National Teachers College
629 Nepomuceno St., Quiapo, Metro Manila
School of Arts, Sciences, and Technology (SoAST)

Corporate E-Waste Monitor Database System

SDG 9 & 12 - (Industry, innovation and infrastructure)
(Responsible consumption and production)

Submitted on :
December 15, 2025

Group Members :
Baltar, Teddy Michael S.
Cunanan, Jeremiah S.
Lopez, Judd Marc C.

I. Introduction

Project Overview: Sustainable E-Waste Management System

The proposed project aims to design a Database Management System (DBMS) that helps individuals and organizations manage their e-waste in a more sustainable and responsible manner, aligning with the United Nations' Sustainable Development Goals (SDGs) 9 and 12.

Objective:

The project's objective is to create a comprehensive DBMS that enables users to track and analyze their e-waste, identify areas for improvement, and reduce their environmental impact. The project will focus on developing a system that promotes sustainable practices, reduces waste, and increases efficiency in e-waste management.

Key Features:

1. E-Waste Tracking: Develop a database to track e-waste generation, collection, and disposal, enabling users to monitor their e-waste management practices.
2. Sustainable E-Waste Management: Create a system to promote sustainable e-waste management practices, such as recycling, reuse, and proper disposal.
3. Waste Reduction: Design a module to help users reduce their e-waste generation, through education and awareness-raising activities.
4. Collaborative Platform: Create a web-based platform for users to share best practices, access resources, and collaborate with stakeholders to promote sustainable e-waste management.
5. Data Analysis: Provide a tool to analyze e-waste data, enabling users to identify trends, patterns, and areas for improvement.

Benefits:

1. Reduced e-waste generation and disposal
2. Increased efficiency in e-waste management
3. Improved environmental sustainability
4. Enhanced brand reputation and customer trust
5. Access to a collaborative platform for knowledge sharing and best practices

Target Users:

1. Individuals and organizations that generate e-waste
2. E-waste collectors and recyclers
3. Environmental and social organizations promoting sustainable practices

Database Design:

The database will consist of several tables, including:

1. E-Waste Generation: information about e-waste generation, including type, quantity, and source
2. E-Waste Collection: information about e-waste collection, including type, quantity, and collection method
3. E-Waste Disposal: information about e-waste disposal, including type, quantity, and disposal method
4. Sustainable E-Waste Management: information about sustainable e-waste management practices, including recycling, reuse, and proper disposal
5. Collaborative Platform: user profiles, discussions, and knowledge sharing

Methodology:

The project will follow a user-centered design approach, involving stakeholders and end-users in the design and development process. The project will also involve a thorough analysis of existing literature and best practices in sustainable e-waste management.

Timeline:

The project will be completed within 6 months, with the following milestones:

1. Literature review and analysis (1 month)
2. User research and stakeholder engagement (1 month)
3. Database design and development (2 months)
4. Testing and evaluation (1 month)
5. Deployment and maintenance (1 month)

Budget:

The project budget will be approximately PHP 5,910,050, covering the following expenses:

1. Personnel (development team, project manager, and stakeholders) (40%)
2. Software and hardware (20%)
3. Travel and training (10%)
4. Contingency fund (30%)

This project overview aligns with SDG 9 by promoting innovation and infrastructure development in the e-waste management sector and aligning with SDG 12 by encouraging responsible consumption and production practices throughout the supply chain.

The project also draws on the following SDG 12 targets:

- Target 12.1: Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns
- Target 12.2: By 2030, achieve the sustainable management and efficient use of natural resources
- Target 12.3: By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses
- Target 12.4: By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment
- Target 12.5: By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse
- Target 12.6: Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle
- Target 12.7: Promote public procurement practices that are sustainable, in accordance with national policies and priorities
- Target 12.8: By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature
- Target 12.a: Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production
- Target 12.b: Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products

- Target 12.c: Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities.

Statement of the Problem

The problem addressed in this study is the Overconsumption and E-waste. These are deeply interconnected with the goals of the SDG 9 (Industry, Innovation, and Infrastructure) and the SDG 12 (Responsible Consumption and Production). The SDG 9 emphasizes the development of infrastructure and having a sustainable industrialization, the quick expansion of the industrial activities and the infrastructure projects that often leads to increased consumption of the natural resources and energy, this will contribute to both degradation and waste generation. This contains the production of the electronic devices, which requires a crucial amount of the raw materials and energy. At the same time, the SDG 12 directly addresses the issue of unsustainable consumption and production also, especially highlighting the increasing problem of the E-waste. With the global E-waste generation reaching 7.8kg per capita in 2022, and only 22.3% of it being properly managed, there is an essential need to improve such as recycling the waste management practices to ensure sustainability of the resources used and also to reduce the environmental harm.

