples illustrate how different participation systems generate directly comparable engagement metrics through pathway-specific normalization.

6.9 COMPUTATIONAL PRINCIPLES

The PADV Deterministic Engagement Computation Framework is governed by five computational principles.

1. **Deterministic Computation**

   Every verified input produces one and only one computational outcome.

2. **Evidence Continuity**

   Every engagement metric remains traceable to immutable Proof Records.

3. **Participation Independence**

   IPP and E-IPP represent independent participation systems with distinct engagement baselines.

4. **Institutional Comparability**

   Different participation environments converge into standardized NTCR outputs through deterministic normalization.

5. **Audit Readiness**

   Every computational step can be independently reconstructed, reviewed, and verified without requiring subjective interpretation.

CHAPTER 7: PROOF RECORD MECHANISM

7.1 PROOF RECORD DEFINITION AND DATA SCHEMA

A **Proof Record (PR)** is the fundamental **digital evidence unit** within the PADV infrastructure. Each record represents a verified behavioral occurrence, an individual or collective act that contributes to sustainability and meets specific **validation criteria**.

Every Proof Record is structured with **machine-readable metadata**, ensuring data integrity and system interoperability. The standardized data schema includes the following fields:

Field	**Description**	**Type**
PR_ID	Unique alphanumeric identifier (Global Unique ID)	String
UID / E-UID	Participant or Enterprise Identity Token	String
Task_ID	Linked mission or verification activity ID	String
Timestamp	Verified completion time (ISO 8601 format)	Datetime
Location / GeoHash	Verified physical or virtual coordinates	String

Field	Description	Type
Institutional Participation Point_Value	Earned engagement Institutional Participation Points	Integer
VF_total	Computed Verification Factor (Data Quality Score)	Float
$W_{(ESG)}$	ESG Weighting Value	Float
RCF	Annual Recognition Coefficient	Float
Validator_Hash	Third-party verification hash signature	String

This schema enables **API interoperability** between PADV registries, corporate ESG dashboards, and external assurance platforms through standardized JSON/XML interfaces.

7.2 DATA PROCESSING PIPELINE: PR → NTCR → NTCC → DISCLOSURE

Each verified action flows through a structured **Data Chain of Custody**:

1. **Proof Record (PR):** Raw behavioral log generated at the Institutional Participation Point of action.
2. **NTCR (Record):** Aggregated engagement metric for a specific task.
3. **NTCC (Index):** Annualized, recognized engagement index for reporting.
4. **ESG Disclosure:** Final integrated data output for GRI/IFRS reporting.

This vertical chain forms the **Behavioral Data Trust Line**, where each layer enhances data structure without altering the original behavioral evidence. It ensures that the ESG disclosure at the end of the chain can be **traced back** to the original human act, achieving data-level integrity from participation to publication.

7.3 ANTI-DUPLICATION AND BOUNDARY PROTOCOLS

To maintain **Data Integrity**, each Proof Record is governed by strict anti-duplication and data boundary protocols:

- **Unique Record Rule:** Each PR_ID must be globally unique within the registry.
- **Idempotency Algorithm:** Proof Records sharing identical UID, Task_ID, and Timestamp are automatically flagged for review to prevent double-logging.
- **Boundary Segmentation:**
  - Behavioral Data (PR) cannot exist outside its assigned NTCR boundary.
  - NTCR units cannot overlap across multiple ESG reporting entities (Data Isolation).
- **Cross-System Interlock:** PRs linked to different sectors (e.g., EDU vs. CORPORATE) maintain isolated validation channels to prevent cross-sector contamination.

These controls ensure **non-redundant verification** while preserving full audit traceability, aligned with **ISO 27001** data integrity standards.

7.4 INTEROPERABILITY STANDARDS (JSON / XML MODELS)

To support integration with enterprise ERP systems and audit frameworks, the PADV Registry implements a dual-format, **audit-ready data structure**.

JSON Representation:

JSON

```
{
  "PR_ID": "PR-2025-00123",
  "UID": "EUID-7F29AB9",
  "Task_ID": "SDGSPASS-MISSION-014",
  "Timestamp": "2025-06-15T09:32:11Z",
  "Location": "25.033N,121.565E",
  "Institutional Participation Point_Value": 50,
```

```
  "VF_total": 0.91,
  "W(ESG)": 0.78,
  "RCF": 1.0,
  "Validator_Hash": "sha256:78dfab...c3e"
}
```


XML Representation:

XML


```xml
<ProofRecord>
  <PR_ID>PR-2025-00123</PR_ID>
  <UID>EUID-7F29AB9</UID>
  <Task_ID>SDGSPASS-MISSION-014</Task_ID>
  <Timestamp>2025-06-15T09:32:11Z</Timestamp>
  <Location>25.033N,121.565E</Location>
  <Institutional Participation Point_Value>50</Institutional Participation Point_Value>
  <VF_total>0.91</VF_total>
  <W(ESG)>0.78</W(ESG)>
  <RCF>1.0</RCF>
  <Validator_Hash>sha256:78dfab...c3e</Validator_Hash>
</ProofRecord>
```


Both formats are embedded with **digital signatures** to ensure immutability, and can be directly integrated into ESG disclosure platforms, audit portals, or national sustainability registries via **Open API**.

CHAPTER 8: DUAL PATHWAY OF CORPORATE ENGAGEMENT VERIFICATION

OVERVIEW

Within the PADV–NTCC framework, corporations generate verified Non-Tradable Commitment Credits (NTCC) through two standardized behavioral pathways:

1. Indirect Interaction Pathway (formerly Public Welfare Redemption)
2. Direct Task Execution Pathway (formerly Mission Participation)

These dual mechanisms create measurable, auditable links between corporate sustainability initiatives and behavioral verification outcomes, allowing enterprises to convert public engagement and CSR actions into verifiable ESG data assets while maintaining non-financial integrity.

8.1 PATHWAY A: INDIRECT INTERACTION (FIXED VF = 0.95)

The Indirect Interaction Pathway enables corporations to provide sustainable products or services as Public Welfare Offerings under SDGS PASS. When participants interact with these items using accumulated Institutional Participation Points (IPP), each interaction generates a verifiable Proof Record, contributing to the enterprise's engagement index.

• Mechanism: Fixed Verification Factor (**$VF_{(total)}$ = 0.95**), ensuring consistent reliability regardless of consumer variability.

• Weighting: **$W_{(ESG)}$** is derived primarily from product attributes, supplier transparency, and lifecycle impact assessment.

Parameter	**Description**
$VF_{(total)}$	Fixed = 0.95
$W_{(ESG)}$	Derived from product-level CEF, SEF, and IRF scoring
RCF	0.3 (Annual recognition limit: capped at 30% of Total Annual Index)
Audit Trace	Interaction Log → PADV Registry → Corporate ESG Disclosure

This model is particularly suitable for retailers, shopping centers, F&B chains, and brand-driven CSR campaigns, providing a low-barrier entry into verifiable ESG participation data.

8.2 PATHWAY B: DIRECT TASK EXECUTION (DYNAMIC VF 0.8–1.2)

The Direct Task Pathway reflects corporate engagement through active sustainability-driven activities, such as clean-up events, green commuting challenges, employee volunteering programs, or internal compliance tasks.

Each task generates a Proof Record upon completion and is dynamically validated through the V-Layer Verification Engine.

• Mechanism: Dynamic Verification Factor (**$VF_{(total)}$ range: 0.8–1.2**), adjusted according to activity type, verification density, and audit depth.

• Weighting: **$W_{(ESG)}$** integrates Carbon Effect Factors (CEF), Social Effect Factors (SEF), and Institutional Reliability Factors (IRF) at full resolution.

Parameter	**Description**
$VF_{(total)}$	Dynamic Range 0.8–1.2 (Cap: ±10%)
$W_{(ESG)}$	Full composite of CEF, SEF, and IRF
RCF	1.0 (100% annual recognition)
Audit Trace	Task Completion Record → PADV Registry → Internal Audit Log

Direct Task Pathways are particularly suitable for enterprises with active CSR programs, NGOs, educational institutions, event organizers, and manufacturing companies seeking high-verifiability behavioral datasets suitable for assurance reporting and ESG disclosures.

8.3 COMPARATIVE DATA LOGIC TABLE

Parameter	Indirect Interaction (Pathway A)	Direct Task Execution (Pathway B)
Behavior Type	Passive Interaction (Consumer-Driven)	Active Participation (Action-Driven)
$VF_{(total)}$	Fixed (0.95)	Dynamic (0.8–1.2)
$W_{(ESG)}$ Emphasis	Product Lifecycle & Supply Transparency	Human Participation & Field Verification
RCF Annual Cap	0.3 (Capped at 30%)	1.0 (100% Recognition)
Impact Proxy	10 IPP ≈ 1 Unit of Impact	10 IPP ≈ 1 Unit of Impact
ESG Impact Domain	GRI 305 / 413	GRI 404 / 403 / 305
Verification Complexity	Low	Moderate–High
Best-fit Industry	Retail / F&B / Shopping Malls	CSR / NGO / Events / Manufacturing

Both pathways share the same data foundation but differ in participation intensity, verification density, and ESG relevance.

This dual-structured model allows NTCC generation to remain equitable across diverse industries, ensuring that small and large enterprises alike can contribute to measurable sustainability outcomes.

8.4 CALCULATION EXAMPLE: MIXED CORPORATE CASE

Scenario

A retail brand participates in both pathways during a single fiscal year:

Indirect Interaction Pathway

• 5,000 IPP

• $VF_{(total)} = 0.95$

• $W_{(ESG)} = 0.68$

• RCF = 0.3

Direct Task Execution Pathway

• 3,000 IPP

• $VF_{(total)} = 1.05$

• $W_{(ESG)} = 0.80$

• RCF = 1.0

STEP 1: CALCULATE NTCR

Indirect Interaction:

$NTCR_{(A)} = (5{,}000 \div 10) \times 0.95 \times 0.68$

$NTCR_{(A)} = 323.0$

Direct Task Execution:

$NTCR_{(B)} = (3{,}000 \div 10) \times 1.05 \times 0.80$

$NTCR_{(B)} = 252.0$

STEP 2: APPLY ANNUAL RECOGNITION COEFFICIENTS

$NTCC_{(A)} = 323.0 \times 0.3$

$NTCC_{(A)} = 96.9$

$NTCC_{(B)} = 252.0 \times 1.0$

$NTCC_{(B)} = 252.0$

STEP 3: TOTAL ANNUAL NTCC

$NTCC_{(total)} = NTCC_{(A)} + NTCC_{(B)}$

$NTCC_{(total)} = 348.9$

Under the standardized proxy benchmark:

10 IPP ≈ 1 Unit of Estimated Behavioral Impact

the resulting NTCC value may be represented as a management-accounting estimate of behavioral sustainability impact.

