CarboniX

Carbon Credit Exchange Platform

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Carbon Credit Exchange Platform

1. Executive Summary

A strategic 12-month project (March 2025-February 2026) to develop Thailand's first data-driven carbon credit exchange platform. With a 5M THB investment, the platform will integrate IoT sensors, real-time monitoring, and predictive analytics to facilitate transparent carbon credit trading. Expected to generate 6.2M THB annual revenue with a realistic 15% first-year ROI and 3-year payback period. Core features include automated data collection, emissions monitoring, trading capabilities, and internationally compliant verification systems. The platform will implement a phased approach to accuracy targets, starting at 85% for MVP with a roadmap to 90% as data quality improves over time.

2. Problem statement

Thailand has been facing an environmental crisis, driven by hazardous air pollution including the particular matter (PM 2.5). A significant portion of PM2.5 emissions has been generated from economic activities including agricultural burning, industrial manufacturing, and transportation. Based on our study, 50% of the PM2.5 is mainly from the open field burning in agriculture, followed by the manufacturers around 16% respectively.

Parallel, international trade dynamics are shifting. The European Union has introduced the **Carbon Border Adjustment Mechanism (CBAM)**, a regulation that imposes carbon tariffs on imported goods with high embedded emissions This presents a serious challenge for Thai exporters, especially those in energy-intensive sectors, who now face mounting pressure to demonstrate measurable carbon reduction or risk losing competitiveness in key markets.

Unfortunately, Thailand currently lacks a unified, transparent, and data-driven system for tracking carbon emissions and rewarding entities that actively reduce pollution. Without this infrastructure,

sustainable farming practices and low-emission manufacturing are difficult to verify, incentivize, or scale.

To address this gap, the **Carbon Credit Exchange Platform** is proposed.

- Build a trusted data ecosystem for air quality and emissions
- Enable fair and traceable carbon credit allocation
- Encourage cleaner practices through market-based incentives
- Help Thai businesses prepare for emerging global regulations like Carbon Border Adjustment Mechanism (CBAM)

This platform will serve as a foundation for Thailand's transition toward a more sustainable, competitive, and climate-resilient future by bridging the gap between environmental responsibility and economic opportunity.

3. Market Opportunity and Competitive Analysis

3.1. Market Opportunity

The revenue projections rely heavily on early-stage subscription and consulting fees. To mitigate potential slow market adoption, additional details on user acquisition strategies and how the platform plans to drive market awareness and adoption should be provided. This may include incentive programs for early users and strategic partnerships with key organizations such as the Thailand Greenhouse Gas Management Organization (TGO)

3.1.1. EU Carbon Border Adjustment Mechanism (CBAM) Impact

3.1.1.1. Over 800 Thai-listed companies exporting to the EU will be directly affected by CBAM from 2026

3.1.1.2. Annual exports to the EU worth approximately €140 billion per year face potential carbon taxes

3.1.2. Domestic Carbon Reduction Requirements

- 3.1.2.1. Thai heavy industries emit approximately 150 million tCO2e annually
- 3.1.2.2. Thailand's TGO commitment requires around 25% reduction by 2030
- 3.1.2.3. Estimated carbon credit market value of 50 billion baht

3.1.3. Strategic Position

- 3.1.3.1. The platform aims to be not just a trading venue but a strategic advisor helping Thai businesses navigate the carbon transition
- 3.1.3.2. Opportunity to lead Thailand's carbon credit market as it develops

3.1.4. Timing Advantage

- 3.1.4.1. Thailand is at a "critical juncture" in carbon reduction efforts
- 3.1.4.2. First-mover advantage in creating an end-to-end carbon management platform for the Thai market

3.2. Competitive Analysis

The competitive landscape for carbon credit exchanges spans several categories.

3.2.1. Global Carbon Exchanges:

- 3.2.1.1. European Union Emissions Trading System (EU ETS)
- 3.2.1.2. China National ETS
- 3.2.1.3. Regional Greenhouse Gas Initiative (RGGI) in the US

3.2.2. Verification & Certification Bodies

- 3.2.2.1. SGS
- 3.2.2.2. Bureau Veritas
- 3.2.2.3. TÜV SÜD

3.2.3. Carbon Credit Project Developers

- 3.2.3.1. South Pole
- 3.2.3.2. Climate Bridge
- 3.2.3.3. First Climate

- 3.3. Domestic Competition
  - 3.3.1. FTIX (FTI's Carbon Credit Exchange Platform)
    - 3.3.1.1. First Thai carbon exchange, launched in early 2023
    - 3.3.1.2. Backed by Federation of Thai Industries (FTI) with Thailand Greenhouse Gas Management Organization (TGO) support
    - 3.3.1.3. Targets Thai companies, especially exporters
    - 3.3.1.4. Weaknesses: Low trading volume (only ~1,800 tons traded in 11 months), lacks advanced features
  - 3.3.2. TGO (Thailand Greenhouse Gas Management Organization) & T-VER Registry
    - 3.3.2.1. Official national carbon credit program certifying GHG reduction projects
    - 3.3.2.2. Strengths: Government backing, local legitimacy, integration with Thai climate policy
    - 3.3.2.3. Weaknesses: Not a full trading platform, bureaucratic processes, primarily local focus
  - 3.3.3. Thailand Voluntary ETS Pilot (V-ETS)
    - 3.3.3.1. Government cap-and-trade testbed targeting GHG-intensive industries
    - 3.3.3.2. Primarily a learning/testing initiative rather than commercial platform
    - 3.3.3.3. Limited in scale and scope
- 3.4. Global Competitors
  - 3.4.1. Standards Organizations (Verra, Gold Standard)
    - 3.4.1.1. Set verification standards but don't provide trading platforms
    - 3.4.1.2. Widely trusted but face challenges with verification speed and integrity concerns
  - 3.4.2. Trading Platforms (AirCarbon Exchange, ClimateTrade)
    - 3.4.2.1. Modern exchanges with advanced features
    - 3.4.2.2. Focus on global markets rather than Thailand-specific needs
  - 3.4.3. ESG/Carbon Management Platforms (Persefoni, etc.)

3.4.3.1. Software for carbon accounting and reporting
3.4.3.2. Don't typically include trading functionality

3.4.4. Digital MRV & Rating Agencies (Pachama, Sylvera)
3.4.4.1. Provide technology-driven verification and quality assessment
3.4.4.2. Not full exchange platforms

3.5. SWOT Analysis

Strengths

- **Advanced Technology** - The system uses IoT sensors, real-time monitoring, and predictive analytics to collect carbon data with high precision
- **Comprehensive Data Structure** - Systematic data collection with clear metadata catalog covering all dimensions of carbon credit trading
- **Multi-layered Verification System** - Uses multi-level verification and cross-validation to ensure data reliability
- **Diverse Business Model** - Multiple revenue streams including transaction fees, consulting services, subscription fees, and training services
- **Financial Integration** - Connected to financial institutions through CSR Loan Programs to facilitate the transition to environmentally friendly production

Weaknesses

- **Initial Data Accuracy** - In the MVP phase, accuracy is at 85%, which needs improvement to reach 90% in subsequent phases
- **Challenges in Connecting Data from Multiple Sources** - Must collect data from multiple sources with different formats and standards

- **Dependence on Unclear Legal Framework** - Potential risks due to carbon credit regulations in Thailand still being in development
- **Need to Build Credibility** - New platform that needs to establish credibility in carbon credit verification and certification
- **System Complexity** - Complex technological infrastructure may create maintenance challenges

Opportunities

- **Implementation of CBAM** - EU will start using the Carbon Border Adjustment Mechanism in 2026, which will affect Thai companies exporting to Europe
- **Growth of Carbon Credit Market in Thailand** - Market value of approximately 50 billion baht with continuous growth
- **First-mover Advantage** - Opportunity to be the first comprehensive platform in Thailand
- **Support for Environmental Policies** - Aligns with Thailand's commitment to reduce greenhouse gas emissions by 25% by 2030
- **Collaboration with Government Agencies** - Opportunities to collaborate with TGO (Thailand Greenhouse Gas Management Organization) and other government agencies

Threats

- **Market Competitors** - Existing players in the market such as FTIX from the Federation of Thai Industries and Thailand Voluntary ETS Pilot (V-ETS)
- **Regulatory Risks** - Potential changes in regulations related to carbon credit trading
- **Data Security Risks** - Risks from cyber attacks and data leakage

- **Verification Challenges** - Difficulty in accurately verifying and certifying greenhouse gas emission data
- **Carbon Credit Market Volatility** - Carbon credit prices may be highly volatile, affecting user confidence in the platform

3.6. TOWS Matrix and Strategies

Offensive Strategies (SO Strategies) – Use strengths to seize opportunities

- **Develop a comprehensive carbon credit data management system** (S1, S2, S3 + O1, O2, O3)
  Use IoT sensors, real-time monitoring, and predictive analytics to lead in creating a comprehensive and transparent carbon credit data ecosystem.

- **Build partnerships with financial institutions and government agencies** (S4, S5 + O4, O5)
  Develop collaborations with Thailand Greenhouse Gas Management Organization (TGO), financial institutions, and government agencies to build credibility and expand user base.

Remedial Strategies (WO Strategies) – Address weaknesses by leveraging opportunities

- **Develop unified standards for data management and integration** (W2, W4 + O3, O5)
  Collaborate with public and private sectors to develop central standards for carbon credit data exchange.

- **Create continuous data quality improvement systems** (W1, W3 + O2, O4)
  Develop mechanisms to verify and improve data quality continuously to increase accuracy from 85% to 90% and beyond.

Defensive Strategies (ST Strategies) – Use strengths to avoid threats

- **Develop multi-layered security and data verification systems** (S3, S5 + T3, T4)
  Strengthen security systems with multi-layered verification technology and strict identity verification systems.

- **Create mechanisms to maintain price stability and market liquidity** (S2, S4 + T1, T5)
  Develop mechanisms to reduce carbon credit price volatility and create market liquidity.

Passive Strategies (WT Strategies) – Reduce weaknesses and avoid threats

- **Develop flexible regulatory tracking and compliance systems** (W3, W5 + T2, T4)
  Create systems that can adapt to changing regulations and policies.

- **Create transparency in data verification and certification processes** (W2, W4 + T1, T3)
  Develop transparent and verifiable processes for carbon credit certification to build credibility and differentiate from competitors.

