

Table Of Content



Introduction

Business Documentation

Overview	01
Market analysis	02
Business Model analysis	03
Pricing Strategy	04
Go-to-market Strategy	05
Social impact metrics	06

Technical Documentation

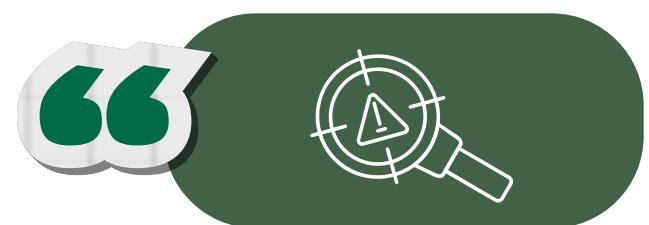
Functional Requirements	01
Use Case Diagram	02
Project Management & Risks	03
Implementation	04
Evaluation Plan	05

CONTEXT

Vietnam's textile dyeing crisis, where industrial discharge exceeds national pollution standards by up to **71 times** while threatening **15%** of export revenue by 2030.

PROBLEM STATEMENT

Vietnam's textile dyeing and finishing SMEs face rising ESG and environmental pressure yet still rely on ...



Manual data and reactive wastewater control (lack affordable, data-driven tools to balance profit with sustainability)

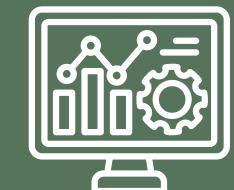
causing frequent **breaches** and **export risks**, especially in Binh Duong, Dong Nai, the most **pollution-prone industrial zones**.

GREENTHREAD'S VISION

to shift from reactive compliance to proactive environmental stewardship, creating verifiable sustainability credentials for global buyers by:



blockchain-verified traceability



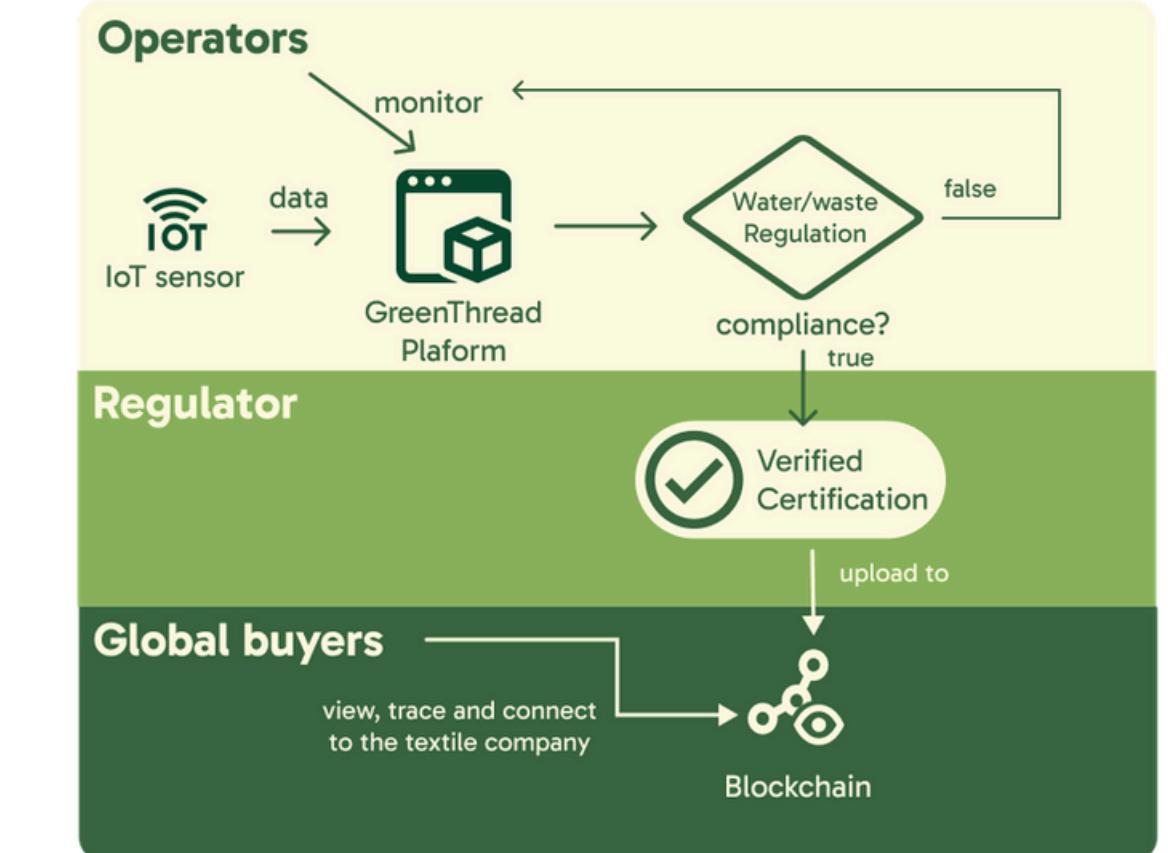
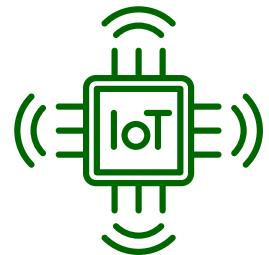
predictive AI analytics



data compliance



IoT real-time monitoring



Business Documentation

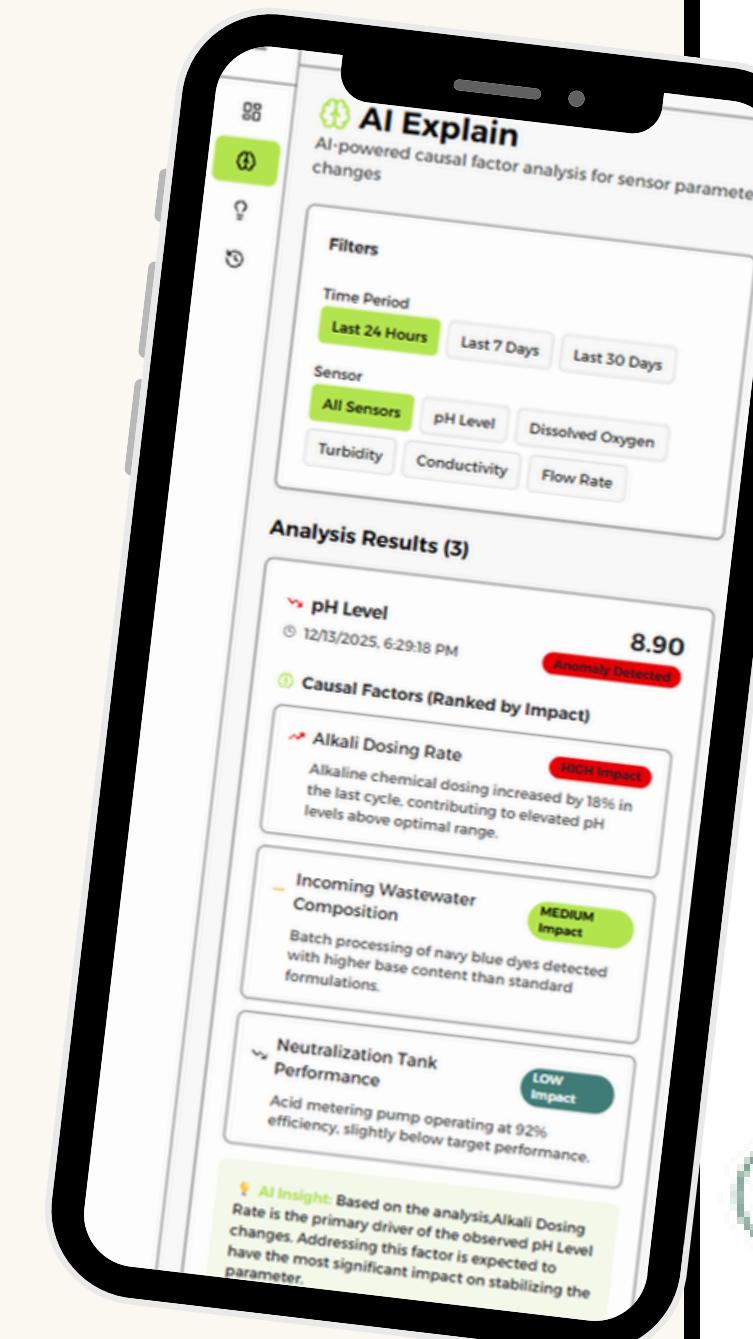
MARKET & COMPETITION

BUSINESS MODEL ANALYSIS

PRICING STRATEGY PROPOSAL

GO-TO-MARKET STRATEGY

SOCIAL IMPACT METRICS



GREENTHREAD TRANSFORMS TEXTILE OPERATIONS, FROM RISK MANAGEMENT TO COMPLIANCE, AND REGULATORS WITH REAL-TIME AI DATA, PREDICTIVE AI AND BLOCKCHAIN-VERIFIED COMPLIANCE—REDUCING POLLUTION WHILE INCREASING EXPORT REVENUE.

Our Product

GREENTHREAD IS AN AI-POWERED WASTEWATER MONITORING PLATFORM THAT TRANSFORMS TEXTILE OPERATIONS THROUGH REAL-TIME INTELLIGENCE AND VERIFIED COMPLIANCE

REAL-TIME MONITORING

AI PREDICTIONS & GUIDANCE

BLOCKCHAIN VERIFICATION

GREEN THREAD



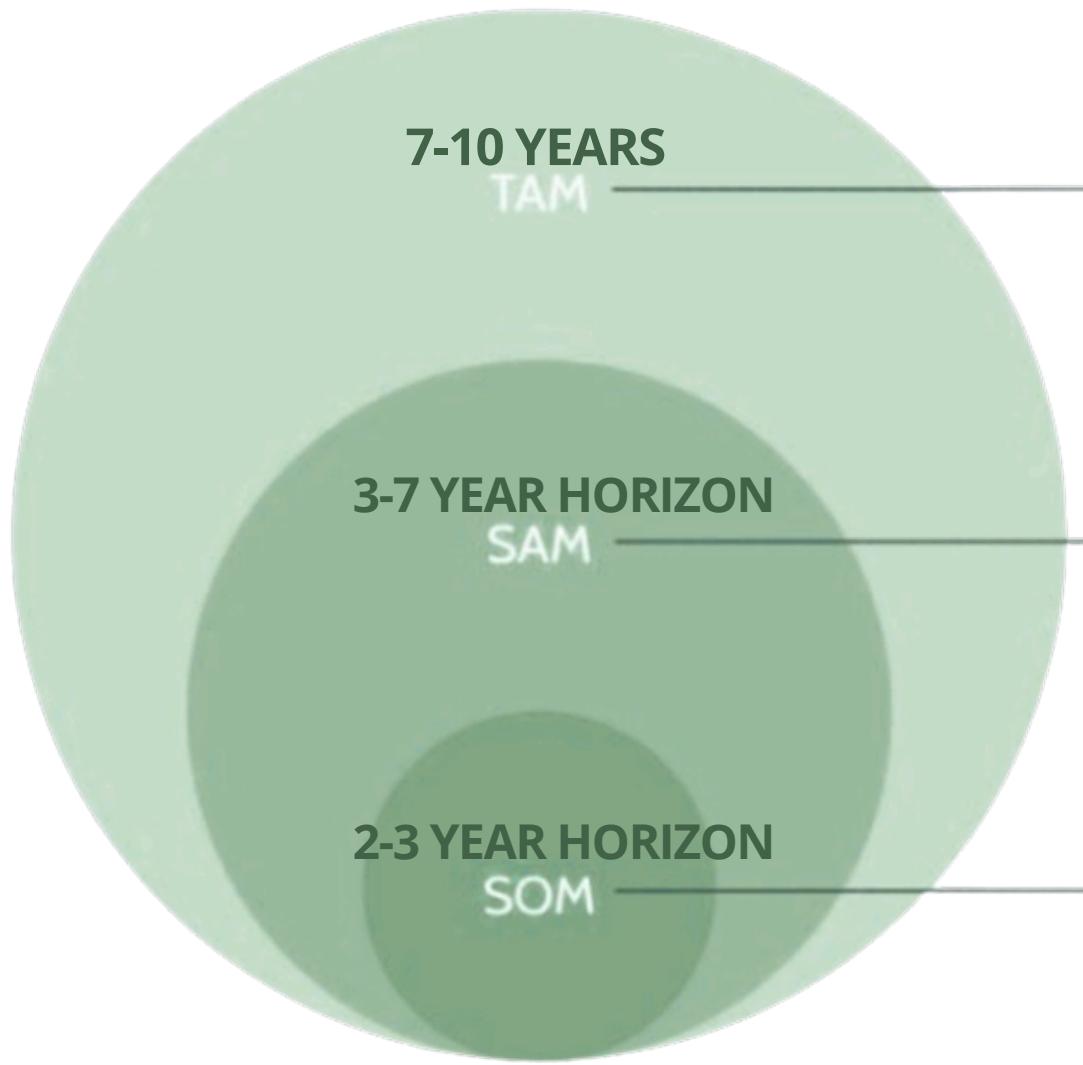
MARKET ANALYSIS & BUSINESS MODEL

7

MARKET ANALYSIS

MARKET SIZE AND GROWTH

TAM SAM SOM



Vietnam textile factories
~6,000
(VITAS, 2024; MONRE, 2023)

Wet-processing
(dyeing/finishing)
≈ 4% → ~240
factories.

