International Journal of Scientific Research & Engineering Trends
Volume 12, Issue 5, Sep-Oct-2026, ISSN (Online): 2395-566X

CarbonWise: A Blockchain-Based Carbon Credit Marketplace for Transparent and Accessible Carbon Trading

Shubham Sharma[1] Vibhav Dadhich[2]
Department of Computer Engineering (AI) Poornima Institute of Engineering & Technology Jaipur, Rajasthan

Abstract—Carbon markets depend on credible measurement, reporting, and verification (MRV), reliable ownership records, and controls against duplicate issuance and retirement of environmental claims. Small and medium-sized cement manufacturers may face high verification and transaction costs and limited access to carbon markets. This paper proposes CarbonWise, a blockchain-based marketplace design for improving the traceability of credit records and access to trading. The proposed architecture uses Solidity smart contracts on an Ethereum-compatible network, an ECO-token representation for approved credits, and InterPlanetary File System (IPFS) references for supporting evidence. It also describes an optional EIP-712 meta-transaction flow in which a relayer could submit a transfer signed by a user. The design separates environmental verification from on-chain execution: a blockchain can record approvals, ownership changes, and retirement events, but cannot independently prove that a claimed emission reduction occurred. We describe the workflow, contract responsibilities, evidence-integrity model, security considerations, and an evaluation plan. The supplied materials do not include test evidence, so we report no performance or security measurements. Implementation details must be checked against the project source code and test results. The paper contributes a sector-focused design and evaluation framework for auditable credit records, evidence references, issuance controls, and optional sponsored transactions.

Index Terms—blockchain, carbon credits, carbon markets, smart contracts, Ethereum, Solidity, IPFS, EIP-712, measurement, reporting, and verification, cement manufacturing

I. INTRODUCTION

Carbon markets aim to make it worthwhile to reduce or remove greenhouse-gas (GHG) emissions. A carbon credit is often linked to one metric tonne of carbon-dioxide equivalent. But that number alone does not tell us whether the credit is reliable. Its quality depends on how the project was measured, who verified it, whether the reduction is additional and lasting, who owns the credit, and how it is retired. So a sound carbon market needs more than digital transfers. It also needs credible measurement, reporting, and verification (MRV), clear accounting, registry oversight, and reliable retirement rules.Digital tools now play a growing role in this discussion. A distributed ledger can give participants a shared record of transactions, and smart contracts can enforce selected rules for issuing, transferring, and retiring credits. Research suggests these tools may make activity easier to see and coordinate. Still, a ledger cannot replace trusted environmental data or the institutions that oversee a carbon market [2, 6, 5, 3, 15]. Tokenized carbon-credit systems and sector-specific marketplaces further demonstrate the possibility of connecting environmental assets to programmable trading infrastructure, while also exposing challenges involving provenance, market quality, regulatory recognition, and user adoption [11, 16, 7, 14].
CarbonWise explores how these ideas might work for small and medium-sized cement manufacturers. In the proposed workflow, participants submit evidence of claimed reductions; supporting documents are referenced through decentralized storage; an authorized verification process reviews the claim; and eligible credits may be issued as ECO tokens and traded. The design also considers an optional EIP-712 gasless transfer flow in which a user signs typed data and a relayer submits a transaction. The architecture remains a proposal until the source code, deployment configuration, tests, and measurements confirm its implementation and performance.

II. BACKGROUND AND MOTIVATION

Carbon-market integrity

Carbon-credit systems must address risks such as inaccurate baselines, over-crediting, non-additional reductions, weak monitoring, double issuance, double claiming, and failure to retire credits properly. A ledger can record that a transaction occurred, but it cannot by itself prove the environmental accuracy of a measurement or the authenticity of a submitted certificate. This distinction is central to CarbonWise: the blockchain layer is an accountability and coordination mechanism, whereas the environmental claim remains dependent on recognized accounting methodologies, qualified verification, evidence quality, and governance.

Cement-sector context

© 2026 IJSRET

Cement manufacturing is a relevant application because it can produce direct process emissions and indirect emissions from energy use. Nevertheless, this paper does not assert a numerical emissions profile for any particular manufacturer. The relevant project boundary, baseline, activity data, emission factors, reduction methodology, and verification standard must be supplied by the author or an independent verifier as to be confirmed with the author.