Strategies for Carbon Credit Exchange Platform
Strategy 1: Develop reliable and efficient digital data infrastructure for carbon credit trading (SO + ST)

Objectives:

- Have accurate and reliable data infrastructure for carbon credit trading
- System capable of efficiently connecting and integrating data from multiple sources

- Data security system following international standards

  Tactics:

  - Provide efficient and secure data infrastructure (SO)
    - Develop IoT sensors for collecting greenhouse gas emission data
    - Create high-efficiency data storage and processing systems
    - Develop data security systems according to ISO 27001 standards

  - Develop multi-layered data verification systems (ST)
    - Use AI technology to detect data anomalies
    - Create cross-verification systems between multiple data sources
    - Develop automated verification processes and human verification when necessary

  Strategy 2: Create a transparent and efficient data ecosystem for carbon credit trading (SO + WO)

  Objectives:

  - Create a system with transparency and accountability at every step of carbon credit trading
  - Develop efficient processes for connecting carbon credit buyers and sellers
  - Build confidence in the quality and accuracy of carbon credits traded on the platform

Tactics:

- Develop transparent and verifiable trading systems (SO)
  - Create end-to-end carbon credit tracking systems
  - Develop disclosure systems for information related to traded carbon credits
  - Create efficient buyer-seller matching mechanisms
- Create unified standards for data management and integration (WO)
  - Develop central standards for carbon credit data exchange
  - Build cooperation with public and private sectors in developing joint standards
  - Develop efficient data connection systems between stakeholders in the carbon credit ecosystem

Strategy 3: Develop continuous data quality improvement systems (WO + WT)

Objectives:

- Increase data accuracy from 85% to 90% and continuously higher
- Create systematic data quality verification and improvement processes
- Develop personnel with expertise in carbon credit data management

Tactics:

- Develop continuous data quality verification and improvement systems (WO)
    - Create automated data quality verification processes
    - Develop clear and measurable data quality indicators
    - Create continuous data quality improvement cycles
- Create transparency in data verification and certification processes (WT)
    - Develop transparent processes for data verification and certification
    - Create random verification systems by independent experts
    - Develop easy-to-understand and accessible data quality reporting

Strategy 4: Build cooperation with stakeholders to develop a sustainable carbon credit ecosystem (SO + WT)

Objectives:

- Build partnerships with government agencies, private sector, and international organizations
- Develop systems that can adapt to changing regulations and policies
- Create widespread awareness and understanding about carbon credits

Tactics:

- Build partnerships with government agencies and private sector (SO)
    - Develop cooperation with TGO and other government agencies
    - Build collaboration with financial institutions to develop financial products related to carbon credits
    - Create cooperation networks with the private sector to develop the carbon credit market
- Develop flexible regulatory tracking and compliance systems (WT)
    - Create teams to monitor relevant regulatory changes
    - Develop systems that can adapt quickly to regulatory changes
    - Build cooperation with experts in environmental law and policy

Strategic Alignment with Core Principles

- Integrated carbon credit data from multiple sources for completeness → Aligns with Strategy 1: Developing data infrastructure capable of connecting data from multiple sources
- Transparent and efficient data ecosystem with verifiable transaction records → Aligns with Strategy 2: Creating a transparent and efficient data ecosystem
- Progressive data accuracy and continuous quality improvement → Aligns with Strategy 3: Developing continuous data quality improvement systems
- Support sustainable carbon credit trading through reliable data management → Aligns with Strategy 4: Building cooperation to develop a sustainable carbon credit ecosystem

3.7. Marketing & Communication Strategy

3.7.1 Marketing Objective

Drive awareness of the platform among target users (exporters, manufacturers, and Agri-cooperatives).Establish CarboniX as a trusted and data-driven carbon credit trading ecosystem.Support user acquisition and engagement through phased campaigns.Promote compliance readiness for CBAM and Thailand’s national sustainability goals.

3.7.2 Target Audience Segmentation

Target Segment	Subgroup	Pain Point	Strategic Message
Exporters	High-emission manufacturers (steel, cement, food)	CBAM risks from EU	“Mitigate CBAM tariffs through verified carbon reduction”
Industrial SMEs	Energy-intensive SMEs	Lack of emission monitoring tools	“Turn your data into profit through carbon credit sales”
Farms/Agri-Cooperatives	Crop-burning zones	No incentive to reduce burning	“Sustainable farming now pays you back”
Financial Institutions	ESG investors, banks	Difficulty in finding verified ESG portfolios	“Thailand’s reliable carbon credit investment platform”

3.7.3 Go to market strategy

Phase	Timeline	Strategy	Key Tactics
Pre-Launch	Mar–May 2025	Build awareness & credibility	Partner with TGO & FTI, host public webinars (e.g. “CBAM Survival Guide”)
Pilot Onboarding	Jun–Sep 2025	Early adopter engagement	Free IoT setup for top 10 users, publish case studies, run expert interviews
Platform Launch	Oct 2025	Market-wide adoption	Press release, launch event, media coverage, industry roadshows
Post-Launch Growth	Nov 2025–Feb 2026	Expand to SMEs and farmers	Localized workshops, CSR loan campaign, referral programs

3.7.4 Communication Channels

Channel	Audience	Purpose
Website & Platform Dashboard	All users	Platform features, registration, real-time trading
LinkedIn	Corporates, policymakers	Thought leadership, market analysis
YouTube & Webinars	General public, SMEs	Educational content, platform demos
Line OA / Facebook	Farmers, cooperatives	Workshop updates, onboarding support
Email Newsletter	Registered users	Monthly updates, success stories
Media & Press	Broader market	Establish credibility, announce milestones

3.7.5 Key Messaging & Positioning

- **Trust & Verification:** “Backed by real-time sensor data and global certification standards.”
- **Monetization:** “Transform emissions reduction into verified income.”
- **Readiness for CBAM:** “Get CBAM-ready before 2026 through measurable climate action.”
- **Sustainability at Scale:** “A national platform connecting data, finance, and green transformation.”

3.7.6 Marketing KPIs

Metric	Target
Website Traffic	10,000 monthly visits by Q3 2025
Early Registrations	500 pilot users onboarded by Sep 2025
Activation Rate	60% active usage among pilot participants
Revenue-Linked Leads	50 corporate accounts with >10,000 tCO2e/year
Social Media Engagement	5,000 LinkedIn followers by end of year
Training Participants	1,000 attendees in certified workshops by Q1 2026

4. Vision, Mission, and Strategic Objectives

4.1. Vision

Create a transparent and efficient data ecosystem to support sustainable carbon credit trading and greenhouse gas emission reduction through reliable and innovation-driven data management from agricultural and industrial in Thailand.

4.2. Mission

4.2.1. Consolidation of trustworthy dataset-related emissions.

4.2.2. Developing Automated Verification Systems

4.2.3. Encourage collaboration among the industrial sector, agricultural, and related parties to create a sustainable carbon credit ecosystem

5. Business Model

The Carbon Credit Exchange serves as a comprehensive digital marketplace, specializing in carbon credit trading, environmental, social, and governance (ESG) consulting, and sustainability management solutions. The

platform strategically generates revenue through multiple complementary streams, effectively catering to diverse client needs and industry demands.

- **Transaction Fees**

The platform charges a transaction fee of 0.45% on each carbon credit exchange processed, thereby monetizing trading activity and market participation. This fee structure is competitive with international exchanges while providing sustainability as trading volumes grow.

- **Enterprise Subscriptions**

Customized enterprise subscription plans, beginning at $5,000 monthly, grant organizations full access to sophisticated sustainability management tools, extensive analytical resources, ESG compliance reporting capabilities, and dedicated client support.

    - Tiered services levels based on organization size and needs.
    - Volume-based pricing for larger enterprises
    - Sector-specific analytics and benchmarking
    - Customizable dashboard and reporting capabilities
- **Corporate ESG Solutions**

Tailored consultancy offerings are provided to assist businesses in defining, implementing, and managing sustainability strategies. This includes facilitating compliance with ESG standards, achieving Net Zero targets, and efficiently navigating evolving regulatory frameworks.

- **Market Data & API Integration**

The platform supplies high-quality market intelligence, detailed analytical reports, and customizable API integration services, equipping organizations with actionable insights into carbon markets and enhancing ESG performance evaluation.

- **Training & Seminars**

Professional education initiatives, including comprehensive workshops, expert-led seminars, and training programs, are provided to build organizational capacity and expertise in carbon credit trading, sustainability best practices, and regulatory compliance.

6. Data Strategies
    - Progressive Data Accuracy & Quality
    - Verifiable, Transparent Ecosystem
    - Integrated Multi-source Carbon Data
    - Sustainable & Adaptive Governance

7. Data Strategy Framework
    - 7.1. Progressive data accuracy and continuous quality improvement
    - 7.2. Transparent and efficient data ecosystem with verifiable transaction records
    - 7.3. Integrated carbon credit data from multiple sources for completeness
    - 7.4. Support sustainable carbon credit trading through reliable data management

8. Data Implement
    - 8.1. Identify Data Assets
        - 8.1.1. Environment Monitoring Data
            - 8.1.1.1. Air Quality from sensors (PM10, PM2.5, CO, NOx, Wind Speed, Temperature)
            - 8.1.1.2. Weather patterns and seasonal variations
        - 8.1.2. Location Data

8.1.2.1. Geolocation (latitude, longitude, station_name, sub-district, district, province, region)
8.1.2.2. Land use classification and change detection
8.1.2.3. Proximity to sensitive environmental areas

8.1.3. Market Data

8.1.3.1. Carbon credits, trade records, and market prices
8.1.3.2. Historical trading volumes and price trends
8.1.3.3. Bid/ask spreads and order book depth
8.1.3.4. International carbon market benchmarks

8.2. Data Roles & Responsibilities

8.2.1. Customer Data

Data Owner	Data Steward
Oversees customer profiles, trade records, and transactions	Ensures customer data accuracy and consistency
Ensures compliance with privacy regulations	Implements data quality checks and cleansing procedures
Responsible for data access control and security	Monitors compliance with data standards
Manages customer data lifecycle and retention policies	Facilitates data issue resolution

8.2.2. Air Quality Data

Data Owner	Data Steward
Manages sensor data (PM10, PM2.5, CO, NOx) and ensures compliance	Monitors air quality data validity and geolocation accuracy
Accountable for sensor network performance and data collection	Implements quality control for sensor data
Oversees data integration from multiple environmental sources	Manages anomaly detection and data cleaning processes
Responsible for environmental data quality standards	Facilitates integration of multiple environmental data sources

8.2.3. Market Price Data

Data Owner	Data Steward
Maintains carbon credit price and market trend data	Updates and validates market price data
Responsible for price integrity and trading analytics	Implements market data quality standards

Data Owner	Data Steward
Oversee market data feed integrations	Monitors for pricing anomalies and market irregularities
Manages historical price archives and benchmark data	Ensures proper data validation before publication

8.2.4. Carbon Credit Data Owner

Data Owner	Data Steward
Manages the creation, trading, and regulation of carbon credits	Ensures compliance and validates credit transactions
Ensures alignment with international standards	Maintains credit registry data integrity
Oversee credit issuance and retirement processes	Implements verification data standards
Responsible for credit registry integration	Monitors credit lifecycle data for completeness

8.3. Data Policies and Quality Standards

8.3.1. Define High Quality Data

Accuracy

- Data accuracy is no less than 85%, which is the industry standard in the initial phase of the platform
- Consistent with technical feasibility of sensor measurements
- Compared with reliable data sources such as Pollution Control Department (PCD), Thailand Greenhouse Gas Management Organization (TGO), Verra, Gold Standard
- Repeatedly measured with multiple sensors in the same area

$$Accuracy = (1 - \frac{|Measured\ Value - Standard\ Value|}{Standard\ Value}) \ x\ 100\%$$

Reliable Sources

- Carbon credit data must be certified by international standards (Verra, Gold Standard)
- Sensor data must come from equipment certified by regulatory authorities

Transparency and Auditability

- Complete record of all data changes
- Ability to trace back to original data

Completeness and Consistency

- Use of standardized formats and units of measurement throughout the system

- Appropriate statistical techniques for estimating missing data
- Systematic process for detecting missing data

Timeliness and Relevance

- Review data usage requirements with users every 6 months
- Monitor data usage to identify datasets with low utilization

8.3.2. Define a Data Quality Strategy

8.3.2.1. Data accuracy in the initial phase, with continuous quality improvement

8.3.2.2. Trading data quality must be verifiable and transparent

8.3.2.3. Carbon credit data must be able to integrate from multiple sources for completeness

8.3.3. Define the Scope of the Initial Assessment

8.3.3.1. Identify Critical Data

- Carbon emission data from installed sensors
- CO and PM2.5 pollution data for dashboard display
- Verified carbon emissions data from organizations (3rd Party)
- Market price data for carbon credits
- Member information and login data
- Carbon credit verification and certification data
- Carbon emission reporting data and alert system

8.3.3.2. Identify Existing Rules and Patterns

- Rules for sensor data validation for accuracy

- Methods for collecting and integrating data from various sources
- Rules for carbon credit certification and verification
- Data cleaning and standardization protocols
- Privacy rules and compliance with GDPR and PDPA regulations