Value/factory
US \$25,000 (ARR)
→ US \$6.0M total potential.

- **Focus regions:** BINH DƯƠNG, DONG NAI, NAM DINH, BINH TAN-TAN TAO
- host ~60-70% of wet-processing operations with shared treatment zones.
- ~150 factories × US\$25,000 → ≈ US\$3.75M.

- Digital-ready factories: ≈15% of SAM (FPT Digital, 2023).
- **20-25** factories ready to adopt IoT-AI platforms in 3-5 years.
- ARR potential: **US\$0.5-0.6M** annually.



GreenThread starts with **20-25** digital-ready factories (SOM), builds trust and awareness through proven AI-IoT results, and scales to all **240** dyeing & finishing plants across Vietnam within **10** years.

MARKET ANALYSIS

MARKET SIZE AND GROWTH

TOTAL ARR (CONSERVATIVE) ~\$20,000-35,000

Component	End-customer price	type/ note
SaaS Platform	\$5,000 – 10,000 / year	In-house (recurring - Dashboard + analytics + compliance API)
IoT Sensor Kit	\$10,000 – 20,000 (one-off)	Pass-through / outsourced
Maintenance & Calibration	\$3,000 – 5,000 / year	Blended (outsourced + margin), Partner onsite service

MARKET VALUATION ESTIMATED VIA ARR-BASED BOTTOM-UP MODEL

MARKET TRENDS - PESTEL

Government pushes wastewater investment (~US\$9B by 2030) but enforcement remains uneven

--> creating demand for real-time digital oversight tools.

Vietnam's water treatment market grows ~**16.7%** CAGR (2023–2028), yet high cost of outsourcing to third-party wastewater treatment vendors, especially for analysis limits SME adoption

--> leaving space for affordable AI-IoT compliance platforms.

Vietnam enforces strict discharge standards (QCVN, LEP 2020) but compliance remains uneven, highlighting the need for transparent, verifiable digital reporting.

--> leaving space for affordable AI-IoT compliance platforms.



With **12 million m³** wastewater discharged daily (**87%** untreated), industrial zones like Binh Duong and Dong Nai face rising community and ESG scrutiny.

Vietnam's IoT market set to hit US\$13B by 2028 and FPT's **US\$200M** AI Factory boosts national AI capacity

--> enabling GreenThread's AI-IoT scaling roadmap.



ESG pressure, AI readiness and uneven enforcement make Vietnam's textile sector ripe for **AI-IoT compliance transformation**.

SWOT ANALYSIS

S

- Predictive AI-IoT monitoring enables early detection and timely treatment of wastewater risks.
- Automatically aligns processed data with chosen certification standards and exports compliance reports for audits.
- Reduces outsourcing costs by automating analysis and anomaly prediction, lowering dependency on third-party service fees.

W

- Early-stage brand and limited traction.
- Relies on external IoT hardware.
- Adoption slowed by factories' low digital readiness.

O

- Rising ESG and certification alignment requirements (ZDHC, QCVN, EVFTA, CPTPP).
- Increasing demand for transparent, automated compliance reporting and affordable green solutions for SMEs.
- Accelerating adoption of AI-IoT and digital compliance tools under Vietnam's Industry 4.0 agenda.

Large players (FPT, Schneider) may enter ESG niche.

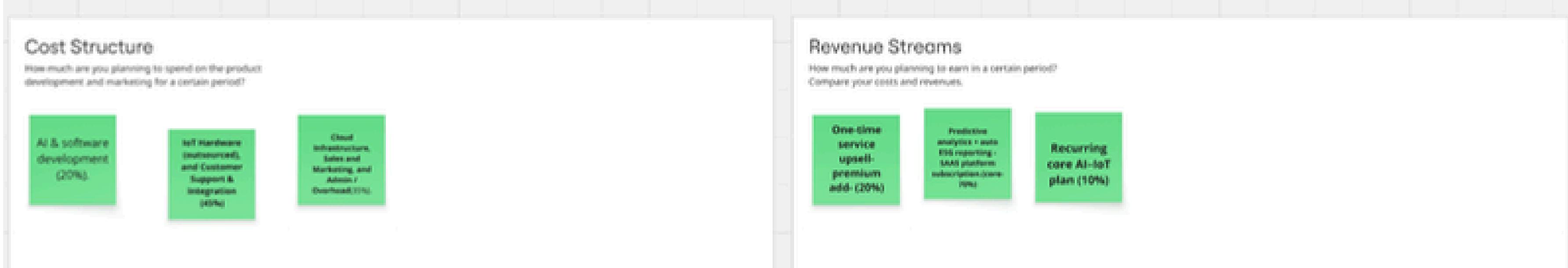
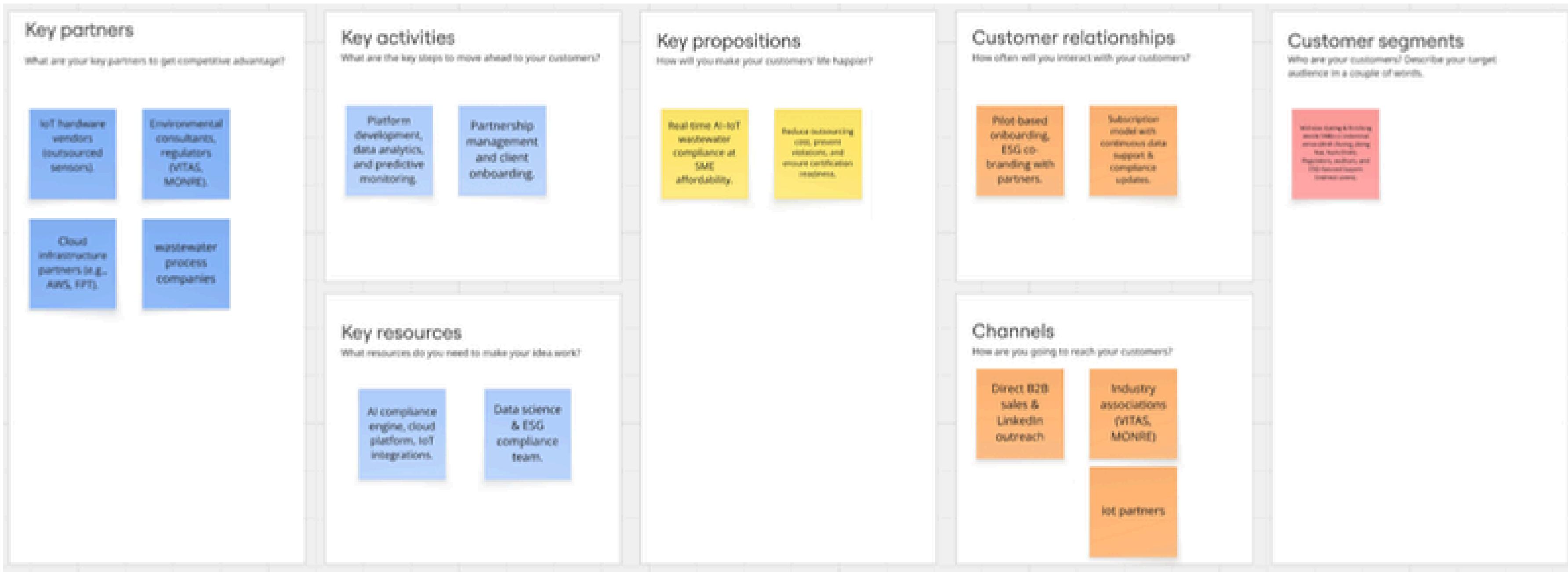
- SME hesitation toward digital transformation and upfront tech investment.
- Competition from established global environmental compliance platforms..

T



GreenThread rides the AI-IoT adoption wave to transform **costly**, reactive wastewater compliance into a **proactive, data-driven, and certification-aligned solution**, helping SMEs overcome digital hesitation and compete with global players.

BUSINESS MODEL CANVAS

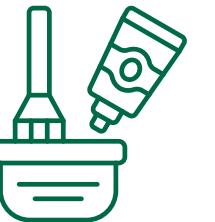


1

CUSTOMER PROFILE

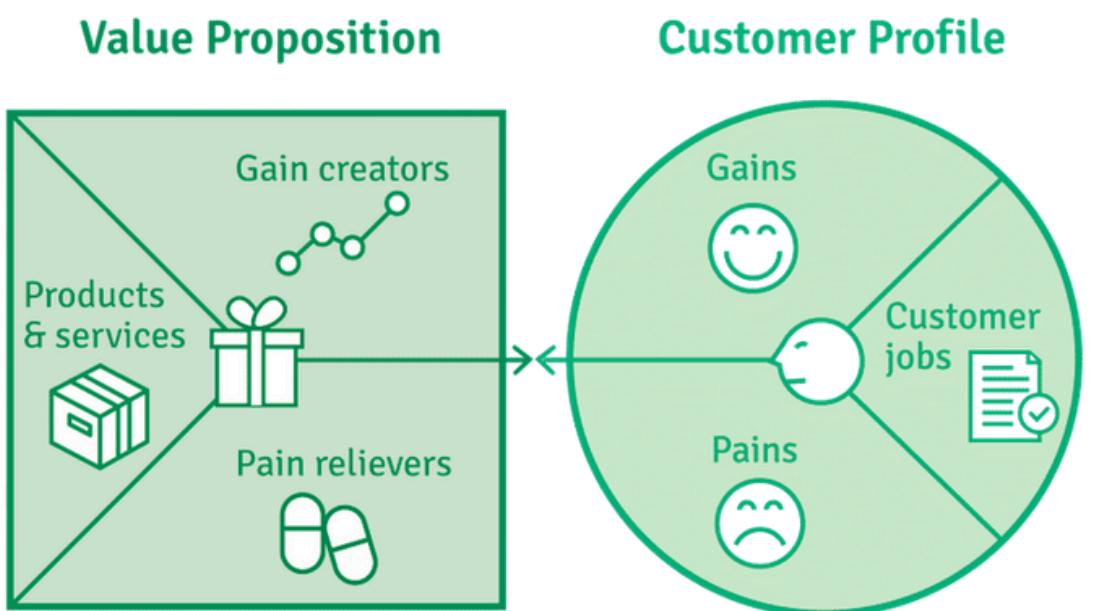
TARGET CUSTOMER

Mid-size dyeing and finishing textile factories facing ESG audits and high wastewater compliance costs.



2

VALUE PROPOSITION CANVAS



PAINS

Factories only react after wastewater violations occur, instead of preventing them in real time.

