

Climate Finance, Carbon Accounting, and Green-Bond Readiness: Building Financial Analytics Frameworks for Sustainable Project Evaluation

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Abstract- Climate risk disclosure requirements, burgeoning green capital markets, and shifting carbon accounting frameworks have presented a clear need for entities to develop strong financial analytics systems for assessing sustainable project value. There is a pressing need to develop robust financial analytics systems for evaluating sustainable projects, driven by convergence in climate risk disclosure, rising green capital markets, and evolving carbon accounting frameworks. We propose an integrated framework that links the principles of structuring green bonds with the carbon accounting frameworks, climate-scenario modelling, and investment appraisal methods in a way that is coherent and easily applicable to practice. The paper builds on the key elements of the Green Bond Principles (GBP), the Task Force on Climate-related Financial Disclosures (TCFD), the Science Based Targets initiative (SBTi), and the GHG Protocol Corporate Accounting and Reporting Standard to construct a five-pillar analytical architecture. This architecture supports organisations from their initial carbon inventory phase to project-level financial modelling, impact-metric documentation, stakeholder reporting, and readiness for issuing green bonds or sustainability-linked bonds. The framework is illustrated through case applications in renewable energy, green buildings, and NbS, while a scenario-driven section discusses emerging issues such as biodiversity credits, Article 6 carbon markets, and AI-enhanced ESG analytics.

Keywords: Climate Finance · Green Bonds · Carbon Accounting · GHG Protocol · TCFD · SBTi · ESG Analytics · Sustainable Investment · Impact Metrics · Net Zero

I. INTRODUCTION

The world economy is at a turning point. The physical and transition risks of climate change have

risen from being a side issue in the environment to central financial and regulatory concerns. At the same time, climate-related risks and opportunities are being called for by central banks, securities regulators, institutional investors, and sovereign governments to be disclosed, quantified, and managed. In this context, the use of sustainable finance instruments, such as green bonds, social bonds, and sustainability-linked bonds, has expanded from a fledgling niche to a multi-trillion-dollar asset class, and global green bond issuance has reached USD 500 billion per year by 2024 (Alamgir & Osińska, 2024).

However, what is missing from the headline numbers is crucial: many organizations looking to access green capital markets are missing the financial analytics infrastructure within themselves to structure, document, and report on sustainable investments in a credible way. They have difficulty in establishing carbon baselines that are defensible, translating environmental metrics to financial cash-flow models, meeting the ‘use of proceeds and impact-reporting requirements of the Green Bond Principles, and aligning capital allocation with science-based decarbonisation pathways. This analytical gap leads to friction in transactions, increases transaction costs, exposes private capital to greenwashing challenges, and, ultimately, hinders the flow of private financing for the sustainable projects that climate commitments demand.

This paper fills that void head-on. It brings together existing practices from climate finance, carbon accounting and investment analysis to an actionable, holistic approach for practitioners, the Sustainable

Project Evaluation Framework (SPEF). In the second section, the paper reviews the climate finance field and the drivers that have led to the regulatory framework. The carbon accounting foundation is developed in Section 3, which is essential to credible project evaluation. The financial modelling architecture for sustainable investments is presented in Section 4. The green-bond readiness assessment and structuring checklist are outlined in Section 5. Documentation and reporting of impact metrics are discussed in Section 6. The section on emerging frontier issues (7) takes a look at some new questions about the frontier. The implementation recommendations are included at the end of Section 8.

II. THE CLIMATE FINANCE LANDSCAPE: REGULATORY DRIVERS AND MARKET ARCHITECTURE

2.1 From Voluntary Commitments to Binding Disclosure

Climate finance is an interface between the environment, macroprudential regulation, and capital markets. The normative framework in which climate finance operates was established by the objective of keeping global warming below 1.5 degrees above pre-industrial levels in the Paris Agreement. The translation of this macro-objective to the level of institutions' financial behaviour, however, has been more directly propelled by a cascade of mandatory disclosure regimes that have been rapidly arriving at the level of the institution from all corners of the world (Nhemachena et al., 2026a).