8.3.4. Perform Initial Data Quality Assessment

8.3.4.1. Identify and prioritize issues

- Inconsistency problems in data formats from various sources, both sensors and external agencies
- Delays in data updates, especially for price data and trading volumes that require real-time information
- Incompleteness of carbon credit project data affecting credibility
- Limitations in accessing data from relevant government and private agencies
- Accuracy of sensor measurements that may deviate in harsh environments
- Challenges in integrating data from multiple sources to achieve a unified standard
- Security risks and compliance with PDPA/GDPR regulations in data management

8.3.4.2. Perform root cause analysis of issues

- Lack of central standards for collecting and exchanging data among stakeholders in the carbon credit ecosystem
- Limitations in real-time data processing infrastructure and lack of automated systems for updating data from various

sources, resulting in delays in updating price and trading volume data

- Verification and certification processes that are not yet automated and rely on human verification
- Absence of clear agreements or cooperation frameworks between agencies, making data access difficult
- Lack of guidelines and standards for selecting and calibrating sensors appropriate for the environment
- Limitations of technological infrastructure supporting large and complex data management
- Absence of a collaborative Data Governance Framework

8.3.5. Identify & Prioritize Improvements

8.3.5.1. Prioritize Actions based on Business Impact

- Develop a high-quality data collection system to achieve at least 80% accuracy in forecasting
- Establish MOUs with government and private agencies to resolve data access issues
- Develop data integration standards to support the carbon credit trading system
- Improve data anonymization systems and compliance requirements to reduce privacy risks

8.3.5.2. Develop Preventative and Corrective Actions

- Implement automated data quality verification systems in the data collection process
- Establish data standards and verification processes
- Train teams on the importance of data quality
- Develop data security systems from the start

- Correction
- Develop data cleaning processes for existing data
- Create data verification and certification systems to increase reliability
- Develop automated data verification mechanisms to identify and resolve issues
- Create emergency plans for cases of low-quality data

8.3.5.3. Confirm Planned Actions

- Hold meetings with stakeholders to confirm data quality improvement plans
- Establish key performance indicators (KPIs) for tracking data quality improvements
- Create documentation confirming action plans with clear timelines
- Assign responsibilities to teams and establish progress reporting mechanisms
- Create mechanisms for monitoring and evaluating plan implementation

8.4. Data Governance Processes

8.4.1. Introduction

The Data Governance Process for the Carbon Credit Exchange Platform is designed to ensure the integrity, accuracy, and transparency of data. This process establishes high-quality data standards, risk mitigation strategies, compliance measures, and auditing mechanisms to support regulatory and operational excellence.

8.4.2. Data Quality Management

8.4.2.1. Data Accuracy & Validation

- Ensure a minimum accuracy level of 85%, with a target of 90%.
- Compare data against industry benchmarks and verified sources such as government agencies (e.g., pollution control departments) and international standards (Verra, Gold Standard).
- Utilize multiple sensors and verification techniques for cross-validation.

8.4.2.2. Source Reliability

- Only certified data from internationally recognized standards are accepted.
- All sensor data must come from approved devices regulated by relevant authorities

8.4.2.3. Transparency & Auditability

- Maintain detailed audit trails for all data changes.
- Implement a system for users and auditors to trace data back to its source.

8.4.2.4. Completeness & Consistency

- Use standardized formats and measurement units across the platform.
- Implement systematic methods to detect and handle missing data.

8.4.3. Risk Assessment & Mitigation

8.4.3.1. Regulatory Compliance & Strategic Risks

8.4.3.1.1. Align governance processes with evolving policies such as the Thailand 20-Year Energy Efficiency Development Plan and CBAM (Carbon Border Adjustment Mechanism).

8.4.3.1.2. Continuously monitor legal requirements and update governance policies accordingly.

8.4.3.2. Operational & Financial Risks

8.4.3.2.1. Implement a proactive risk management strategy, including regular assessments.

8.4.3.2.2. Maintain contingency funds and compliance protocols to minimize disruptions.

8.4.4. Roles & Responsibilities

8.4.4.1. Data Governance Team

8.4.4.1.1. Oversee the implementation and continuous improvement of data governance activities.

8.4.4.1.2. Ensure adherence to established policies and compliance measures.

8.4.4.2. Advisory Role

8.4.4.2.1. Appoint industry experts and regulatory advisors for oversight.

8.4.4.2.2. Provide strategic guidance on improving governance frameworks.

8.5. Metadata Catalog and Data Discoverability

This Metadata Catalog has been created to define the structure and standards of data used in the carbon credit exchange platform.

1. Ensure data accuracy: Define necessary data items and reference standards to ensure data accuracy of no less than 85%
2. Enable traceability: Collect necessary data for tracking and verifying carbon credits throughout their lifecycle
3. Promote transparency and reliability: Identify sources and reference standards for each type of data
4. Support interoperability: Facilitate data exchange between various systems within the platform and with external systems

This document categorizes metadata into 8 main types covering all dimensions of carbon credit exchange platform operations.

1. Carbon Project Metadata

MetadaItem	Description	DataType	Example	Data Source
project_id	Unique project code	string	TH-CCEP-2025-0001	Automatically generated
project_name	Project name	string	Ban Huay Sak Community Forest	Project registrant

2. Carbon Credit Transaction Metadata

MetadaItem	Description	DataType	Example	Data Source
transaction_id	Unique transaction code	string	TRX-2025-123456	Automatically generated
seller_id	Seller code	string	ACC-2025-	Trading

MetadaItem	Description	DataType	Example	Data Source
			001	system
buyer_id	Buyer code	string	ACC-2025-002	Trading system

3. Sensor and Measurement Metadata

MetadaItem	Description	DataType	Example	Data Source
sensor_id	Sensor code	string	SEN-CO2-0012	Sensor registration system
sensor_type	Sensor type	enum	co2, methane, temperature, humidity	System administrator

4. Measurement Data Metadata

MetadaItem	Description	DataType	Example	Data Source
measurement_id	Measurement code	string	MEAS-2025-123456789	Automatically generated
sensor_id	Sensor code that performed the measurement	string	SEN-CO2-0012	Sensor system
timestamp	Time of measurement	datetime	2025-06-15T13:45:30+07:00	Sensor system

5. User and Account Metadata

MetadaItem	Description	DataType	Example	Data Source
user_id	User code	string	USER-2025-001	Registration system
account_id	Account code	string	ACC-2025-001	Registration system
account_type	Account type	enum	individual, corporation, government, ngo	User

6. Certification and Verification Metadata

MetadaItem	Description	DataType	Example	Data Source
certification_id	Certification code	string	CERT-2025-0001	Certification body
project_id	Project code	string	TH-CCEP-2025-0001	System

7. Carbon Credit Tracking Metadata

MetadaItem	Description	DataType	Example	Data Source
credit_batch_id	Credit batch code	string	BATCH-2025-000	Credit issuance system

8. Forecast and Model Metadata

MetadaItem	Description	DataType	Example	Data Source
model_id	Model code	string	MODEL-CO2-2025-01	Forecast system
model_name	Model name	string	CO2	Forecast

MetadaItem	Description	DataType	Example	Data Source
			Emission Forecast Model	system
model_type	Model type	enum	regression, time_series, neural_network	Forecast system

9. Carbon Market and Pricing Metadata

MetadaItem	Description	DataType	Example	Data Source
market_data_id	Market data code	string	MKT-DATA-2025-06-15	Market system
timestamp	Time of data recording	datetime	2025-06-15T16:00:00+07:00	Market system
credit_type	Credit type	enum	forestry, renewable, methane, energy_efficiency	Market system
current_price	Current price (THB/tCO2e)	float	135.50	Market system

10. Compliance and Regulatory Metadata

MetadaItem	Description	DataType	Example	Data Source
regulation_id	Regulation code	string	REG-TH-2025-001	Regulatory system
regulation_name	Regulation name	string	Climate Change Act B.E. 2568	Regulatory system

Implementation and Maintenance

Implementation

- This Metadata Catalog should be used as a standard for designing databases and APIs of the platform
- Developers should strictly adhere to the defined data types and formats
- In case new metadata items need to be added, they should be proposed to the data governance committee

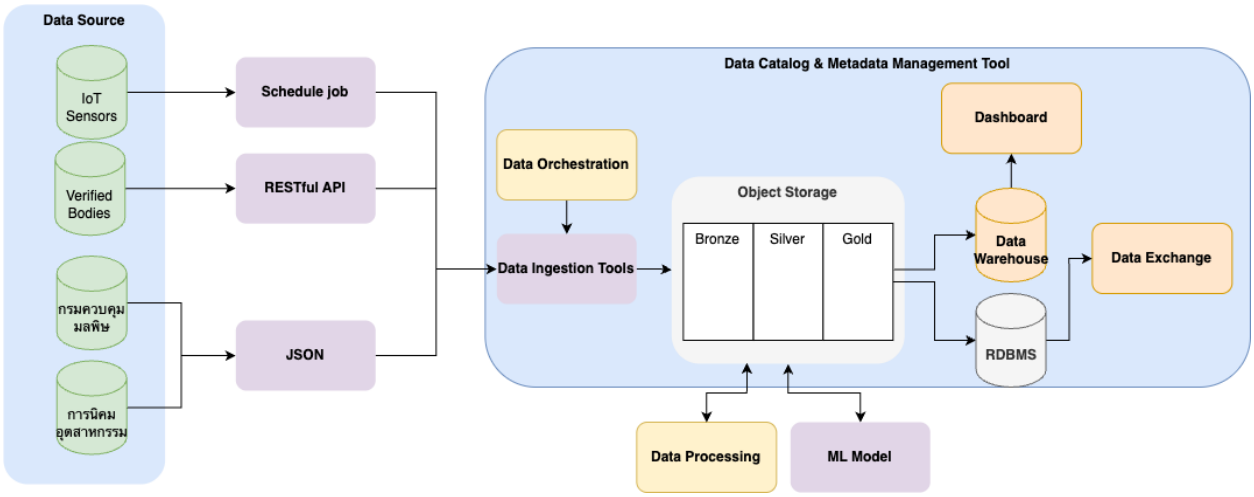
Maintenance

- Review and update the Metadata Catalog every 6 months
- Monitor changes in industry standards and update accordingly
- Maintain a history of changes to the Metadata Catalog and reasons for changes

Performance Measurement

- Track the compliance rate with the Metadata Catalog
- Assess the quality of data recorded according to the defined metadata structure
- Collect and analyze user feedback for improvements