High cost of outsourcing to 3rd-party treatment vendors.

Fragmented data systems → slow audits and weak compliance proof.

GAINS

Real-time AI-IoT monitoring enables timely treatment of wastewater sections flagged as at risk of non-compliance, preventing exceedances before they occur.

Reduced outsourcing expenses through AI-assisted analysis and early detection, helping factories cut compliance costs while maintaining existing treatment partners.

Unified dashboard consolidates all compliance data, enabling faster audits and clearer proof of conformity.



GreenThread empowers **mid-size textile factories** to shift from **reactive, high-cost compliance** toward **proactive, data-driven** wastewater management.

COMPETITIVE OVERVIEW

COMPETITOR MATRIX

Must have

Good to have

Company	description	Business	Technology	Business	Technology
GreenThread		★★★	★★★	★★	★★★
EnviSoft Vietnam- Direct 1	Local compliance software but lacks real-time IoT integration and predictive analytics.	★★	★	★	
IoTLink Enviro - Direct 2	Hardware-focused; no AI-driven analysis or compliance reporting.	★	★	★	★
EcoStruxure Water (Schneider) - Direct 3	High cost and complexity, built for large industrial zones.	★	★★★	★★★	★★★
FPT Digital / akaMES - Indirect 1	Focus on digital manufacturing; no ESG compliance focus yet.	★	★★	★★★	★★★
ZDHC / GOTS Tools - Indirect 2	Provide frameworks, not real-time monitoring or process validation.	★	★	★	



GreenThread outperforms both **local** and **global** competitors on all must-have ESG-tech criteria, delivering AI-driven compliance at SME affordability.

COMPETITIVE BREAKDOWN

Must have

Good to have

Business Capabilities		Technology Capabilities		Business Capabilities		Technology Capabilities	
Element	Rationales	Element	Rationales	Element	Rationales	Element	Rationales
Local ESG Alignment (QCVN/ZDHC)	VN-specific discharge standards; localization essential.	Real-time IoT Integration	Compliance needs instant data, not manual uploads.	Partnership Scalability (Clusters & Zones)	Ability to deploy per industrial zone boosts adoption speed.	Cloud / Edge Hybrid Flexibility	On-premise + cloud model critical for Vietnam's factory IT maturity.
Affordability for SMEs	Most factories are SME-size; low-cost SaaS = adoption driver.	Predictive AI	Transforms raw data into early, proactive warnings	Brand Credibility and Global ESG Linkages	Buyers trust certified ecosystems → improves market entry.	API Ecosystem & Integration (IoT / MES / ERP)	Ensures interoperability with existing factory systems.
Demonstrated ROI (cost-saving, audit-proof)	Clear ROI accelerates B2B decision cycles.	Regulatory Reporting Automation	Saves hours of manual work & ensures data traceability.			Data Security & Audit Traceability	Growing ESG scrutiny needs tamper-proof logs.

PROBLEM - OPPORTUNITY FIT

(Customer unmet needs - Problems)

PAINS

Factories only react after wastewater violations occur, instead of preventing them in real time.

GAINS

Real-time AI-IoT monitoring enables timely treatment of wastewater sections flagged as at risk of non-compliance, preventing exceedances before they occur.

High cost of outsourcing to 3rd-party treatment vendors.

Reduced outsourcing expenses through AI-assisted analysis and early detection, helping factories cut compliance costs while maintaining existing treatment partners.

Fragmented data systems → slow audits and weak compliance proof.

Unified dashboard consolidates all compliance data, enabling faster audits and clearer proof of conformity.

MARKET GAP

Predict and detect non-compliance risks in real time.

A unified dashboard for real-time monitoring, early alerts, and instant audit-ready reports for government or buyers.

Automate analysis and reporting, reducing factories' reliance on costly third-party service providers

Compare processed data against chosen certifications (e.g., QCVN, ZDHC, GOTS) and automatically report to government.

OUR SOLUTION



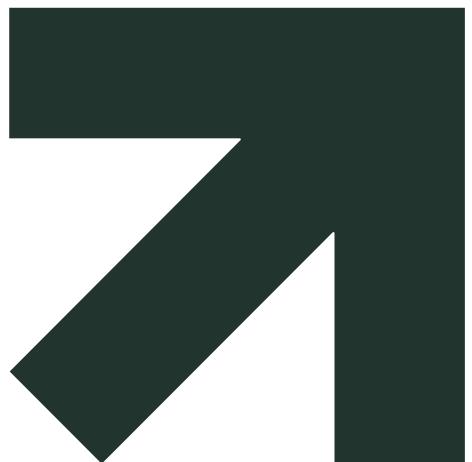
Value Proposition Statement:

' GreenThread transforms wastewater compliance for Vietnam's textile SMEs from reactive and costly to **proactive, data-driven, and certification-aligned, enabling real-time ESG** readiness at a fraction of the cost of global platforms.'



PRICING STRATEGY

PROPOSAL



VALUE-BASED PRICING

GreenThread's pricing is based on the measurable value it delivers



Helping factories
reduce audit costs



Minimize
compliance risks



Strengthen ESG trust and
hitting the ROI earlier

QUANTIFIED VALUE

Impact Area	Average Annual Cost Saved / Avoided	Average Annual Cost Saved / Avoided
Audit & Certification Costs	\$8,000 - 12,000	50% captured → \$5,000-6,000
Labor & Manual Reporting	\$5,000 - 8,000	50% captured → \$3,000-4,000
Environmental Violation Risks	\$10,000	30% captured → \$3,000+
Total Value Delivered	\$25,000-30,000 / year	Optimal pricing ≈ \$20,000-25,000/year



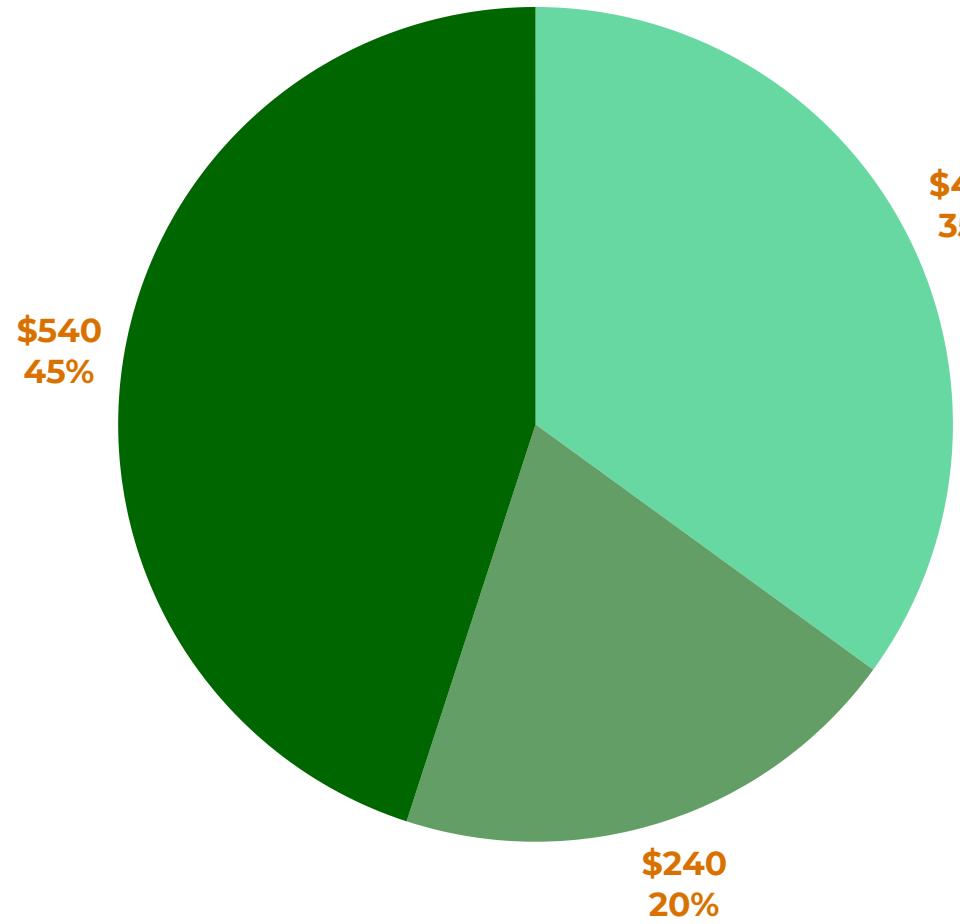
**ROI for clients
Nearly**



**from measurable
savings.**

COST STRUCTURE AND REVENUE STREAM

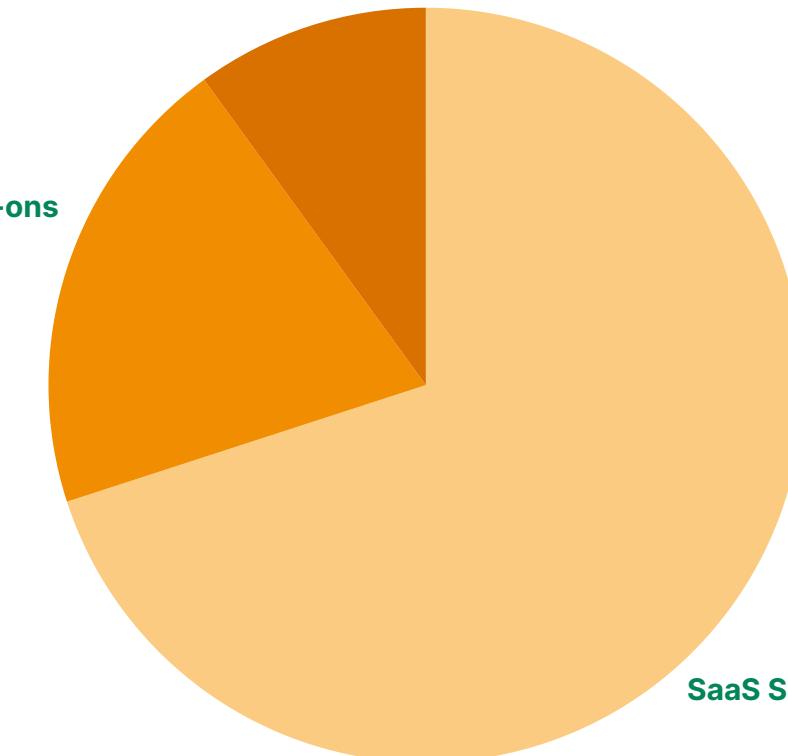
Total Estimated Annual
Operating Cost
(\$1,200/factory/year)



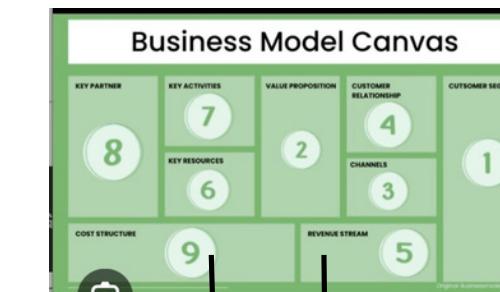
9
Total ARPU (weighted) ≈
\$2,200/factory/year

API Integration / Custom Services
10%

Premium Add-ons
20%



5



Recurring core AI-IoT plan

Predictive analytics + auto ESG reporting

One-time service upsell

=> total ARPU: \$ 2,200/ Factory

Break-even Analysis

Break Even Point =
$$\frac{\text{Fixed Cost}}{\text{Selling Price Per Unit} - \text{Variable Cost Per Unit}}$$

BEP=40,000/ (2,200–1,200) =40 factories

=> Expected by Year 4 (midpoint of 3-5 year roadmap).

After Year 4 → Each additional factory generates ~\$1,000 gross margin/year.