Purpose

This research goal is to create a Sustainable E-trash Management Database System which is going to deal with the problem of electronic trash that is getting bigger and bigger one hundred percent based on the same reason that overconsumption is the main factor. The situation is such that larger and larger quantities of new gadgets and digital devices create equally large amounts of waste electronics which are hazardous to the environment, and also sources of depletion, and are improperly disposed of. This research sets out to provide a solution whereby both individuals and businesses would have their e-wastes from overconsumption understood, measured, and managed properly. The project intends to create a centralized, digital, data-driven platform where users will be able to monitor their e-waste, pinpoint the unsustainable consumption patterns, and get guidance on proper disposal, recycling, or reuse thereof. The system will facilitate the engagement of clients in good buying, using, and waste disposal of electronic devices through means that identify and inform consumers of waste trends and consumption patterns. The digital platform is also going to be a means of bringing together recyclers, consumers, and organizations who are teaching and practicing eco-friendly methods of handling e-waste to promote and practice sustainable e-waste handling. The specific objective of the research is to diminish the unfavorable impacts of overconsumption on the environment by: The raise of electronic waste has become an issue through which innovation and waste management infrastructure development (SDG 9) are promoted. Moreover, it is essential to support responsible consumption patterns and sustainable waste management practices that slow down gadget replacement and eliminate wrong disposal (SDG 12). This study that emphasizes the link between overconsumption and electronic waste generation facilitates the development of sustainable lifestyles and the reduction of long-term harm from e-waste.

II. Requirements and Analysis

Functional and Non-Functional Requirements

The following Functional Requirements (FRs) and Non-Functional Requirements (NFRs) define the core features and qualities of the Sustainable E-Waste Management System. The FRs focus on the specific actions the system must perform, such as tracking e-waste, providing educational resources, and enabling collaboration among users. The NFRs define how the system should perform, covering aspects like performance, security, usability, and sustainability. Together, these requirements ensure the system is effective, reliable, and aligned with responsible e-waste management practices.

Functional Requirements (FRs)		
ID	**Requirement**	**Details**
FR1	Users can register and log in to access the platform.	Use an authentication system (sign-up form, email/password validation, password hashing) with user roles (regular users, admins). Store credentials in a secure user database table and implement login sessions or JWT tokens for persistent authentication.

FR2	Users can input, track, and update e-waste data.	Provide forms and UI interfaces for users to enter e-waste records (type, weight, date, source). Save entries to the database and allow edit/delete operations with CRUD (Create, Read, Update, Delete) APIs.
FR3	Users can categorize e-waste by type.	Include dropdowns or tagging features for categories such as electronics, batteries, plastics. Use relational database tables to manage types and link them to user entries.
FR4	System calculates and shows total e-waste over time.	Run backend queries (e.g., SQL aggregations) that sum e-waste amounts over user-selected time ranges and display graphs/charts.
FR5	System notifies users about sustainable disposal practices.	Use a notification engine or scheduled tasks to send reminders/tips based on user activity or thresholds (e.g., email alerts about recycling options).
FR6	System provides educational resources to reduce e-waste.	Embed a content management section that delivers articles, videos, or guides — admins can upload content that's displayed in the UI.
FR7	Users can share best practices and collaborate with others.	Build forums, comment sections, or shared dashboards where users can post tips and resources;

		implement user profiles and messaging.
FR8	System generates reports and visualizations for analysis.	Use reporting tools or libraries (like Chart.js or D3.js) to build dashboards. Reports should be query-driven and exportable.
FR9	System flags unusually high e-waste generation.	Set threshold rules (e.g., over a user's average + x%) and implement automated alerts or tagging of flagged entries in the system.
FR10	Admins can manage users, categories, and platform content.	Admin dashboards with elevated privileges, including user moderation, category modifications, and upload/approval of educational content.