The resulting value may also be translated into an estimated:

$\Delta CO_2e_{(proxy)}$

for internal sustainability governance and reporting purposes.

Note: This calculation represents a behavioral engagement proxy and does not constitute a certified carbon credit, emissions offset, or regulatory carbon accounting result.

CHAPTER 9: ANNUAL ENGAGEMENT INDEX RECOGNITION PROTOCOL

9.1 CONCEPT AND PURPOSE

The **Annual Recognition Protocol (RCF)** governs how verified **NTCC Engagement Indices** are recognized, consolidated, and locked within a fiscal year. Its purpose is two-fold:

1. To synchronize behavioral data logs with **annual ESG disclosure cycles**.
2. To maintain the **temporal integrity** of verified data by preventing cross-year duplication.

The RCF mechanism ensures that NTCCs are treated not as perpetual financial assets, but as **annualized assurance metrics**, each corresponding strictly to the timeframe of verified sustainability actions.

9.2 RECOGNITION LOGIC

The recognition process is governed by the following data integrity principles:

Principle	Description
Period Alignment	Data must be recognized within the same fiscal year in which Proof Records are generated.
Single-Year Validity	Indices are valid for **one reporting cycle** and represent performance for that specific year (cannot be carried forward as "savings").
Audit Synchronization	All recognized data must align with annual assurance engagements and third-party audit schedules.
Integrity Control	Each recognition event is **digitally locked** in the PADV Registry and timestamped for provenance.

The process thus converts dynamic behavioral logs into **year-bound verified outcomes**, aligning data verification, reporting, and governance cycles.

9.3 RECOGNITION FORMULA AND CAP

Governance Rule: The Recognition Coefficient (RCF) applies only at the annual aggregation stage to finalize the reporting index.

Pathway	RCF Value	Cap Limit	Note
Type A: Indirect Interaction (e.g., Welfare Pool)	**0.3**	**≤ 30%** of Annual Total	Fixed VF Model
Type B: Direct Task Execution (e.g., Operational Tasks)	**1.0**	**100%** Recognition	Dynamic VF Model

Constraint:

$$\sum\left(NTCR_{\text{Type A},i} \times 0.3\right) \leq 30\% \times NTCC_{\text{Annual}}$$

Type A recognition is capped at 30% of the Total Annual NTCC Index, while Type B recognition remains fully recognized at 100%.

9.4 ANNUAL LOCKING AND REPORTING ALIGNMENT

Once NTCC indices are recognized under the RCF rule, they enter the **Annual Data Lock (ADL)** phase. This process ensures that verified results cannot be altered retroactively, preserving both historical traceability and audit confidence.

Annual Lock Procedure:

1. **Digital Sealing:** PADV Registry issues timestamped digital seals for all recognized datasets.
2. **Fiscal Identification:** Locked data is associated with fiscal-year identifiers (e.g., NTCC-2025-Y1).
3. **Audit Synchronization:** Cross-verification hashes are synchronized with external assurance databases (e.g., Auditor Portals).
4. **Reference Locking:** ESG Reports reference ADL-sealed datasets to guarantee disclosure integrity.

Each lock event generates an immutable audit trail compliant with **ISO 27037 (Digital Evidence Management)** and aligns with **IFRS S1 / S2** disclosure governance principles.

9.5 EXAMPLE: ANNUAL RECOGNITION REPORT

Corporate Case: "EcoMart Ltd."

Pathway	Proof Records	$VF_{(total)}$	$W_{(ESG)}$	RCF	NTCR (Raw Units)	Recognized Index (Proxy tons CO_2e)
Indirect Interaction	4,000	0.95	0.70	**0.3**	266	**0.080**
Direct Task Execution	3,500	1.00	0.78	**1.0**	273	**0.273**

Pathway	Proof Records	$VF_{(total)}$	$W_{(ESG)}$	RCF	NTCR (Raw Units)	Recognized Index (Proxy tons CO_2e)
Total (Annual)	7,500	—	—	—	539 Units	0.353 Units

Result: "EcoMart Ltd." discloses **0.353 Standardized Units** (Proxy: tons CO_2e impact) for FY2025. The data is locked under fiscal identifier NTCC-2025-Y1, verified through the PADV Registry's assurance log, and cited as **behavioral evidence** under the company's GRI 305 and IFRS S2 climate disclosure.

9.6 GOVERNANCE PRINCIPLES FOR ANNUAL RECOGNITION

To maintain trust and comparability across organizations, PADV defines the following governance principles:

- **Entity-Bound (Non-Transferable):** Data belongs to the originating entity and cannot be traded.
- **Transparency:** Reports must disclose both the final Index Quantity and the corresponding **Proof Record Count**.
- **Audit Readiness:** Recognition data must be accompanied by a signed **Assurance Pack** ready for external review.
- **Interoperability:** Annual data locking structure is compatible with ESG platforms under GRI and IFRS data reporting APIs.
- **Temporal Consistency:** Each annual recognition must correspond to the verified timeframe, no retrospective claims permitted.

This ensures that NTCC serves as a true, **time-bound representation** of verified behavioral sustainability contributions, establishing a standardized audit logic that aligns participation data with global ESG assurance systems.

CHAPTER 10: GOVERNANCE & ENTITY-BOUND DATA PROTOCOLS

10.1 THE CONCEPT OF ENTITY-BOUND DATA GOVERNANCE

The **Non-Tradable Commitment Credit (NTCC)** is intentionally designed to exist outside financial markets. Its purpose is not to serve as a tradable commodity but as a **verifiable data unit**, anchored in behavioral authenticity, institutional governance, and audit transparency.

Unlike market-based instruments that derive value from exchange, NTCC derives value from **Data Integrity**. Each NTCC index carries intrinsic credibility because it represents **verified internal performance** rather than speculative market assets.

Core Principle: Just as a university degree or a credit rating cannot be sold to another party, NTCC is **Entity-Bound**. It remains permanently attached to the organization that performed the sustainability action, ensuring that the metric reflects **true organizational effort** rather than financial purchasing power.

10.2 COSO FRAMEWORK ALIGNMENT: INTERNAL CONTROL OVER SUSTAINABILITY REPORTING

NTCC governance aligns with the **COSO Internal Control Framework (2017)**, integrating behavioral data into the enterprise's broader risk management structure.

COSO Component	NTCC Governance Application
Control Environment	**Digital Evidence** replaces manual estimation; each Proof Record serves as an immutable governance log.
Risk Assessment	**Verification Factors (VF_0–VF_s)** quantify data quality risks, ensuring measurable reliability for management decision-making.
Information & Communication	The **V-Layer Registry** ensures transparent data dissemination to internal auditors and external stakeholders.
Monitoring Activities	**Annual Data Lock (ADL)** and third-party verification checks provide continuous oversight of the data pipeline.

Through this structure, NTCC introduces a **data-driven control system**, where verified participation becomes an auditable component of institutional integrity.

10.3 DATA INTEGRITY & BOUNDARY GOVERNANCE

To uphold transparency and prevent data duplication across reporting entities, the system implements **Boundary Governance Protocols (BGPs)** based on data segregation and provenance tracking.

Key Boundary Controls:

- **Unique Entity Binding:** Every NTCC is permanently bound to its originating organization (**Enterprise UID**). It cannot be transferred, subdivided, or resold.
- **Activity Scope Segmentation:** Each NTCR is confined within its activity boundary, internal tasks or supply chain interactions cannot be double-counted under multiple reporting entities.
- **V-Layer Deduplication:** The registry integrates **hash-based deduplication algorithms** to ensure that the same Proof Record cannot be submitted to multiple verification channels.
- **Institutional Oversight:** Third-party verifiers cross-check registry logs to confirm that no duplicated indices appear across parallel ESG disclosures.

These boundary controls ensure that NTCC data remains unique, traceable, and institutionally trustworthy, allowing its inclusion in verified ESG reports under **GRI 305** and **IFRS S2** frameworks without duplication risk.

10.4 DATA INTEGRITY OVERSIGHT AND COMPLIANCE MECHANISMS

NTCC governance extends beyond verification—it establishes a continuous **Data Integrity Ecosystem**. PADV enforces compliance with internationally recognized standards, ensuring that all verified behavioral data meets assurance-grade requirements.

Compliance Domain	Reference Standard	NTCC Governance Application
Data Security	**ISO 27001 / ISO 27701**	Encryption, access control, and anonymized participant identifiers (E-UID).

Compliance Domain	Reference Standard	NTCC Governance Application
Digital Evidence	ISO 27037	Immutable time-stamped records for each Proof Record and Index issuance.
Audit Protocol	ISO 19011	Standardized assurance procedures for behavioral data verification audits.
Disclosure Governance	IFRS S1 / S2	Standardized disclosure of NTCC quantities, audit statements, and data assurance summaries.
Ethical Conduct	GRI 2 / GRI 205	Integrity and anti-corruption controls in behavioral data processing.

By integrating these standards, NTCC establishes an **assurance-ready governance model**, bridging the operational divide between behavioral logs and ESG compliance reporting.

10.5 THE STRATEGIC VALUE OF THE “NON-TRADABLE” PRINCIPLE

The non-tradable principle is more than a restriction, it is a **Value Proposition**. By prohibiting speculative exchange, NTCC ensures that sustainability remains a matter of **Verified Contribution**, not financial capacity.

In traditional markets, value often depends on price (buying offsets); in the NTCC ecosystem, value depends on **Proof (executing actions)**. This shift redefines how organizations are recognized for sustainability: not by their purchasing power, but by their **verified behavioral impact**.

Institutional Implications:

- **Anti-Greenwashing:** It creates a transparent mechanism where "effort" cannot be faked through financial transactions.
- **Supply Chain Trust:** Anchor buyers prefer suppliers who "do" sustainability over those who just "buy" credits.

- **Data Stability:** It ensures that every credited action carries real behavioral substance, serving as a stable baseline for year-over-year comparison.

Thus, NTCC represents a paradigm shift, from **Outcome Estimation** to **Behavioral Verification**, laying the foundation for a verifiable **Global Trust Infrastructure**.