=> total estimated cost: \$ 1,200



GO-TO-MARKET

STRATEGY



GO TO MARKET STRATEGY - 2-3 FIRST YEARS

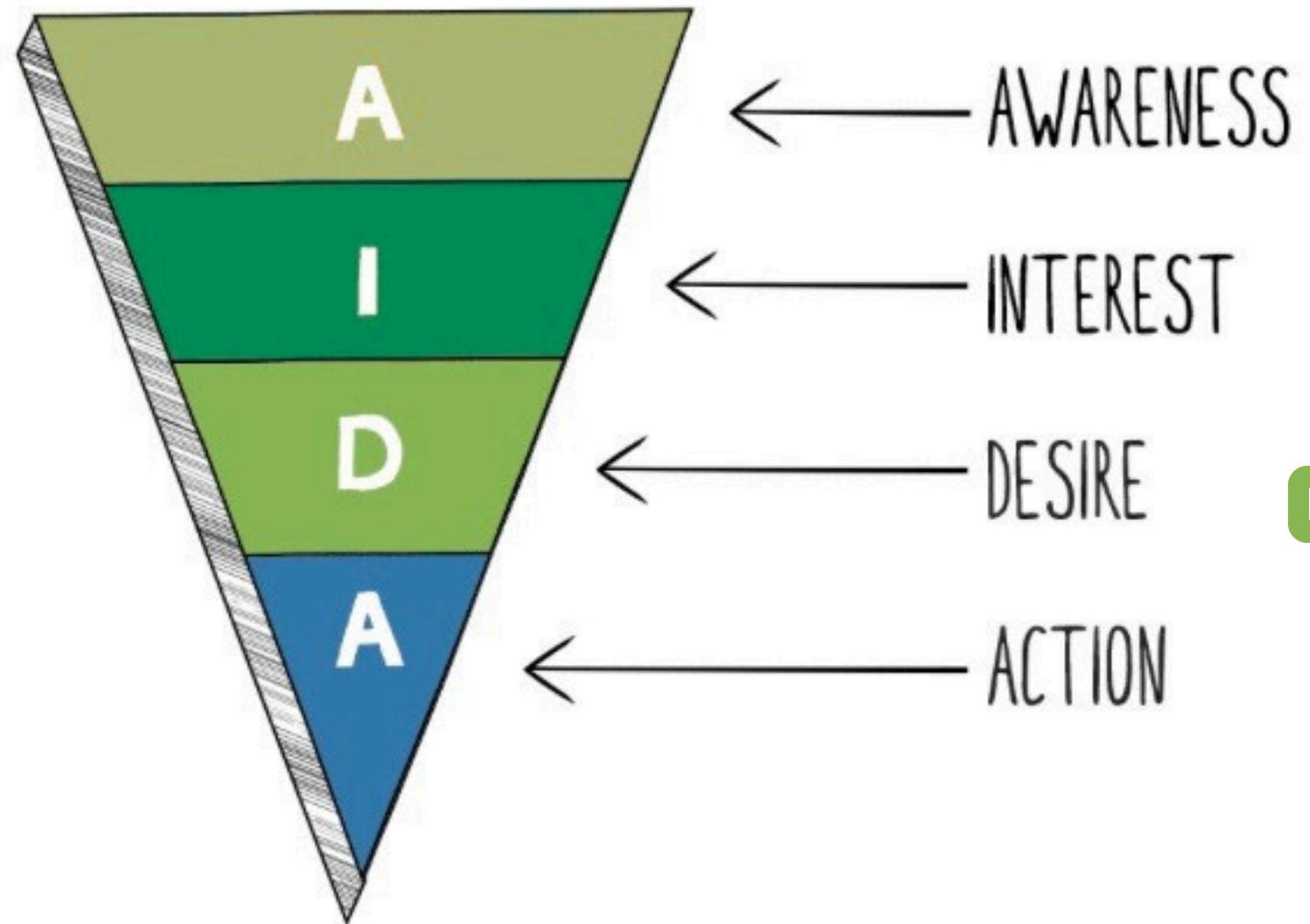
(Targeting 20-25 factories)

OBJECTIVE

Launch GreenThread as Vietnam's trusted AI-IoT compliance platform for textile SMEs through partnership-based entry and pilot-driven adoption.



THE AIDA MODEL



Customer Value Chain / Stakeholders

Key Channels & Actions

Co-host ESG webinars, LinkedIn awareness campaign, and green compliance workshops.

Product demo videos, email marketing, case studies on early adopters.

Joint pilot programs; offer AI-IoT predictive analysis with partners' hardware.

Subscription sales via direct B2B channels; export audit-ready reports to buyers/regulators.

Outcome

SMEs aware of ESG requirements & GreenThread solution.

Inquiries & trial sign-ups.

Pilot validation & credibility.

Paid users & long-term renewals.



Strategic partnerships, pilots, and direct B2B outreach make GreenThread discoverable, trusted, and adopted as Vietnam's go-to AI-IoT compliance solution.



SOCIAL IMPACT

METRICS



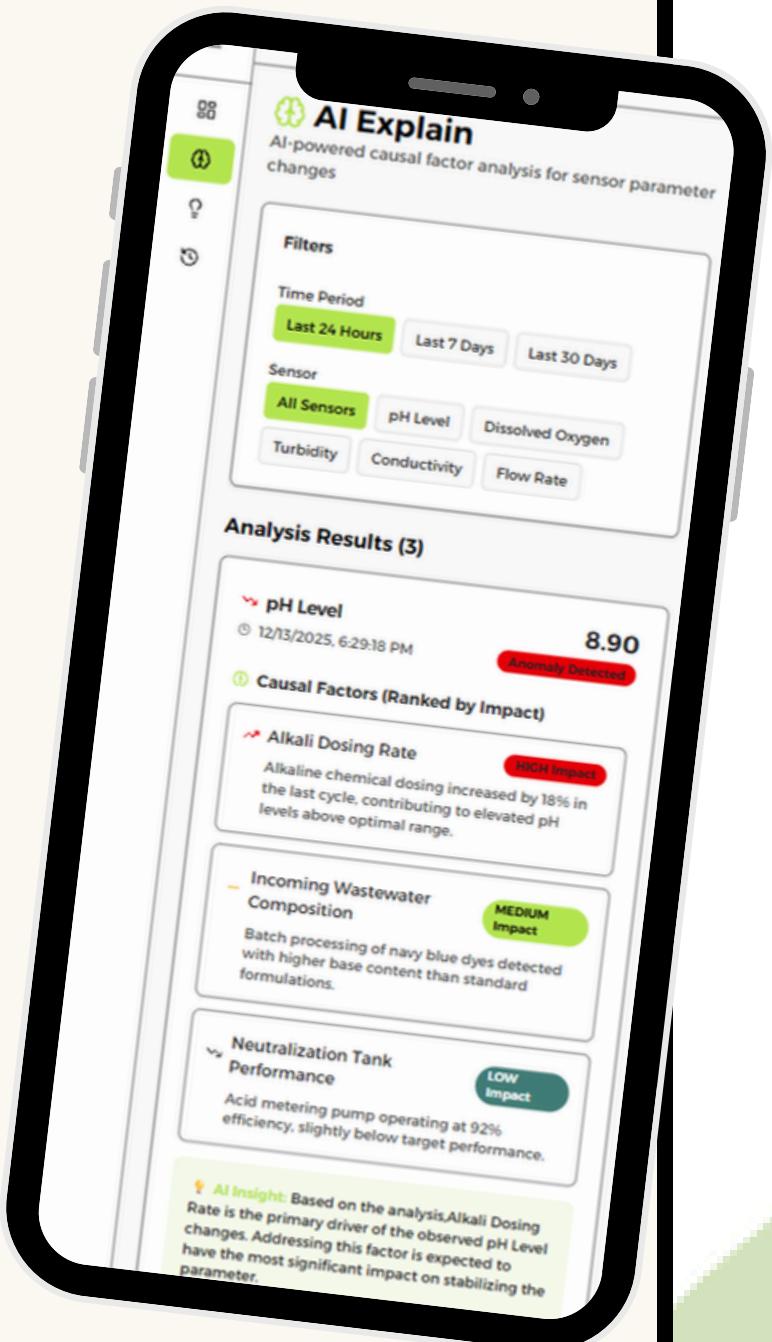
PESTLE FACTOR	METRIC (WHAT)	MEASUREMENT & MONITORING (HOW)	SDG ALIGNMENT	EXPECTED IMPACT (WHY)
POLITICAL	70% of partner factories maintain EVFTA/CPTPP compliance within 24 months	Automated dashboard logs vs QCVN standards, quarterly VITAS reports. Track adoption through user logs and annual surveys	SDG 12	Improves ESG governance and trade credibility for Vietnam's textile exports
ECONOMIC	30% audit/report/ processs cost (~US\$12K-20K saved/factory/year)	Financial comparison: baseline vs post-implementation	SDG 12, 13	Enhances industrial efficiency and global competitiveness
SOCIAL	20% BOD/COD in effluents within 12 months	Initiate baseline survey: Collect health data from local clinics and community interviews, and see IoT data and AI predictions to track reductions. For monitoring, compile annual health reports from integrated dashboards	SDG 6, 11	Cleaner water, improved health, stable livelihoods for nearby communities
TECHNOLOGICAL	25 factories ($\approx 15\%$) adopt AI-IoT compliance by year 3	Platform analytics + Digital reports	SDG 12	Accelerates Industry 4.0 adoption and digital transformation
LEGAL & ENVIRONMENTAL	15% wastewater discharge	ESG dashboard	SDG 13, 12	56% GHG reduction by 2030



GreenThread quantifies its impact on clean water, sustainable communities, responsible production, and climate action, turning ESG compliance into tangible social and environmental change.

Technical Documentation

1. FUNCTIONAL REQUIREMENTS
2. USE CASE DIAGRAM
3. PROJECT MANAGEMENT & RISKS
4. IMPLEMENTATION
5. EVALUATION PLAN



GREEN THREAD

GET STARTED WITH GREENTHREAD [↗](#)

GREENTHREAD IS HERE. TEXTILE OPERATIONS, WASTE MANAGEMENT, COMPLIANCE AND ENVIRONMENTAL REGULATIONS - ONE PLACE YOUR ROLE AND BODY REAL-TIME COMPLIANCE INFORMATION.

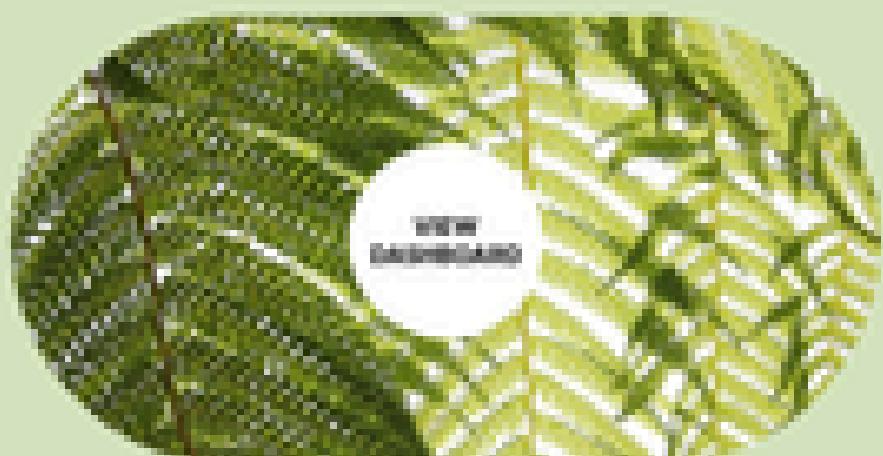
ACCESS LIVE DASHBOARDS

REAL TIME MONITORING OF 100,000+ PH EQUIPMENT, INDUSTRIAL FIBER FILTRATION AND ANOMALY ALERTS

REQUEST COMPLIANCE REPORTS

SEE AI PLAN & SUGGESTION

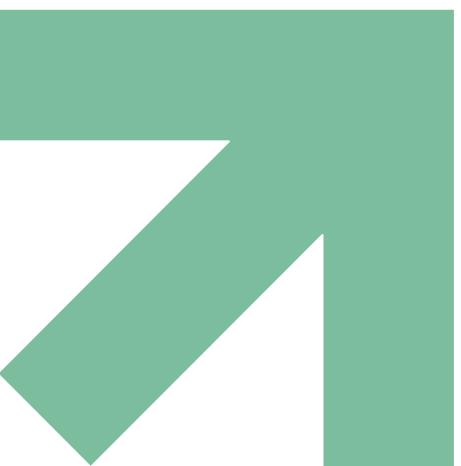
Live Dashboard [↗](#)