The TCFD framework, supported by the regulators in the United Kingdom, the European Union, Japan, Singapore, and now more and more in the United States, calls for companies to report on climate-related risks and opportunities under four thematic areas: governance, strategy, risk management, and metrics and targets (Calian, 2026). The European

Union's Corporate Sustainability Reporting Directive (CSRD) will be fully implemented in 2024-2025 (Contipelli, 2025). It would require around 50,000 companies to report on sustainability, including requiring detailed reporting on double materiality, which considers both the effect of climate change on the company (financial materiality) and the impact of the company on the climate (impact materiality) (Efrag, 2023).

The International Sustainability Standards Board (ISSB), under the IFRS Foundation, released IFRS S1 (standards for general sustainability disclosures) and IFRS S2 (standards for climate-specific disclosures) (Straoanu, 2025). These standards, which are now embraced or are underway for adoption in more than 40 jurisdictions, are establishing a de facto global benchmark based on the recommendations of the TCFD and adding more specific quantitative guidance (Houseblend, 2026). For organisations looking to issue green bonds, these disclosure standards are fast becoming a precondition, rather than a differentiator.

2.2 The green and sustainable market

According to the International Capital Market Association (ICMA) Green Bond Principles (GBP), the four elements that bonds must meet to be considered green bonds are that the proceeds are directed towards eligible green projects, there is a clearly established process for project evaluation and selection, the bond proceeds are managed in a ring-fenced or tracked account, and there is impact reporting on an annual basis (ICMA, 2024). The ICMA's Harmonized Framework for Impact Reporting offers a set of standardized templates for various industry sectors such as renewable energy, green buildings, clean transportation, water, and biodiversity.

Table 1: Taxonomy of Sustainable Debt Instruments and Governing Standards

Bond Type	Proceeds Use	Coupon Mechanism	Key Standards
Green Bond	Green projects only	Fixed / Floating	ICMA GBP, EU GBS
Sustainability-Linked Bond	General corporate use	Step up if KPIs are	ICMA SLBP

(SLB)		missed	
Social Bond	Social projects only	Fixed / Floating	ICMA SBP
Sustainability Bond	Green + Social projects	Fixed / Floating	ICMA SuBP
Blue Bond	Ocean/water projects	Fixed / Floating	ICMA GBP (adapted)
Transition Bond	High-carbon sector transition	Fixed / Floating	ICMA Climate Trans.

The EU Green Bond Standard (EU GBS), finalized in 2023 and to be implemented in 2024, is a more robust framework, where full alignment is required with the EU Taxonomy for Sustainable Activities which is a science-based classification system that determines whether an economic activity substantially contributes to one of the 6 environmental objectives and does not cause significant damage (DNSH) to the others (Merler, 2025) & (Nhemachena et al., 2026b). The alignment requirement, together with the requirement for external review by EU-registered verifiers, is the strictest one in the world for green bonds and is likely to serve as the de facto benchmark for regulatory convergence.

III. CARBON ACCOUNTING: SUSTAINABLE FINANCE'S ANALYTICAL BACKBONE

3.1 GHG Protocol's Emissions Trading System (ETS) Principles

Anything but a well-established carbon accounting basis is unfeasible in the area of credible green-finance analytics. The GHG Protocol Corporate Accounting and Reporting Standard (CA&R), created by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), is the international benchmark for GHG inventories of organizations (WRI & WBCSD, 2015). It breaks down emissions into three scopes:

- Scope 1 covers direct emissions directly owned or controlled by the organisation (e.g., emissions from combustion in boilers owned by the organisation and emissions from the organisation's vehicles).
- Scope 2 — Indirect emissions resulting from the use by the organization of purchased electricity, heat, steam, or cooling, calculated

using both market-based and location-based approaches.

- Scope 3 – All other indirect emissions in the value chain, including 15 types of emissions such as purchased goods/services (Category 1), use of sold goods/services (Category 11), or investments (Category 15).

Financial institutions (FIs) are especially interested in Scope 3 Category 15 (financed emissions) because it mandates that they must disclose the GHG emissions associated with their loans, investments, and underwriting. This method of calculating GHG emissions was standardized by the Partnership for Carbon Accounting Financials (PCAF, 2025).