Table 1: Functional Requirements (FRs)

Non-Functional Requirements (NFRs)		
ID	**Requirement**	**Details**
NFR1	NFR1: System handles up to 5,000 concurrent users efficiently.	Design with scalable infrastructure (load balancers, caching like Redis, horizontal scaling) and performance testing.
NFR2	NFR2: Interface is intuitive and tasks can be completed in 3 clicks.	UX design principles, user testing, clear navigation paths, and streamlined UI/UX layouts.

NFR3	NFR3: System uptime is 99.5% per month.	Use cloud hosting with redundancy (e.g., AWS/GCP/Azure), failover mechanisms, and monitoring services.
NFR4	NFR4: All user data is encrypted in storage and transit.	Use HTTPS/TLS for all communications and encrypt sensitive database fields (AES-256 or equivalent).
NFR5	NFR5: System can scale to support more users and e-waste types.	Modular design, microservices where applicable, scalable database schemas, and containerization (Docker/Kubernetes).
NFR6	NFR6: Code is modular for easy updates and maintenance.	Follow software design patterns, layered architecture, documentation, and version control.
NFR7	NFR7: System ensures data integrity and prevents duplicates.	Use database constraints (unique keys) and validation logic at input forms or APIs.
NFR8	NFR8: Platform is accessible on desktop and mobile devices.	Responsive web design or progressively enhanced UI frameworks (React/Vue/Bootstrap).
NFR9	NFR9: Reports can be exported in standard formats (CSV, PDF).	Export features tied to report generation modules, using libraries for PDF/CSV creation.
NFR10	NFR10: System is optimized for energy efficiency and sustainability.	Cloud autoscaling, serverless functions where applicable, efficient query designs, and green hosting considerations.

Table 2: Non-Functional Requirements (NFRs)

Data Requirements

The Sustainable E-Waste Management System requires structured and well-organized data to support tracking, analysis, and reporting of e-waste activities. The system stores user-generated data, system-generated analytics, and administrative content to ensure accurate monitoring and sustainable decision-making.

The required data includes user information, such as user IDs, login credentials, roles, and profile details, which are necessary for authentication and access control. E-waste records are also required, including the type of waste, quantity, date of generation, disposal method, and associated user. These records allow the system to track e-waste trends and calculate totals over time.

Additionally, the system stores e-waste categories to standardize classification and prevent inconsistencies in data entry. Educational content data such as articles, guides, and sustainability tips are maintained to support awareness and waste reduction initiatives. System logs and notifications are also recorded to track flagged activities, alerts, and administrative actions.

All data must be accurate, consistent, and securely stored to ensure reliability, usability, and compliance with sustainable management goals.

2.2 Schema Normalization Analysis

The database schema of the Sustainable E-Waste Management System is designed following database normalization principles to minimize redundancy and ensure data integrity.

First Normal Form (1NF)

All tables contain atomic values, meaning each field stores a single, indivisible value. Repeating groups and multi-valued attributes are eliminated. For example, e-waste entries store one waste type per record instead of multiple types in a single field.

Second Normal Form (2NF)

The schema ensures that all non-key attributes are fully functionally dependent on the primary key. For instance, e-waste details such as quantity and disposal method depend entirely on the unique e-waste record ID, not partially on user information. User data is stored in a separate table to avoid duplication.

Third Normal Form (3NF)

All transitive dependencies are removed by separating related data into distinct tables. Categories, users, and educational resources are stored independently and referenced using foreign keys. This prevents issues such as updating the same category name in multiple places and improves consistency.

By applying normalization up to Third Normal Form (3NF), the database achieves efficient storage, reduces redundancy, and ensures data integrity while maintaining flexibility for future expansion, such as adding new e-waste categories or analytical features.

III. Design Specification

1. Tables

The table of e-waste compliance system utilizes a table-based structure designed to keep an eye to environmental accountability while managing the procurement workflows. The data is being organized into various tables that track the companies, their estimated and reported e-waste generation, and compliance flags triggered by the discrepancies between the projections and the actual submissions. This kind of design supports the regulatory oversight by empowering the automated variance analysis to identify the potential non-compliance. The main purpose of this system differs from the procurement databases, which focus on transactional processes and also inventory control. In contrast, the e-waste system will emphasize compliance monitoring, data consistency, and enforcement actions. These tables are structured to support the analytical queries that will reveal trends in e-waste generation and reporting behavior over time. While both systems benefit from structured data organization, the e-waste database prioritizes auditability and regulatory enforcement. Automated flagging mechanisms are used to systematically identify companies that fail to report, exceed limits, or show inconsistent data. This approach contrasts with the transactional focus of procurement systems, where the emphasis is on tracking purchases and managing stock levels. The table-based architecture will enable efficient data retrieval, comparison, and reporting also, which is essential for effective compliance monitoring.