Accessibility for smaller participants

Small and medium-sized enterprises (SMEs) may lack dedicated carbon-market staff, blockchain expertise, or the financial capacity to absorb repeated intermediary and transaction costs. A platform that requires users to obtain cryptocurrency, manage gas, understand raw contract calls, and independently evaluate complex evidence may remain inaccessible even if its ledger is transparent. CarbonWise therefore treats usability and optional sponsored transactions as design concerns, not as automatic consequences of decentralization. Research on SME-oriented carbon applications and tokenized environmental assets provides a relevant comparison point, but does not establish that CarbonWise itself improves access until user testing and cost measurements are performed [14, 11, 21].

Problem Statement

The design challenge is to make credit transactions easier to trace while keeping environmental checks separate from blockchain actions. The system must address the following problems:

- Provenance and auditability: participants need a consistent record of approvals, ownership changes, transfers, and retirements.
- Issuance control: only an authorized process should be able to issue tokens, and issuance should be linked to a defined evidence and verification record.
- Duplicate accounting: the design should provide identifiers and state transitions that make duplicate issuance, re-use, or re-entry of retired credits detectable.
- Evidence integrity: supporting reports and certificates are too large and operationally unsuitable for direct on-chain storage, but off-chain documents need verifiable references.
- Usability and cost: participants should not be required to understand gas management for every supported action, while the system must make sponsorship risks visible.
- Environmental validity: immutable records cannot correct fraudulent, incomplete, or misleading measurements submitted before recording.

Research Objectives And Contributions

The objectives are:

- evaluate how DLT can improve traceability and auditability of carbon-credit transactions;
- design smart-contract controls for issuance, ownership, transfer, and retirement;
- evaluate IPFS-referenced evidence for integrity and retrievability;
- specify and, if implemented, measure EIP-712 gasless transfers;
- assess the accessibility implications for small and medium-sized cement manufacturers; and
- identify technical, regulatory, environmental, privacy, and scalability limitations.

This paper presents a sector-focused system design and evaluation framework. It combines programmable credit-state transitions, an auditable ledger, content-addressed evidence references, and optional sponsored transactions. The project repository and test artifacts are needed to confirm contract behavior, frontend and backend integration, relayer behavior, and test outcomes.

III. LITERATURE REVIEW

DLT for carbon markets and governance

Franke et al. designed a blockchain model for the Paris Agreement's carbon-market mechanism and discussed how ledger infrastructure could support coordination and accounting [6]. Rawat et al. proposed a decentralized framework covering carbon accounting, trading, and governance [5]. Mandaroux et al. developed an evaluation framework for applying DLT to the European Emissions Trading System, showing that recording transactions is only one part of the question; the institutional and technical arrangements must also suit a regulated market [4]. Tian's systematic review synthesized the scope and purposes attributed to blockchain in carbon markets and is useful for positioning CarbonWise among prior conceptual and application-oriented work [15]. Heister et al. examined DLT as a possible catalyst for carbon-credit market integrity, while Marchant et al. argued for technological transparency in carbon-credit trading [3, 8]. These studies motivate a traceability layer, but their implications do not remove the oracle problem: information about a physical reduction must still be measured and verified outside the ledger. Galenovich et al. described a broader blockchain ecosystem for carbon markets and environmental assets, demonstrating that tokenization is connected to rights, liabilities, and governance rather than only to a transfer function [16].

1. Tokenization and marketplace design

Tokenization maps an environmental claim or credit record to a blockchain representation. The mapping is useful only if the token's issuance, ownership, retirement, and metadata are linked to the governing carbon methodology. Ballesteros-Rodríguez et al. analyzed tokenized carbon credits in voluntary markets through the KlimaDAO case, showing how tokenization can create new market structures and why

© 2026 IJSRET

credit quality, market mechanisms, and governance require scrutiny [11]. Venkatesh et al. and Prapulla et al. present marketplace and carbon-credit-management approaches that are close in application area to CarbonWise, although the available records do not establish that they use the same contract architecture or evaluation protocol [7, 12]. Mahfudiyah et al. proposed a taxonomy of blockchain-based carbon-credit tokenization, which supports comparing CarbonWise by asset representation, governance, evidence, and market interaction rather than by token terminology alone [13].