3.2 Establishing a Carbon Baseline for Project Evaluation

Organisations need to put in place a documented carbon baseline, or counterfactual emissions trajectory, before any project-level financial modelling can take place – against which the project's climate benefits will be compared (GHG Protocol, 2025). This baseline construction consists of three analytical steps: (1) defining the organizational boundary (as an equity share, financial control or operational control approach); (2) choosing the baseline year and using the GHG Protocol's guidance on how to handle recalculation policies; and (3) applying the emission factors for non-CO₂ GHGs from an authoritative database, such as the IEA World Energy Statistics, a national grid emission factor registry or the IPCC AR6 characterization factors for non-CO₂ GHGs.

Additional requirement for project-level accounting is to define a project baseline scenario, the most likely scenario of what would have happened if the project were not implemented, in accordance with the additionality requirements of the voluntary carbon

market (VCM) methodologies, such as Verra's Verified Carbon Standard (VCS) and Gold Standard (Ayers et al., 2025). Additionally, the idea that any emission reductions or removals must be in addition to what would have occurred without the project underlies the financial value of a carbon credit, as well as the environmental credibility of a green-bond project.

3.3 Carbon Pricing and its Integration into Financial Models

Carbon pricing systems (mandatory and voluntary) need to be part of the financial calculations for sustainable projects. The TCFD makes a clear recommendation to use internal carbon prices to manage risk and allocate capital, and other significant initiatives like the CDP disclosure project request the information on internal carbon prices in the corporate questionnaire.

To prepare for financial modelling, organisations should take a dual approach to carbon pricing: an operational price reflecting current policy (such as EU ETS allowance prices, regional carbon tax rates) is useful for short-term cash-flow projections, while a long-run shadow price is associated with the high-transition scenarios from the Network for Greening the Financial System (NGFS) or IEA Net Zero by 2050 projections, at USD 130-250 per tonne of CO₂-

equivalent by 2030 in the most stringent scenarios. This approach is a dual one, enabling sensitivity analysis to account for the breadth of transition risk scenarios that the TCFD-scenario analysis needs.

IV. FINANCIAL MODELLING ARCHITECTURE FOR SUSTAINABLE PROJECTS

4.1 Integrated Climate-Financial Model Structure

A sustainable project financial model differs from a conventional capital project model in several important respects. It must simultaneously track financial cash flows (revenues, operating costs, capital expenditures, financing costs) and environmental flows (GHG emission reductions, resource consumption, biodiversity impacts) (Olinmah et al., 2024). It must apply climate-scenario sensitivity analysis to key financial assumptions. And it must produce outputs that map to the reporting templates required by green-bond impact reports, TCFD disclosures, and sustainability accounting standards.

The proposed Sustainable Project Evaluation Framework (SPEF) organizes the model into five integrated modules:

Table 2: SPEF Five-Module Financial Analytics Architecture

Module	Primary Function	Key Inputs	Key Outputs
M1: Carbon Accounting	Establish GHG baseline & reductions	Activity data, emission factors, project specs	tCO ₂ e baseline, reduction volume, additionality score
M2: Financial Appraisal	Project NPV, IRR, payback period	CapEx, OpEx, revenue, WACC, carbon price	NPV, IRR, LCOE/LCCA, carbon-adjusted return
M3: Scenario Analysis (Battiston et al., 2017)	Climate transition & physical risk stress-test	NGFS scenarios, carbon price paths, and weather data	Value-at-risk, stress NPV, scenario matrix
M4: Impact Metrics	Quantify & document environmental co-benefits	Project monitoring data, LCA inputs	Aligned KPIs per ICMA Harmonized Framework
M5: Green-Bond Structuring	Assess issuance readiness & structure bond	Proceeds requirement, use-of-proceeds taxonomy	Term sheet parameters, SPO scope, reporting schedule

4.2 Carbon-Adjusted Financial Returns

One of the key innovations of the SPEF is the systematic embedding of Carbon Value in the project

return metrics. Three adjustments are made to the traditional net present value (NPV) calculation to incorporate carbon effects:

- Carbon Revenue / Cost Avoidance: Carbon revenue/cost avoidance from carbon compliance instruments (for VCM eligible projects) is discounted at a carbon-risk-adjusted discount rate reflecting the price uncertainty of carbon markets. In this case, for voluntary carbon credits, it should reflect a liquidity discount and a risk for reversibility (or a permanence risk discount) especially for nature-based solutions with material reversibility risk.
- Carbon liability exposure. Where the project is in a regulated sector, any residual carbon liability costs after the project (i.e., the cost of buying allowances or offsets to cover emissions that are not offset by the project) should be included in the NPV and sensitised across the NGFS Orderly, Disorderly, and Hot House World scenarios.
- Stranded Asset Risk: The loss of asset value due to the earlier than expected retirement of the asset, based on the probability of retires across different scenarios, as per IEA scenario analysis, should be considered for capital expenditures in carbon intensive assets within the Project boundary (e.g., for a renewable energy project, the value of backup diesel generators should be assessed as stranded asset risk) (Dellai, 2025).