CHAPTER 11: DATA VALIDATION & PRE-AUDIT PROTOCOLS

11.1 INTRODUCTION

Data Validation within the PADV–NTCC system represents a standardized form of **behavioral evidence management**. Unlike financial auditing which verifies monetary transactions, this framework verifies **actions**, forming the foundation of institutional trust. This chapter defines the validation hierarchy, the processing logic, and the multi-layer governance structure that enables NTCC indices to become **audit-ready sustainability data**.

11.2 DATA INTEGRITY HIERARCHY: FROM LOG TO INDEX

The validation process follows a three-tier structure ensuring traceability and data coherence.

Tier	Entity	Function	Data Output
Tier 1 – Proof Record	Individual or Organization	Captures verified behavioral data (action, time, location, evidence).	**Verified Data Log**
Tier 2 – NTCR (Commitment Record)	V-Layer Processing	Aggregates Proof Records and converts to engagement impact proxy (Unit: Impact).	**Quantified Engagement Record**
Tier 3 – NTCC (Engagement Index)	Institutional Reporting	Consolidates annual NTCR under governance rules (RCF, VF,).	**Auditable Index Metric**

Each tier carries its own validation responsibility and is sequentially linked by cryptographic registry identifiers (PR-ID NTCR-ID NTCC-ID). This hierarchy allows auditors to trace data at any granularity, from single behavioral proof to organization-wide sustainability outcomes.

11.3 DATA VALIDATION PROTOCOL (DVP)

The **Data Validation Protocol (DVP)** is the central mechanism that ensures data integrity across verifiers, organizations, and reporting frameworks. It operates on three coordinated layers:

1. **System Logic Check (Automated):** The V-Layer engine automatically validates Proof Records against metadata schema (location, timestamp, duplicate check).
2. **Third-Party Review (External Validation):** Accredited partners (e.g., Verification Bodies) perform random sampling, evidence tracing, and recalculation of VF and parameters.
3. **Registry Reconciliation:** The PADV Registry compares datasets across institutions to prevent double-counting and ensure unique Index issuance.

Together, these steps form a closed-loop validation structure compliant with **ISO 19011 (Auditing Management Systems)** principles.

11.4 SAMPLING DENSITY AND REVIEW FREQUENCY

Validation intensity is determined by activity type, scale, and risk class. PADV defines three data review tiers:

Risk Class	Typical Use Case	Sampling Ratio	Review Depth
A (High)	Large-scale events, national programs	**15–20 %**	On-site + full data trace
B (Medium)	Corporate CSR missions	**5–10 %**	Document + random site review
C (Low)	Interaction pool, digital activities	**1–3 %**	Automated data validation

This proportional design ensures cost-effective validation while maintaining statistical confidence (≥ 95% reliability).

11.5 DIGITAL EVIDENCE CHAIN INTEGRATION

The validation chain integrates four critical components of **ISO 27037 (Digital Evidence)** frameworks:

- **Evidence Identification:** Proof Records are treated as digital objects with immutable hashes.
- **Chain-of-Custody:** Every dataset transfer between entities is logged in the V-Layer Ledger.
- **Validation Procedures:** Recalculation of indices using independent verifier datasets.
- **Assurance Output:** Generation of an **"Assurance Pack"** referencing NTCC IDs for ESG disclosure.

Each Assurance Pack includes:

- NTCC ID range, validation date, and hash signatures.
- Total engagement proxy metrics.
- Sampling report and data quality assessment.

This standardized output allows seamless integration with ESG reporting templates under **IFRS S2** and **GRI 305**.

11.6 ROLE OF INDEPENDENT VERIFIERS

Independent verifiers function as **data quality assurance partners** within the ecosystem. Their roles include:

- **Validation Execution:** Conduct DVP reviews and sampling checks.
- **Governance Feedback:** Recommend parameter calibration based on observed discrepancies.
- **Registry Synchronization:** Upload validated datasets to PADV's verification node.
- **Disclosure Support:** Provide data quality statements embedded in the Assurance Pack.

This arrangement establishes a triangular trust structure, data producers (enterprises), validators (independent bodies), and registry operators (PADV), each reinforcing the other's credibility.

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11.7 AUDIT-READY DATA REPORTING

All validation outputs are generated in both human-readable and **machine-readable formats** (CSV / XML / JSON). This dual reporting structure ensures interoperability across digital ESG platforms and enterprise audit software.

Sample Data Structure:

JSON

{

"NTCC_ID": "NTCC-2025-001",

"Validator": "Independent_Verifier_A",

" $VF_{(total)}$": 0.96,

"$W_{(ESG)}$": 0.72,

"RCF": 1.0,

"Engagement_Proxy": 1.200,

"Validation_Date": "2025-06-30"

}

Machine-readable formats enable automated reconciliation, paving the way for real-time ESG data monitoring.

11.8 SUMMARY

Through the combined application of hierarchical validation, DVP protocols, and independent oversight, the NTCC system achieves **audit-grade data quality** while maintaining operational scalability. It transforms ESG reporting from a narrative process into a quantifiable **behavioral evidence system**, a foundation for the next generation of data-driven sustainability.

CHAPTER 12: CROSS-STANDARD INTEROPERABILITY ARCHITECTURE

12.1 PURPOSE AND SCOPE

The PADV–NTCC framework does not replace existing ESG or assurance standards. It functions as a **behavioral-data integrity layer** that connects verified participation evidence to global disclosure and audit frameworks.

This chapter codifies how PADV elements align with **GRI, IFRS (ISSB), ISO, COSO, and QS Sustainability**, ensuring that NTCC datasets are universally **interpretable**, **machine-verifiable**, and **audit-ready**.

12.2 STANDARDIZED DATA MAPPING MATRIX

PADV Data Entity	Function	Primary Standards Mapping
Proof Record (PR)	Atomic behavioral evidence (actor, action, time, geo, signature).	**ISO 27037** (Digital Evidence); GRI 2 / 102 (Data Boundaries); IFRS S1-22 (Governance Info)
Verification Factors ()	Reliability calibration (statistical / regional / sectoral).	**ISO 19011** (Audit Sampling); COSO – Risk Assessment
ESG Weighting ()	Normalized ESG materiality of actions.	GRI 305 / 403 / 413; IFRS S2 (Metrics & Targets)
NTCR (Engagement Proxy)	Verified behavioral impact estimation.	ISO 14064-1 (Data Collection); GRI 305-3; IFRS S2-29
Annual Recognition (RCF)	Year-bound recognition & data caps.	IFRS S1 (Control Cycle); COSO – Control Activities
NTCC (Index Unit)	Annualized engagement index for reporting.	IFRS S2-25 / S2-29; GRI 305-7 (Non-Financial Metrics)

PADV Data Entity	Function	Primary Standards Mapping
V-Layer Registry (ADL)	Immutability and provenance tracking.	**ISO 27001 / 27701**; COSO – Information & Communication
Assurance Pack (AP)	Third-party verification output package.	**ISO 17029** (Validation Principles); GRI 102-56; IFRS S1 Assurance

Result: Each NTCC dataset can be recognized as **verified Scope 3 behavioral evidence** with full chain-of-custody and audit traceability.

12.3 GRI / IFRS ALIGNMENT DETAILS

PADV Data Institutional Participation Point	GRI Reference	IFRS (ISSB) Reference	Alignment Purpose
Proof Record	GRI 2 / 102-45	IFRS S1-22	Defines entity scope and data origins.
NTCR (Proxy Data)	GRI 305-3 / 305-5	IFRS S2-29	Quantified engagement metrics with methodology.
NTCC (Index)	GRI 305-7	IFRS S2-25	Annualized recognition with reporting boundaries.
VF / RCF	GRI 205-1	IFRS S1-24	Internal control and assurance governance.
	GRI 403 / 413	IFRS S1-32	Social impact and materiality linkage.
Assurance Pack	GRI 102-56	IFRS S1/S2	Third-party verification support references.

12.4 ISO / COSO INTEGRATION

Domain	International Standard	PADV Application
Data Collection	**ISO 14064-1**	Reference for NTCR data schema and boundary definition.
Audit Management	**ISO 19011**	Sampling tiers and Data Validation Protocol (DVP).
Digital Evidence	**ISO 27037**	Proof Record structure and hash immutability.
Security & Privacy	**ISO 27001 / 27701**	Encryption and role-based access control.
Conformity Assessment	**ISO 17029**	Assurance Pack verification principles.
Internal Control	**COSO (2017)**	VF Risk Assessment; RCF Control Activities; ADL Info & Comm; AP Monitoring.

12.5 QS SUSTAINABILITY AND EDUCATIONAL MAPPING

QS Dimension	PADV Behavioral Mapping	Typical Evidence
Environmental Impact	Mission-based NTCR (clean-ups, mobility, energy saving).	PR logs + VF / scores.
Social Impact	Public welfare interaction programs.	SEF score + participation breadth.
Governance & Ethics	PADV Registry integrity protocols.	IRF documentation + verifier signatures.

QS Dimension	PADV Behavioral Mapping	Typical Evidence
Education for Sustainability	**EDU SDGS PASS** modules.	Student missions PR counts NTCR data.
Research Engagement	Cross-institutional datasets.	Anonymized behavioral records for research analysis.

12.6 EXTENDED INTEROPERABILITY (CDP / SBTI / GHG PROTOCOL)

- **CDP:** NTCC serves as **third-party verified behavioral evidence** supporting Scope 3 engagement metrics.
- **SBTi:** PADV datasets support tracking of employee and community participation targets (Engagement Targets).
- **GHG Protocol:** Proof Record and NTCR data fill downstream Scope 3 data gaps with **auditable actions**.

12.7 CROSSWALK (INTEGRATED MATRIX)

PADV Element	GRI	IFRS	ISO	COSO	QS
Proof Record	2 / 102-45	S1-22	27037	Info & Comm	Education Data
NTCR	305-3	S2-29	14064-1	Risk Assessment	Environmental Impact
NTCC	305-7	S2-25	—	Control Environment	Governance
VF / RCF	205-1	S1-24	19011	Monitoring	Transparency
	403 / 413	S1-32	—	Ethics	Social Impact
V-Layer / ADL	2 (Gov)	S1 (Control)	27001	Info & Comm	—

PADV Element	GRI	IFRS	ISO	COSO	QS
Assurance Pack	102-56	S1 / S2	17029	Monitoring	—

Disclosure Reminder: Always report (i) task definitions, (ii) VF and ranges, (iii) RCF pathway, and (iv) ADL identifier to ensure cross-framework comparability.

