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1.0 Introduction

Effective urban stormwater management is a critical challenge in Sri Lanka due to the recurring issues of solid waste accumulation and silt deposition. These problems frequently lead to clogs, flooding, and inefficient drainage operations, particularly in urban areas with deteriorating infrastructure. Many stormwater systems contain "dysfunctional sections" or completely blocked sections of drains where sand, silt, and waste accumulate, preventing water from flowing through. Such inefficiencies exacerbate urban flooding and disrupt city-wide drainage functionality.

The Smart Drain system offers a cutting-edge solution to these persistent issues by integrating advanced retrofittable units designed to address sediment and waste build-up in clog-prone sections of storm drains. This research focuses on the development of an optimised retrofit version of the Smart Drain to provide an effective and efficient solution for mitigating clogs and restoring flow capacity in stormwater channels.

To demonstrate the practicality and scalability of this innovation, case study projects will be implemented at two critical locations: the Sri Lanka Atomic Energy Board (SLAEB) premises and Ali Mudukukkuwa, one of the small trader's precincts of the Kandy Municipal Council (KMC) area. These sites have been chosen based on their existing drainage challenges, making them ideal testbeds for assessing the Smart Drain's effectiveness in improving stormwater disposal efficiency, reducing system overflows, and ensuring optimal drainage performance.

The proposed retrofit version of the Smart Drain is designed to integrate with existing open stormwater channels. Its functionality extends beyond unclogging drains to prevent recurrent debris accumulation, ensuring a sustained, debris-free water flow. By employing a targeted retrofit approach, the system eliminates the need for costly, large-scale infrastructure replacements, instead providing a cost-effective, localised rectification solution. This innovative intervention improves drainage efficiency and significantly reduces maintenance costs while enhancing urban resilience to flooding.

This research and its subsequent implementation will serve as a blueprint for scalable, city-wide adoption of Smart Drain technology, contributing to sustainable and efficient stormwater management in Sri Lanka.

Case Study Sites

Sri Lanka Atomic Energy Board (SLAEB): This site features a newly constructed open drain section that experiences overflows despite its recent construction. This is due to the solid waste blockage within the drain and an underground obstruction at the outflow point. The Smart Drain retrofit aims to prevent solid waste accumulation along the drain and at the critical junction near the receiving water body.

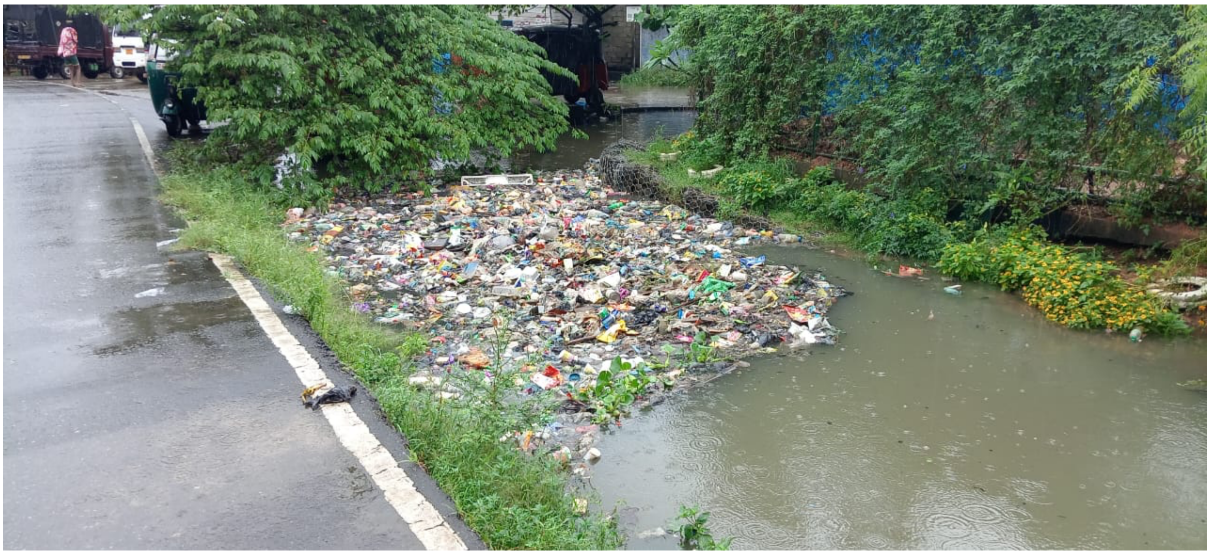

Figure 1: Receiving water canal near the Atomic Energy Board, burdened by sediment and plastic pollution. The open storm drain feeding into this canal highlights the pressing need for better waste management and environmental care in the area