Carbon NPV and internal rate of return (IRR) offer a more comprehensive assessment of the value creation potential of a project in an uncertain climate, in addition to the conventional financial NPV and IRR, and are directly relevant to the scenario analysis disclosures under the TCFD and ISSB S2 (Dhavale et al., 2015).

4.3 Illustrative Sector Applications

To demonstrate the use of the framework, three sector cases are briefly outlined:

4.3.1 Renewable Energy (Solar PV)

In a utility-scale solar PV project, Module M1 estimates emissions reduction by subtracting the emission factor of the electricity system at the time the project is operated (the grid emission factor, GEF) from the emission factor of the electricity

system that would be used if the solar PV project did not operate. The operating margin / build margin methodology is applied in a manner similar to the CDM and VCS methodologies. Module M2 calculates the levelized cost of electricity (LCOE) with and without the inclusion of panel degradation curves, inverter replacement schedules, and land lease costs (Fraunhofer ISE, 2024). Module M3 tests the financial model by stressing the components of a solar power plant agreement with scenarios of accelerating solar cost deflation (the reduction in the future contract price) and grid curtailment risk (the increased physical production uncertainty) (NGFS, 2025). This carbon-adjusted IRR is used as a foundation for structuring green bond finance in Module M5. In the energy industry, in particular, the changing responsibilities of management accountants to incorporate risk management and internal controls within the assessment process of capital-intensive projects guarantee that carbon baselines, CapEx accounting, and scenario assumptions are valid under scrutiny (Mupa et al., 2024).

4.3.2 Green Buildings

Module M1 calculates the operational carbon saving compared to the building energy code criteria baseline and accounts for embodied carbon from building construction materials through a lifecycle assessment (LCA) in compliance with EN 15978 for a commercial real estate green-building project aiming for EDGE or LEED Platinum certification. Note that all the metrics of Module M4 are required under the ICMA Harmonized Framework for Green Buildings: energy intensity (kWh/m²/year), water consumption (litres/m²/year), waste diversion rate, and indoor air quality metrics. The financial model in M2 captures the green premium (higher rental yields and lower vacancy rates reported in green-certified buildings) compared to the capital cost premium for the green design specifications.

4.3.3 Nature-Based Solutions (NbS)

Reforestation, better forest management, blue carbon (mangroves, seagrasses), and soil carbon sequestration are the analytically most complex applications of the SPEF framework. Carbon accounting under the Module M1 requirements needs to be carefully managed to take into account

additionality, non-permanence buffer pools, and leakage (displacement of emissions to outside project boundaries). Probabilistic Monte Carlo simulation of carbon reversal probabilities is required in Module M3 scenario analysis, and should include physical climate risks to biological carbon stocks (drought, wildfire, pest infestation). The biodiversity co-benefits from Module M4 should be documented on new indicators (Taskforce on Nature-related Financial Disclosures (TNFD) LEAP approach and Mean Species Abundance (MSA) indices).

V. GREEN-BOND READINESS ASSESSMENT AND STRUCTURING

5.1 The Green-Bond Readiness Diagnostic

An organization will only be able to issue a green bond or be eligible for sustainability-linked financing if it is ready in many respects (Lindner & Chung, 2023). Issuance could be delayed, or the external review may be costly, or the issuer may be subject to post-issuance greenwashing risk, should any dimension fail. The SPEF approach defines what readiness is by providing a structured diagnostic in six areas. For community-serving and growth-stage organizations, readiness should be anchored on an operational control system that brings together tax compliance, internal controls, and SOPs (Nhemachena et al., 2026). This will be in addition to the six diagnostic criteria listed below.