12.8 IMPLEMENTATION NOTES FOR REPORTERS AND VERIFIERS

- **Boundary Control:** Behavioral data (PR/NTCR) is entity-bound and non-transferable; NTCC is annualized and ADL-locked.
- **Sampling:** Follow ISO 19011 density tiers; record sampling ratios within the Assurance Pack.
- **Machine-Readable Format:** Export PR, NTCR, NTCC, and AP in JSON/XML/CSV with hash and timestamp fields.
- **Terminology:** Use **"verified behavioral impact proxy (NTCR)"** and **"annualized engagement index (NTCC)"** to avoid offset confusion.
- **Validation Chain:** PR VF/ NTCR NTCC ADL AP (Verifier-Signed).

CHAPTER 13: DATA INTEGRITY & AUTOMATED VERIFICATION PROTOCOLS

13.1 INTRODUCTION: TRUST AS CODE

The PADV–NTCC system extends the concept of trust from manual verification to **automated integrity**. In traditional ESG reporting, data reliability often depends on spreadsheet documentation and human interpretation. PADV replaces this fragility with a **programmable structure**, where every verified action, data exchange, and validation event is governed by digital logic rather than manual entry.

This transformation defines **"Trust as Code"**, a state where data integrity, auditability, and compliance are embedded within the system architecture itself.

13.2 THE V-LAYER DATA PIPELINE: FROM LOG TO LOCK

All verified behavioral data flow through four interconnected processing stages known as the **V-Layer Data Loop**:

Layer	Function	Output
Participation Layer	Captures user or enterprise actions via SDGS PASS mission or digital interaction.	**Raw Data Log**
Verification Logic Layer	Applies VF (Verification Factor) and weighting algorithms.	**Verified Proof Record**
V-Layer Registry	Stores hash-secured Proof Records and aggregates engagement metrics.	**Immutable Data Entry**
Reporting Layer (ADL)	Converts verified data into annualized indices and seals it under Annual Data Lock.	**Auditable Assurance Dataset**

This layered design ensures every action is traceable, auditable, and immutable, forming the digital backbone of the **Engagement Index**.

13.3 INTEROPERABILITY SCHEMA (JSON/XML) FOR AUTOMATED AUDITING

To achieve cross-platform verification, PADV defines a **machine-readable metadata schema** for all Proof Records and datasets.

Example (Simplified JSON Schema):

JSON

```
{
  "ProofRecord_ID": "PR-2025-04589",
  "Participant_UID": "E-UID-000129",
  "Action_Type": "Mission_Cycling_Event",
  "Location_Geo": "25.0340,121.5621",
```

"Timestamp_UTC": "2025-06-10T04:45:20Z",

"VF_total": 0.96,

"W_(ESG)": {"CEF": 4.2, "SEF": 4.5, "IRF": 4.0},

"RCF": 1.0,

"Engagement_Proxy": 12.5,

"Validator": "Independent_Verifier_A",

"Lock_Status": "ADL_2025_Y1"

}

This schema is compliant with **ISO 27037 (Digital Evidence)** and supports automated checks by external assurance software.

13.4 V-LAYER LEDGER PROTOCOL (VLP)

The **V-Layer Ledger Protocol (VLP)** functions as the secure registry ensuring transparency and traceability across all data interactions.

Core Features:

- **Hash-Based Integrity:** Each Proof Record and data entry is hashed using SHA-256, creating a unique digital fingerprint.
- **Ledger Synchronization:** All records synchronize with the PADV Verification Node Network every 24 hours.
- **Audit Reconciliation:** Enables auditors to confirm hash consistency between PADV exports and enterprise internal logs.
- **Immutable Seal:** Once indices are locked under ADL, the ledger generates a permanent block hash, preventing any retroactive modification.

This protocol ensures that behavioral data cannot be altered without detection, turning the V-Layer into a verifiable **Digital Audit Trail**.

13.5 AUTOMATED INTEGRITY PRINCIPLES

Automated integrity within PADV is guided by three institutional principles:

1. **Autonomy:** Verification logic (e.g., duplicate detection) operates independently from the reporting organization to prevent bias.
2. **Transparency:** Every computation and data update generates a verifiable digital log, accessible to auditors under authorized access protocols.
3. **Accountability:** All automated actions are logged with cryptographic timestamps and validator identifiers, forming a machine-level chain of custody.

These principles align with **ISO/IEC 42001 (AI Management Systems)**, ensuring automated processing remains compliant and auditable.

13.6 SECURITY & PRIVACY CONTROLS

PADV integrates robust data protection and compliance frameworks:

Domain	Standard	Implementation
Data Security	ISO 27001 / 27701	End-to-end encryption & anonymized UID system.
Privacy Protection	PDPA / GDPR	Consent-based data collection & deletion rights.
Evidence Retention	ISO 27037	7-year archival period for Proof Records (Audit requirement).
Access Control	Role-Based Access	Multi-level permissions (Enterprise / Verifier / Regulator).

This ensures that data assurance is achieved without compromising privacy, balancing transparency with individual and institutional rights.

13.7 INTEROPERABILITY FRAMEWORK (API STANDARDS)

PADV's data architecture is designed to integrate seamlessly with global ESG reporting platforms. The **Interoperability Framework (IFW)** defines standard API end Institutional Participation Points for data exchange:

Function	API End Institutional Participation Point	Integration Partner
Upload Proof Record	/api/pr/upload	SDGS PASS / Enterprise ERP
Verify Parameters	/api/verify/vf	Verification Bodies
Retrieve Index Report	/api/ntcc/report	ESG Reporting Tools
Cross-Check Ledger	/api/ledger/check	External Audit Systems
Lock ADL	/api/adl/finalize	PADV Registry Admin

This structure transforms PADV–NTCC into a machine-verifiable **ESG data layer**, enabling interoperability across platforms like CDP, GRI Data Portal, and corporate sustainability dashboards.

13.8 SUMMARY

By embedding automated integrity into the system, the framework transitions from a human-reliant verification process to a **digitally self-verifying infrastructure**. Data no longer requires belief, it provides **proof**. This is the essence of PADV as a data assurance solution: trust encoded, verified, and locked.

CHAPTER 14: INDUSTRY USE CASES & COMPLIANCE APPLICATIONS

14.1 INTRODUCTION: FROM SYSTEM DESIGN TO INDUSTRY ADOPTION

The PADV–NTCC framework demonstrates that verified behavioral data can evolve beyond academic methodology to become a **business-compatible infrastructure** for sustainability assurance. Rather than depending on estimated disclosures or self-declared achievements, it provides measurable, auditable, and standardized evidence of participation.

This chapter presents a set of cross-sectoral applications, illustrating how the PADV–NTCC system operates as a replicable **Data Governance Tool** for corporate, educational, and supply chain ecosystems.

14.2 THE DATA GAP IN ESG GOVERNANCE

Despite the maturity of global ESG frameworks, a structural gap remains between policy commitments and **execution verification**. Many institutions continue to rely on narrative-based reporting, creating a **"Data Confidence Deficit"** that weakens stakeholder trust.

The PADV–NTCC model addresses this gap through a new form of **Behavioral Assurance**, anchored in verifiable data logs rather than financial estimation. It operationalizes three key compliance objectives:

Compliance Dimension	**PADV–NTCC Contribution**
Transparency	Behavioral actions are traceable via Proof Records with immutable identifiers.
Accountability	Verification Factors (VF) and Recognition Protocols ensure proportional and auditable outcomes.
Participation	SDGS PASS mechanisms incentivize measurable engagement across citizens, employees, and organizations.

This structure converts intangible sustainability intent into **quantifiable, time-bound, and auditable data assets**.

14.3 CROSS-SECTOR PILOT VALIDATIONS

The PADV–NTCC model has been successfully tested in multiple ESG data pilots, involving collaboration among verification bodies, private-sector alliances, and academic partners.

Key Achievements:

- Generated **8.7 units** of verified NTCC engagement metrics (proxy: tons CO_2e).
- Accumulated over **2.45 million** engagement Institutional Participation Points through task-based actions.
- Participation from over **18 organizations** across various industries.

- Integrated verified records into corporate sustainability reporting aligned with **GRI 305** and **IFRS S2** data requirements.

These results confirm that behavioral data verification can function as an **enterprise-grade assurance layer**, bridging the space between voluntary participation and institutional accountability.

14.4 DATA GOVERNANCE ALIGNMENT

In regions emphasizing data integrity and digital governance, PADV–NTCC is positioned as a **Data Assurance Infrastructure** rather than a market mechanism. Its architecture reflects the principles of open data interoperability and sustainability assurance by design.

Key characteristics include:

- A registry framework enabling **cross-verifier data synchronization**.
- Compatibility with **digital trust** and open data frameworks adopted internationally.
- Scalability for **SME digital transformation** and ESG data readiness.

Through these features, NTCC functions as a **Trust Layer** for sustainability data, supporting regulators, corporations, and verifiers in creating unified ESG assurance ecosystems.

14.5 CORPORATE IMPLEMENTATION: BEHAVIORAL VERIFICATION IN PRACTICE

Corporations adopt PADV–NTCC primarily through two operational channels:

1. **ESG Integration:** Using NTCC as verified **Scope 3 behavioral datasets** in sustainability reports.
2. **CSR and Stakeholder Programs:** Launching mission-based activities that generate **Proof Records** through SDGS PASS.

Sector	**Implementation Model**	**Verified Output**
Retail & F&B	Indirect Interaction (Welfare Pool)	Quantified low-carbon consumer behavior logs

Sector	Implementation Model	Verified Output
Finance	Employee ESG Missions, Green Literacy	Measurable participation data for internal control
Manufacturing	SDGS PASS for Supply Chain Actions	Verified Scope 3 behavioral data
Event Management	ESG-linked Missions and Exhibitions	Auditable NTCC engagement metrics

This approach ensures that corporate sustainability is proven through **verified participation**, not merely through expenditure or policy declarations.

14.6 EDUCATIONAL APPLICATIONS: FROM LEARNING TO MEASURABLE IMPACT

The academic adaptation, **EDU SDGS PASS**, translates sustainability learning into quantifiable behavioral records. Universities employ mission-based education modules that link students' sustainability actions to verified Proof Records.

Demonstrated Outcomes:

- Integration with **QS Sustainability Ranking** through verified participation indicators.
- Collaboration among academic institutions to standardize sustainability literacy benchmarks.
- Behavioral data exportable to PADV Registry for **ESG-compatible assurance**.

This framework converts educational engagement into a verifiable component of institutional sustainability performance.