9. Data Architecture and Workflow

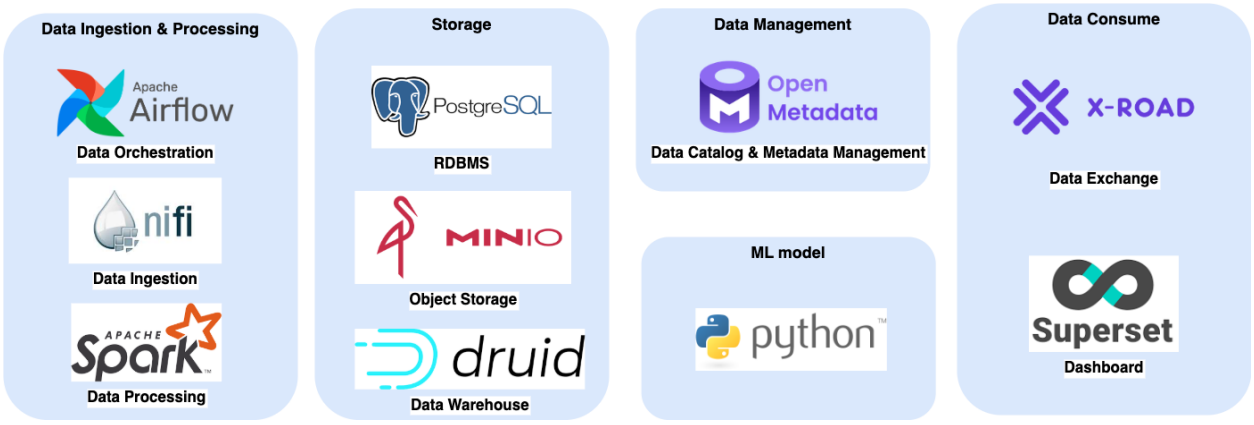


The Carbon Credit Exchange Platform will collect data from various sources

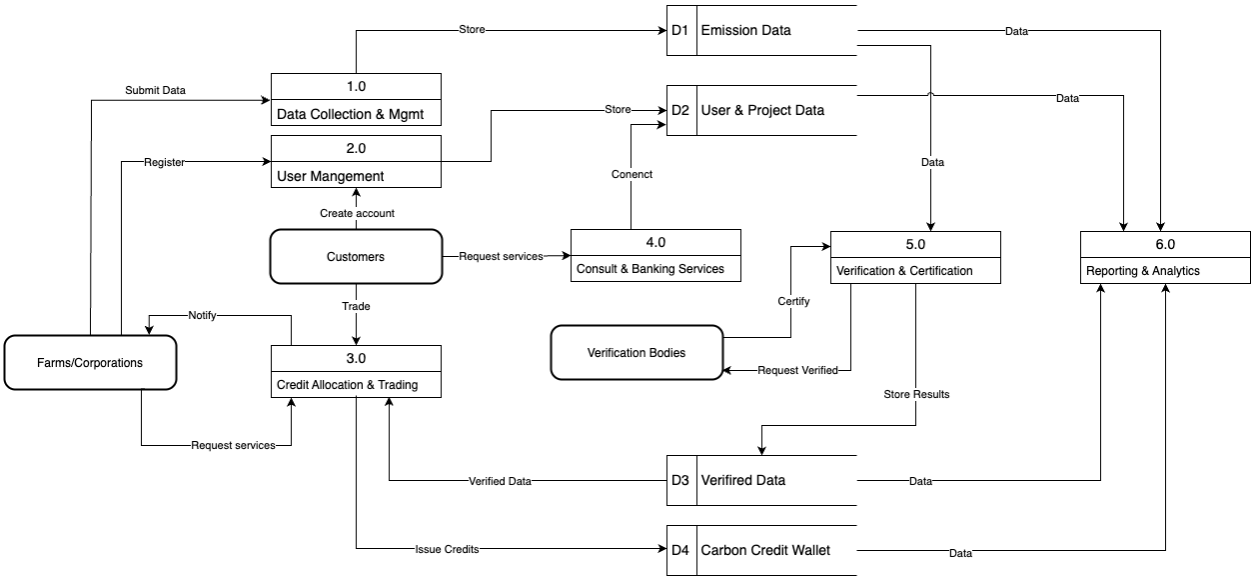
1. **Structured Data Sources**:
    - IoT sensor networks collecting emissions data (CO2, methane, PM2.5)
    - Environmental parameters (temperature, humidity, wind speed)
    - Transaction records from trading activities
    - User registration and account information
    - Project documentation and verification results

2. **Unstructured Data Sources**:
    - Satellite imagery for land use verification
    - Verification reports and certification documents
    - Project documentation and methodology descriptions
    - Environmental impact assessments
3. **Data Acquisition Methods**:
    - **Real-time data collection**: IoT sensors transmitting at 5-minute intervals
    - **API integrations**: With TGO Registry, verification bodies, and market data providers

- **Batch uploads**: For verification documents and project registrations
- **Web scraping**: For regulatory updates and market information
- **Manual input**: For user registration and project details



Data Flow Diagram



External Entities

Represent people, organizations, or other systems that interact.

1. **Farms/Corporations** - The primary sources of emissions data and beneficiaries of carbon credits
2. **Customers** - Users who trade carbon credits and consume services
3. **Verification Bodies** - Third-party organizations that validate emissions data

Processes (Functional Areas)

Main activities performed by the system.

1. **Data Collection & Management (1.0)** - Receives and processes emissions data from farms/corporations
2. **User Management (2.0)** - Handles user registration and account management
3. **Credit Allocation & Trading (3.0)** - Manages the issuance and trading of carbon credits
4. **Consult & Banking Services (4.0)** - Provides additional services to users
5. **Verification & Certification (5.0)** - Manages the verification process for emissions data
6. **Reporting & Analytics (6.0)** - Generates reports and analytical insights

Data Stores

Represent the databases where information is stored.

1. **D1: Emission Data** - Stores raw emissions information
2. **D2: User & Project Data** - Stores user accounts and project details
3. **D3: Verified Data** - Stores emissions data that has been verified
4. **D4: Carbon Credit Wallet**- Records all carbon credit transactions

Key Data Flows

Initial Data Entry and User Registration

- Farms/Corporations submit emissions data to Process 1.0, which stores it in D1
- Farms/Corporations and Customers register with Process 2.0, which creates accounts in D2

Verification Workflow

- Process 5.0 (Verification & Certification) retrieves data from D1 and D2
- It then interacts with external Verification Bodies to certify the data
- Verified results are stored in D3

Credit Management Workflow

- Process 3.0 accesses verified data from D3
- Credits are issued and recorded in D4 (Carbon Credit xxx)
- Farms/Corporations are notified about credit issuance
- Customers can trade credits through Process 3.0

Services and Reporting

- Both types of users can request services from Process 4.0
- Process 6.0 generates reports using data from all data stores
- Process 4.0 connects with user data in D2 to provide personalized services

Data Collection Components

The diagram effectively shows multiple data collection pathways

Farms/Corporations submit data to the Data Collection & Management process (1.0). This represents the critical first step of any data project acquiring raw information from primary sources. In a typical data project, these sources might include

- API connections to other systems
- IoT devices providing real-time measurements
- Manual uploads from stakeholders
- Web scraping and public datasets
- Survey responses and customer feedback

The User Management process (2.0) shows how we collect a different type of data - user information and credentials. This represents the important distinction between operational data (emissions, in this case) and administrative data (user accounts and permissions).

Data Storage Architecture

The diagram illustrates four distinct data stores (D1-D4), which demonstrates a sophisticated approach to data storage.

D1 (Emission Data) represents the raw data repository, similar to a data lake where unprocessed information first lands. This might use technologies like

- Object storage (MinIO) for object storage data
- Relational databases (PostgreSQL) structured information

D2 (User & Project Data) shows how administrative data requires separate storage considerations, often with higher security requirements since it contains personal information.

D3 (Verified Data) demonstrates the concept of a curated data layer - information that has been processed, validated, and approved for analytical use. This typically resembles a data warehouse structure with well-defined schemas.

D4 (Carbon Credit Wallet) represents a transactional database that tracks activity based on the processed data. This might be implemented as a relational database with strong consistency guarantees.

Data Management Processes

The diagram elegantly shows several critical data management functions:

The Verification & Certification process (5.0) illustrates data validation and quality assurance. This represents how raw data must undergo scrutiny before being trusted for decision-making. In a typical data project, this might involve

- Automated data quality checks
- Manual review processes
- Third-party validation
- Reconciliation against trusted sources

The flow from D3 to process 3.0 (Credit Allocation & Trading) shows how validated data becomes actionable information that drives business processes. This represents the transition from data as a passive asset to data as an operational driver.

The Reporting & Analytics process (6.0) demonstrates how data from multiple sources can be combined to generate insights, pulling from all four data stores to create comprehensive views of the business.

Data Processing and Analytics Workflows

1. Data Processing Architecture

1.1 Processing Methodologies

Batch Processing	The foundational mode of operation. Data ingestion and transformation are executed at consistent intervals (e.g., hourly or daily), thereby ensuring stability and enabling rigorous quality assurance. Real-time streaming is purposefully excluded to preserve deterministic execution.

1.2 ETL Pipeline Structure

Extract Phase

Primary data inputs include:

- Emission metrics (CO_2, CH_4, PM2.5) and environmental conditions from IoT sensors
- User profile and project registration data
- Transactional records from the carbon trading
- Certification and verification outcomes from third-party entities
- Market and regulatory datasets via external APIs

Acquisition methods:

- **API integrations:** Automated data exchange with TGO, Verra, and ESG partners
- **Batch processing:** Scheduled uploads of verified documentation and project datasets
- **Web crawling/scraping:** Continuous ingestion of news, policies, and regulatory announcements
- **Manual data entry:** Curated uploads and validations by project developers and administrators

Transform Phase
Key transformation processes:

- Handling of incomplete, erroneous, or anomalous values
- Normalization of data types, formats, and measurement units
- Application of business logic rules (e.g., emission thresholds, geospatial mapping)

Load Phase
Processed data is organized into discrete storage layers:

- **D1: Emission Data** — Raw sensor-derived environmental and emissions data
- **D2: User & Project Data** — Secure administrative and identity records
- **D3: Verified Data** — Certified and standardized datasets for operational use
- **D4: Carbon Credit Wallet** — Tamper-evident transactional record of issued and traded credits

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2. Analytics Workflows

2.1 Analytics Lifecycle

Phase	Functionality
1. Data Cleaning	Preprocessing during the transformation stage, including error correction, outlier elimination, and enforcement of schema conformity.
2. Validation	Verification protocols and third-party audits (Process 5.0) that ensure compliance, reliability, and fitness for downstream modeling.

3. Modeling	Quantitative estimation and allocation of carbon credits using deterministic models (Process 3.0), based on validated emissions data.
4. Visualization and Reporting	Aggregated visualizations and reports generated via Process 6.0, drawing from all storage layers (D1–D4) to inform both internal and external stakeholders.

2.2 Analytical Capabilities

- Longitudinal analysis of emission patterns across regions and sectors
- Attribution modeling for optimization of credit issuance
- Certification lifecycle tracking and compliance reporting
- Behavioral analysis of user activity and platform engagement

3. Automation and Orchestration Framework

3.1 Automation Protocols

Workflow Component	Automation Strategy
ETL Execution	Time-triggered workflows manage recurring data ingestion, transformation, and loading with consistency and minimal human intervention.
Anomaly Detection and Alerts	Automated rules monitor data quality, triggering alerts for inconsistencies, anomalies, or deviations from expected behavior.
Reporting	Scheduled or data-refresh-driven report generation supports operational monitoring and regulatory compliance.

3.2 Orchestration Framework Recommendations

The system is well-positioned to integrate enterprise-grade orchestration tools for modular, scalable data management.

Functional Area	Recommended Technologies
Workflow Scheduling	Apache Airflow, Prefect
Data Testing & Quality Assurance	dbt (Data Build Tool), Great Expectations
Visualization & BI	Tableau, Power BI, Apache Superset
Data Storage & Management	PostgreSQL, MinIO

10. Carbon Credit Exchange Mechanism and Solution

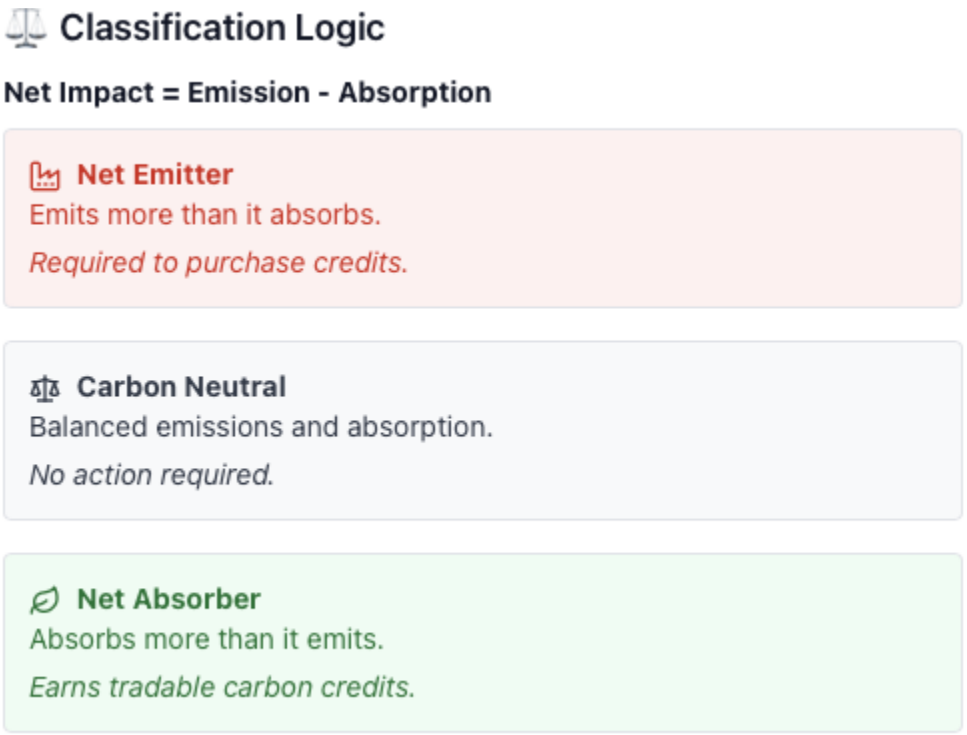
10.1. Farm and Corporate Classification System

The Farm and corporate Classification System forms the foundation of our Carbon Credit Exchange Platform by categorizing agricultural operations and manufacturing activities based on their environmental impact. This innovative system uses advanced data analytics and IoT sensors to create a transparent, evidence-based classification.