Table 3: Green-Bond Readiness Diagnostic Framework

Readiness Dimension	Assessment Criteria	Minimum Standard	Best Practice
Taxonomy Alignment	Share of proceeds in EU Taxonomy-eligible activities	>70% DNSH-screened activities	100% Technical Screening Criteria met
Carbon Accounting	Scope 1/2/3 inventory quality	Third-party verified Scope 1 & 2	Full Scope 3 verified incl. Cat. 15
Impact Metrics System	KPI data collection & monitoring	Ex-ante impact projections documented	Real-time monitoring with the MRV system
Governance Framework	Board-level sustainability oversight	Sustainability committee at the management level	Board-level ESG committee + policy
Reporting Capability	Annual impact report production	ICMA Harmonized Framework templates	ISSB S2 + TCFD + GRI double disclosure
External Review	Second Party Opinion (SPO) / Verification	Pre-issuance SPO from a recognized reviewer	Post-issuance verification + SPO

5.2 Use-of-Proceeds Documentation

The GBP and EU GBS impose a requirement to allocate proceeds to eligible green projects, which requires issuers to keep a comprehensive and auditable record of how bond proceeds are used. This entails a formal Project Evaluation and Selection (PES) process (e.g. defined in a Green Finance Framework), which includes the following elements: taxonomy of eligible project categories and associated eligibility criteria; governance process for the nomination, evaluation and approval of projects

(including the sustainability committees and independent internal verification); tracking mechanism for ring-fencing proceeds (dedicated account, internal ledger allocation, or portfolio approach); and timeline for full allocation, with proceeds not allocated held in eligible liquid instruments. The lessons drawn from donor-backed development programs show that proper control systems, documentation processes, and audit trail procedures, which are critical in restricted funds, can be readily adopted in green bonds use-of-proceeds

monitoring and ring-fenced accounts management (Hlahla et al., 2025b).

A critical assumption that should be captured in the financial model is the allocation schedule — the anticipated allocation and rate of deployment of proceeds to eligible projects during the tenor of the bond. The allocation delay can result in financial risk (as the proceeds remain in low-yield liquid assets) and reputational risk (as a potential perception of greenwashing). The SPEF framework calls for a thorough stress-testing of the allocation schedule assumptions using sensitivity analysis of the 6 to 12-month allocation delay on the financial return profile for the entire green bond transaction in M2.

5.3 Second Party Opinion and External Verification

The independent verification value chain is multi-layered and helps to build green bond credibility. A Second Party Opinion (SPO) is a pre-issuance assessment by a reputable environmental, social, and governance (ESG) research and advisory firm to evaluate the consistency of the issuer's Green Finance Framework with the relevant principles, as well as the credibility of the issuer's sustainability approach (Lindner & Chung, 2023). An independent auditor monitors the proceeds and verifies the impact metrics annually after the issuance, ensuring that proceeds are used as described and that impact metrics are accurate. In the case of EU GBS-compliant bonds, the external review process, both before and after issuance, needs to be carried out by an EU-registered External Reviewer, in a regulated regime administered by the European Securities and Markets Authority (ESMA) (Bunse et al., 2025).

VI. Documentation of impact metrics and reporting to stakeholders

6.1 Impact Metric Selection Principles

The accountability system of green bonds is different from traditional bonds, and it is the “impact reporting” that gives investors impact proof to show their portfolios are aligned with their own stakeholders' expectations on ESG issues. The ICMA Harmonized Framework for Impact Reporting, last updated in 2023, offers sector-specific KPI templates for renewable energy, energy efficiency, clean

transportation, sustainable water and wastewater management, waste management, green buildings, biodiversity and climate change adaptation (Climate Bonds Initiative, 2025). There are four principles to choose impact metrics:

- **Materiality:** It is important to reflect on the most material environmental impacts on the financed project and not just the most easily measurable impacts. The total renewable energy generated by a wind farm (MWh/year) and GHG emissions avoided (tCO₂e/year) are material; carbon sequestration (tCO₂e/year), biodiversity uplift (hectares of habitat restored), and urban heat island mitigation (°C reduction in local surface temperature) are all material for an urban reforestation project.
- **Comparability:** Metrics should be in consistent units and methods, if possible, to allow comparison to peers. ICMA Harmonized Framework offers metric definitions and calculation methodologies specific to each sector that facilitate comparability.
- **Verifiability:** Metrics should be based on documented and auditable data sources, including energy meters, satellite monitoring data, certified LCA studies, and not on unverified estimates or engineering proxies without a validation basis.
- **additionality documentation:** The impact report should clearly differentiate the environmental performance of the financed project (absolute impact) and the additional environmental performance that can be attributed to the active intervention of the green finance instrument (additionality), especially if the project would have occurred without the intervention of that instrument.