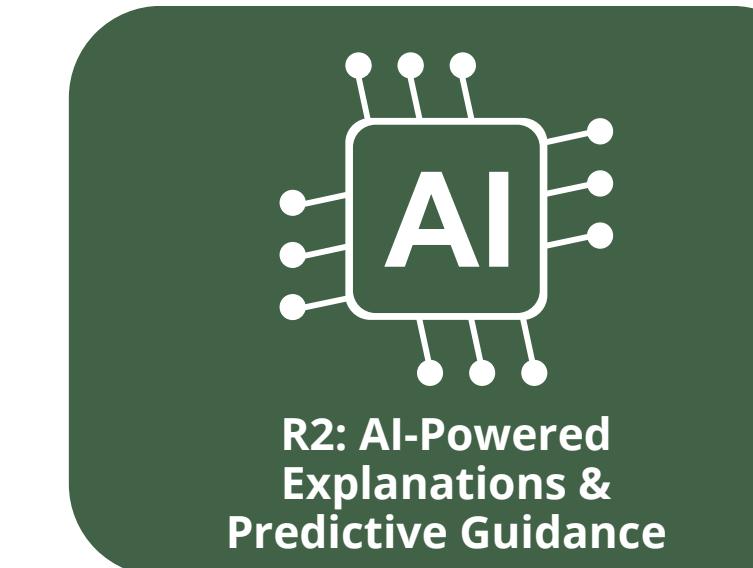
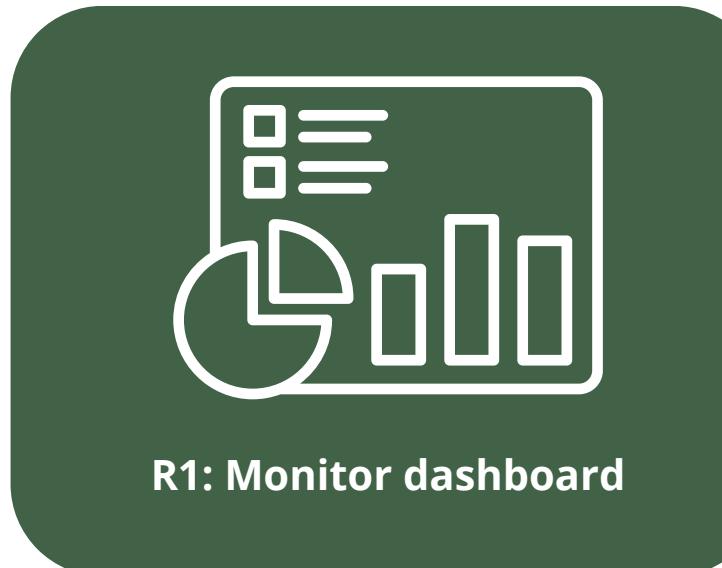
1

FUNCTIONAL REQUIREMENTS



MoSCoW prioritization framework

No.	Priority	ID	Feature	Description
1	Must Have	R1.1	Real-Time Sensor Dashboard	Displays live IoT sensor data with compliance thresholds and status
2	Must Have	R1.2	Automated Alert System	Notifies users when values exceed thresholds
3	Must Have	R1.3	Historical Trend Visualization	Charts showing data trends over time
4	Must Have	R2.1	AI Predictive Exceedance	Provide predictive warnings on potential compliance violation in the future
5	Should Have	R2.2	AI Causal Factor Explanation	AI explains what causes parameter changes
6	Should Have	R2.3	Corrective Action Recommendation	AI suggests actions to achieve certification
7	Could Have	R3.1	Blockchain Anchoring for Certificates	Records certifications earned on blockchain
8	Won't Have	R3.2	Public Verification Portal	Partners can verify company certifications



HOW OUR FEATURES ALIGN WITH BUSINESS ANALYSIS?

Our solution	Features aligned	How?
Predict and detect non-compliance risks in real time.	- R2.1 AI Predictive Exceedance - R2.2 AI Causal Factor Explanation	AI forecasts potential violations and explains root causes behind parameter shifts.
Unified dashboard for real-time monitoring, early alerts, and audit-ready reports.	R1.1 Real-Time Sensor Dashboard R1.2 Automated Alert System R1.3 Historical Trend Visualization	Displays live IoT data, alerts when thresholds are breached, and visualizes trends for audits
Automate analysis and reporting to reduce reliance on third-party services.	R2.3 Corrective Action Recommendation R1.3 Historical Trends R3.1 Blockchain Anchoring for Certificates	AI suggests corrective steps and stores earned certificates securely on blockchain.
Compare processed data with certifications (QCVN, ZDHC, GOTS) and auto-report.	R1.1 Dashboard R2.1 Predictive Exceedance R3.2 Public Verification Portal (future)	Matches sensor data to regulatory standards and prepares verified compliance reports.

SYSTEM LAYERS



IoT Layer (R1.1–R1.3): Collects & visualizes water quality data.

AI Layer (R2.1–R2.3): Predicts, explains, and recommends fixes.

Compliance Layer (R3.1–R3.2): Secures and verifies certification records.

MUST-HAVE FEATURES

R1.1

Title: Real-Time Sensor Data Display

Purpose: Display live data from IoT sensors alongside government regulation thresholds to give immediate visibility into wastewater conditions and compliance status.

Rationale: Operators need to see not just the current numbers, but context on whether those numbers are within thresholds. This allows them to respond to issues quickly and avoid penalties.

User Story: As a factory operator, I want to see live sensor readings compared against compliance limits on my dashboard, so that I can instantly be notified if current conditions are safe.

Acceptance Criteria:

Scenario 1: Viewing current sensor data with benchmarks

- **Given:** The operator is logged into the dashboard and IoT sensors are transmitting data.
- **When:** The operator opens the monitoring page.
- **Then:** Current sensor readings (e.g., pH, COD) are displayed with timestamps.
- **And:** The relevant government compliance threshold is clearly displayed next to or on the same graph as the reading.

Scenario 2: Visual indication of threshold status

- **Given:** The dashboard is displaying real-time data.
- **When:** A specific sensor reading (e.g., pH 9.5) exceeds the defined compliance threshold (e.g., pH 6.0 - 9.0).
- **Then:** The data visualization for that parameter immediately changes visual style (e.g., status icon changes from a green checkmark to a red warning) to indicate an exceedance.

MUST-HAVE FEATURES

R1.2

Title: Automated Alert System

Purpose: Automatically notify users when sensor values exceed safe thresholds.

Rationale: Proactive alerts enable immediate response to prevent violations and environmental damage.

User Story: As a factory manager, I want to receive automatic alerts when parameters exceed limits, so that I can take corrective action immediately.

Acceptance Criteria:

Scenario: Alert triggered by threshold breach

- **Given:** Alert thresholds are configured in the system
- **And:** The system is monitoring sensor data
- **When:** A sensor reading exceeds the defined threshold
- **Then:** An alert notification is sent to designated users

MUST-HAVE FEATURES

R1.3

Title: Historical Trend Visualization

Purpose: Display historical data trends through charts and graphs.

Rationale: Understanding patterns over time helps identify recurring issues and measure improvement.

User Story: As an analyst, I want to view historical trends of sensor data, so that I can identify patterns and plan improvements.

Acceptance Criteria:

Scenario: Viewing historical data

- **Given:** Historical sensor data exists in the database
- **When:** The analyst selects a time range and parameter
- **Then:** A trend chart is displayed showing data over the selected period

MUST-HAVE FEATURES

R2.1

Title: AI Predictive Exceedance

Purpose: Utilize a machine learning model to analyze real-time data trends and forecast the probability of any wastewater parameter exceeding threshold within next hours.

Rationale: This feature provides predictive warnings, allowing operators to prevent potential exceedances from happening and shifting compliance from reactive to proactive.

User Story: As a factory operator, I want the system to proactively alert me to future compliance risks based on current trends, so that I can intervene early and adjust the wastewater process.

Acceptance Criteria:

Scenario 1: Successful prediction of a future breach

- **Given:** The system is analyzing real-time data, and the current COD level is 125 mg/L (still within the 150 mg/L compliance limit).
- **And:** The AI model, based on historical data, recognizes that the current trends are a potential sign of a COD spike.
- **When:** The operator is viewing the main dashboard.
- **Then:** A predictive alert is displayed with a message such as: "WARNING: High probability of COD exceeding the 150 mg/L limit within the next 3 hours."

Scenario 2: Visualizing the predicted trend

- **Given:** A predictive alert for pH is active, forecasting a drop below the 6.0 limit within the next hour.
- **And:** The current real-time pH reading is still compliant at 6.3.
- **When:** The operator clicks on the pH data visualization to see more details.
- **Then:** The system displays a graph showing the recent trend line, which is then extended with a future trend line indicating the predicted drop.
- **And:** The alert is clearly labeled as "Predictive" to distinguish it from an immediate "Critical" alert for a current violation.

SHOULD-HAVE FEATURES

R2.2

Title: AI Causal Factor Explanation

Purpose: AI analyzes data and explains what factors are causing parameter changes.

Rationale: Understanding root causes helps operators make informed decisions about process adjustments.

User Story: As a factory operator, I want AI to explain why parameters are changing, so that I can understand the root causes of issues.

Acceptance Criteria:

Scenario: Receiving causal explanation

- **Given:** A parameter shows unusual readings
- **When:** The operator requests an explanation from the AI
- **Then:** The AI displays ranked causal factors contributing to the change