Three-Tier Classification Framework

1. Net Emitters
    - Farms and corporations produce more PM2.5 and greenhouse gases than they absorb
    - Typically characterized by intensive burning practices, heavy machinery usage, and limited carbon sequestration
    - Required to purchase carbon credits to offset their environmental impact
    - Provided with tailored transition plans and technological recommendations
2. Net Neutral
    - Farms and corporations maintain a balanced carbon profile through careful management
    - Implementing moderate sustainable practices like reduced tillage and partial cover cropping
    - Neither required to purchase nor eligible to sell carbon credits
    - Offered incentives to improve practices and transition to Net Absorber status
3. Net Absorbers
    - Farms and corporations actively sequester more carbon than they emit
    - Employing regenerative agriculture practices, agroforestry, or dedicated carbon farming
    - Eligible to generate and sell carbon credits based on verified absorption rates

- Showcased as industry leaders with premium market positioning



Advanced Classification Methodology

Our classification system employs multiple data sources to ensure accuracy and credibility:

- IoT Sensor Network: Strategically placed sensors measuring real-time emissions, soil carbon content, and environmental conditions
- Satellite Imagery Analysis: Remote sensing to verify land use, crop coverage, and burning incidents
- Comprehensive Carbon Accounting: Full life cycle assessment considering all emission sources and sequestration activities
- Independent Verification: Third-party auditing to maintain integrity and compliance with international standards

The system recalculates classifications quarterly based on updated data, allowing farms and corporations to track their progress and adjust practices accordingly. This dynamic approach encourages continuous improvement across the agricultural sector.

10.2. Credit Allocation and Trading

10.2.1. **Science-Based Calculation**

10.2.1.1. Credits allocated based on verified PM2.5 and carbon impact data

10.2.1.2. Standard measurement: 1 credit = 1 tCO2e (ton of carbon dioxide equivalent) reduced or sequestered

10.2.1.3. Differentiated credit types reflecting various environmental benefits (e.g., biodiversity enhancement, water conservation)

10.2.1.4. Vintage classification system to account for the timing of emission reductions

10.2.2. **Verification Process**

10.2.2.1. Multi-level verification protocol combining automated data collection and expert assessment

10.2.2.2. Regular on-site inspections to validate sensor data and farming practices

10.2.2.3. Machine learning algorithms to detect anomalies and prevent fraud

10.2.2.4. Alignment with Thailand Greenhouse Gas Management Organization (TGO) standards and international frameworks

10.2.3. Credit Issuance

10.2.3.1. Quarterly issuance schedule based on verified performance data

10.2.3.2. Smart contracts automatically creating and allocating credits to qualified farms

10.2.3.3. Dynamic adjustment based on seasonal factors and agricultural cycles

10.2.3.4. Transparent issuance records accessible to all stakeholders

10.3. Data Monetization

Training & Seminars

- Professional education initiatives including workshops and expert-led seminars
- Training programs on carbon credit trading
- Education on sustainability best practices
- Guidance on regulatory compliance

Market Data & API Integration

- Market intelligence and detailed analytical reports
- Customizable API integration services
- Actionable insights into carbon markets
- Tools for ESG performance evaluation

Enterprise Subscription Services

- Customized enterprise subscription plans
- Access to sophisticated sustainability management tools
- Extensive analytical resources
- ESG compliance reporting capabilities
- Dedicated client support

Trading Platform Features

1. **User-Friendly Marketplace**

- Intuitive interface accessible via web and mobile applications
- Real-time price discovery and market analytics
- Automated matching of buyers and sellers based on preferences
- Multiple transaction types including spot trades, futures, and recurring purchases

2. **Trust and Transparency**
   - Complete credit provenance tracking from issuance to retirement
   - Public verification of credit validity and environmental claims
   - Compliance with international carbon market standards
3. **Market Support Mechanisms**
   - Liquidity pool to ensure market stability during early adoption
   - Price floors and ceilings to prevent extreme volatility
   - Market maker programs to enhance trading volume
   - Educational resources for new market participants
4. **Integration Capabilities**
   - API connections to international carbon marketplaces
   - Compatibility with corporate carbon accounting systems
   - Reporting tools for regulatory compliance (e.g., CBAM requirements)
   - Integration with Thailand's National Carbon Registry

10.4. CSR Loan Integration

The CSR Loan Integration module connects financial institutions with farmers and businesses that need capital to transition away from high-emission practices. It provides targeted, low-interest financing for environmental improvements, helping reduce barriers to adopting

sustainable practices while enabling banks to meet their ESG and CSR objectives.

8.3.1 Service Journey for CSR Loan

1. Emission Assessment : Analyze baseline emissions data from farms and industries using platform sensors and records.
2. Classification & Eligibility : Automatically classify as Net Emitter, Net Neutral, or Net Absorber. Flag eligible zones for CSR loan or consultancy services (AI Rule Based Engine)
3. Apply for CSR Loan / Consultancy : Eligible participants submit loan applications or request consulting directly through the platform.
4. Verification & Approval : Data-driven verification automates approval workflows, supported by platform analytics.
5. Service Delivery & Monitoring : Loan disbursement or consultancy sessions begin. Progress is monitored via real-time data feeds.
6. Carbon Credit Generation : Successful emission reduction generates carbon credits, ready for trade or offset claims.
7. Impact Reporting & ROI : Participants and financial partners receive clear impact reports, credit statements, and ROI summaries.

The CSR loan program on this platform creates shared value for all parties involved, benefiting our platform, borrowers such as farmers and entrepreneurs, as well as commercial banks.

<u>Farmer and Entrepreneurs</u>

- Simplified Access to Financing : Easy identification of loan eligibility based on verified environmental data.
- Reduced Financial Burden : Preferential loan terms, lower interest rates, and flexible repayment plans.
- Support for Sustainable Transition : Funding supports investments in clean farming technology and high carbon-absorbing crops.
- Streamlined Application Process : Automated documentation reduces administrative workload.
- Additional Revenue Opportunities : Eligible participants can generate and monetize carbon credits from verified emission reductions.

Banks and Financial Institutions

- Alignment with CSR and ESG Objectives : Finance activities directly tied to measurable sustainability outcomes.
- Expansion into New Customer Segments : Reach underbanked farmers and emerging businesses.
- Operational Efficiency : Pre-validated data from the platform reduces manual verification workload.
- Carbon Credit Asset Generation : Financed projects create carbon credits to offset the bank’s own emissions.
- Enhanced ESG Profile : Strengthens the bank’s position as a leader in sustainable finance, appealing to investors and regulators.

Platform Ecosystem

- Seamless Data-to-Impact Cycle : Emission data drives loan decisions, financing enables sustainable actions, and actions generate measurable impact.
- Transparent Impact Tracking : Real-time monitoring and reporting of project outcomes for all stakeholders.
- Scalable Design : Ready for integration with public-sector programs and international green financing schemes.
- Strengthened Stakeholder Connectivity : Acts as a trusted data intermediary between banks, farmers, and businesses.

10.5. Carbon Credit Management Consultancy

The Carbon Credit Management Consultancy offered through the platform is designed to enable businesses, cooperatives, and public organizations to fully capture the economic and environmental value of their carbon reduction efforts. This service provides comprehensive guidance across the entire carbon credit lifecycle — from understanding baseline emissions to achieving certification and participating in the carbon credit marketplace.

By leveraging this consultancy, clients can unlock new revenue streams, reduce regulatory risks, and strengthen their leadership position in the sustainability economy.

<u>Service Components</u>

1. Emission Baseline Assessment

- Conduct a detailed analysis of client operations to establish accurate carbon emission baselines.

- Identify key emission sources and prioritize reduction opportunities that offer the highest impact.
- Value Creation: A clear understanding of emission profiles helps clients quantify potential carbon credits and prepare for monetization strategies.

2. Strategic Roadmapping
   - Develop actionable, step-by-step strategies to transition from Net Emitter to Net Neutral or Net Absorber status.
   - Customize roadmaps for different operational scales, whether individual farms, industrial clusters, or corporate entities.
   - Monetization Insight: Structured pathways accelerate clients' readiness for carbon credit generation, shortening time to market for credit sales.
3. Carbon Credit Certification Assistance
   - Provide end-to-end support for registration with recognized international and national standards (e.g., Verra, Gold Standard, TGO).
   - Assist with preparing documentation, designing monitoring protocols, and navigating third-party validation audits.
   - Value Creation: Certification unlocks verified carbon credits, which can be listed and monetized through the platform's marketplace.
4. Market Access and Trading Strategy
   - Advise on optimal pricing models, market timing, and engagement with potential buyers.

- Connect clients directly with verified credit purchasers via the platform's integrated trading system.
- Monetization: Proactive market strategies help maximize returns from credit sales, increasing revenue predictability and market reach.

5. Regulatory & Compliance Support

- Ensure alignment with evolving regulations, such as the EU's CBAM (Carbon Border Adjustment Mechanism) and domestic GHG frameworks.
- Assist in the preparation of ESG disclosures and audit-ready compliance reports.
- Risk Reduction: Avoid penalties and compliance risks, while enhancing the client's reputation and eligibility for green funding initiatives.

<u>Value for Clients</u>

- Revenue Growth: Access new income streams through the sale of verified carbon credits.
- Regulatory Confidence: Navigate complex compliance requirements with expert guidance, minimizing legal and financial risks.
- Market Leadership: Position the organization as a proactive leader in climate action and sustainability.
- Risk Mitigation: Hedge against carbon pricing volatility and evolving policy landscapes with a forward-looking strategy.

Through these services, clients not only meet regulatory obligations but transform carbon reduction into a tangible financial asset.

The Carbon Credit Management Consultancy empowers businesses and communities to confidently enter and thrive within the carbon economy. By transforming emission reductions into verified carbon credits and creating transparent market access, clients realize both financial rewards and reputational advantages.

This service is integral to the platform's mission of building a self-sustaining, data-driven ecosystem where environmental responsibility translates directly into economic opportunity.

11. Monitoring and Evaluation

11.1. OKRs & KPIs

OKRs (Objectives and Key Results**)**

The OKRs are divided according to the project's phases to align with the timeline and milestones outlined in the PID.

Phase 1: Initiation & Planning (March 2025)

Objective 1: Establish a strong foundation for the Carbon Credit Exchange Platform.

- Key Result 1: Conduct the Project Kickoff meeting and secure 100% stakeholder agreement by March 7, 2025.
- Key Result 2: Complete the Data Audit and identify all necessary data cleansing tasks by March 21, 2025.
- Key Result 3: Gather stakeholder requirements and obtain full scope approval by March 28, 2025.

Phase 2: Data Infrastructure (April-May 2025)

Objective 2: Build a reliable data infrastructure.