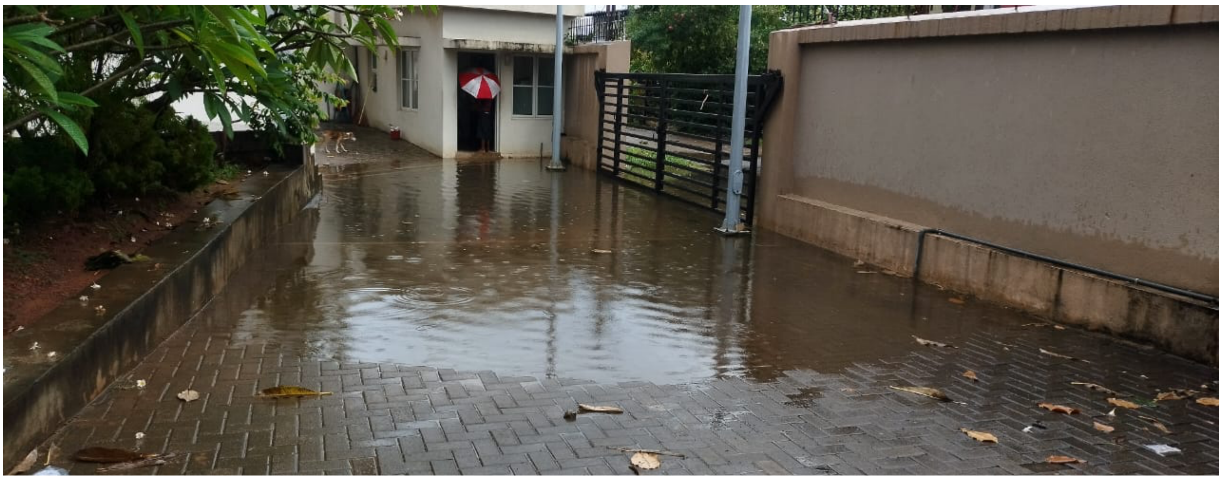

Figure 2: Overflowing drain turns the building entrance into an unpleasant and messy location, highlighting the need for improved drainage solutions.