SHOULD-HAVE FEATURES

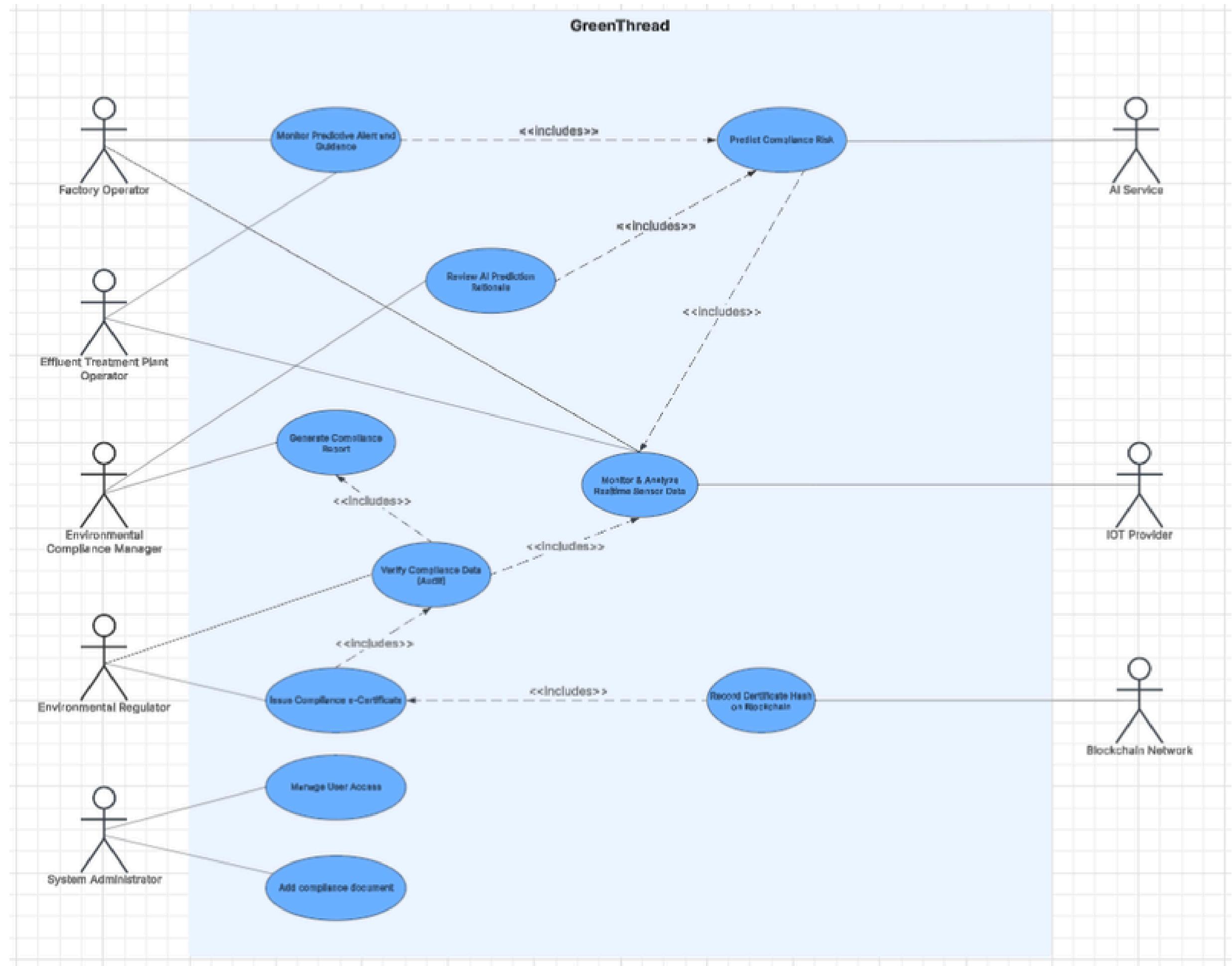
R2.3

Title: Corrective Action Recommendation	
Purpose: AI suggests specific actions to bring parameters into compliance and achieve certifications.	Rationale: Actionable guidance helps companies efficiently work toward certification goals.
User Story: As a factory operator, I want to see live sensor readings compared against compliance limits on my dashboard, so that I can instantly be notified if current conditions are safe.	
Acceptance Criteria: <i>Scenario: Getting action recommendations</i> <ul style="list-style-type: none">• Given: The system has analyzed current data against certification requirements• When: The officer requests a certification action plan• Then: The AI generates prioritized recommendations to achieve compliance	

COULD-HAVE FEATURE

R3.1

Title: Blockchain Anchoring for Certificates	
Purpose: Record all certifications earned by the company on blockchain for permanent, tamper-proof documentation.	Rationale: Blockchain ensures certification records cannot be altered, building trust with regulators and partners.
User Story: As a factory owner, I want my certifications recorded on blockchain, so that I have permanent proof of compliance.	
Acceptance Criteria: <i>Scenario: Recording certification on blockchain</i> <ul style="list-style-type: none">• Given: A company has achieved a certification milestone• When: The certification is confirmed in the system• Then: A timestamped record is created on the blockchain	



PRIMARY ACTORS

Factory Operator: Monitors general factory process alerts and guidance to ensure smooth and compliant operations

Effluent Treatment Plant Operator: Directly monitors and responds to real-time alerts and guidance to manage the wastewater treatment process.

Environmental Compliance Manager: Analyzes compliance data, reviews AI prediction rationales, and generates official reports for strategic oversight.

Environmental Regulator: Audits the factory's compliance data through the system and issues official e-certificates upon successful verification.

System Administrator: Manages user access permissions and uploads new compliance documents into the system.

SECONDARY ACTORS

AI Service: Provides the core intelligence for the system by predicting risks, explaining causes, and generating user guidance.

IOT Provider: Supplies the system with the continuous stream of real-time sensor data from the physical monitoring hardware.

Blockchain Network: Provides the decentralized infrastructure used by the system to immutably record and verify compliance certificates.

MONITOR & ANALYZE REALTIME SENSOR DATA

Use Case Name	Monitor & Analyze Realtime Sensor Data
Actors	Factory Operator (Primary), Effluent Treatment Plant Operator (Primary), LLM Service (Secondary)
Description	This is the foundational use case where the system ingests, processes, and stores the continuous stream of wastewater data from the IoT sensors.
Preconditions	The IoT gateway is configured and connected to the network. The GreenThread platform's data endpoint (e.g., MQTT broker) is active.
Trigger	IoT sensors automatically push new data packets at regular intervals.
Main Flow	<ol style="list-style-type: none">1. The IOT Provider's sensors transmit raw data to the on-site gateway.2. The gateway preprocesses the data and securely sends it to the GreenThread platform's cloud endpoint.3. The platform validates, cleans, and stores the time-stamped data in its database.4. The processed data is made available to other system components (dashboards, AI models).
Postconditions	The system's database is updated with the latest sensor readings.
Expected Outcome	Accurate, real-time data is reliably available for monitoring, prediction, reporting, and auditing.

MONITOR PREDICTIVE ALERT AND GUIDANCE

Use Case Name	Monitor Predictive Alert and Guidance
Actors	Factory Operator (Primary), Effluent Treatment Plant Operator (Primary), LLM Service (Secondary)
Description	Allows the Factory Operator to view real-time wastewater data, receive predictive alerts about potential non-compliance events, and get actionable guidance to prevent them.
Preconditions	The Factory Operator is logged into the GreenThread platform. The IoT sensors are active and transmitting data.
Trigger	The operator accesses the main monitoring dashboard.
Main Flow	<ol style="list-style-type: none">1. The system displays real-time visualizations of key wastewater parameters (pH, COD, BOD).2. The system continuously predicts any chemical risks in the background.3. If a high-risk prediction is made, an alert is prominently displayed on the dashboard.4. Alongside the alert, the system shows LLM-generated guidance (e.g., "Potential COD spike in 2 hours. Suggest reducing dye batch size by 10%").
Postconditions	The operator is aware of the current operational status and any impending compliance risks.
Expected Outcome	The operator takes timely corrective action based on the alert and guidance, preventing a pollution event and ensuring compliance.

PREDICT COMPLIANCE RISK

Use Case Name	Predict Compliance Risk
Actors	AI Service (Secondary)
Description	The system uses AI models to analyze incoming sensor data and predict the probability of wastewater parameters exceeding legal limits within a future timeframe (e.g., 1-6 hours).
Preconditions	The system is receiving a continuous stream of valid sensor data. The AI model is trained and deployed to be accessible via API.
Trigger	This is an automated, time-based, or event-driven process that runs continuously as new data arrives.
Main Flow	<ol style="list-style-type: none">1. The system ingests and preprocesses real-time data2. The data is fed into the predictive AI model to forecast future parameter values.3. The model outputs a risk score and identifies key contributing factors (Explainable AI).4. The system sends the prediction output to the AI Service to generate human-readable guidance.
Postconditions	A compliance risk prediction and associated actionable guidance are generated and stored.
Expected Outcome	The system has a quantifiable risk level and a clear recommendation ready to be displayed to the operators or Environmental Compliance Manager.

REVIEW AI PREDICTION RATIONALE

Use Case Name	Review AI Prediction Rationale
Actors	Environmental Compliance Manager (Primary)
Description	Allows the manager to investigate the "why" behind a specific predictive alert, using the Explainable AI (XAI) component to understand the key factors that led to the prediction.
Preconditions	The Manager is logged into the GreenThread platform. At least one predictive alert has been generated by the system.
Trigger	The Manager clicks on a specific alert or prediction in their dashboard to view details.
Main Flow	<ol style="list-style-type: none">1.The Manager selects a predictive alert for review.2.The system displays the detailed prediction, including the predicted values and confidence score.3.The system presents the XAI output, highlighting the top factors influencing the prediction (e.g., "75% of risk is due to a rapid 20% increase in turbidity in the last hour").
Postconditions	The Manager has a clear understanding of the AI's reasoning for the alert.
Expected Outcome	The Manager can confidently validate the alert and authorize or refine the recommended corrective actions, building trust in the system.

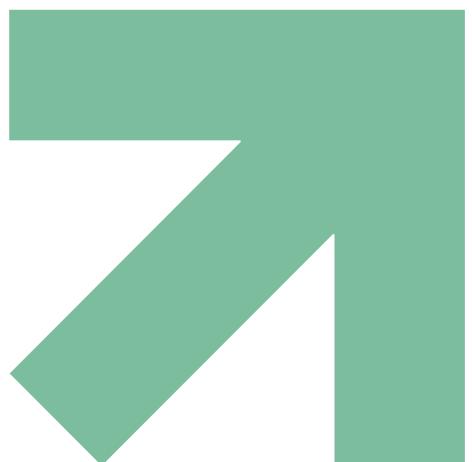
VERIFY COMPLIANCE DATA (AUDIT)

Use Case Name	Verify Compliance Data (Audit)
Actors	Environmental Regulator (Primary)
Description	Allows a regulator to securely access a factory's historical compliance data on the GreenThread platform to perform an official audit and verify adherence to environmental standards (e.g., QCVN 13-MT:2015).
Preconditions	The Regulator has a valid, authorized account on the GreenThread platform. The factory being audited is registered on the system.
Trigger	An official audit of a textile factory is initiated.
Main Flow	<ol style="list-style-type: none">1. The Regulator logs in and navigates to the audit section.2. The Regulator selects the factory and the audit period.3. The system retrieves the relevant, immutable historical data by invoking the Monitor & Analyze Realtime Sensor Data functionality.4. The data, along with any blockchain-verified certificates, is presented to the Regulator for verification.
Postconditions	The Regulator has completed their data review for the audit.
Expected Outcome	The Regulator can make an informed and evidence-based decision on the factory's compliance status.