2. MRV, fraud, and double counting

The literature repeatedly treats MRV and registry integrity as coupled problems. A blockchain can provide tamper-evident ordering after data entry, but it cannot determine whether a sensor, report, baseline, or verifier was truthful. Studies connecting carbon registries to transportation, IoT, or automated monitoring illustrate attempts to improve the evidence pipeline, but they also increase the importance of data provenance and oracle security [18, 20]. Research on credit evaluation and environmental-asset governance similarly indicates that verification and institutional rules must accompany technical recording [10, 17].

CarbonWise adopts a conservative boundary: it can record a verification decision and prevent unauthorized contract-level minting if the authorization logic is correctly implemented, but it cannot certify a reduction merely because a document has an IPFS content identifier. Duplicate issuance and retirement can be made more detectable by using unique project, monitoring-period, and credit-batch identifiers, but the relationship between an on-chain token and an external registry must still be governed. The literature on transparency and token traceability supports this design concern, while not proving that an arbitrary token is a recognized carbon credit [9, 19].

3. IPFS and decentralized evidence references

IPFS is relevant to CarbonWise because it can provide content-addressed references for documents while avoiding the cost of storing full reports on a public blockchain. A document identifier can be recorded in a contract or application database, and a later retrieval can be hashed and compared with the expected content. Aziz et al. studied IPFS node communication in an Ethereum smart-contract context, offering a technical precedent for connecting decentralized storage with smart contracts [22]. A content address does not guarantee that a document will remain available, private, or environmentally accurate. The system still needs clear rules for pinning, replication, access, encryption, and retention.

4. Comparative synthesis

Table tab:literature summarizes the relationship between selected literature and CarbonWise

.

Work	Primary method or system	Relevant finding or emphasis	Limitation relative to CarbonWise
Franke et al. [6]	Blockchain model for Paris Agreement mechanisms	Examines how blockchain could support carbon-market coordination and accounting	Broad mechanism design; not a validated SME cement marketplace
Mandaroux et al. [4]	DLT evaluation framework for the European ETS	Emphasizes assessment of institutional and technical suitability	Does not supply CarbonWise's evidence, token, or gasless workflow
Rawat et al. [5]	Decentralized carbon accounting, trading, and governance framework	Connects ledger functions with governance concerns	The supplied record does not establish implementation measurements for CarbonWise-like access barriers
Ballesteros-Rodríguez et al. [11]	Case analysis of tokenized voluntary credits and KlimaDAO	Shows that tokenization changes market structure and governance requirements	Focuses on an existing ecosystem rather than a cement-SME workflow
Hirlekar [1]	Blue-carbon MRV, tokenization, IoT, ML, and gasless transactions	Demonstrates an integrated direction combining evidence, estimation, tokens, and sponsored interaction	Different environmental domain; does not validate CarbonWise implementation
Aziz et al. [22]	IPFS–Ethereum node communication analysis	Provides a precedent for decentralized document references connected to contracts	Does not establish document availability or privacy for CarbonWise
Tsai [14]	SME-oriented blockchain carbon-trading proposal	Directly motivates attention to access barriers for smaller participants	The available record is not evidence of CarbonWise usability or deployment

5. Gasless transactions and AI/ML assistance

Gasless transfers can be implemented through a typed-data signature and a relayer. A user signs a structured message that specifies the intended operation, while an authorized relayer submits the corresponding transaction and pays the network fee. This can reduce the need for users to hold native

© 2026 IJSRET

cryptocurrency, but introduces relayer trust, replay protection, nonce management, fee sponsorship, denial-of-service, and key-management considerations. Hirlekar's work is particularly relevant because it combines a carbon MRV and tokenized marketplace design with gasless transactions, IoT telemetry, and machine-learning-based estimation [1]. CarbonWise should treat such techniques as optional components and must not represent AI or ML as an independent environmental certifier. AI may estimate, classify, or flag anomalies; a qualified verification process remains necessary.

III. RESEARCH GAP

Prior work has addressed blockchain-based carbon registries, tokenized environmental assets, governance, MRV, and carbon-market applications. A narrower gap concerns implementation evidence for marketplaces designed for smaller cement manufacturers. In particular, existing work provides limited evidence on how such a marketplace can combine issuance controls, document references, transfers, and optional gasless transactions while keeping ledger integrity separate from environmental validity. CarbonWise addresses this question as a proposed design and evaluation framework. Its implementation and contribution still require evidence from source code, tests, transaction-cost measurements, evidence-integrity checks, and usability or workflow evaluation.

IV. PROPOSED SYSTEM ARCHITECTURE

The proposed architecture contains four layers.