COMPANIES

```
CREATE TABLE companies (
  company_id     VARCHAR(10) PRIMARY KEY,
  company_name   VARCHAR(255) NOT NULL,
  headquarters   VARCHAR(255),
  main_products  TEXT,
  is_active      BOOLEAN DEFAULT TRUE,
```

```
    created_at     TIMESTAMP DEFAULT CURRENT_TIMESTAMP
) ENGINE=InnoDB;
```

ESTIMATED E-WASTE

```
CREATE TABLE estimated_ewaste (
    id                        INT AUTO_INCREMENT PRIMARY KEY,
    company_id                VARCHAR(10),
    year                      INT NOT NULL,
    assumed_device_share      DECIMAL(6,4),
    estimated_generated_tonnes  BIGINT,
    cost_cap                  DECIMAL(15,2),
    notes                     TEXT,
    created_at                TIMESTAMP DEFAULT CURRENT_TIMESTAMP,

    CONSTRAINT uq_company_year_est
        UNIQUE (company_id, year),

    CONSTRAINT fk_est_company
        FOREIGN KEY (company_id)
        REFERENCES companies(company_id)
) ENGINE=InnoDB;
```

REPORTED E-WASTE

```
CREATE TABLE reported_ewaste (
    id           INT AUTO_INCREMENT PRIMARY KEY,
    company_id   VARCHAR(10),
    year         INT NOT NULL,
    metric       VARCHAR(100),
    tonnes       DECIMAL(15,2),
    cost_cap     DECIMAL(15,2),
    notes        TEXT,
    reported_at  TIMESTAMP DEFAULT CURRENT_TIMESTAMP,

    CONSTRAINT fk_rep_company
        FOREIGN KEY (company_id)
        REFERENCES companies(company_id)
) ENGINE=InnoDB;
```

FLAGGED COMPANIES

```
CREATE TABLE flagged_companies (
    flag_id         INT AUTO_INCREMENT PRIMARY KEY,
    company_id      VARCHAR(10) NOT NULL,
    year            INT NOT NULL,
    flag_reason     ENUM(
                    'FAILED_TO_REPORT',
                    'EXCEEDED_EWASTE_LIMIT',
                    'INCONSISTENT_DATA',
                    'LATE_REPORTING',
                    'SUSPICIOUS_VARIANCE'
                  ) NOT NULL,
    reported_tonnes  DECIMAL(15,2),
    estimated_tonnes BIGINT,
    ewaste_limit     BIGINT DEFAULT 8000000,
    flagged_at       TIMESTAMP DEFAULT CURRENT_TIMESTAMP,
    remarks          TEXT,

    CONSTRAINT fk_flagged_company
        FOREIGN KEY (company_id)
        REFERENCES companies(company_id)
) ENGINE=InnoDB;
```

SUMMARY VIEW

```
CREATE VIEW vw_company_ewaste_summary AS
SELECT
    c.company_name,
    e.year,
    e.estimated_generated_tonnes,
    r.tonnes AS reported_tonnes,
    (e.estimated_generated_tonnes - IFNULL(r.tonnes, 0)) AS variance
FROM companies c
LEFT JOIN estimated_ewaste e
    ON c.company_id = e.company_id
LEFT JOIN reported_ewaste r
    ON c.company_id = r.company_id
   AND e.year = r.year;
```

2. Primary Key

The Corporate E-waste primary key in every table serves as a unique identifier that will distinguish the individual records and will ensure the data integrity. In the companies table, the company_id functions as the primary key and serves as their unique identifier for each organization within the system. The estimated_ewaste and reported_ewaste both of these tables use an auto-incrementing id field as their primary key, which will automatically generate a unique sequential number for every record entry. The flagged_companies table similarly employs an auto-incrementing flag_id as its primary key also and uniquely identifies each compliance flag instance. These primary keys have a big role to prevent duplicate entries, enable efficient data retrieval, and establish the foundation for the foreign key relationships that will link related tables together, making sure that the referential integrity across the entire database system.