3

PROJECT MANAGEMENT &

RISKS



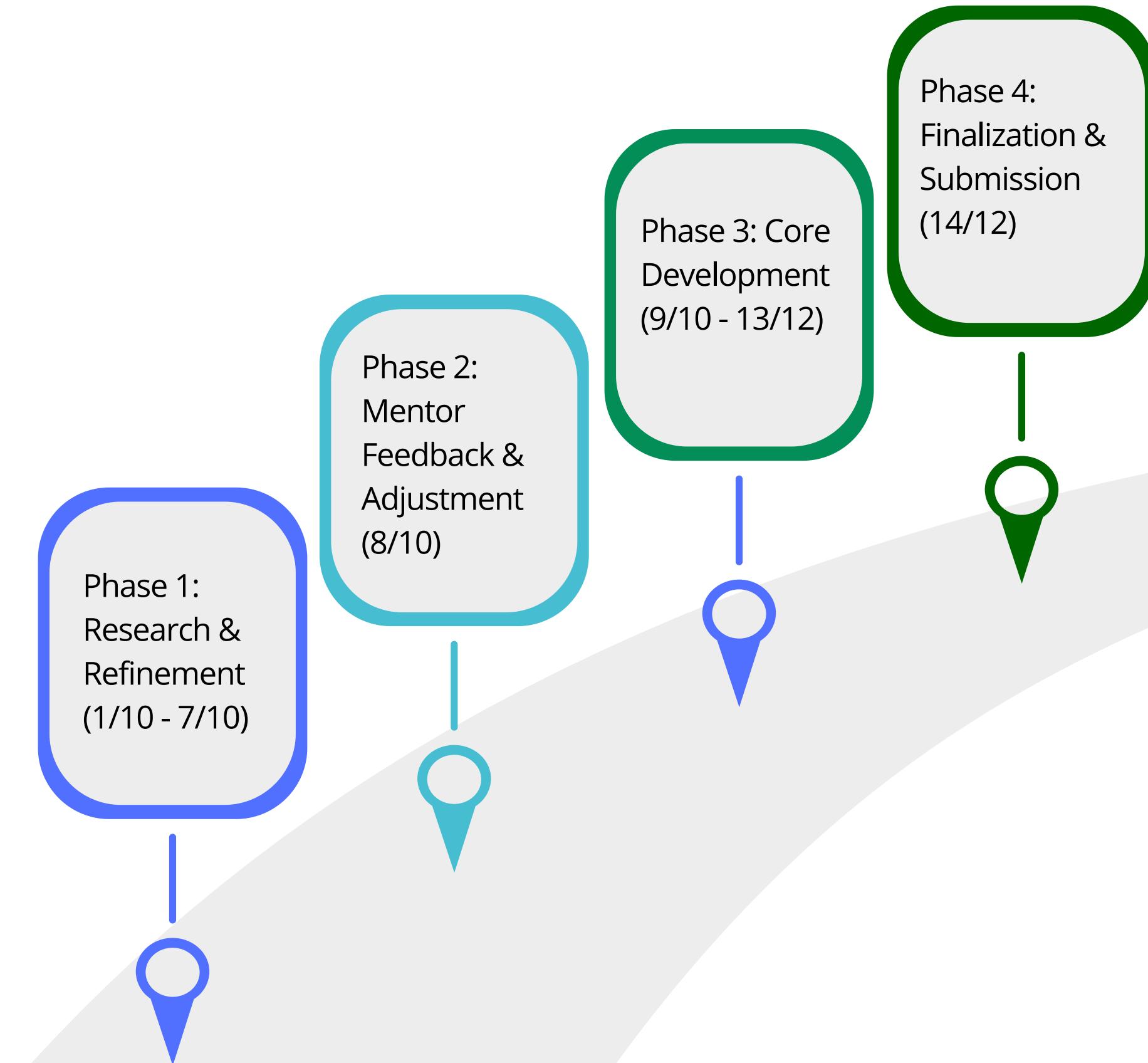
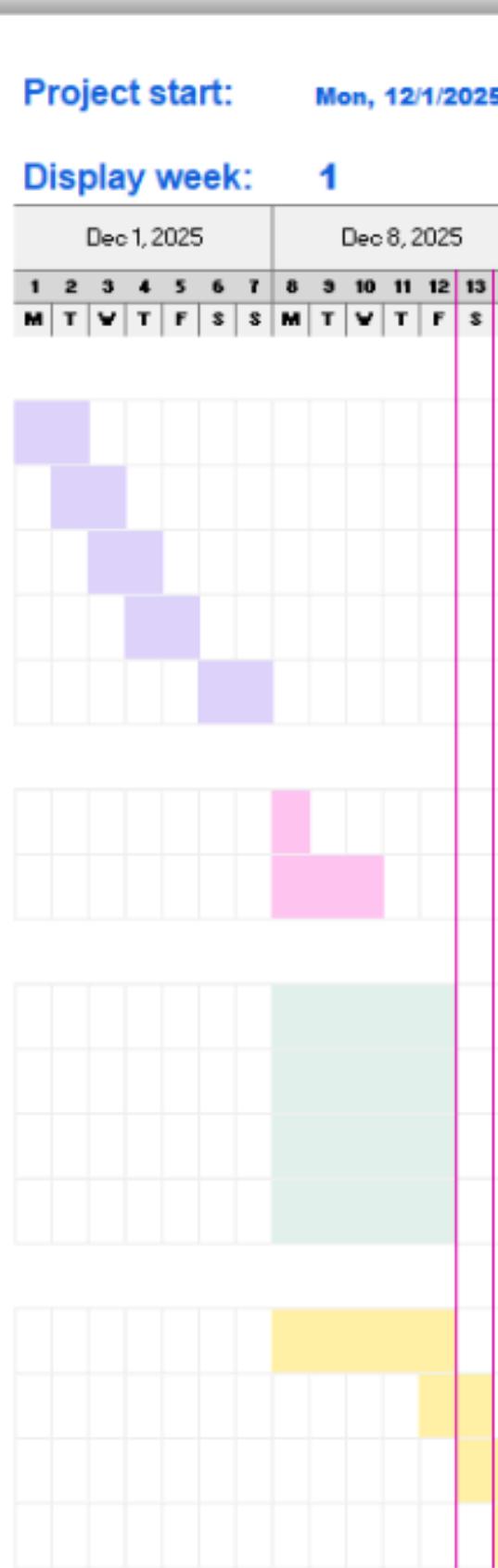
REALISTIC TIMELINE PHASES & MILESTONES

Round 2 Doc

HiDistincters

Project lead: Ven Gia Nghia

Task	Assigned To	Progress	Start	End
Phase 1: Research & Refinement				
Re-define problem statement	Long	100%	12/1/25	12/2/25
Analyze midstream wastewater processes	Nghia	100%	12/2/25	12/3/25
Key features/core values justification	Chi, Khang	100%	12/3/25	12/4/25
Members' expertise division	Chi, Long	100%	12/4/25	12/5/25
Find slides for Round 2	Nghia	100%	12/6/25	12/7/25
Phase 2: Mentor Feedback & Adjustment				
Post-meeting discussing	Khang, chi	100%	12/8/25	12/8/25
Plan updates	Long, Nghia	100%	12/8/25	12/10/25
Phase 3: Core Development				
Business general study (1-4)	Long	100%	12/8/25	12/12/25
Func-Req & Prototype product designing	Chi	100%	12/8/25	12/12/25
Use case diagram & Architecture	Khang	100%	12/8/25	12/12/25
Management, risks analyze & social impacts metrics	Nghia	100%	12/8/25	12/12/25
Phase 4: Finalization & Submission				
Finishing documentation	All	100%	12/8/25	12/12/25
Video presentation	All	100%	12/12/25	12/13/25
Editing	Chi, Nghia	100%	12/13/25	12/14/25
SUBMISSION	Nghia	100%	12/14/25	12/14/25



REALISTIC TIMELINE PHASES & MILESTONES

3-YEAR EXCEL GANTT CHART for GreenThread

Methodology and Tools for Coordination and Progress Tracking

For coordination and tracking, we utilize **Confluence** (**Atlassian suite**) as our primary tool, leveraging nearly 100% of its capabilities for seamless collaboration. Specific usages include:

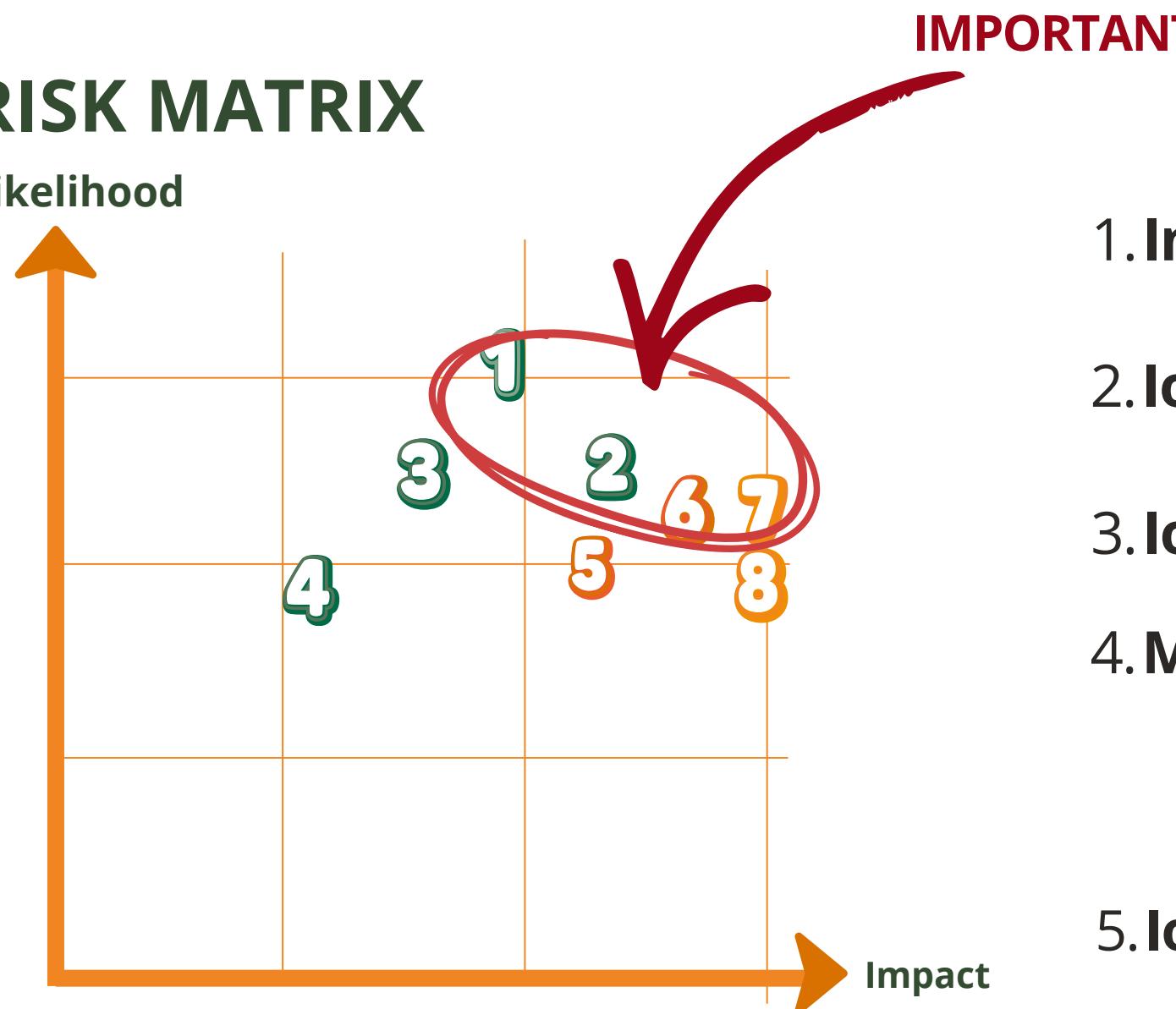
- Live Docs: Shared draft files for collaborative editing.
- Jira Integration: Task boards for tracking progress. This helps visualize blockers.
- Meeting Notes: Dedicated pages for recording sessions.
- Researching Area: Centralized space for midstream context.
- Guideline Area: Templates and standards collected from the released guidelines to maintain consistency.
- File Storage: Uploading attachments like workflow images, FR.pdf, Use Case PDFs, and references for easy access.
- Separated Business & Technical Areas
- Google Drive also play an important role in storing Audio file from the meetings.

The screenshot shows the Confluence interface. The left sidebar includes links for 'For you', 'Recent', 'Starred', 'Spaces', 'Apps', and a 'MaChile' space section containing 'Shortcuts', 'Jira', 'Meeting notes in space', 'Content', and a search bar. The main content area displays the 'Overview' page with sections for 'Recent content that I've worked on' (listing 'Round 2 Documentation's Tasks' and 'System Architecture Diagram Description'), 'Recent updates' (listing 'Important links' and 'Use Case Description'), and 'Get in touch' (with icons for email and LinkedIn). A footer note at the bottom right reads: 'End with a bang! Some options are: "I am so grateful to be here at <Insert company name> and very you!"'

RISK CALCULATION

Risk Category	Risk	Likelihood	Impact	Description
Technical	Inaccurate AI predictions	Medium	High	Models (XGBoost/LSTM in Predictive AI) may fail due to noisy or insufficient wastewater data, leading to false alert.
Technical	IoT sensor security	Medium	High	Misconfigurations in IoT sensor and gateway networks pose critical security flaws, leading to unauthorized external access, data manipulation, and illegal control of connected actuators.
Technical	IoT sensor reliability	High	Medium	Sensors in harsh industrial environments could face calibration issues, data tampering, or failures, affecting real-time monitoring.
Technical	Maintenance requirements	Medium	Low	Regular calibration and cleaning of IoT sensors in harsh wastewater conditions may cause temporary downtime and higher post-deployment maintenance costs if not managed systematically.
Business	IoT Dependency	High	High	Reliance on outsourced IoT hardware causing slow ROI due to setup cost & maintenance.
Business	Price Competitiveness	High	High	Cost may not undercut traditional wastewater firms, limiting adoption.
Business	SME Resistance	High	Medium	Service providers blocking factory integration or low digital readiness.
Business	Data Credibility	Medium	Medium	Stakeholders doubt AI data validity or objectivity.