CarbonWise component responsibilities and evidence status

The blockchain should store small records that can be checked, rather than entire reports. A credit-batch record may include a project identifier, monitoring period, quantity, methodology identifier, verifier identifier, evidence CID, status, and retirement information. The application may organize events into reports. For ownership changes on the blockchain, though, the contract state and event log are the records to check.

Component	Intended responsibility	Status in this draft
Ethereum-compat ible chain	Records contract state, approvals, ownership changes, and transfers	Proposed; network and deployment are to be confirmed with the author
Solidity contracts	Enforce issuance, transfer, retirement, and authorization rules	Proposed; source and ABI are to be confirmed with the author
ECO token	Represents an approved credit unit under project rules	Proposed; token standard and decimals are to be confirmed with the author
IPFS	Stores or references supporting evidence using content identifiers	Proposed; pinning and privacy policy are to be confirmed with the author
Frontend and wallet	Provides participant interaction and signing	Proposed; framework and wallet integration are to be confirmed with the author
Relayer / backend	Submits sponsored transactions if enabled	Optional; implementation and trust model are to be confirmed with the author
MRV / verification	Assesses physical and documentary evidence before issuance	External or governed process; methodology is to be confirmed with the author

Participant / Frontend\\ evidence submission and wallet signature\\ Verification and MRV process → IPFS evidence reference\\ authorized approval\\ CarbonCreditToken and marketplace contracts\\ events, ownership, transfers, retirement\\ Ethereum-compatible ledger and reporting indexer

Logical CarbonWise architecture. The verification process is intentionally separated from the ledger because blockchain does not independently validate physical emission reductions.

V. SYSTEM DESIGN AND WORKFLOW

The intended workflow is as follows:

© 2026 IJSRET

- A participant registers through the application and connects a wallet. Identity, eligibility, and role requirements are to be confirmed with the author.
- The participant submits activity data and supporting reports describing a claimed reduction.
- Documents are uploaded to IPFS or another approved content-addressed service. The resulting CID is associated with the submission.
- A qualified verifier assesses the submission against the selected methodology. The reviewer may be human, institutional, or supported by software; the exact process is to be confirmed with the author.
- An authorized approval triggers issuance only if the deployed contract supports the required role and validation rules.
- The approved quantity is represented by ECO tokens according to the project's actual token rules. The intended mapping is one ECO token per metric tonne of verified CO■e reduced, but this is not an established implementation fact.
- Eligible credits are listed and transferred through the marketplace if the relevant marketplace contract and eligibility checks exist.
- Contract events record ownership and transfer changes. Retirement should make a credit unavailable for subsequent trading.
- Reports aggregate balances, evidence references, transactions, and retirement state. Any off-chain indexer must be checked against on-chain data. Table tab:workflow distinguishes the intended workflow from implementation evidence available for this draft.

Implementation-status classification based on supplied materials.

Functionality	Classification
Participant wallet connection	Proposed; frontend evidence unavailable
Evidence submission	Proposed; source and data schema unavailable
IPFS reference	Proposed; CID storage and retrieval code unavailable
Qualified verification	Required governance process; verifier implementation unavailable
Authorized issuance	Proposed; contract roles and mint function unavailable
Functionality	Classification
ECO token	Proposed model; deployed token rules unavailable
Marketplace listing and transfer	Proposed; marketplace contract unavailable
Auditable ownership history	Architectural property if deployed on a public ledger; deployment evidence
	unavailable
Reports and analytics	Proposed; indexer and reporting code unavailable
Gasless transfer	Optional; EIP-712 domain, nonce, relayer, and contract implementation unavailable

VI. SMART CONTRACT DESIGN AND IMPLEMENTATION

CarbonCreditToken

The CarbonCreditToken contract is intended to manage ECO-token issuance, ownership, and token operations. The precise standard must be confirmed from the project source code: ERC-20 is suitable for interchangeable units, whereas ERC-1155 or another semi-fungible design may preserve batch-level identifiers and metadata. The current draft does not establish which standard was implemented.

A sound issuance design should enforce this rule:

Q_minted(b) □ Q_approved(b),

where b is a credit batch, Q_minted is the cumulative quantity minted for that batch, and Q_approved is the quantity approved by the verification process. If one token represents one tonne, the unit conversion must be explicit and must not be inferred from token decimals.