- Key Result 1: Design and implement the Data Collection System (including IoT Sensors) 100% complete by April 15, 2025.
- Key Result 2: Set up the Unified Data Warehouse (Apache Druid) and complete initial data integration by May 1, 2025.

- Key Result 3: Conduct Initial Data Validation and achieve 85% data accuracy by May 15, 2025.

Phase 3: Model Development (June-July 2025)
Objective 3: Develop an effective prediction model and dashboard.

- Key Result 1: Create and deploy the Pollution Dashboard for the Customer Success team by June 30, 2025.
- Key Result 2: Develop the LSTM-based Prediction Model and achieve at least 85% accuracy by July 31, 2025.
- Key Result 3: Complete Feature Engineering and Performance Validation by July 15, 2025.

Phase 4: System Integration (August 2025)
Objective 4: Integrate the system to prepare for trading.

- Key Result 1: Develop and fully integrate the Carbon Exchange Platform with the Pollution Dashboard by August 31, 2025.
- Key Result 2: Implement the Login/Membership System and pass the Security Certification by September 15, 2025.
- Key Result 3: Complete System Integration and API testing for all components by September 5, 2025.

Phase 5: Testing & Launch (September-October 2025)
Objective 5: Successfully launch the platform and ensure operational readiness.

- Key Result 1: Conduct User Acceptance Testing (UAT) and resolve 98% of defects by September 15, 2025.
- Key Result 2: Deploy a Pilot with 5,000 users, achieving a 60% adoption rate by September 30, 2025.
- Key Result 3: Fully launch the platform and provide 24/7 service by October 15, 2025.

KPIs (Key Performance Indicators)

KPIs cover both business performance (Business KPIs) and operational performance (Operational KPIs) to measure project success over a 12-month period (March 2025 - February 2026). These are aligned with the PID targets, such as 6.2M THB in revenue, 15% ROI, and improving data accuracy from 85% to 90% while ensuring deliverables and risk management.

1. Business KPIs
    - Revenue Growth: Achieve 6.2M THB in total revenue (from Transaction Fees, Subscriptions, Consulting, and Training).
        - Source: Financial Model in the PID (6.2M THB in Year 1).
    - First-Year ROI: Achieve a 15% return on investment (ROI) (Net Profit of 0.75M THB from an investment of 5M THB).
        - Source: Adjusted from the 22% ROI target in the PID to a more realistic 15%.
    - Customer Churn Rate Reduction: Reduce churn rate from 18% to 13.5% (a 25% reduction).
        - Source: Success Metrics in the PID.
    - Customer Lifetime Value (CLV) Increase: Increase CLV by 15% within 12 months.
        - Source: Success Metrics in the PID.
    - Transaction Volume: Reach 330,000 tCO2e carbon credit transactions in the first year.
        - Source: Transaction Fee Revenue Model in the PID.
2. Operational KPIs
    - Data Accuracy Rate: Improve data accuracy from 85% (MVP) to 90% by year-end.
        - Source: Scope in the PID specifying the roadmap to improve accuracy.
    - Prediction Model Accuracy: Achieve >95% accuracy in the LSTM Prediction Model within 6 months post-launch.
        - Source: Operational KPIs in the PID.
    - Dashboard Adoption Rate: Ensure >80% adoption rate of the Pollution Dashboard by the Customer Success team within 6 months.
        - Source: Operational KPIs in the PID.
    - System Uptime: Ensure 99.9% uptime throughout platform operations.
        - Source: Real-time trading platform requirement.
    - Defect Resolution Rate: Resolve 98% of defects before Full Launch.
        - Source: Phase 5 Testing in the PID.
3. Project Delivery KPIs

- On-Time Delivery Rate: Deliver >95% of milestones on schedule.
    - Measured from: PID Milestones (e.g., Data Collection System by May 15, Platform Launch by October 15).
- Budget Adherence: Keep spending within 5M THB (variance <5%).
    - Source: Investment Structure in the PID.
- Pilot Adoption Rate: Ensure a >60% adoption rate from the 5,000 pilot users by September 30, 2025.
    - Source: Phase 5 Pilot Deployment in the PID.

4. Risk Management KPIs
    - Data Quality Issue Rate: Keep data quality issues <5% post-cleansing.
        - Source: Risk "Poor data quality" in the PID.
    - Compliance Violation Incidents: Ensure 0 violations of GDPR/PDPA.
        - Source: Risk "Privacy & compliance risks" in the PID.
    - Scalability Downtime: Keep system downtime due to scalability issues <1 hour per month.
        - Source: Risk "Scalability issues" in the PID.

Implementation Approach

1. OKRs:
    - Review Frequency: At the end of each phase (e.g., end of March for Phase 1) and adjust goals based on progress.
    - Tracking Method: Bi-weekly Sprint Reviews and Jira Dashboard, as defined in the PID.
    - Example: The Data Analyst team will track 85% Data Validation success in Phase 2.
2. KPIs:
    - Review Frequency: Monthly tracking with an annual review in February 2026.
    - Tracking Method: Real-time Monitoring Tools (Prometheus + Grafana) and Monthly Steering Committee Updates per PID.
    - Example: Monthly Revenue Growth is tracked from Transaction Fees, compared against the 6.2M THB target.

Alignment with PID

- OKRs reflect the timeline and deliverables, such as developing the Pollution Dashboard (June 2025) and Full Launch (October 2025).
- KPIs align with Success Metrics, such as reducing churn by 25%, achieving 6.2M THB revenue, and ensuring >95% model accuracy.
- Both OKRs and KPIs address project challenges like Poor Data Quality and Scalability Issues.

11.2. Continuous Improvement

Continuous improvement in the carbon credit exchange business involves optimizing processes, increasing transparency, and enhancing the efficiency of carbon trading. Here are some key areas for continuous improvement:

1. Market Efficiency & Transparency

- Automated Verification: Utilize AI and real-time carbon credit verification and to prevent fraud.
- Standardized Metrics: Work with regulatory bodies to standardize carbon credit valuation and reporting.

2. User Experience & Accessibility

- Simplified Onboarding: Create an easy-to-use platform interface for businesses, investors, and small carbon credit holders.
- Mobile & Web Accessibility: Develop a responsive, user-friendly platform to improve accessibility.
- Education & Awareness: Offer training sessions and resources to attract new participants.

3. Integration with ESG & Green Financing

- Partnerships with Financial Institutions: Integrate carbon credits into ESG investment portfolios.
- Green Bonds & Carbon Offsetting: Work with governments and corporations to enable carbon offset purchases via green bonds.

4. Regulatory Compliance & Risk Management

- Real-time Regulatory Updates: Implement an AI-driven compliance system to track policy changes.
- Auditable Transactions: Maintain immutable audit trails for better credibility and trust.
- Cybersecurity Measures: Ensure robust cybersecurity to protect sensitive trading data.

5. AI & Data-Driven Insights

- Carbon Market Forecasting: Use AI-driven analytics to predict carbon credit demand and price fluctuations.
- Machine Learning for Risk Assessment: Identify fraud risks and ensure compliance with AI-powered monitoring.

6. Ecosystem Expansion

- Corporate Adoption Programs: Help large corporations integrate carbon credits into CSR strategies.
- Decentralized Trading Options: Explore peer-to-peer (P2P) carbon credit trading for broader participation.
- Support for SMEs & Individuals: Provide easier access to carbon offset projects for small businesses and individuals.

12. Financial Projection & ROI

12.1. Market Overview

- Thailand officially opened a carbon credit trading market in 2025, backed by the Stock Exchange of Thailand.
- Recent market growth: Q1 2025 recorded 101,894 tons CO2e traded at 17.78M THB with average price of 174.52 THB/tons (40% year-over-year increase).
- Current market supply: approximately 19.48 million tCO2eq credits available in Thailand.
- Historical data: 2022 trading reached 124.8M THB with 1.16 million tons at average price of 107.23 THB/tons.

12.2. Project Framework

- 8-month development timeline (March-October 2025) with 5M THB initial investment.
- Five-phase implementation strategy culminating in October 15, 2025 full launch.
- Integration of IoT sensors, real-time monitoring, and predictive analytics targeting 95% prediction accuracy.
- Comprehensive scope including automated data collection, verification systems, trading capabilities, and carbon emission reporting.

12.3. Revenue Model Refinement

- Transaction Fees: 1.9M THB first year, based on 0.45% fee structure with 5.2% market share of projected 330M THB trading volume.
- Consulting Fees: 1.3M THB from 13 corporate projects at 100,000 THB average fee.
- Subscription: 0.5M THB from 85 standard subscribers at 5,900 THB annual fee.
- Enterprise Subscription: 1.3M THB from 26 corporate clients at 50,000 THB average annual fee.
- Training & Seminars: 0.8M THB from 4 certification programs and 8 specialized workshops.

- API Integration: 0.4M THB from 8 enterprise integration projects at 50,000 THB each.

12.4. Financial Projections

- Year 1 (2025): 6.2M THB revenue with 1.1M THB net profit (18% margin).
- Progressive growth: 7.8M THB (Year 2), 11.3M THB (Year 3), 15.0M THB (Year 4), 19.1M THB (Year 5).
- ROI: 22% first-year return.
- Payback period: 2.78 years with 21% 5-year IRR.

12.5. Technical Infrastructure

- Multi-layered data architecture with dedicated object storage, data warehouse, and relational database.
- Advanced data pipeline utilizing Apache Kafka/Airflow for seamless sensor integration.
- Containerized deployment with Kubernetes orchestration and comprehensive monitoring.

12.6. Risk Assessment

- Sensitivity analysis shows IRR remains above 16% even in worst-case scenarios.
- Key risks identified: slow market adoption (16.2% IRR impact), increased verification costs (4% margin reduction), and regulatory delays (30% revenue growth reduction).
- Mitigation strategies include 5,000-user pilot program, verification, and regulatory engagement budget.

12.7. Strategic Advantages

- First-mover advantage in Thailand's developing carbon credit market.
- Differentiated approach combining IoT data collection with trading functionality.
- Diverse revenue streams reducing dependency on transaction volume.

- Scalability potential for international carbon credit trading expansion.
- Strategic alignment with Thailand's climate policy development timeline and ESG compliance needs.

13. Risk Mitigation and Issue Management

13.1. Strategic & Regulatory Risks

Risk	Likelihood	Impact	Enhanced Mitigation Strategy
CBAM Enforcement (2026)	High	High	• Develop early CBAM compliance modules for exporters • Partner with EU regulatory experts • Create education programs for Thai exporters • Build verification systems aligned with EU requirements
Thai Regulatory Framework Changes	High	High	• Establish relationships with key regulatory bodies • Create a dedicated regulatory affairs team • Implement flexible system architecture to accommodate policy changes • Develop scenario planning for different regulatory outcomes
Market Fragmentation	Medium	High	• Develop interoperability standards with other carbon markets• Establish protocols for cross-market credit verification• Create bridge mechanisms between Thai and international standards

Risk	Likelihood	Impact	Enhanced Mitigation Strategy
TGO* Standards Alignment	High	High	• Align verification processes with TGO methodologies• Seek early certification from TGO for platform operations • Participate in TGO working groups on standardization • Implement TGO reporting frameworks
Licensing Requirements	Medium	High	• Proactively obtain necessary permits and certifications• Maintain ongoing dialogue with licensing authorities • Build compliance into core platform functionality • Create a regulatory compliance calendar
Technology Obsolescence	Medium	Medium	• Implement modular architecture for platform components • Schedule quarterly technology reviews
SEC Oversight on Carbon Trading	Medium	High	• Engage with SEC during platform development • Design trading mechanisms that align with securities regulations• Implement KYC/AML protocols that exceed current requirements • Establish transparent reporting mechanisms