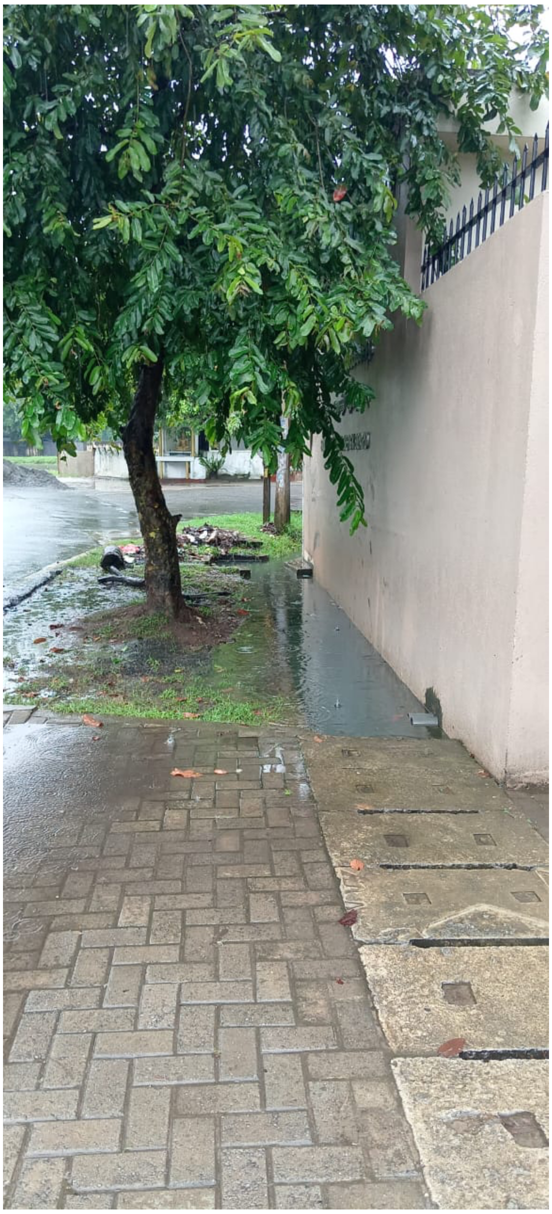

Figure 3: Overflowing Storm Water Drains due to Sedimentation and Solid Waste Clogging

Ali Mudukkuwa (Kandy Municipal Council): This location has a long-standing problem of overflowing drains caused by solid waste clogging in drains that are nearly a century old. These drains are narrow and filled with silt and debris. The Smart Drain solution is intended to rectify the "dysfunctional stretches" of this drain section.