Only an approved issuer or verifier role should be able to mint tokens. A robust implementation should also specify role administration, revocation, emergency pause behavior, event emission, and whether an approval can be consumed only once. These properties require contract source and tests before they can be reported as implemented.

Ownership, transfer, and retirement

Transfer rules should show clearly what has happened to each credit. A minimal lifecycle is proposed □ verified □ issued □ transferred □ retired. A retired credit must not be transferable or reissued. If a fungible token is used, the contract or a linked registry must preserve sufficient batch-level information to prevent a single undifferentiated balance from obscuring heterogeneous methodologies, vintages, or retirement restrictions.

Algorithmic issuance logic

A basic issuance process could work like this:

- validate that the caller has the issuer role;
- validate that the batch identifier has not been consumed;
- validate that the evidence reference is present and bound to the batch;
- validate the approved quantity and beneficiary address;

© 2026 IJSRET

- record the batch and verifier decision;
- mint no more than the approved quantity; and
- emit an event containing the batch identifier, quantity, beneficiary, verifier, and evidence reference.

This is a design specification, not a claim about deployed behavior.

VII. CARBON CREDIT TOKENIZATION AND MARKETPLACE MECHANISM

Tokenization turns a verified environmental claim into a digital record that software can handle. CarbonWise should treat the token as a representation of a governed credit record rather than as proof of a reduction. The marketplace may support listing, price, seller, quantity, expiration, and settlement state. Atomic settlement is desirable: either the payment and token transfer both occur, or neither occurs. The contract should prevent a seller from listing more units than are available and should invalidate or update listings after transfer or retirement.

For a credit batch b, the aggregate outstanding quantity can be represented as:

$$Q_{outstanding}(b) = Q_{issued}(b) - Q_{retired}(b),$$

provided that issuance and retirement are tracked consistently for each batch. Transfers change ownership but do not reduce aggregate outstanding supply.

This equation is a design invariant, not a measured CarbonWise result.

VIII. IPFS-BASED EVIDENCE MANAGEMENT

A document is not written directly to the Ethereum state in the proposed design. Instead, the application stores the document through IPFS or an approved pinning service and records a CID or equivalent digest. At verification time, the retrieved byte sequence D' should satisfy:

$$H(D') = H(D_{recorded}),$$

where H is the hash function represented by the CID or by an application-level digest. If the hashes match, the retrieved file has the same contents as the recorded file. That still does not show that the document is accurate, complete, up to date, or written by a qualified verifier.

Sensitive reports should not be uploaded in plain text to a public content-addressed network. The system needs clear rules for encryption, key sharing, access, revocation, retention, and deletion. IPFS files also need to be pinned and replicated if they are to remain available. An availability test should record the pinning setup, retrieval attempts, delays, and failures.

Gasless Transaction Mechanism Using Eip-712 If implemented, EcoMetaTransfer can support a sponsored transfer using an EIP-712 typed-data signature. The user signs a structured message containing at least the token or batch identifier, recipient, amount, nonce, deadline, and domain information. The relayer submits a transaction to a contract that verifies the signature and executes the transfer.

Conceptually, the signed digest is:

$$d = keccak256(0x1901 \,||\, h_{domain} \,||\, h_{message}),$$

where h_domain binds the signature to the intended contract, chain, and protocol domain, and h_message commits to the transfer fields. The contract must reject an invalid signature, an expired deadline, a previously used nonce, a wrong chain or verifying contract, and an amount exceeding the signer's available balance.

A relayer does not need the user's private key. It can still choose to delay, reorder, ignore, or selectively submit signed requests. A production design should consider relayer authentication, fee policy, replay protection, nonce synchronization, rate limits, monitoring, and recovery from a failed submission. The EcoMetaTransfer implementation must be inspected to verify that it follows these rules.

IX. RESEARCH METHODOLOGY

This study follows a Design Science Research (DSR) approach. Its proposed artifact is the CarbonWise architecture and workflow. The evaluation plan covers functional correctness, security properties, evidence integrity, transaction behavior, and usability barriers; no completed prototype or evaluation results are provided in the supplied materials.

The reproducible phases are:

- define the credit lifecycle, roles, evidence schema, and threat model;
- identify the deployed network, compiler version, contract dependencies, token standard, and deployment configuration;
- implement or inspect the contracts and frontend/backend integration;
- construct unit, integration, adversarial, and property-based tests;
- measure gas, confirmation time, relayer overhead, and IPFS retrieval behavior under a documented configuration;
- evaluate security findings and classify unresolved risks; and
- compare observations against the stated objectives without claiming environmental improvement from ledger use alone.