14.7 LARGE-SCALE EVENT MISSIONS

PADV–NTCC has been validated in large-scale public sustainability events—including clean-up missions, charity cycling, and ESG exhibitions.

Typical Data Flow:

1. Participants register via QR-based mission onboarding.
2. Proof Records generated automatically through on-site or IoT-linked validation.
3. NTCC calculated based on participation volume and VF-weighted impact proxy.
4. Event organizers receive **Post-Event Assurance Summaries** compatible with GRI and IFRS structures.

Example Outcome:

A regional ESG-themed exhibition produced verified engagement metrics equivalent to 8,700 kg CO_2e proxy impact, supported by thousands of public participation Proof Records. This confirms NTCC's adaptability across multiple engagement scales.

14.8 QUANTIFIED IMPACT AND SCALABILITY

Metric	**Verified Result (2025 Pilot Data)**
Proof Records	> 2,500,000 entries
Verified NTCC Index	**8.7 units** (Proxy: tons CO_2e)
Participating Organizations	18+
Individual Participants	> 30,000
Data Accuracy	**100%** validated by system logic

The evidence demonstrates that PADV–NTCC delivers a replicable and scalable model for translating human participation into **institutional trust**. Its relevance lies in enabling:

- Integration into **corporate ESG data platforms**;
- Adoption by assurance organizations as a **pre-audit tool**;
- Alignment with international **sustainable data interoperability** frameworks.

Through these outcomes, PADV–NTCC proves that verified participation can evolve into **industry infrastructure**, bridging human behavior, data assurance, and governance credibility.

CHAPTER 15: CONCLUSION & FUTURE ECOSYSTEM EVOLUTION

15.1 CLOSING REFLECTION: FROM BEHAVIOR TO INFRASTRUCTURE

The journey of PADV–NTCC demonstrates that sustainability data does not emerge from estimation, but from **verified behavior**. When human participation becomes measurable, and verification becomes standardized, sustainability evolves from narrative claims into **evidence-based compliance**.

This transformation marks the beginning of a new **Data Era**, where impact estimation, ESG disclosure, and behavioral science converge into a single verifiable logic. **NTCC**, as the standardized **Engagement Index**, anchors this logic within the domain of social participation and collective accountability, distinct from financial carbon markets.

15.2 THE ROLE OF PADV AS DATA INFRASTRUCTURE

PADV serves as the underlying **Operating System (OS)** that operationalizes NTCC: a four-ring model that ensures Participation (P), Action (A), Data (D), and Value (V) are continuously linked.

Through this structure, verified behaviors become **machine-readable trust components**, the fundamental units of sustainable transformation. By standardizing the Proof Record, $VF_{(total)}$, and weighting, PADV transforms human actions into structured datasets suitable for **enterprise governance**.

Each verified act, whether individual or organizational, thus contributes to a larger **Behavioral Data Assurance Framework (BDAF)** supporting ESG integrity at scale.

15.3 ECOSYSTEM EVOLUTION PATHWAY

The adoption roadmap of PADV–NTCC follows three progressive stages of **Infrastructure Maturity**:

Stage	Description	Strategic Focus
Phase I: Validation	Establishment of Proof Record and NTCC measurement framework.	**Data Integrity & Methodological Rigor**
Phase II: Interoperability	Integration with international standards (GRI, IFRS, ISO, QS).	**API Connectivity & Audit Readiness**
Phase III: Ecosystem Scale	Adoption by supply chains, verifiers, and global data platforms.	**Industry Standardization & Global Replicability**

This progression transforms PADV–NTCC from a methodological prototype into a **Data Infrastructure** embedded in the global supply chain, capable of supporting ESG assurance ecosystems globally.

15.4 TOWARD THE NEXT PHASE: AI-DRIVEN AUTOMATED COMPLIANCE

The next evolution of PADV lies in the intersection of **AI Governance** and **Behavioral Data Validation**. Machine-verifiable integrity will enable **autonomous ESG reporting systems**, where Proof Records are generated, verified, and disclosed without human bias or delay.

In this future, NTCC functions as the **Trust Unit** for autonomous sustainability systems, while PADV provides the **Data Logic** ensuring that every machine decision remains accountable to human values and international standards. This paradigm redefines "trust", from being declared, to being **computed, verified, and locked**.

15.5 GLOBAL STANDARDIZATION AND OPEN DATA COLLABORATION

The significance of PADV–NTCC extends beyond compliance. It introduces a unified, auditable **data logic** applicable across scientific, educational, and corporate systems.

Future collaborations are expected to include:

- **Integration** with global academic consortia on behavioral sustainability metrics.
- **Co-development** of ISO-compatible verification models for Scope 3.
- **Cross-validation studies** on Proof Record reliability and VF calibration.

- **Establishment of PADV Open Repository** for global academic access.

Through these initiatives, PADV–NTCC is envisioned not merely as a data framework, but as a **standardized language** for the age of behavioral sustainability.

15.6 CLOSING STATEMENT

In an era where sustainability is both a business imperative and a data challenge, PADV–NTCC provides a third path, not purely economic (trading), not purely regulatory (forcing), but **infrastructural** (enabling).

It represents a bridge between intention and proof, between participation and trust, between individual action and global accountability. As a system born from **verified human behavior**, NTCC will continue to evolve as a cornerstone of future **ESG Assurance**, while PADV stands as its enduring foundation—a framework where data is not merely collected, but secures the very trust that sustains our shared future.

ACKNOWLEDGMENTS AND SUPPORTING INSTITUTIONS

The completion of the **NTCC (Non-Tradable Commitment Credit)** Methodology White Paper v2.0 has been shaped and strengthened by the collaboration, insights, and professional guidance of stakeholders across academia, verification bodies, public institutions, and industry partners in both Singapore and Taiwan.

We express our deepest appreciation to the following contributors and organizations:

- **Pilot partners and corporate participants** who provided field data from exhibitions, ESG events, and CSR initiatives—enabling validation of NTCC's dual-pathway mechanism and real-world **behavioral impact estimation** accuracy.

- **Academic and research advisors** for their contributions in sustainability governance, data methodology, and behavioral verification, ensuring international alignment with ESG, Scope 3, and institutional assurance frameworks.

- **Audit and verification experts** from assurance firms and Big 4–aligned organizations who provided essential feedback on Verification Factors (VF), Recognition Coefficients (RCF), and assurance sampling methods, advancing NTCC's **pre-audit readiness**.

- **Industry and ESG event organizers** whose participation across exhibitions and campaigns helped demonstrate the scalability and replicability of the NTCC system as a **SaaS infrastructure**.

- **Verification and governance body: ARES International Certification (Taiwan)**, for its technical consultation on NTCC's assurance architecture and for contributing to the standardization of verification logic within the PADV–NTCC ecosystem.

- **Market and regulatory institutions**, notably the **Taiwan Stock Exchange (TWSE)** and **Taipei Exchange (TPEx)**, for their constructive input on corporate governance trends and sustainability reporting frameworks.

- **Singapore regulatory and innovation agencies**, including the **Monetary Authority of Singapore (MAS)**, Enterprise Singapore, National Environment Agency (NEA), and Government Technology Agency (GovTech), for their constructive feedback and recommendations regarding **digital trust infrastructure** and system development considerations.

- **Governmental authorities in Taiwan**, including the **Financial Supervisory Commission**, National Development Council, Ministry of Environment, and Ministry of Education, for their valuable perspectives on **data-driven governance** and institutional alignment.

Their insights and engagement have been instrumental in transforming NTCC from a conceptual methodology into an **operational verification framework** bridging behavioral data, ESG assurance, and cross-border institutional governance.

Disclaimer: The inclusion of the above institutions acknowledges their participation through **technical consultation and feedback**. The final content, interpretations, and recommendations expressed in this white paper are the sole responsibility of the author and **do not constitute formal endorsement** by any of the listed parties.

APPENDIX

APPENDIX 0

Methodology Foundation and Governance Basis

A0.1 METHODOLOGY FOUNDATION

The PADV (Participation Activity Data Verification) Methodology is an evidence normalization methodology developed to transform standardized participation activities into structured, continuity-preserved evidence.

Its primary objective is to support evidence continuity, governance interoperability and decision-grade evidence across multiple governance ecosystems.

PADV is designed to operate as an upstream evidence methodology before disclosure, reporting, assurance or regulatory assessment activities occur.

Accordingly, PADV focuses on the standardization of participation-derived evidence rather than the evaluation of organizational sustainability performance.

A0.2 METHODOLOGY POSITION

PADV is designed as an independent methodology.

It is not intended to function as:

- a sustainability reporting framework;
- an ESG rating methodology;
- a certification or accreditation scheme;
- an assurance standard;
- a regulatory requirement;
- a carbon credit methodology;
- an organizational performance evaluation system; or
- a financial risk assessment model.

Instead, PADV provides a standardized methodology for evidence normalization that supports governance interoperability while preserving institutional independence.

A0.3 METHODOLOGY-SPECIFIC PARAMETERS

The following parameters are introduced exclusively under the PADV Methodology.

These parameters provide standardized normalization mechanisms across all PADV Native Task Modules.

Parameter	Description
IPP	Institutional Participation Points representing standardized individual participation activities.
E-IPP	Enterprise Institutional Participation Points representing standardized organizational participation activities.
VF	Verification Factor representing standardized evidence verification confidence.
W_ESG	Task Governance Weight representing the governance characteristics of standardized task modules.
RCF	Recognition Coefficient controlling annual recognition normalization.
NTCR	Non-Tradable Commitment Recognition generated from completed standardized tasks.
NTCC	Annual accumulated Non-Tradable Commitment Credits representing governance participation recognition.

These parameters are methodology-specific constructs.

They are not defined, prescribed or approved by any individual international standard or regulatory framework.

A0.4 GOVERNANCE AND METHODOLOGY REFERENCES

PADV is informed by multiple internationally recognized governance, sustainability and assurance ecosystems.

These frameworks provide conceptual references for methodology development.

They do not prescribe PADV methodology parameters or numerical coefficients.

Research Program: Evidence Infrastructure Research Series

Framework / Organization	Methodological Role
IFRS Sustainability Disclosure Standards (ISSB)	Governance architecture, sustainability disclosure interoperability and decision-useful information concepts
SASB Standards	Industry-specific sustainability topic mapping
GRI Standards	Sustainability disclosure structure and topic mapping
ESRS	European sustainability disclosure interoperability concepts
COSO Internal Control Framework	Governance, accountability and internal control principles
GHG Protocol	Greenhouse gas accounting concepts where applicable
Scope 3 Guidance	Supply chain emissions boundary concepts where applicable
TNFD	Nature-related governance and disclosure concepts
TISFD	Social impact governance concepts
ISO 19011	Audit methodology and verification process principles
ISO/IEC 27037	Digital evidence identification, collection and traceability concepts
United Nations Sustainable Development Goals (SDGs)	Participation taxonomy and sustainability objective references

These frameworks provide governance concepts, disclosure structures, verification principles and interoperability references.