3. Foreign Key

Foreign keys not only form relationships between the tables by pointing to the primary key of another table, but they also secure the referential integrity and keep the data consistent across the database. In such an e-waste compliance system, foreign keys act as the connecting rods that hang the relevant data in the tables: the company_id in the estimated_ewaste table points to the primary key company_id in the companies table thus making sure that every estimated e-waste record is linked to a valid company. Likewise, the company_id in the reported_ewaste table directs to the companies table thereby making sure that the reported data is correctly assigned to the existing organizations. Also, the foreign key in the flagged_companies table connects with the companies table which means that there is always a link between the compliance flags and the companies being monitored. These relationships imply that no data can be input in the child tables without a valid entry in the parent companies table thus preventing orphaned records and ensuring data accuracy. Moreover, the foreign key constraints make it possible to access the data by means of joins in an effective way as the system can simply merge the data from the different tables without breaking the relationships between them.

4. Trigger

The use of primary keys for each table has a significant impact on the unambiguous identification of every single record and the prevention of data duplication, which is essential for the system's data integrity in a complex scenario. Keys such as department_id, supplier_id, item_id, request_id, and detail_id provide a distinct identifier for each entity, allowing precise tracing and distinguishing of records even if data looks alike. In the inventory table, item_id is the primary key and also a foreign key that links to the items table thus valid items can be tracked in inventory only. The system restricts the non-negative quantity hence, data is protected from being unreliable and from inconsistencies. The foreign key relationships among the tables help to keep data in agreement, and no orphaned records are created as a result. The combination of primary and foreign keys creates a strong relational structure which not only allows the transactions to be monitored accurately but also keeps the data integrity throughout the procurement process. Though this approach is very successful in procurement systems, it is necessary to point out that the specific use cases and data requirements vary enormously from those of an e-waste compliance system.

5. Stored Procedure

The Stored procedures are database routines that have been precompiled and are designed to encapsulate complex logic and operations, thus allowing efficient and consistent execution of frequently used tasks.

Stored procedures may be utilized in this e-waste compliance system to automate the most critical processes, for instance, the flagging of non-compliant companies, the creation of compliance reports, or the calculation of the variance between estimated and reported e-waste.

As an illustration, a stored procedure might be devised to automatically verify inconsistencies in the vw_company_ewaste_summary view and, accordingly, insert the relevant records from the flagged_companies table that are based on the criteria already established. Such a method guarantees that compliance monitoring is regular, the possibility of human errors is reduced, and the system's performance is enhanced owing to the fact that redundant query execution is minimized.

In addition, stored procedures improve security by cutting down the access that is given directly to the underlying tables and by offering a controlled interface for data manipulation.

Moreover, they could be scheduled to execute at regular intervals, thus allowing the real-time monitoring of the compliance status and the prompt identification of the potential violations. In essence, by employing stored procedures, which are business logic centralized within the database, the task of maintenance becomes less complicated, and it is also ensured that all users interact with the system through standardized and reliable processes   processes.

3.1 Implementation Details

This section describes the database-level mechanisms used to support data integrity, automation, and reporting within the Waste Management Database System. The implementation relies on stored procedures, triggers, and views to enforce business rules and streamline data processing.

A. Stored Procedure

Stored procedures are used to encapsulate core database operations and ensure consistent handling of e-waste data across the system. In this implementation, stored procedures are designed to manage the insertion and validation of estimated and reported e-waste records.

When a new e-waste record is submitted, the stored procedure verifies that the target company exists in the companies table and enforces the unique company–year constraint defined in the estimated_ewaste table. This prevents duplicate yearly estimates for the same company. The procedure may also perform preliminary checks, such as ensuring that reported values are non-negative and logically aligned with predefined cost caps.

By centralizing this logic at the database level, the system minimizes redundant validation code at the application layer and guarantees consistent rule enforcement regardless of the data source.

B. Trigger

Triggers are implemented to automatically monitor compliance and detect anomalies during data insertion or update events. Specifically, triggers are associated with the reported_ewaste and estimated_ewaste tables.

When reported e-waste data is inserted, a trigger compares the reported tonnage against the corresponding estimated value. If predefined conditions are met—such as exceeding the allowed e-waste limit, large unexplained variance, or missing reports—the trigger automatically inserts a record into the flagged_companies table. The flag includes the company ID, reporting year, detected issue type, and relevant tonnage values.