* TGO = Thailand Greenhouse Gas Management Organization

** SEC = Securities and Exchange Commission

13.2. Operational Risks

Risk	Likelihood	Impact	Enhanced Mitigation Strategy
Poor Data Quality	High	High	• Implement multi-layered data validation systems • Develop AI-powered anomaly detection • Create standardized data collection protocols with third-party verification • Establish data quality SLAs with sensor providers
Data Accessibility	High	High	• Create tiered data access protocols based on sensitivity • Implement secure API gateway for third-party integration • Develop robust authentication and authorization framework • Establish clear data governance policies
Verification Credibility	High	High	• Partner with international verification bodies • Establish independent verification committee • Create multi-level validation protocols
Provincial Regulatory Inconsistencies	Medium	Medium	• Create province-specific compliance modules • Develop relationships with key provincial environmental offices • Establish standard operating procedures for local compliance
Stakeholder Resistance	Medium	High	• Engage key stakeholders early in the project • Adjust scope based on continuous feedback • Develop targeted value

Risk	Likelihood	Impact	Enhanced Mitigation Strategy
			propositions for different stakeholder groups • Create education programs to address concerns
Project Delays	Medium	High	• Develop detailed project timeline with buffer periods • Implement agile methodology with regular sprints • Establish clear escalation paths for timeline risks • Create contingency plans for critical path activities

13.3. Financial Risks

Risk	Likelihood	Impact	Enhanced Mitigation Strategy
Profitability	Medium	High	• Develop diverse revenue streams beyond transaction fees • Create tiered service offerings for different customer segments • Establish clear value metrics to demonstrate ROI to clients• Implement dynamic pricing based on market conditions
Market Volatility	High	Medium	• Create hedging mechanisms for carbon credit value • Develop forward contracts and futures options • Implement price stabilization protocols during market fluctuations

Risk	Likelihood	Impact	Enhanced Mitigation Strategy
CBAM Compliance Costs	High	High	• Develop cost-sharing models for exporters • Create economies of scale through group verification • Establish partnerships with certification bodies for preferential rates
BOI Investment Incentives Dependency	Medium	Medium	• Diversify value proposition beyond tax incentives • Document ROI independently of government incentives • Develop business models that remain viable without incentives

13.4. Data Privacy, Data Security, and Compliance

Risk	Likelihood	Impact	Enhanced Mitigation Strategy
GDPR/PDPA Non-Compliance	High	High	• Implement privacy by design principles • Conduct regular data protection impact assessments • Appoint a dedicated Data Protection Officer • Create data minimization protocols • Develop a comprehensive consent management system • Establish data subject rights fulfillment procedures
Data Breach	Medium	Critical	• Implement end-to-end encryption for all sensitive data• Establish multi-factor authentication for all platform access • Conduct regular penetration testing • Create a comprehensive incident response plan with clear roles • Set up real-time monitoring and alert systems• Maintain offline backups with proper encryption
Verification Fraud	Medium	High	• Use multi-layer validation with different verification bodies • Create anomaly detection algorithms for unusual verification patterns • Establish random audit protocols by independent third parties • Implement biometric verification for critical operations • Develop cross-verification with satellite imagery

Risk	Likelihood	Impact	Enhanced Mitigation Strategy
Unauthorized API Access	Medium	High	• Implement OAuth 2.0 with strong token management • Create API request rate limiting • Develop granular API permissions • Set up anomaly detection for API usage patterns • Conduct regular API security audits • Implement IP-based restrictions and geofencing
Regulatory Framework Changes	High	High	• Create dedicated regulatory monitoring team • Develop modular platform architecture for rapid compliance updates • Establish relationships with key regulatory bodies • Create scenario planning for different regulatory outcomes • Implement a compliance dashboard with automated alerts • Join industry working groups for early awareness
Sensor Data Tampering	Medium	High	• Implement tamper-evident seals on physical sensors • Use cryptographic signing of sensor data • Develop statistical anomaly detection for unusual readings • Create multi-sensor verification protocols • Establish regular physical inspections • Implement GPS tracking for mobile sensors

14. Appendix

System Requirements

Data Storage

1. **Object Storage** → MinIO (alternative to AWS S3/GCP Cloud Storage)
    - Organized in Bronze/Silver/Gold tiers for progressive data refinement
    - Supports both structured and unstructured data storage
2. **Data Warehouse** → Apache Druid
    - Real-time analytics database optimized for time series data
    - Supports high concurrency for dashboard queries and ML model access
3. **RDBMS** → PostgreSQL
    - Handles transactional data and structured records
    - Supports the membership system and trading platform

Data Pipeline

1. **Ingestion**
    - Apache NiFi for batch ETL processes
    - RESTful APIs for verified organization data integration
    - Scheduled jobs for IoT sensor data collection (hourly)
    - JSON parsers for pollution control and industry analysis data
2. **Processing**
    - Apache Spark for data transformations and batch processing
    - Python for ML model development
3. **Orchestration**
    - Apache Airflow for workflow management and scheduling
    - Manages data quality checks and pipeline dependencies

Data Management

1. **Metadata Management** →OpenMetadata
    - Central repository for data assets and their relationships
    - Supports data discovery, lineage tracking, and governance
2. **Data Exchange** → X-Road
    - Secure data exchange platform for carbon credit trading
    - Supports standardized data sharing protocols

Visualization & User Interface

1. **Dashboard** → Apache Superset
    - Provides interactive visualizations for emissions data
    - Supports custom reporting for carbon credit analytics
2. **Trading Platform** →Custom web application
    - Carbon credit listing and trading functionality
    - Integration with verification and certification systems

Infrastructure

1. **Container Orchestration** →Kubernetes
    - Manages containerized microservices
    - Supports auto-scaling for varying workloads
2. **CI/CD** → GitLab CI
    - Automated testing and deployment
    - Infrastructure as Code management
3. **Monitoring**
    - Prometheus for metrics collection
    - Grafana for visualization dashboards
    - Alerting for system health and carbon emission thresholds
4. **Security**
    - Role-based access control
    - Audit logging for compliance

Metadata Catalog

1. Carbon Project Metadata

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
project_id	Unique project identifier	String	TH-CCEP-2025-0001	System-generated	-
project_name	Project name	String	Ban Huai Sak Community Forest	Project registrant	-
project_type	Type of carbon credit project	Enum	forestry, renewable_energy, methane_reduction, energy_efficiency	Project registrant	Verra/Gold Standard categories
project_location	Project location coordinates	GeoJSON	{"type": "Point", "coordinates": [100.523186, 13.736717]}	Project registrant	-
project_area	Project area (rai)	Number	1250.5	Project registrant	-
project_owner	Project owner	String	Green Thai Co., Ltd.	Project registrant	-
project_start_date	Project start date	Date	2025-03-15	Project registrant	ISO 8601

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
project_end_date	Project end date	Date	2045-03-14	Project registrant	ISO 8601
validation_body	Validation entity	String	VR Verification Co., Ltd.	Validation entity	ISO 14064
verification_body	Certification authority	String	TGO	Certification authority	-
verification_standard	Certification standard	Enum	Verra, Gold_Standard, TGO_T-VER	Certification authority	-
verification_date	Latest certification date	Date	2025-05-20	Certification authority	ISO 8601
verification_report_url	Verification report URL	URL	https://example.com/verification/TH-CCEP-2025-0001	Certification authority	-
total_credits_issued	Total credits issued (tCO_2e)	Number	15000	Certification authority	-

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
credits_available	Credits available for sale (tCO_2e)	Number	12500	System-calculated	-
credit_vintage	Credit vintage year	Number	2025	Certification authority	-
methodology	Carbon reduction calculation methodology	String	AR-ACM0003	Project registrant	UNFCCC/Verra methodologies
monitoring_plan_url	Monitoring plan URL	URL	https://example.com/monitoring/TH-CCEP-2025-0001	Project registrant	-
sdg_impacts	Related Sustainable Development Goals (SDGs)	Array	["SDG-13", "SDG-15"]	Project registrant	UN SDGs
data_quality_score	Data quality score (0-100)	Number	87	System-calculated	-

2. Carbon Credit Transaction Metadata

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
transaction_id	Unique transaction ID	String	TRX-2025-123456	System-generated	-
seller_id	Seller account ID	String	ACC-2025-001	Trading system	-
buyer_id	Buyer account ID	String	ACC-2025-002	Trading system	-
project_id	Associated project ID	String	TH-CCEP-2025-0001	Trading system	-
credit_amount	Amount of credits traded (tCO_2e)	Number	500	Trading system	-
credit_price	Price per unit (THB)	Number	130.50	Trading system	-
transaction_date	Transaction date and time	DateTime	2025-06-15T13:45:30+07:00	Trading system	ISO 8601
transaction_status	Transaction status	Enum	pending, completed, canceled	Trading system	-
transaction_hash	Transaction hash for verification	String	0x1a2b3c4d5e6f...	Trading system	-

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
payment_method	Payment method	Enum	bank_transfer, escrow, token	Trading system	-
payment_status	Payment status	Enum	pending, completed, failed	Trading system	-
credit_serial_numbers	Serial numbers of traded credits	Array	["CR-2025-001-001", "CR-2025-001-002",...]	Trading system	-
retirement_status	Retirement status of credits	Boolean	false	Trading system	-
retirement_purpose	Purpose of retirement	String	corporate offsetting	Trading system	-
retirement_date	Retirement date	Date	null	Trading system	ISO 8601

3. Sensor and Measurement Metadata

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
sensor_id	Sensor ID	String	SEN-CO2-0012	Sensor registration system	-
sensor_type	Type of sensor	Enum	co2, methane, temperature, humidity	System administrator	-

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
manufacturer	Sensor manufacturer	String	Vaisala Thailand	System administrator	-
model_number	Sensor model number	String	GMP252	System administrator	-
serial_number	Sensor serial number	String	TH2025123456	System administrator	-
installation_date	Installation date	Date	2025-02-20	System administrator	ISO 8601
calibration_date	Last calibration date	Date	2025-01-15	System administrator	ISO 8601
next_calibration_date	Next calibration due date	Date	2025-07-15	System-calculated	ISO 8601
location	Sensor installation location	GeoJSON	{"type": "Point", "coordinates": [100.523186, 13.736717]}	System administrator	-
project_id	Project ID where the sensor is installed	String	TH-CCEP-2025-0001	System administrator	-
measurement_unit	Measurement unit	String	ppm, °C, %	System administrator	SI units

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
measurement_range	Measurement range	String	0-2000 ppm	System administrator	-
accuracy	Sensor accuracy (±)	String	±2%	Sensor manufacturer	-
sampling_frequency	Data sampling frequency	String	5 min	System administrator	-
certification	Sensor certifications	Array	["ISO 9001", "TIS 17025"]	Sensor manufacturer	-
connection_type	Connection type	Enum	4G, WiFi, LoRaWAN, Satellite	System administrator	-
power_source	Power source	Enum	grid, solar, battery	System administrator	-
status	Current sensor status	Enum	active, maintenance, offline	Automated monitoring system	-
last_maintenance_date	Last maintenance date	Date	2025-04-10	System administrator	ISO 8601

4. Measurement Data Metadata

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
measurement_id	Measurement ID	String	MEAS-2025-123456789	System-generated	-
sensor_id	Sensor ID used for measurement	String	SEN-CO2-0012	Sensor system	-
timestamp	Measurement timestamp	DateTime	2025-06-15T13:45:30+07:00	Sensor system	ISO 8601
value	Measured value	Number	412.5	Sensor system	-
unit	Measurement unit	String	ppm	Sensor system	SI units
quality_flag	Data quality status	Enum	good, suspicious, bad	Quality control system	-
uncertainty	Measurement uncertainty	Number	0.5	Sensor system	-
raw_value	Raw value before adjustment	Number	413.2	Sensor system	-
calibration_applied	Calibration applied	Boolean	true	Sensor system	-

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
calibration_id	Calibration ID applied	String	CAL-2025-0012-01	Sensor system	-
weather_conditions	Weather conditions during measurement	JSON	{"temperature": 32.5, "humidity": 75, "pressure": 1013.2}	Weather system	-
maintenance_flag	Maintenance status	Boolean	false	Sensor system	-
validated	Validation status	Boolean	true	Quality control system	-
validation_method	Validation method	String	cross-validation	Quality control system	-
batch_id	Data batch ID	String	BATCH-2025-0615-1	System-generated	-