© 2026 IJSRET

X. EXPERIMENTAL SETUP AND EVALUATION METRICS

No test results, deployment address, dataset, or implementation repository was supplied. For that reason, the table below sets out what should be evaluated; it does not report completed experiments.

Reproducible evaluation plan

Area	Test or measurement	Metric	Required evidence
Access control	Attempt minting from issuer and non-issuer accounts	Authorized success; unauthorized revert	Contract source, roles, transaction traces
Issuance	Mint valid, zero, excessive, repeated, and malformed batches	Pass/fail; state invariants	Unit-test output and event logs
Transfers	Transfer valid, insufficient balance, restricted recipient, and retired credit	Pass/fail; balance conservation	Test cases and contract configuration
Retirement	Retire a valid credit and retry transfer or retirement	Pass/fail; retired quantity	State snapshots and logs
Gas and cost	Execute mint, transfer, retirement, and marketplace actions	Gas units and currency cost under stated prices	Network, block, compiler, and price assumptions
Confirmation	Measure submission-to-confirmation intervals	Median, percentile, and variance	Timestamp source and sample size
Gasless flow	Sign valid and invalid EIP-712 messages; replay and expiration tests	Success rate, relayer gas, latency, failure reasons	Domain, nonce, relayer logs
IPFS integrity	Retrieve, hash, alter, and re-upload evidence	Hash-match rate, retrieval latency, availability	CID, pinning, and hash records
Duplicate issuance	Reuse batch identifier or approval	Rejection rate; duplicate state count	Adversarial tests and contract state
Scalability	Increase users, batches, listings, and event volume	Throughput, latency, indexing delay, cost growth	Workload generator and environment
Usability	Observe representative SME workflows or conduct structured testing	Task completion, errors, time, perceived burden	Participant protocol and ethics approval if required

Experimental configuration

The author should provide the chain identifier, RPC endpoint type, block time, compiler and optimizer settings, Solidity version, contract addresses, token decimals, test accounts, IPFS provider and pinning policy, relayer configuration, sample sizes, and date of measurement. Results should be reported with enough information to reproduce the experiment. Mainnet cost comparisons should not be presented without a stated exchange-rate and gas-price snapshot.

XI. RESULTS AND DISCUSSION

The supplied materials contain no implementation artifacts or measurements, so this section reports no empirical results. Table tab:results lists measures that remain to be collected.

Evaluation results currently available in this draft

Measure	Result
Smart-contract correctness	Not yet measured
Unauthorized minting resistance	Not yet measured
Duplicate issuance resistance	Not yet measured
Minting gas	Not yet measured
Transfer gas	Not yet measured
Confirmation time	Not yet measured

© 2026 IJSRET

Gasless transfer success rate	Not yet measured
Relayer overhead	Not yet measured
IPFS retrieval and hash verification	Not yet measured
Scalability bottleneck	Not yet measured
SME usability evidence	Not yet measured

If the contracts are deployed correctly and their events are indexed, the architecture could provide an audit trail. It does not justify the stronger claim that CarbonWise reduces verification time, carbon emissions, or market costs. Such claims require controlled measurements and a comparison baseline. Similarly, gasless interaction may reduce the need for users to hold native cryptocurrency, but it does not necessarily reduce total system cost because the relayer pays gas and must be operated securely.

1. Security, Privacy, And Threat Analysis

Principal threats and proposed controls.

Threat	Possible control	Residual limitation
Unauthorized minting	Role-based access, multisignature approval, pause and revocation controls	Compromised authorized keys can still mint
Compromised verifier	Independent review, separation of duties, audit logs, credential rotation	Governance and human judgment remain necessary
Fraudulent reduction claim	Recognized methodology, independent MRV, evidence review, anomaly detection	Blockchain cannot validate physical reality
Duplicate or retired credit	Batch identifiers, one-time approvals, retirement state, registry reconciliation	Cross-registry duplication may remain
Private-key theft	Hardware or managed wallets, secure custody, recovery policy, least privilege	User and operator key compromise remains possible
Malicious relayer	Nonces, deadlines, domain separation, relayer monitoring, user-visible status	Censorship and denial of service are still possible
Smart-contract vulnerability	Audits, static analysis, unit and property-based tests, limited upgrade authority	Undiscovered bugs may persist
Off-chain document loss	Pinning, replication, backups, integrity checks	Availability and governance are operational
		responsibilities
Privacy leakage	Encryption, access control, selective disclosure, minimal on-chain metadata	Public chains expose transaction relationships