This approach ensures real-time enforcement of compliance rules and removes the need for manual auditing, allowing violations to be captured immediately as data enters the system.

C. Views

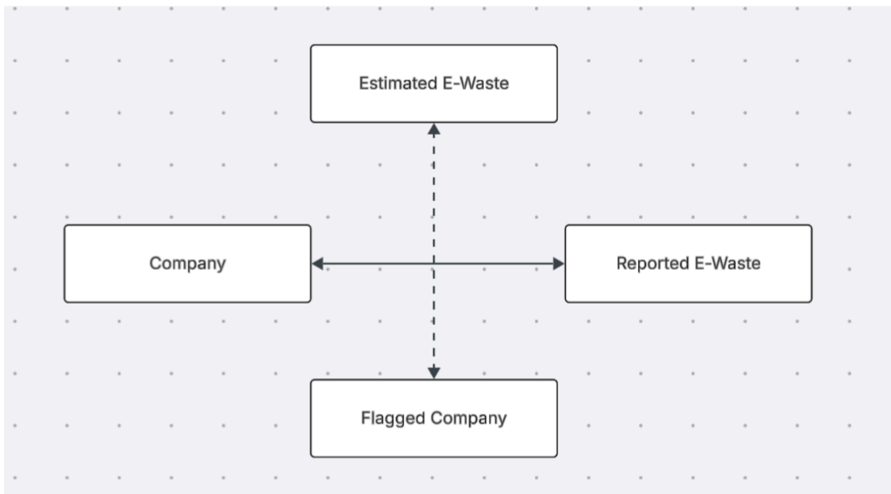
Database views are used to simplify data analysis and reporting without duplicating stored data. The vw_company_ewaste_summary view provides a unified, read-only summary of company e-waste performance.

This view combines data from the companies, estimated_ewaste, and reported_ewaste tables using left joins to ensure visibility even when reported data is missing. It presents the estimated tonnage, reported tonnage, and the computed variance for each company per year.

By abstracting complex joins and calculations into a view, the system enables faster report generation, easier data interpretation, and safer access for analytics or visualization tools without exposing raw transactional tables.

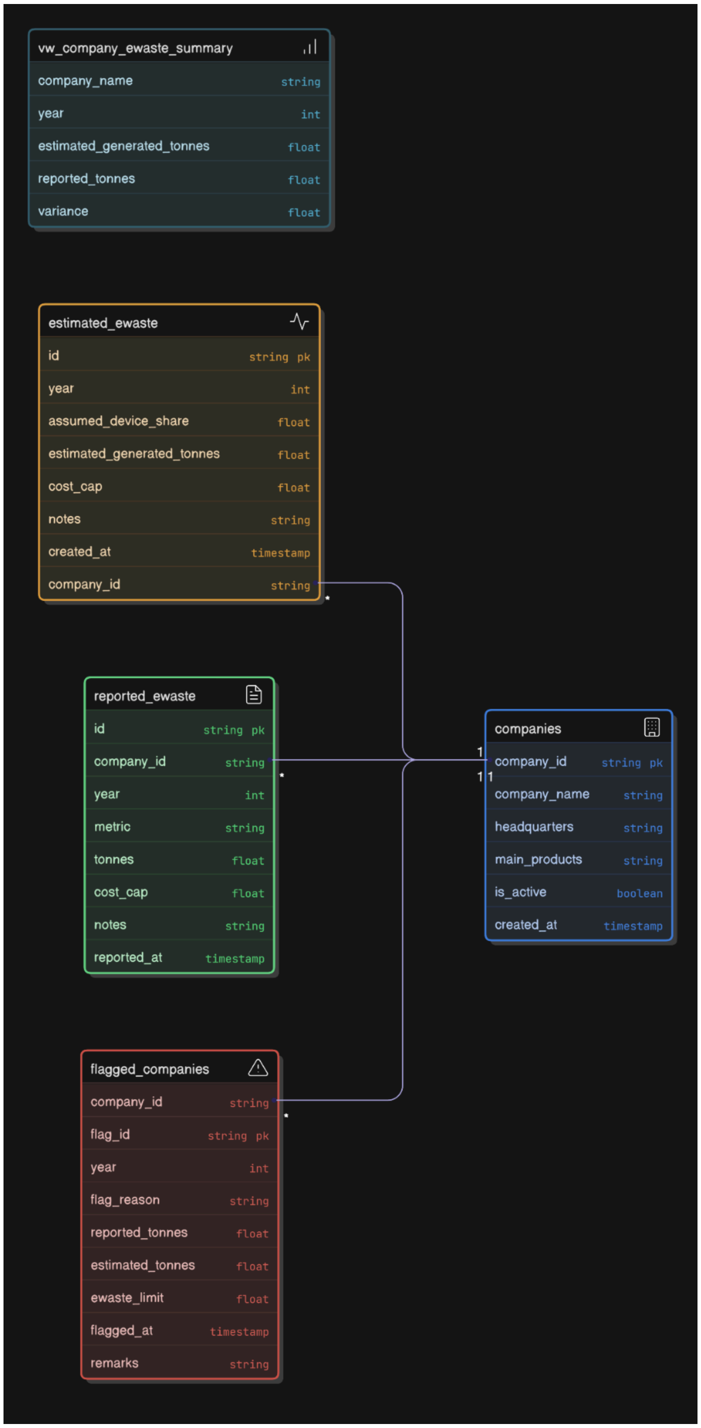
3.2. ER Diagram:

A. Conceptual ERD

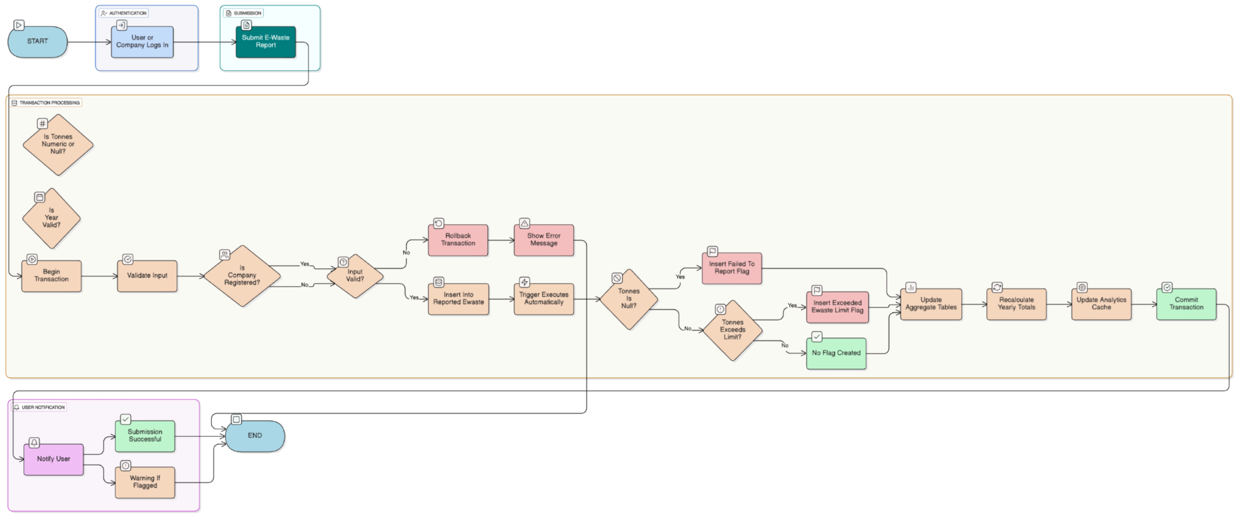


B. Logical ERD

C. Physical ERD



3.3. Transaction Flowchart:



IV. Conclusion

The rapidly increasing volume of electronic waste highlights an alarming pattern of excessive production and consumption that directly links corporate manufacturing practices with modern consumer lifestyles. Companies continue to release new devices at accelerated cycles, while consumers are encouraged to frequently replace functional electronics, resulting in a significant rise in discarded devices. This cycle of overproduction and overconsumption has intensified environmental degradation, resource depletion, and improper e-waste disposal, making sustainable intervention increasingly urgent.

The Corporate E-Waste Monitor Database System addresses this issue by providing a structured, data-driven platform that connects corporate e-waste generation with measurable environmental impact. By enabling systematic tracking, analysis, and automated flagging of excessive e-waste levels, the system exposes unsustainable practices and promotes accountability among organizations. At the same time, it empowers consumers and stakeholders with information that encourages responsible consumption and proper disposal behaviors.