6.2 Auditing and Assumption Registry

A frequent flaw in green bonds' impact reporting that is under the microscope for greenwashing is the lack of transparency in assumptions being made in calculating impacts. The SPEF framework requires that a formal Assumption Registry be maintained with information about each impact metric, including the data source, vintage, emission factor or conversion coefficient used, baseline or counterfactual scenario assumed, any

normalization/allocation methodology applied (e.g., multi-purpose projects where environmental impacts need to be allocated to multiple outcomes), and any material changes in assumptions between reporting periods with explanation. The climate-focused data governance models, such as the ones established to track timber under GRC models, show how supply chain emissions data can become decarbonized and auditable. This is an example of the type of operational model that could be used in the Assumption Registry (Hagan et al., 2026).

This is an Assumption Registry that can be used twice. Inside, it's the analytical rigor needed to deliver defensible impact calculations from one year to the next. On the outside, it offers transparency to enable independent validation of impact numbers by external reviewers, advanced investors, and regulators, and this is increasingly needed as increasingly mandatory ESG disclosure regimes apply the same legal liability requirements for impact reports as they do for financial statements.

6.2 Integrated Reporting and Double Materiality

Leading practice in sustainable project reporting is transitioning towards providing a financial performance narrative and an environmental performance narrative altogether in a coherent report – rather than two distinct but parallel reports. Integrated reporting is guided by a conceptual framework known as the International Integrated Reporting Framework (IIRC) that is now part of the IFRS Foundation (Kohler & Minci, 2026). The same imperative is captured in the CSRD's double materiality requirement, which calls for disclosure of climate risks to the organization, as well as climate impacts on the organization (Dunfjäll, 2025).

The reality for green-bond issuers is that annual impact reports need to meet the reporting requirements in ICMA reporting templates, TCFD impact reporting metrics and targets disclosures, ISSB S2 quantitative reporting requirements and GRI Universal Standards disclosures. This multi-standard alignment presents a real challenge in reporting, but it also places the organisation in a better position for the reporting convergence that regulatory paths clearly suggest: a single, audited, machine-readable

sustainability disclosure accessible to and open to financial markets, regulators, and civil society.

VII. FRONTIER ISSUES AND EMERGING CHALLENGES

7.1 Carbon Markets and Their Financial Implications

Article 6 of the Paris Agreement provides for international cooperation on carbon markets, with two types of carbon markets: bilateral Internationally Transferred Mitigation Outcomes (ITMOs) between countries (Article 6.2) and a centralized multilateral carbon market mechanism (Article 6.4). The operationalization of Article 6, which was agreed at COP29 in 2024 after several years of negotiations, will have a significant impact on the financial modelling of carbon credits (European University Institute, 2025). The corresponding adjustments, which require other jurisdictions to adjust their Nationally Determined Contributions (NDCs) to include the carbon credits that have been sold to them, mean that carbon credits are counted once in the global accounts of carbon credits, and not twice. This will have important pricing considerations: Article 6 credits from high-quality programs may be sold at a much higher price to this market than voluntary market credits prior to COP26 due to their scarcity and robustness of the regulations.

7.2 Biodiversity Credits and Nature Finance

The future of sustainable finance analytics is in nature-related financial risks and the growing biodiversity credit market. The Taskforce on Nature-related Financial Disclosures (TNFD), which came up with its recommendations in 2023, offers a structurally similar four-pillar approach to assessing the dependencies, impacts, risks, and opportunities that nature presents, which is known as LEAP (Locate, Evaluate, Assess, Prepare) (TNFD, 2025). The adoption of regulations is picking up, with the European Sustainability Reporting Standards (ESRS) of the CSRD incorporating a separate standard on biodiversity and ecosystems (ESRS E4) in addition to climate (ESRS E1).