They should not be interpreted as defining, prescribing, approving or endorsing any PADV methodology parameter.

A0.5 METHODOLOGY DEVELOPMENT PRINCIPLES

PADV is developed according to five core methodological principles.

STANDARDIZATION

All standardized task modules follow a common methodological architecture, ensuring consistent evidence representation across different participation scenarios.

EVIDENCE CONTINUITY

Evidence should remain continuously observable, traceable and reusable throughout its lifecycle.

GOVERNANCE INTEROPERABILITY

Evidence should support interoperability across governance, reporting and institutional ecosystems without requiring harmonization between individual standards.

TRACEABILITY

Evidence should preserve execution history, identity continuity and verification history throughout the participation lifecycle.

METHODOLOGICAL CONSISTENCY

All methodology parameters are applied consistently across standardized task modules using a common governance process.

A0.6 PADV METHODOLOGY GOVERNANCE

The PADV Methodology maintains a standardized governance process for all methodology parameters.

This governance process includes:

- Standardized Task Definitions
- Task Metadata

- IPP Allocation
- E-IPP Allocation
- Verification Factor (VF)
- Task Governance Weight (W_ESG)
- Recognition Coefficient (RCF)
- NTCR Calculation Rules
- NTCC Recognition Rules

All methodology parameters are maintained through version-controlled methodology governance to ensure consistency across participating organizations.

Organizations implementing PADV may execute standardized task modules but shall not independently modify methodology parameters while claiming PADV methodological consistency.

A0.7 INTERPRETATION OF METHODOLOGY PARAMETERS

The methodology parameters defined within PADV are intended solely for evidence normalization and governance interoperability.

They shall not be interpreted as:

- ESG ratings;
- sustainability scores;
- carbon credit values;
- credit ratings;
- organizational rankings;
- assurance opinions;
- certification results;
- regulatory assessments; or

- organizational performance evaluations.

PADV evaluates standardized task characteristics rather than organizational sustainability performance.

A0.8 BOUNDARY STATEMENT

PADV does not replace:

- IFRS Sustainability Disclosure Standards;
- SASB Standards;
- GRI Standards;
- ESRS;
- COSO;
- TNFD;
- TISFD;
- ISO standards;
- assurance standards; or
- regulatory compliance frameworks.

Similarly, PADV does not replace:

- ERP systems;
- supply chain management systems;
- ESG reporting platforms;
- audit procedures;
- assurance activities; or
- organizational governance processes.

PADV operates as an upstream Evidence Infrastructure Methodology that standardizes participation-derived evidence before disclosure, reporting, assurance and regulatory assessment activities occur.

A0.9 IMPORTANT STATEMENT

The internationally recognized frameworks referenced throughout this methodology provide governance concepts, disclosure structures, verification principles and interoperability references.

They do not define, prescribe, approve or endorse any PADV methodology parameter, numerical coefficient or calculation mechanism.

Accordingly, all methodology parameters—including IPP, E-IPP, VF, W_ESG, RCF, NTCR and NTCC—are independently developed under the PADV Methodology.

These parameters are intended exclusively to support evidence normalization, evidence continuity, governance interoperability and decision-grade evidence across multiple governance ecosystems.

CLOSING STATEMENT

The purpose of this appendix is to distinguish internationally recognized governance concepts from methodology-specific constructs developed under PADV.

By establishing transparent methodological foundations, governance principles and reference boundaries, PADV seeks to support standardized evidence normalization while maintaining interoperability with internationally recognized governance, sustainability and assurance ecosystems.

APPENDIX A – VERIFICATION FACTOR (VF) & DATA QUALITY MODEL

A.1 DEFINITION AND PURPOSE

The Verification Factor (VF) is the quantitative algorithm that transforms raw participation logs into high-fidelity engagement metrics. It measures the reliability, contextual stability, and data completeness of each behavioral record, thereby ensuring that the resulting Impact Proxy values are statistically grounded and reproducible.

VF serves as the **Data Quality Score (DQS)** between raw behavioral inputs and verified ESG datasets. Within the PADV–NTCC framework, it functions as the statistical **"Integrity Coefficient"** that normalizes data variance across different regions, event types, and measurement conditions.

A.2 MATHEMATICAL STRUCTURE

The complete VF computation is defined as:

$VF_{(total)} = (VF_0 + VF_n + VF_s)/3$

Symbol	Term	Description	Typical Range
VF_0	**Baseline Reliability**	Reflects the inherent reliability of the data capture system (e.g., API vs. manual entry) and institutional environment.	**0.90 – 0.95**
VF_n	**Participation Fidelity**	Adjusts for completion rate, engagement depth, and record validation ratio.	**0.85 – 1.00**
VF_s	**Contextual Stability**	Evaluates temporal and operational stability during data collection (e.g., system latency, event continuity).	**0.88 – 0.97**
RCF	**Recognition Protocol**	Annual recognition cap depending on the nature of participation (Direct Task = 1.0; Indirect Interaction = 0.3).	**{1.0, 0.3}**

This formula ensures that participation with high contextual stability and accurate recording achieves proportionally higher **data weight**.

A.3 ALGORITHMIC INTERPRETATION

- **Baseline Calibration (VF_0):** Derived from system audits and **ISO 27001** security assessments. It anchors all subsequent calculations, representing the inherent trustworthiness of the reporting infrastructure.

- Participation Fidelity (VF_n): Computed from real-time validation logs:

$VF_n = \frac{\text{Verified Records}}{\text{Total Attempts}}$

(Bounded to 1.00 maximum).

- Stability Adjustment (VF_s): Incorporates variance in operational conditions:

$VF_s = 1 - \sigma$

Where σ denotes the normalized deviation of measurement conditions.

- **Recognition Protocol (RCF):** Enforces annual data integrity limits (Applied at aggregation stage):
  - **Type B (Direct Task Execution)** $\rightarrow$ Full Recognition (RCF = 1.0)
  - **Type A (Indirect Interaction)** $\rightarrow$ Capped Recognition (RCF = 0.3)

A.4 EXAMPLE COMPUTATION (DATA QUALITY SCORING)

A corporate compliance task reports:

- **Completion Rate** = 92%
- **System Quality** = High ($VF_0 = 0.92$)
- **Participation Consistency** = Excellent ($VF_n = 0.95$)
- **Operational Stability** = Good ($VF_s = 0.90$)

$VF_{total} = \frac{0.92 + 0.95 + 0.90}{3} = \mathbf{0.923}$

Result: $VF_{total} = 0.923 \rightarrow$ High Data Integrity.

In audit practice, a score of ≥ 0.90 indicates a "Fully Trustworthy" record class suitable for external reporting.

A.5 ANNUAL RECOGNITION FRAMEWORK

Behavior Type	RCF Value	Recognition Rate	Definition of Scope
Direct Task Execution	**1.0**	**100%**	Direct operational participation, measurable impact, system-verified logs.
Indirect Interaction	**0.3**	**30%**	Indirect engagement through community pool or product interaction.

Annual recognition values prevent **data inflation** (over-accrual) while maintaining consistency with conservative audit and disclosure standards.

A.6 CROSS-STANDARD MAPPING

VF Component	Primary Function	GRI Reference	IFRS Reference	ISO/COSO Alignment
VF_0	**Data Integrity & Reliability**	GRI 102	IFRS S1-22	ISO 27037 / COSO: Control Environment
VF_n	**Performance Verification**	GRI 403	IFRS S1-29	ISO 19011 / COSO: Monitoring
VF_s	**Stability Measurement**	GRI 305	IFRS S2-27	ISO 14064-1 / COSO: Info & Communication
RCF	**Recognition Governance**	GRI 201	IFRS S1-24	ISO 37000 / COSO: Risk Management

A.7 INTERPRETATION GUIDELINES

- **VF acts as a universal confidence index** for any PADV-verified dataset.
- **VF \ge 0.90** \rightarrow **High Fidelity:** Suitable for third-party ESG reporting and Scope 3 integration.

- **VF 0.75 – 0.89** \rightarrow **Medium Fidelity:** Conditionally verifiable; requires additional sampling or reconciliation.
- **VF $< 0.75** \rightarrow **Low Fidelity:** Rejected or archived for internal research only (Non-Disclosure Grade).

All VF records are subject to annual **audit reconciliation** and checksum verification to ensure the immutability of the Engagement Index.

APPENDIX B – ESG ENGAGEMENT WEIGHTING MODEL ($W_{(ESG)}$)

B.1 PURPOSE AND CONCEPTUAL ROLE

Within the PADV–NTCC framework, the **ESG Weighting Factors** translate qualitative sustainability attributes into quantitative, verifiable **algorithmic coefficients**.

They ensure that each verified behavioral record not only represents a proxy for environmental effect but also encapsulates the **Social** and **Governance** value dimensions required for holistic ESG disclosure.

Each NTCR (Non-Tradable Commitment Record) carries a composite weight, calculated as:

$W_{(ESG)}$ = \text{Average}(CEF, SEF, IRF)

This value forms the second critical multiplier following the Verification Factor (VF), ensuring that the final **Engagement Index** reflects the multidimensional quality of the action.

B.2 STRUCTURE AND DEFINITIONS

Dimension	**Code**	**Definition**	**Typical Range (1–5)**	**Measurement Source**
Environmental Impact Proxy	**CEF**	Quantifies the relative environmental efficiency, including emission avoidance effort, resource optimization, or waste prevention.	**3 – 5**	Derived from ISO 14064 inventory data or LCA benchmarks

Dimension	Code	Definition	Typical Range (1–5)	Measurement Source
Social Engagement Factor	**SEF**	Represents inclusiveness, volunteer participation depth, educational reach, or community benefit.	**2 – 5**	Derived from participation logs and social impact surveys
Institutional Reliability Factor	**IRF**	Captures data governance integrity, process transparency, and internal control strength of the organizing entity.	**3 – 5**	Based on ISO 27001 compliance or Internal Audit logs

B.3 SCORING ALGORITHM

1. Normalization Scale

All three dimensions are scored from 1 to 5, where:

- **5** = High-Performance / Best Practice
- **3** = Baseline Compliance
- **< 3** = Trigger for Quality Review (Data Flagged)

2. Weight Computation

The normalized ESG weight is the arithmetic mean:

W₍ESG₎ = \frac{CEF + SEF + IRF}{15}

3. Integration with Engagement Index

The resulting W₍ESG₎ is multiplied with VF_{total} to generate a balanced NTCC Index that reflects both quantitative accuracy (VF) and qualitative ESG alignment (W₍ESG₎).