Aligned with Sustainable Development Goals 9 and 12, the system demonstrates how database technologies can be leveraged to confront the growing e-waste crisis through transparency, compliance monitoring, and informed decision-making. Ultimately, this project emphasizes that mitigating the e-waste problem requires both corporate responsibility and conscious consumer behavior, supported by reliable data systems that guide sustainable production and consumption patterns.

V. References

United Nations. (2016). *The sustainable development goals report 2016*. United Nations.

United Nations. (2017). *The sustainable development goals report 2017*. United Nations.

United Nations. (2018). *The sustainable development goals report 2018*. United Nations.

United Nations. (2019). *The sustainable development goals report 2019*. United Nations.

United Nations. (2020). *The sustainable development goals report 2020*. United Nations.

United Nations. (2021). *The sustainable development goals report 2021*. United Nations.

United Nations. (2022). *The sustainable development goals report 2022*. United Nations.

Statista. (n.d.). *Generation of electronic waste worldwide from 2019 to 2030*. https://www.statista.com/statistics/1067081/generation-electronic-waste-globally-forecast/

Database Management Systems (DBMS)

Elmasri, R., & Navathe, S. B. (2016).

Fundamentals of Database Systems (7th ed.). Pearson Education.

— Reference for ERD design, normalization, relational schema, and constraints.

Silberschatz, A., Korth, H. F., & Sudarshan, S. (2020).

Database System Concepts (7th ed.). McGraw-Hill Education.

— Reference for transactions, ACID properties, triggers, views, and stored procedures.

Date, C. J. (2019).

An Introduction to Database Systems (8th ed.). Addison-Wesley.

— Reference for schema normalization (1NF–3NF), functional dependencies, and relational theory.

Oracle Corporation.

MySQL 8.0 Reference Manual.

— Reference for SQL syntax, triggers, InnoDB engine behavior, foreign keys, and views.

https://dev.mysql.com/doc/

Physical ERD & Schema Design

Connolly, T., & Begg, C. (2015).

Database Systems: A Practical Approach to Design, Implementation, and Management. Pearson.

— Reference for physical ERD modeling and implementation-level schema design.

Batini, C., Ceri, S., & Navathe, S. (1992).

Conceptual Database Design: An Entity-Relationship Approach. Benjamin-Cummings.

— Reference for ERD methodology and entity relationships.

Triggers, Automation, and Data Integrity

MySQL Documentation.

CREATE TRIGGER Syntax and Usage.

— Reference for trigger-based automation and business rule enforcement.

https://dev.mysql.com/doc/refman/8.0/en/triggers.html

ISO/IEC 9075:2016.

Information Technology — Database Languages — SQL.

— Reference for standard SQL behavior and constraints.

E-Waste, Sustainability, and Environmental Thresholds

United Nations University (UNU). (2020).

The Global E-waste Monitor 2020.

— Primary reference for global e-waste statistics and environmental thresholds.

https://ewastemonitor.info/

United Nations University (UNU). (2024).

The Global E-waste Monitor 2024.

— Reference for updated global e-waste generation data and trends.

United Nations.

Sustainable Development Goals (SDGs) — Goals 9 & 12.

https://sdgs.un.org/goals

— Reference for sustainability alignment and project justification.

Basel Convention Secretariat.

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes.

— Reference for regulatory frameworks on e-waste management.

Real-World Company E-Waste Reporting Sources

Apple Inc.

Environmental Progress Report.

https://www.apple.com/environment/

Samsung Electronics.

Sustainability Report.

https://www.samsung.com/global/sustainability/

Dell Technologies.

Sustainability & Circular Economy Report.

https://www.dell.com/en-us/dt/corporate/social-impact.htm

HP Inc.

HP Sustainable Impact Report.

https://www.hp.com/sustainableimpact

Lenovo Group.

Environmental, Social, and Governance (ESG) Report.

https://www.lenovo.com/sustainability

Google (Alphabet Inc.).

Environmental Report.

https://sustainability.google/

Environmental Thresholds & Policy Context

European Commission.

Waste Electrical and Electronic Equipment (WEEE) Directive.

— Reference for regulatory benchmarks on acceptable e-waste levels.

World Economic Forum. (2019).

A New Circular Vision for Electronics.

— Reference for circular economy thresholds and corporate accountability.