RISK MATRIX



MITIGATION

TECHNOLOGICAL RISKS

1. **Inaccurate AI predictions** ➤ Validate data sources; incorporate mentor feedback for model retraining.
2. **IoT sensor security** ➤ Isolate IoT devices on a separate, local network statement with restricted network access and least privileges
3. **IoT sensor reliability** ➤ Fallback to simulated data if failures occur before submission.
4. **Maintenance requirement** ➤ Ongoing sensor and system upkeep (e.g., cleaning/calibrating water sensor in corrosive wastewater)

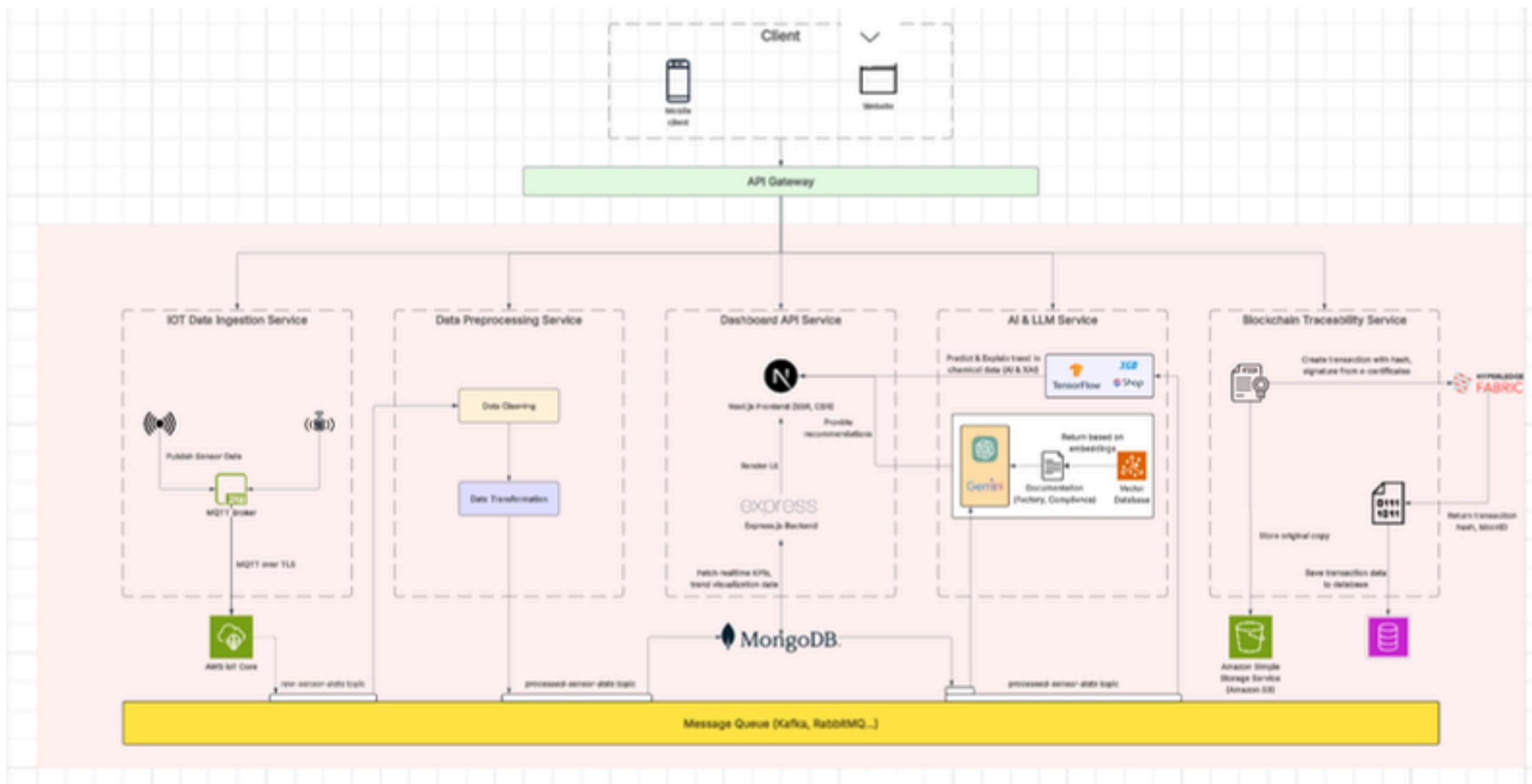
BUSINESS RISKS

5. **IoT Dependency** ➤ Partner with trusted local IoT firms (e.g., FPT, Viettel) under SLA for uptime & maintenance.
6. **Price competitiveness** ➤ Modular pricing + long-term ROI communication.
7. **SME Resistance** ➤ Collaborate with MONRE & VITAS on ESG pilot zones to drive official adoption.
8. **Data Credibility** ➤ Third-party ESG audits for verified transparency.



By addressing high-likelihood and high-impact risks through **verified data, local partnerships, and adaptive pricing**, GreenThread minimizes uncertainty and strengthens investor and client confidence.

KEY COMPONENTS



Microservices Architecture Diagram for GreenThread

- **IoT Data Ingestion Service**: Securely collects high-frequency sensor data from the factory floor and streams it to the cloud for processing.
- **Data Preprocessing Service**: Cleans and transforms raw, noisy sensor streams into a standardized, high-quality format, ensuring all other services work with reliable data.
- **Dashboard API Service**: The user-facing web application that provides real-time dashboards, alerts, and trend visualizations for factory operators and managers.
- **AI & LLM Service**: The core intelligence engine that analyzes data to predict compliance risks, explain their causes, and generate actionable, human-readable recommendations.

DATA FLOW

Asynchronous Flow: Real-Time Data Pipeline

Data Ingestion

IoT sensors stream real-time wastewater data to the cloud via **MQTT** over **TLS**

Queuing for Decoupling

All incoming data is published to a **Message Queue**, decoupling the system for scalability and resilience.

Preprocessing and Storage

A dedicated service consumes raw data, cleans it, and stores the structured result in **MongoDB** for historical analysis.

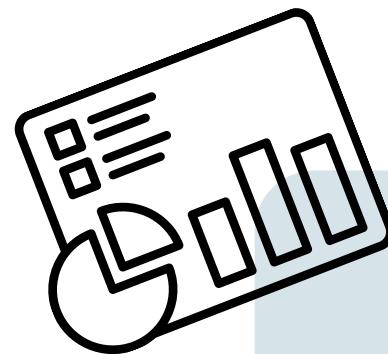
AI Analysis and Recommendation Generation

The **AI & LLM Service** consumes the clean data to predict compliance risks, explain their root causes, and generate actionable, human-readable guidance.

DATA FLOW

Synchronous Flow: User-Initiated Actions

DASHBOARD VISUALIZATION



A user requests to view the dashboard



The backend API queries MongoDB for the latest data and historical trends.



Data is returned to the frontend to render real-time charts and AI-generated alerts.



DATA FLOW

Synchronous Flow: User-Initiated Actions

E-CERTIFICATE ISSUANCE AND BLOCKCHAIN ANCHORING

A Regulator issues an e-certificate and performs API call to **Blockchain Service**



The **Blockchain Service** stores the certificate file and creates an immutable transaction on the **Hyperledger Fabric** network.



The final transaction ID and file link are saved to the database for permanent verification.

JUSTIFICATION

SCALABILITY

Message Queue allows to scale individual components independently based on load. If sensor data spikes, more processing workers will be added to handle the queue to avoid bottlenecks.

SECURITY

Sensor's limit to protected local network allow the data to be securely transferred, while the blockchain's cryptographic hash makes compliance e-certificates verifiable and tamper-proof

MAINTAINABILITY

The **microservices architecture** allows for independent updates (fix bugs, deploy) without affecting other services. This simplifies development and reduces the risk of system-wide failures.

PORTABILITY

Microservices can be packaged into containers, allowing **GreenThread** to run consistently on any cloud provider or infrastructure. This ensures the system can be deployed in different environments.

Clear, Testable Goals and Hypotheses

- Goal 1: Improve Prediction Accuracy** – Hypothesis: Integrating **XGBoost/LSTM** with **SHAP/LIME** will predict pollution spikes (e.g., COD > QCVN thresholds) with **90% accuracy**, reducing undetected violations by **50%** compared to manual monitoring.
- Goal 2: Enhance System Performance** – Hypothesis: **MQTT/IoT** gateway with **MongoDB** will enable real-time alerts (<2s latency), minimizing response time to breaches by **70%** in simulated industrial settings.
- Goal 3: Boost Data Quality and Usability for Operators** – Hypothesis: Through targeted collection of high-quality labeled wastewater data and refinement of the web dashboard with generative AI guidance, we will improve AI model accuracy to F1-score **>85%** while achieving a **System Usability Scale (SUS)** score **>80**, increasing simulated operator adoption from a baseline of **~60% to >85%** in usability tests.
- Goal 4: Ensure Security and Data Integrity** – Hypothesis: **Blockchain** integration combined with encrypted **IoT** transmission will result in zero security breaches or data tampering incidents during testing and pilot phases, enabling **100% verifiable compliance records** and building trust for **ESG** reporting in midstream supply chains.

Metrics with Numeric Targets

Dimension	Metrics	Numeric Targets	Rationale/Link to System
Correctness	AI Prediction Accuracy (F1-score, Precision/Recall for spikes); Blockchain Immutability (tamper detection rate); Data Integrity (error rate in IoT feeds)	F1 >90%; Precision >85%; 100% tamper resistance; <1% data errors	Ensures reliable alerts (e.g., COD predictions); tests Use Cases like "Predict Compliance Risk".
Performance	Latency (alert delivery); Throughput (data points/sec); Scalability (concurrent users)	<2s latency; >100 points/sec; Handle 50 users without >10% slowdown	Critical for real-time midstream ops; evaluates MQTT/MongoDB integration.
Usability	SUS Score; Task Completion Rate; User Satisfaction (NPS)	SUS >80; >95% completion; NPS >70	Measures dashboard intuitiveness for operators; aligns with FR "Real-Time Sensor Dashboard".
Impact	Pollution Reduction (% BOD/COD compliance); Cost Savings (fines avoided); Adoption Rate (% SMEs using); ESG Score Improvement	>70% compliance increase; Save >20% fines (484B VND baseline); >50% adoption; +15% ESG	Quantifies business value (e.g., export growth); supports SDG alignment.

Evaluation Methods and Coverage

- **Unit/Integration Testing** (Covers: Correctness, Performance): Automated scripts (e.g., Python/PyTest) test components—e.g., XGBoost accuracy on synthetic wastewater data (BOD/COD simulations), MQTT latency under load. Coverage: 80% code; targets F1>90%.
- **Simulation Testing** (Covers: All Dimensions): Virtual environments (e.g., AWS IoT Core) mimic midstream scenarios (e.g., dye chemical spikes); evaluate blockchain transactions for scalability.
- **Usability Testing** (Covers: Usability): Heuristic evaluation and user sessions with 10-15 factory operators (via Zoom prototypes); measure SUS/NPS.
- **Pilot Studies** (Covers: Impact): Deploy MVP in 2-3 SMEs (e.g., Bình Dương partners via VITAS); track real-world metrics over 1 month

Data Capture and Analysis

- **Capture Methods:** Logs from system (e.g., MongoDB for AI outputs, blockchain hashes for audits); surveys/interviews for usability (Google Forms); sensor telemetry for performance (e.g., timestamped MQTT packets); pre/post-pilot metrics (e.g., water samples for BOD/COD via lab tests).
- **Analysis:** Quantitative: Stats tools (Python/Scipy) for metrics (e.g., MAE/R² for AI); qualitative: Thematic analysis of feedback (NVivo). Thresholds trigger alerts (e.g., if accuracy <90%, flag for retrain). Visualizations (e.g., dashboards) aid interpretation.