5. User and Account Metadata

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
user_id	User ID	String	USER-2025-001	Registration system	-
account_id	Account ID	String	ACC-2025-001	Registration system	-
account_type	Account type	Enum	individual, corporation, government, ngo	User input	-
registration_date	Registration date	Date	2025-03-01	Registration system	ISO 8601
verification_status	Identity verification status	Enum	pending, verified, rejected	Verification system	-
verification_date	Verification date	Date	2025-03-05	Verification system	ISO 8601
organization_name	Organization name	String	Green Thai Co., Ltd.	User input	-
organization_type	Organization type	Enum	private, public, government, ngo	User input	-
tax_id	Tax ID	String	0123456789012	User input	-

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
contact_name	Contact person name	String	Mr. Somchai Jaidee	User input	-
contact_email	Contact person email	String	somchai@greenthai.co.th	User input	-
contact_phone	Contact person phone	String	+66812345678	User input	E.164
address	Address	String	123 Sathorn Road, Thung Maha Mek, Sathorn, Bangkok 10120	User input	-
documents_submitted	Documents submitted	Array	["company_registration", "id_card", "power_of_attorney"]	User input	-
account_status	Account status	Enum	active, suspended, closed	System	-
last_login_date	Last login date	DateTime	2025-06-14T09:30:45+07:00	System	ISO 8601
role	System role	Enum	buyer, seller, verifier, admin	Registration system	-

6. Certification and Verification Metadata

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
certification_id	Certification ID	String	CERT-2025-0001	Certification body	-
project_id	Project ID	String	TH-CCEP-2025-0001	System	-
standard_body	Standard organization	String	Verra	Certification body	-
standard_version	Standard version	String	4.2	Certification body	-
certification_type	Certification type	Enum	validation, verification, issuance	Certification body	-
certification_date	Certification date	Date	2025-05-20	Certification body	ISO 8601
valid_until	Certification expiry date	Date	2026-05-19	Certification body	ISO 8601
certifier_id	Certifier ID	String	VB-2025-003	Certification body	-

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
certifier_name	Certifier name	String	VR Verification Co., Ltd.	Certification body	-
certifier_accreditation	Certifier accreditations	Array	["ISO 14065", "TGO"]	Certification body	-
certification_scope	Certification scope	String	Scope 1 and 2 emissions	Certification body	GHG Protocol
baseline_methodology	Baseline calculation methodology	String	AR-ACM0003	Certification body	UNFCCC/Verra methodologies
monitoring_methodology	Monitoring methodology	String	AR-MN0003	Certification body	UNFCCC/Verra methodologies
verification_report_url	Verification report URL	URL	https://example.com/verification/TH-CCEP-2025-0001	Certification body	-
certification_status	Certification status	Enum	active, suspended, expired	Certification body	-

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
credits_certified	Number of certified credits	Number	15000	Certification body	-
certification_document_hash	Certification document hash	String	0x1a2b3c4d5e6f...	System	-

7. Carbon Credit Tracking Metadata

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
credit_batch_id	Credit batch ID	String	BATCH-2025-0001	Credit issuance system	-
project_id	Project ID	String	TH-CCEP-2025-0001	Credit issuance system	-
issuance_date	Credit issuance date	Date	2025-05-25	Credit issuance system	ISO 8601
credit_quantity	Quantity of credits (tCO_2e)	Number	5000	Credit issuance system	-
credit_vintage	Credit vintage year	Number	2025	Credit issuance system	-
serial_number_start	Starting serial number	String	TH-VER-2025-0001-1-000001	Credit issuance system	-
serial_number_end	Ending serial number	String	TH-VER-2025-0001-1-005000	Credit issuance system	-
credit_status	Credit status	Enum	issued, transferred, retired, cancelled	Tracking system	-

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
issuance_verification_id	Pre-issuance verification ID	String	VERIFY-2025-0001	Credit issuance system	-
current_owner	Current owner	String	ACC-2025-001	Tracking system	-
transfer_history	Transfer history	Array of Objects	[{"from": "ACC-2025-001", "to": "ACC-2025-002", "date": "2025-06-15", "quantity": 1000}]	Tracking system	-
retirement_date	Retirement date	Date	null	Tracking system	ISO 8601
retirement_beneficiary	Retirement beneficiary	String	null	Tracking system	-
retirement_purpose	Retirement purpose	String	null	Tracking system	-
credit_registry	Credit registry	String	TGO Registry	Credit issuance system	-

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
buffer_pool_allocation	Buffer pool allocation (credits)	Number	500	Credit issuance system	-
credit_pathway_url	Credit pathway URL	URL	https://example.com/credit-pathway/TH-VER-2025-0001-1	Tracking system	-

8. Forecast and Model Metadata

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
model_id	Model ID	String	MODEL-CO2-2025-01	Forecasting system	-
model_name	Model name	String	CO2 Emission Forecast Model	Forecasting system	-
model_type	Model type	Enum	regression, time_series, neural_network	Forecasting system	-
model_version	Model version	String	2.3.1	Forecasting system	-
creation_date	Model creation date	Date	2025-04-10	Forecasting system	ISO 8601

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
last_updated	Last updated date	DateTime	2025-06-01T14:30:00+07:00	Forecasting system	ISO 8601
creator	Model creator	String	DATA-SCI-TEAM-03	Forecasting system	-
input_features	Input features	Array	["historical_emissions", "temperature", "rainfall", "economic_activity"]	Forecasting system	-
output_features	Output features	Array	["predicted_emissions"]	Forecasting system	-
accuracy_score	Accuracy score	Number	87.5	Forecasting system	-
accuracy_method	Accuracy measurement method	String	RMSE	Forecasting system	-
training_dataset_id	Training dataset ID	String	DATASET-TRAIN-2025-01	Forecasting system	-
validation_dataset_id	Validation dataset ID	String	DATASET-VAL-2025-01	Forecasting system	-

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
model_parameters	Model parameters	JSON	{"learning_rate": 0.01, "max_depth": 5, "n_estimators": 100}	Forecasting system	-
forecast_horizon	Forecast horizon	String	12 months	Forecasting system	-
uncertainty_range	Forecast uncertainty range	String	±10%	Forecasting system	-
confidence_level	Confidence level (%)	Number	95	Forecasting system	-
forecast_update_frequency	Forecast update frequency	String	weekly	Forecasting system	-
model_documentation_url	Model documentation URL	URL	https://example.com/model-docs/MODEL-CO2-2025-01	Forecasting system	-
dependencies	Software or library dependencies	Array	["tensorflow 2.5", "scikit-learn 1.0"]	Forecasting system	-

9. Carbon Market and Pricing Metadata

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
market_data_id	Market data ID	String	MKT-DATA-2025-06-15	Market system	-
timestamp	Data timestamp	DateTime	2025-06-15T16:00:00+07:00	Market system	ISO 8601
credit_type	Credit type	Enum	forestry, renewable, methane, energy_efficiency	Market system	-
current_price	Current price (THB/tCO_2e)	Number	135.50	Market system	-
daily_low	Daily low price	Number	133.25	Market system	-
daily_high	Daily high price	Number	136.75	Market system	-
daily_volume	Daily trading volume (tCO_2e)	Number	12500	Market system	-
weekly_average	Weekly average price	Number	134.80	System-calculated	-
monthly_average	Monthly average price	Number	132.60	System-calculated	-

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
price_change_24h	24-hour price change (%)	Number	+1.2	System-calculated	-
price_change_7d	7-day price change (%)	Number	+3.5	System-calculated	-
bid_price	Highest bid price	Number	135.00	Market system	-
ask_price	Lowest ask price	Number	136.00	Market system	-
spread	Bid-ask spread	Number	1.00	System-calculated	-
open_orders	Open orders count	Number	45	Market system	-
market_sentiment	Market sentiment	Enum	bullish, neutral, bearish	Market analysis system	-
vintage_premium	Vintage year price premium	JSON	{"2023": -5, "2024": -2, "2025": 0, "2026": +3}	Market analysis system	-

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
price_forecast_30d	30-day price forecast	Number	140.25	Forecasting system	-
liquidity_index	Liquidity index (0–100)	Number	78	Market analysis system	-
external_benchmark	External benchmark prices	JSON	{"EU-ETS": 550, "VCS": 160, "Gold_Standard": 175}	External market system	-

10. Compliance and Regulatory Metadata

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
regulation_id	Regulation ID	String	REG-TH-2025-001	Regulatory system	-
regulation_name	Regulation name	String	Climate Change Act B.E. 2568	Regulatory system	-
issuing_authority	Issuing authority	String	Ministry of Natural Resources and Environment	Regulatory system	-
effective_date	Effective date	Date	2025-01-01	Regulatory system	ISO 8601
compliance_requirements	Compliance requirements	Array	["emission_reporting", "carbon_offset", "renewable_target"]	Regulatory system	-
affected_sectors	Affected sectors	Array	["energy", "manufacturing", "transportation"]	Regulatory system	-
compliance_thresholds	Compliance thresholds	JSON	{"emission_threshold": 25000, "renewable_percentage": 20}	Regulatory system	-

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
reporting_frequency	Reporting frequency	String	quarterly	Regulatory system	-
next_reporting_deadline	Next reporting deadline	Date	2025-09-30	Regulatory system	ISO 8601
penalty_for_non_compliance	Penalty for non-compliance	String	Fine up to 100,000 THB per day	Regulatory system	-
compliance_status	Compliance status	Enum	compliant, non_compliant, pending_review	Tracking system	-
last_audit_date	Last audit date	Date	2025-03-15	Tracking system	ISO 8601
audit_findings	Audit findings	String	Passed without defects	Tracking system	-
remediation_deadline	Remediation deadline	Date	null	Tracking system	ISO 8601
regulation_document_url	Regulation document URL	URL	https://example.gov.th/regulation/REG-TH-2025-001	Regulatory system	-

Metadata Item	Description	Data Type	Example	Data Source	Reference Standard
compliance_officer	Compliance officer	String	Mr. Mana Raklok	Regulatory system	-

Financial Projection & ROI

Transaction Fees 1.9M THB first year

- 0.45% fee on transaction value, competitive with global carbon exchanges
- Based on capturing 5.2% market share of Thailand's projected 330M THB trading volume
- Average transaction size: 15,000 THB with approximately 2,800 transactions
- Growth potential as market liquidity increases and voluntary carbon market matures

Consulting Fees 1.3M THB first year

- 13 corporate consulting projects at average fee of 100,000 THB
- Focus on carbon footprint assessment, reduction strategy, and offset portfolio optimization
- Target industries: manufacturing, energy, hospitality, and logistics
- Includes follow-up implementation support and compliance documentation

Subscription 0.5M THB first year

- 85 standard subscribers at 5,900 THB annual fee
- Designed for SMEs, project developers, and individual traders
- Includes market data access, basic analytics, and trading capabilities
- Tiered pricing with quarterly and annual payment options

Enterprise Subscription 1.3M THB first year

- 26 corporate clients at average of 50,000 THB annual fee
- Comprehensive dashboard with customized reporting for corporate ESG teams
- Advanced analytics, portfolio management, and compliance reporting
- Includes dedicated account manager and quarterly performance reviews

Training & Seminars 0.8M THB first year

- 4 comprehensive certification programs (180,000 THB each)
- 8 specialized workshops at 35,000 THB per session
- Topics covering carbon accounting, market trading, regulatory compliance, and project validation
- Mix of in-person and online delivery formats with certification options

API Integration 0.4M THB first year

- 8 enterprise API integration projects at 50,000 THB each
- Custom data feeds for integration with client sustainability management systems
- Real-time carbon market data integration with corporate ESG reporting platforms
- Development of bespoke carbon tracking applications using platform data