In projects where biodiversity is a concern, or financial models are assessing NbS, the SPEF should also include biodiversity impact metrics, such as

Mean Species Abundance (MSA), numbers of species at risk, and ecosystem service valuations based on approaches like the Ecosystem Services Valuation Database (ESVD), in addition to carbon metrics. Eventually, these biodiversity credit markets (which are now being developed under the Biodiversity Net Gain requirement in the United Kingdom, as well as under voluntary frameworks like the GBFF Biodiversity Credit Principles) will offer market-clearing prices for biodiversity units to be incorporated into project financial models as is done for carbon prices.

7.3 AI-Augmented ESG Analytics

AI and machine learning are quickly making it easier for businesses to gather, process, and analyse the information they need to do meaningful climate finance analytics (Polagani, 2025). Incorporating machine learning object detection with satellite remote sensing allows for near-real-time monitoring of forest cover change, solar farm production, construction of green building projects, and even methane emission plumes, not possible before with costly on-the-ground measurement campaigns. The automated extraction of data on GHG inventories and sustainability performance indicators from corporate reports at scale by using NLP would allow for benchmarking and peer comparisons, which sophisticated institutional investors demand.

However, there are auditability, methodology transparency, and liability concerns relating to the use of AI-generated data in green-bond impact reports. But regulators, such as ESMA, in guidelines on methodologies for ESG ratings, are starting to give answers to these questions by mandating ESG data providers to make the same disclosures about their methodologies and data sources that credit rating agencies are required to make. As AI-enhanced data sources grow in use by organizations developing analytics capabilities aligned with the SPF principles, they can expect to increasingly be held accountable to government regulators, as well as use standards for documentation of the inputs provided by AI that are consistent with the rest of their Assumption Registry rules.

VIII. CONCLUSION AND IMPLEMENTATION RECOMMENDATIONS

The paper introduces the Sustainable Project Evaluation Framework (SPEF), a systematic, multi-disciplinary way to come to grips with the increasing complexity of climate finance analytics. The framework provides a seamless, fully integrated architecture to integrate carbon accounting, financial modelling, climate scenario analysis, green-bond structuring, and impact reporting, allowing organisations to develop the analytical infrastructure needed to make a credible entry into sustainable capital markets and meet the growing demands of climate disclosure regulation.

The development and implementation of the SPEF framework should be done in four stages corresponding to stages of organizational maturity:

- Phase 1 — Foundation (Months 1-6) includes: GHG inventory (Scope 1, 2, and priority Scope 3) and an internal carbon price, and the green-bond readiness diagnostic (Table 3 criteria). This stage is where the data and governance infrastructure are established that will support all subsequent analytical work. Small firms, non-profits, and other resource-limited organizations venturing into green capital markets need to ensure that this foundational stage incorporates sustainable budgeting frameworks and financial literacy skills capable of supporting future carbon accounting and reporting capabilities (Hlahla et al., 2025).
- Phase 2 — Model Development (Months 7-12): Develop the integrated M1–M4 finance and environmental model for a priority project pipeline. Set up the Assumption Registry and the impact metric monitoring system. Create the Green Finance Framework document for the purpose of SPO engagement.
- Phase 3 — Market Engagement (Months 13–18): Reach out to a known SPO provider, and review the pre-issuance framework. Create investor presentation materials which incorporate financial return and impact metrics, taking into account carbon. Schedule and design green bond transaction terms (purpose of proceeds, bond terms, covenants, reporting of impact), and issue bonds.

- Phase 4 — Continuous Improvement (Ongoing): Report on impacts on a continuous basis, aligned with ICMA Harmonized Framework & ISSB S2 requirements, annually. Perform post-issuance verification and update the Assumption Registry to show the actual monitoring data as compared to the ex-ante projections. Build on the SPEF framework gradually as the nature disclosure and carbon market integration continue to develop under Article 6 of the Paris Agreement.

The core idea of this paper is that the credibility of climate finance is not a communications problem; it is an analytics problem. Genuinely value-creating capital allocation decisions will increasingly be possible in an economy that is structurally and irreversibly repricing climate risk, and organizations with robust financial and environmental measurement infrastructure, transparent assumption documentation, and integrated reporting systems will take advantage of green capital on better terms. This window of opportunity is now, and the organisations that seize it first will create lasting competitive advantages in the sustainable capital markets of the 2020s and beyond, as regulators, investors, and technology converge to build this infrastructure.

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