An unchangeable record is not the same as a true one. A recorded hash, approval, or transfer may reveal later changes, but it cannot show whether the original report was accurate, the baseline was suitable, or the reduction was additional and lasting. CarbonWise therefore requires qualified verification, recognized carbon accounting methodologies, independent auditing, and governance rules suitable for the relevant carbon market. The design should not claim regulatory compliance without mapping its implementation and operating model to applicable requirements.

2. Limitations

First, the supplied materials describe the intended design but include no source code, contract interfaces, deployment addresses, test data, or user-study materials. Second, the one-token-per-tonne model is an intended abstraction, not evidence that the deployed system implements that unit relationship. Third, a public Ethereum deployment may introduce fees, confirmation variability, privacy exposure, and throughput constraints. Fourth, IPFS references do not guarantee availability or confidentiality. Fifth, gasless transfers introduce relayer and replay risks. Sixth, a marketplace token is not automatically a recognized carbon credit. Seventh, the literature set contains heterogeneous conceptual, conference, preprint, and institutional materials; each reference should be checked by the author against the authoritative publisher or issuing body before submission.

3. Future Scope

The next step is to document the implementation: repository, contract source, ABI, deployment configuration, tests, and versioned architecture diagrams. Additional technical work can investigate batch-aware token standards, layer-2 deployment, event indexing, cross-registry reconciliation, encrypted evidence access, verifiable credentials, and monitored relayer services. Environmental work should integrate an explicit MRV methodology for cement-sector interventions, define baselines and emission factors, and compare the system with an existing registry or manual workflow. Human-centred evaluation should recruit representative participants, measure task burden and error rates, and document the cost of onboarding, wallet custody, verification, and trading. AI or ML components may be added as decision-support or anomaly-detection tools, but their outputs should remain reviewable and must not independently certify a reduction.

© 2026 IJSRET

XII. CONCLUSION

CarbonWise is a proposed design for testing whether smart contracts on an Ethereum-compatible network, digital credit records, IPFS evidence references, and optional EIP-712 transactions can make a marketplace easier to trace and use for smaller cement manufacturers. The design links these mechanisms while keeping ledger records separate from environmental MRV. With sound contract and governance controls, a blockchain can make ownership changes, approvals, and retirements easier to audit. It cannot establish that a claimed reduction occurred, prevent all fraudulent inputs, guarantee document availability, or give a token regulatory recognition.

This paper has no measurements yet for correctness, gas use, confirmation time, relayer success, IPFS availability, scalability, or ease of use. The proposed evaluation protocol should be completed before making claims about these outcomes. Before submission, the author should verify implementation-dependent statements against the repository, replace each to be confirmed with the author placeholder with confirmed information, check citations against authoritative sources, report test results, and align terminology with the applicable carbon-market methodology and governance framework.