B.4 ILLUSTRATIVE SCORING EXAMPLES

Case ID	Description	CEF	SEF	IRF	$W_{(ESG)}$	Interpretation
M-001	**Corporate Green Commuting Mission**	4.7	4.3	4.5	**0.90**	High integration; direct environmental benefit with strong governance.
M-002	**University Clean-up Campaign**	4.6	4.8	4.4	**0.92**	Excellent social engagement backed by institutional validation.
R-005	**Eco-Product Interaction**	3.6	3.9	4.0	**0.76**	Moderate impact; consumer-driven behavioral change.
R-008	**CSR Webinar (Education)**	3.4	4.2	4.3	**0.79**	High educational value with indirect environmental gain.

(Note: $W_{(ESG)}$ values are normalized decimals used in the NTCC formula.)

B.5 DATA UTILITY CLASSIFICATION (THRESHOLDS)

$W_{(ESG)}$ Score	Data Utility Class	Disclosure Eligibility
\ge 0.85	**High Fidelity**	**Primary Evidence** for Scope 3 and GRI 305 reporting.
0.70 – 0.84	**Medium Fidelity**	**Supporting Evidence** with narrative context.
$<$ 0.70	**Low Fidelity**	**Internal Management Use** (Retained for improvement analysis).

B.6 CROSS-FRAMEWORK INTEROPERABILITY

PADV Factor	Primary Meaning	GRI Reference	IFRS Reference	ISO / COSO Alignment
CEF	Emission and resource efficiency	GRI 305-5 / 306	IFRS S2-27	ISO 14064-1 / 14067
SEF	Social inclusion and engagement	GRI 413-1	IFRS S1-29	ISO 26000 / COSO Monitoring
IRF	Governance and data integrity	GRI 201-2 / 102-18	IFRS S1-22	ISO 27001 / COSO Control Env

B.7 OPERATIONAL GUIDELINES

- **Baseline Definition:** Each organization must define its own ESG baseline matrix aligned with national regulations and industry standards.
- **Periodic Review:** All $W_{(ESG)}$ parameters shall be subject to annual review under the **Data Validation Protocol (DVP)**.
- **Regional Calibration:** For multi-country datasets, local weight calibration (\Delta \le \pm 0.2) is permitted to reflect regulatory variances.
- **Immutability:** Once verified, the final $W_{(ESG)}$ value is **locked** in the V-Layer Proof Record.

B.8 INTERPRETIVE REMARKS

The ESG Engagement Weighting System bridges quantitative and qualitative ESG dimensions. It ensures that every recognized NTCC index embodies not just a numerical score, but **ethical governance accountability**.

Through CEF / SEF / IRF, PADV translates complex behavioral data into **institutionally meaningful management metrics**, laying a common foundation for audit, assurance, and policy integration across international frameworks.

APPENDIX C: PADV COMPUTATIONAL STANDARD (PCS)

C.1 PURPOSE

The PADV Computational Standard (PCS) defines the deterministic computational architecture governing how verified behavioral participation is transformed into standardized engagement metrics within the PADV Evidence Infrastructure.

Rather than introducing additional ESG indicators, PCS standardizes the computational rules through which behavioral evidence is processed, verified, normalized, recognized, and ultimately transformed into disclosure-ready institutional evidence.

PCS serves as the canonical computational specification for all PADV implementations, ensuring that identical behavioral evidence always produces identical governance outcomes regardless of implementation environment.

Accordingly, PCS functions as the reference computational standard for system developers, assurance providers, auditors, regulators, and institutional adopters.

C.2 COMPUTATIONAL ARCHITECTURE

The PADV computational architecture consists of seven deterministic computational layers.

Layer	**Computational Function**	**Output**
Evidence Layer	Verified behavioral evidence	Proof Record
Participation Layer	Participation quantification	IPP / E-IPP
Verification Layer	Evidence quality assessment	VFtotal
Governance Layer	ESG significance weighting	WESG
Computation Layer	Engagement computation	NTCR
Recognition Layer	Annual institutional recognition	NTCC
Disclosure Layer	Disclosure-ready evidence	Standardized Output

Each layer performs one independent computational responsibility.

No computational layer replaces another.

Each output becomes the deterministic input of the subsequent layer.

C.3 DUAL PARTICIPATION STANDARD

PCS defines two standardized participation systems.

Category	**A-Series**	**B-Series**
Participation Unit	IPP	E-IPP
Full Name	Institutional Participation Points	Enterprise Institutional Participation Points
Primary Environment	Public Participation	Enterprise Operations
Computational Baseline	10 IPP ≈ 1 Unit	1 E-IPP ≈ 1 Unit
Computational Path	Public Pathway	Enterprise Pathway

IPP and E-IPP represent computationally independent participation units.

They shall never be interpreted as equivalent point systems.

Instead, they represent different participation densities operating under the same governance framework.

C.4 CANONICAL COMPUTATIONAL PIPELINE

All PADV implementations shall execute the following deterministic computational sequence.

Behavior → Proof Record → IPP / E-IPP → Verification Factor → ESG Weight → NTCR → Recognition → NTCC → Disclosure-ready Evidence

This pipeline represents the canonical processing sequence of the PADV Computational Standard.

No implementation shall modify the computational order.

C.5 CANONICAL COMPUTATIONAL RULES

PUBLIC PARTICIPATION

Applicable to A-Series.

$$NTCR = (IPP \div 10) \times VF_{total} \times W_{ESG}$$

ENTERPRISE PARTICIPATION

Applicable to B-Series.

$$NTCR = EIPP \times VF_{total} \times W_{ESG}$$

Although different participation units are used, both computational pathways generate identical NTCR structures.

Consequently, NTCR remains the standardized engagement metric throughout the PADV ecosystem.

C.6 COMPUTATIONAL INTEGRITY PRINCIPLES

Every implementation of PCS shall satisfy the following computational requirements.

DETERMINISTIC

Identical inputs always generate identical outputs.

TRACEABLE

Every NTCC shall be reconstructable to its originating Proof Records.

IMMUTABLE

Previously verified computational results cannot be modified without generating a new verification record.

ENTITY-BOUND

Every computational result remains permanently associated with its originating entity.

VERSION-CONTROLLED

Every computational output shall record

- PCS Version
- PADV Version
- Algorithm Version
- Verification Version

This guarantees long-term computational reproducibility.

C.7 CANONICAL VARIABLES

Variable	**Definition**
Proof Record	Immutable behavioral evidence
IPP	Institutional Participation Points
E-IPP	Enterprise Institutional Participation Points
VF_0	Behavioral Verification
VF_n	Regional Verification
VF_s	Sector Verification
VFtotal	Composite Verification Factor
CEF	Carbon Effect

Variable	Definition
SEF	Social Effect
IRF	Institutional Reliability
WESG	ESG Weighting
NTCR	Standardized Engagement Metric
RCF	Annual Recognition Coefficient
NTCC	Annual Governance Engagement Index

C.8 COMPUTATIONAL COMPLIANCE

A computational implementation shall be considered PCS-compliant only when all of the following conditions are satisfied.

✓ Evidence originates from verified Proof Records.

✓ Participation follows the standardized IPP or E-IPP definitions.

✓ Verification is performed according to the PADV Verification Framework.

✓ ESG weighting follows the canonical weighting model.

✓ NTCR computation follows the canonical equations.

✓ Annual recognition follows the official RCF protocol.

✓ Every output remains fully reconstructable.

C.9 INSTITUTIONAL POSITIONING

The PADV Computational Standard does not establish a sustainability reporting framework.

It does not replace GRI, IFRS Sustainability Disclosure Standards, ISO standards, COSO, or other reporting or assurance frameworks.

Instead, PCS defines the deterministic computational layer that precedes reporting by transforming verified behavioral participation into standardized institutional evidence.

Accordingly, PCS functions as a pre-disclosure computational standard within the broader Evidence Infrastructure architecture.

APPENDIX D – V-LAYER METADATA SCHEMA

D.1 PURPOSE AND SCOPE

The PADV–NTCC framework relies on a **verifiable, machine-readable metadata architecture** that enables cross-standard auditability. This appendix defines the schema used to record, verify, and transfer **Proof Records** across the V-Layer data validation network.

Each Proof Record is a cryptographically signed entry that connects:

- A verified **participation event**;
- Its computed **VF (Verification Factor)** and **$W_{(ESG)}$ values**;
- Its resulting **NTCR (Non-Tradable Commitment Record)** Engagement Index.

All records comply with **ISO 19011 (Audit Management)**, **ISO 27037 (Digital Evidence Handling)**, and **COSO Control Environment** standards.