REFERENCES

REFERENCES

1. A. V. Hirlekar, ``A decentralized blue-carbon MRV system and tokenized carbon credit marketplace with gasless transactions, IoT telemetry, and ML-driven SOC estimation," pp. 882–889, Dec. 2025, doi: 10.1109/ICICNIS66685.2025.11315559.
2. ``Governing carbon markets with distributed ledger technology," 2022, doi: 10.1017/9781108919166.
3. S. Heister, F. K. P. Hui, D. I. Wilson, and Y. Anker, ``Beyond opacity: Distributed ledger technology as a catalyst for carbon credit market integrity," Computers, vol. 14, no. 9, p. 403, Sep. 2025, doi: 10.3390/computers14090403.
4. R. Mandaroux, C. Dong, and G. Li, ``A European Emissions Trading System powered by distributed ledger technology: An evaluation framework," Sustainability, vol. 13, no. 4, p. 2106, Feb. 2021, doi: 10.3390/SU13042106.
5. V. Rawat, N. Dahiya, S. Rai, and A. Arora, ``A blockchain-based decentralized framework for carbon accounting, trading and governance," May 2022, doi: 10.1145/3543712.3543755.
6. L. A. Franke, M. C. Schletz, and S. Salomo, ``Designing a blockchain model for the Paris Agreement's carbon market mechanism," Sustainability, vol. 12, no. 3, p. 1068, Feb. 2020, doi: 10.3390/SU12031068.
7. P. Venkatesh, V. Kumar, R. Karthik, and U. Scholar, ``Blockchain powered carbon credit marketplace," pp. 582–585, Apr. 2024, doi: 10.1109/ICCSP60870.2024.10543794.
8. G. E. Marchant, Z. N. Cooper, and P. J. Gough-Stone, ``Bringing technological transparency to tenebrous markets: The case for using blockchain to validate carbon credit trading markets."
9. [9] R. Panwar, A. Kumar, P. Dhar, A. K. Sharma, A. Sharma, and P. K. Goel, ``Ensuring transparency in carbon markets with blockchain technology," pp. 149–172, Apr. 2025, doi:10.4018/979-8-3373-2091-5.ch007.
10. H. Cao, Y. Chen, X. Deng, Y. Sui, Y. Cai, and H. Zhang, ``A credit evaluation structure for voluntary emission reduction mechanism based on blockchain technology," Advances in Transdisciplinary Engineering, Oct. 2023, doi: 10.3233/ATDE230312.
11. A. Ballesteros-Rodríguez, J. De-Lucio, and M.-A. Sicilia, ``Tokenized carbon credits in voluntary carbon markets: The case of KlimaDAO," Frontiers in Blockchain, Oct. 2024, doi: 10.3389/fbloc.2024.1474540.
12. S. B. Prapulla, R. Hamsaveni, N. R. Himashree, M. Madhubala, M. Lavanya, A. Sata, and S. Patra, ``Blockchain-powered carbon credit management: Innovating sustainability tracking," pp. 1–7, Nov. 2024, doi: 10.1109/CSITSS64042.2024.10817037.
13. N. Mahfudiyah, A. Alamsyah, and H. Irawan, ``Integrated taxonomy of blockchain-based carbon credit tokenization and frontiers exploration," pp. 1–7, Aug. 2025, doi: 10.1109/ICCIT65724.2025.11167788.
14. Y.-C. Tsai, ``Blockchain-driven solutions for carbon credit trading: A decentralized platform for SMEs," arXiv preprint arXiv:2504.16085, Dec. 2024, doi: 10.48550/arXiv.2504.16085.
15. G. Tian, ``Blockchain's scope and purpose in carbon markets: A systematic literature review," Sustainability, vol. 15, no. 11, p. 8495, May 2023, doi: 10.3390/su15118495.
16. A. Galenovich, S. Lonshakov, and A. Shadrin, ``Blockchain ecosystem for carbon markets, environmental assets, rights, and liabilities: Concept design and implementation," pp. 229–242, 2018, doi: 10.1016/B978-0-12-814447-3.00017-3.
17. M. C. Schletz, A. Constant, A. Hsu, S. J. D. Schillebeeckx, R. Beck, and M. E. Wainstein, ``Blockchain and regenerative finance: Charting a path toward regeneration," Frontiers in Blockchain, vol. 6, Jul. 2023, doi: 10.3389/fbloc.2023.1165133.

© 2026 IJSRET

18. X. Liu, T. Bagchi, C. L. Sy, and H. O. Gao, ``A blockchain-based carbon registry platform for credible climate action in transportation,'' 2026. Available: https://www.nature.com/articles/s44168-026-00342-w
19. R. Abbas and O. F. Valilai, ``Evaluating the transparency and traceability of carbon tokens: Blockchain's role in circular economy certification,'' 2026. Available: https://www.sciencedirect.com/science/article/pii/S1877050926005193
20. C. Ningthoujam, B. Thoudam, and M. B. Devi, ``Blockchain IoT integration for automated carbon credit trading and environmental monitoring,'' International Journal for Multidisciplinary Research, vol. 7, no. 5, Sep. 2025, doi: 10.36948/ijfmr.2025.v07i05.56211.
21. P. Basu, P. Deb, and A. K. Singh, ``Blockchain and the carbon credit ecosystem: Sustainable management of the supply chain,'' Journal of Business Strategy, Jan. 2023, doi: 10.1108/JBS-09-2022-0157.
22. A. M. Aziz, A. Widjajarto, and A. Budiyono, ``Analysis and implementation of nodes communication between InterPlanetary File System (IPFS) in smart contract Ethereum,'' vol. 5, no. 1, Jan. 2020.

© 2026 IJSRET