D.2 VERSIONING & GOVERNANCE

Field	**Description**
Schema ID	padv.ntcc.schema
Schema Version	**3.0.0**
Data Model Version	**2025.12**
Change Policy	Semantic Versioning (Major.Minor.Patch)
Namespace	urn:padv:ntcc:v3

Field	Description
Maintainer	EMJ.LIFE Technical Operations Division
Primary Formats	**JSON** (API Primary), **XML** (Enterprise Integration), **CSV** (Bulk Audit)

D.3 JSON SCHEMA (SIMPLIFIED FOR READABILITY)

JSON

```
{
  "$schema": "https://json-schema.org/draft/2020-12/schema",
  "$id": "urn:padv:ntcc:v3:proofrecord",
  "title": "PADV–NTCC Proof Record",
  "type": "object",
  "properties": {
    "pr_id": { "type": "string", "pattern": "^PR-[0-9]{4}-[0-9A-Z]{5,}$" },
    "participant": {
      "type": "object",
      "properties": {
        "euid": { "type": "string", "minLength": 8 },
        "role": { "type": "string", "enum": ["individual","employee","student"] }
      }
    },
    "activity": {
      "type": "object",
```

```
    "properties": {
      "task_id": { "type": "string" },
      "type": { "type": "string", "enum": ["direct_task","indirect_interaction"] },
      "evidence_hash": { "type": "string", "pattern": "^(sha256:)[0-9a-f]{64}$" }
    }
  },
  "metrics": {
    "type": "object",
    "properties": {
      "Institutional Participation Points": { "type": "integer", "minimum": 1 },
      "vf_total": { "type": "number", "minimum": 0.40, "maximum": 1.00 },
      "W(ESG)": { "type": "number", "minimum": 1, "maximum": 5 },
      "ntcr_proxy_value": { "type": "number", "description": "Engagement Impact Proxy" }
    }
  },
  "audit_trail": {
    "type": "object",
    "properties": {
      "timestamp_utc": { "type": "string", "format": "date-time" },
      "validator_sig": { "type": "string" },
      "ledger_lock": { "type": "string", "enum": ["pending","ADL_YYYY_Yn","locked"] }
    }
  }
```

```
    }
}
```

D.4 JSON EXAMPLE (AUDIT-READY)

JSON

```
{
    "pr_id": "PR-2025-0A3XZ",
    "participant": {"euid": "E-UID-7F29AB9", "role": "employee"},
    "organization": {"org_id": "EUID-ACME01"},
    "activity": {
        "task_id": "SDGSPASS-MISSION-014",
        "type": "direct_task",
        "category": "green_commuting",
        "evidence_hash": "sha256:8a1c...f0e"
    },
    "metrics": {
        "Institutional Participation Points": 120,
        "vf_total": 0.95,
        "W_(ESG)": 4.43,
        "ntcr_proxy_value": 10.2
    },
    "audit_trail": {
        "timestamp_utc": "2025-06-15T09:32:11Z",
        "validator_sig": "sig_verifier...",
```

```
    "ledger_lock": "pending"
  },
  "mappings": {"gri": "305-3", "ifrs": "S2-29", "iso": "14064-1"}
}
```


D.5 XML SCHEMA (EXCERPT)

XML


```xml
<ProofRecord xmlns="urn:padv:ntcc:v3">
  <PR_ID>PR-2025-0A3XZ</PR_ID>
  <Participant>
    <EUID>E-UID-7F29AB9</EUID>
    <Role>employee</Role>
  </Participant>
  <Metrics>
    <Institutional Participation Points>120</Institutional Participation Points>
    <VF_Total>0.95</VF_Total>
    <W(ESG)>4.43</W(ESG)>
    <NTCR_Proxy_Value>10.2</NTCR_Proxy_Value>
  </Metrics>
  <Audit_Trail>
    <Timestamp_UTC>2025-06-15T09:32:11Z</Timestamp_UTC>
    <Validator_Signature>sig_verifier...</Validator_Signature>
    <Ledger_Lock>pending</Ledger_Lock>
  </Audit_Trail>
```

</ProofRecord>

D.6 FIELD DICTIONARY & STANDARDS CROSSWALK

Field	**Description**	**GRI**	**IFRS**	**ISO**	**COSO**
PR_ID	Global Unique Proof Record Identifier	102-45	S1-22	ISO 27037	Information & Communication
EUID	Anonymized Enterprise/User Identifier	102-8	S1-22	ISO 27701	Control Environment
$VF_{(total)}$	Aggregated Verification Factor	205-1	S1-24	ISO 19011	Monitoring Activities
$W_{(ESG)}$	ESG Composite Weighting Coefficient	403 / 413	S1-32	ISO 26000	Ethical Governance
$NTCR_i$	Behavioral Engagement Impact Proxy	305-3	S2-29	ISO 14064-1	Information & Communication
Ledger_Lock	Annual Data Lock and Recognition Status	102	S1	ISO 27037	Monitoring Activities

D.7 VALIDATION RULES

- **Deterministic Formulas:**
  - base_proxy = Institutional Participation Points / 10
  - vf_total = $(VF_0 + VF_n + VF_s) / 3$
  - w_norm = $W_{(ESG)} / 5$
  - ntcr_proxy_value = base_proxy × vf_total × w_norm
- **Constraints:**

- pr_id must be globally unique.
- Institutional Participation Points ≥ 1.
- timestamp_utc unique per (euid + task_id).
- ledger_lock ∈ {pending, ADL_YYYY_Yn, locked}.

D.8 PRIVACY & SECURITY (GDPR/PDPA COMPLIANCE)

- **PII Minimization:** Only anonymized euid and salted hashes are stored.
- **Hash Protection:** All evidence is stored via **SHA-256 digest**.
- **Crypto Chain:** Each record is linked by prev_registry_hash, forming a verifiable chain of custody.
- **Retention:** Default **7 years** per ISO 27037 requirements for digital evidence.
- **Access:** Controlled by privacy_level flag (Public / Restricted / Confidential).

D.9 CHECKSUM & LEDGER REGISTRY NOTE

Each Proof Record is integrated into the **V-Layer Assurance Ledger**. A rolling Merkle tree is maintained to validate record immutability.

Component	**Function**
Record Hash	SHA-256 digest of serialized Proof Record
Prev Registry Hash	Previous Merkle root for chain continuity
Validator Signature	Cryptographic endorsement by authorized partner
Ledger Height	Sequential index for audit traceability

This ensures NTCC records cannot be altered or forged without invalidating the entire **Data Chain**.

APPENDIX E: CANONICAL DEFINITIONS, TERMINOLOGY & COMPUTATIONAL VARIABLES

E.1 PURPOSE

This appendix establishes the canonical definitions, terminology, and computational variables used throughout the PADV–NTCC Methodology.

The terminology and variable definitions presented in this appendix are normative and shall be applied consistently throughout this methodology unless explicitly stated otherwise.

The objective of this appendix is to ensure semantic consistency, computational integrity, and interoperability across methodology implementation, software development, audit procedures, and sustainability reporting.

E.2 CORE EVIDENCE TERMINOLOGY

Term	Definition
Behavioral Participation	A verified sustainability-related action performed by an individual or organization within the PADV ecosystem.
Proof Record (PR)	The smallest immutable evidence unit representing one verified behavioral activity.
Evidence Continuity	The preservation of traceability from behavioral participation through computation to disclosure-ready evidence.
Entity-Bound	A governance principle requiring every verified record and computed result to remain permanently associated with its originating participant or organization.
Disclosure-ready Evidence	Standardized engagement outputs suitable for governance, assurance, and ESG reporting.

Term	Definition
Deterministic Computation	A computational process that always produces identical outputs from identical verified inputs.
Audit-Ready	A condition in which every computational result can be independently reconstructed, verified, and reviewed.

E.3 PARTICIPATION VARIABLES

Variable	Full Name	Applicable Scope	Definition
IPP	Institutional Participation Points	A-Series Modules	Standardized participation points assigned to verified public or community sustainability activities.
E-IPP	Enterprise Institutional Participation Points	B-Series Modules	Standardized participation points assigned to verified enterprise sustainability task execution.

PARTICIPATION BASELINES

Participation System	Computational Baseline
IPP	**10 IPP ≈ 1 Unit Engagement Impact**
E-IPP	**1 E-IPP ≈ 1 Unit Engagement Impact**

INTERPRETATION RULE

IPP and E-IPP are independent participation units designed for different operational environments.

They represent different engagement densities and shall not be interpreted as equivalent point systems.

No direct conversion between IPP and E-IPP shall be performed except through the canonical computational rules defined in this methodology.

E.4 VERIFICATION VARIABLES

Variable	Definition
VF_o	Behavioral Verification Factor evaluating activity-level verification quality.
VF_n	Regional Verification Factor adjusting for regional implementation conditions.
VF_s	Sector Verification Factor adjusting for sector-specific implementation characteristics.
$VF_{(total)}$	Composite Verification Factor derived from VF_o, VF_n, and VF_s.

E.5 ESG WEIGHTING VARIABLES

Variable	Definition
CEF	Carbon Effect representing environmental significance.
SEF	Social Effect representing social sustainability significance.
IRF	Institutional Reliability representing institutional governance significance.
$W_{(ESG)}$	Composite ESG weighting coefficient calculated from CEF, SEF, and IRF.

E.6 ENGAGEMENT COMPUTATION VARIABLES

Variable	Definition
NTCR	Non-Tradable Commitment Record representing standardized engagement impact generated from verified participation.
RCF	Recognition Coefficient governing annual institutional recognition.
NTCC	Non-Tradable Commitment Credit representing annual governance recognition of verified NTCR values.

E.7 CANONICAL COMPUTATIONAL RELATIONSHIPS

A-SERIES (PUBLIC PARTICIPATION)

NTCR = (IPP ÷ 10) × $VF_{(total)}$ × $W_{(ESG)}$

B-SERIES (ENTERPRISE PARTICIPATION)

NTCR = E-IPP × $VF_{(total)}$ × $W_{(ESG)}$

ANNUAL RECOGNITION

NTCC = Σ(NTCR × RCF)

These equations constitute the canonical computational relationships of the PADV–NTCC Methodology.

E.8 COMPUTATIONAL INTEGRITY PRINCIPLES

All computational implementations shall satisfy the following principles.

DETERMINISTIC

Identical verified inputs shall always produce identical computational outputs.

TRACEABLE

Every NTCC shall be reconstructable to its originating Proof Records.

IMMUTABLE

Previously verified computational records shall not be modified.

Any correction shall generate a new Proof Record rather than overwrite an existing record.

ENTITY-BOUND

All computational outputs shall remain permanently associated with their originating participant or organization.

VERSION-CONTROLLED

Every computational output shall record its applicable methodology version to ensure long-term reproducibility and auditability.

E.9 CANONICAL ABBREVIATIONS

Abbreviation	**Full Term**
PADV	Participation–Action–Data–Value
PR	Proof Record
UID	User Identity
Enterprise UID	Enterprise Unique Identifier
IPP	Institutional Participation Points
E-IPP	Enterprise Institutional Participation Points
VF	Verification Factor
VF_0	Behavioral Verification Factor
VF_n	Regional Verification Factor
VF_s	Sector Verification Factor

Abbreviation	Full Term
$VF_{(total)}$	Composite Verification Factor
CEF	Carbon Effect
SEF	Social Effect
IRF	Institutional Reliability
$W_{(ESG)}$	ESG Weighting Coefficient
NTCR	Non-Tradable Commitment Record
RCF	Recognition Coefficient
NTCC	Non-Tradable Commitment Credit

E.10 GOVERNANCE NOTE

The variables and terminology defined in this appendix constitute the canonical reference vocabulary of the PADV–NTCC Methodology.

All chapters, appendices, implementation documents, interoperability mappings, software systems, and audit procedures shall interpret these definitions consistently unless superseded by a formally published future version of this methodology.