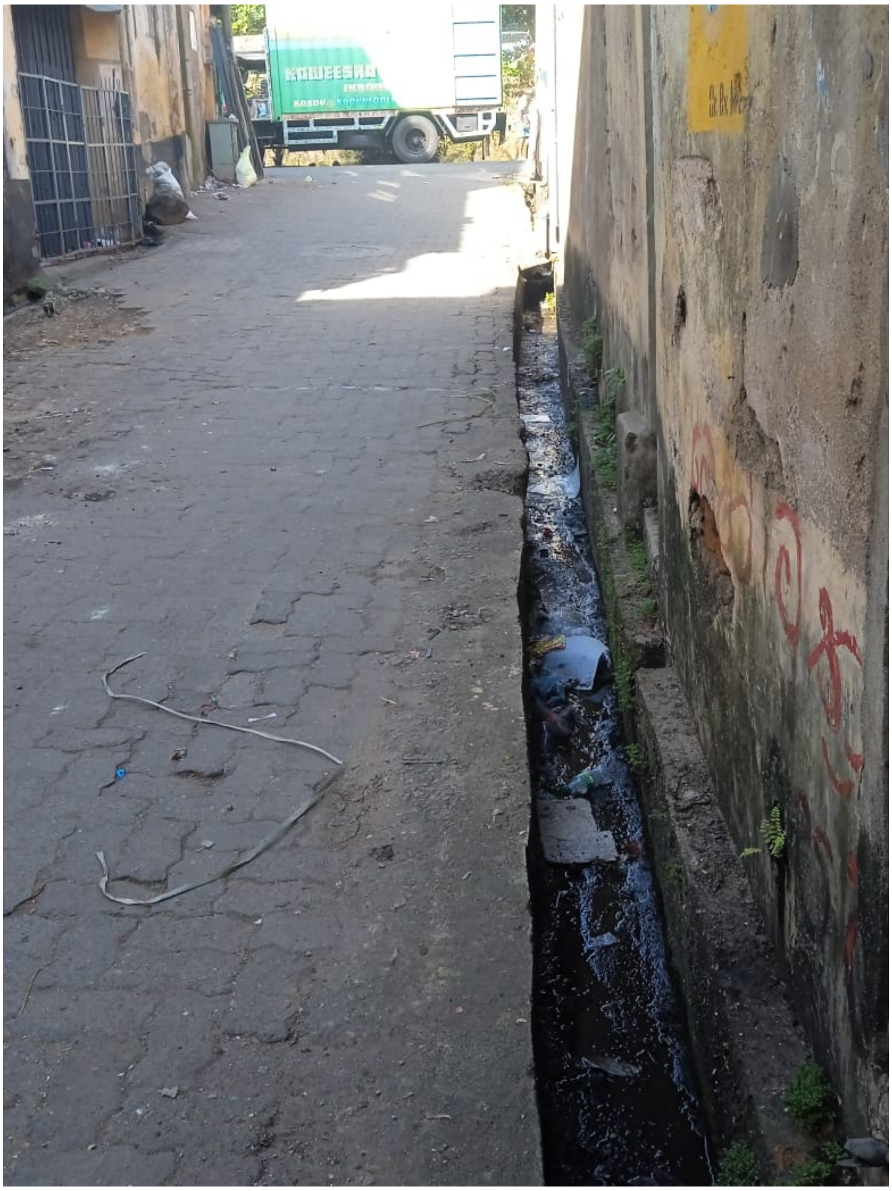

Figure 4: Stormwater drains at Ali Mudukkuwa: centuries-old, narrow, and dilapidated, frequently clogged with solid waste, reflecting the urgent need for restoration and maintenance.

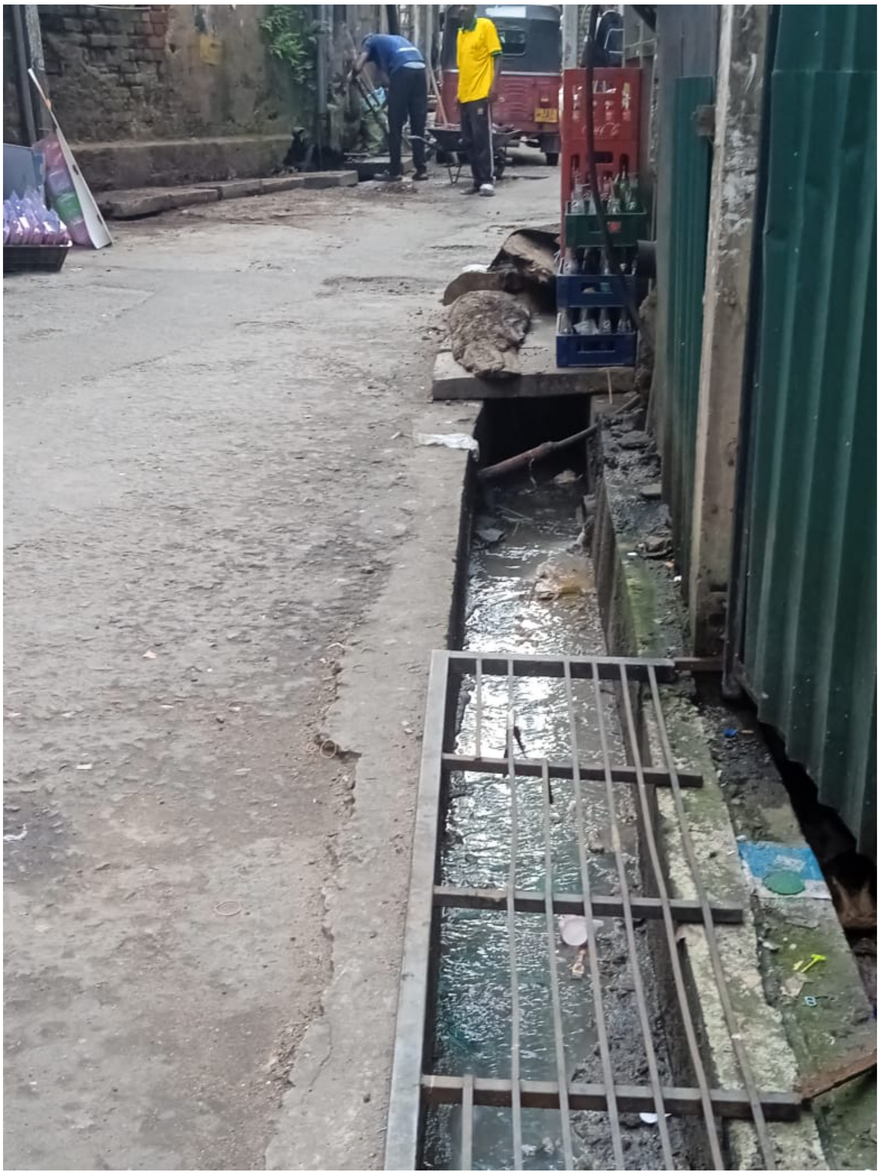

Figure 5: Clogged drains at Ali Mudukkuwa cause chaos during rainy days, underscoring the need for effective drainage management.

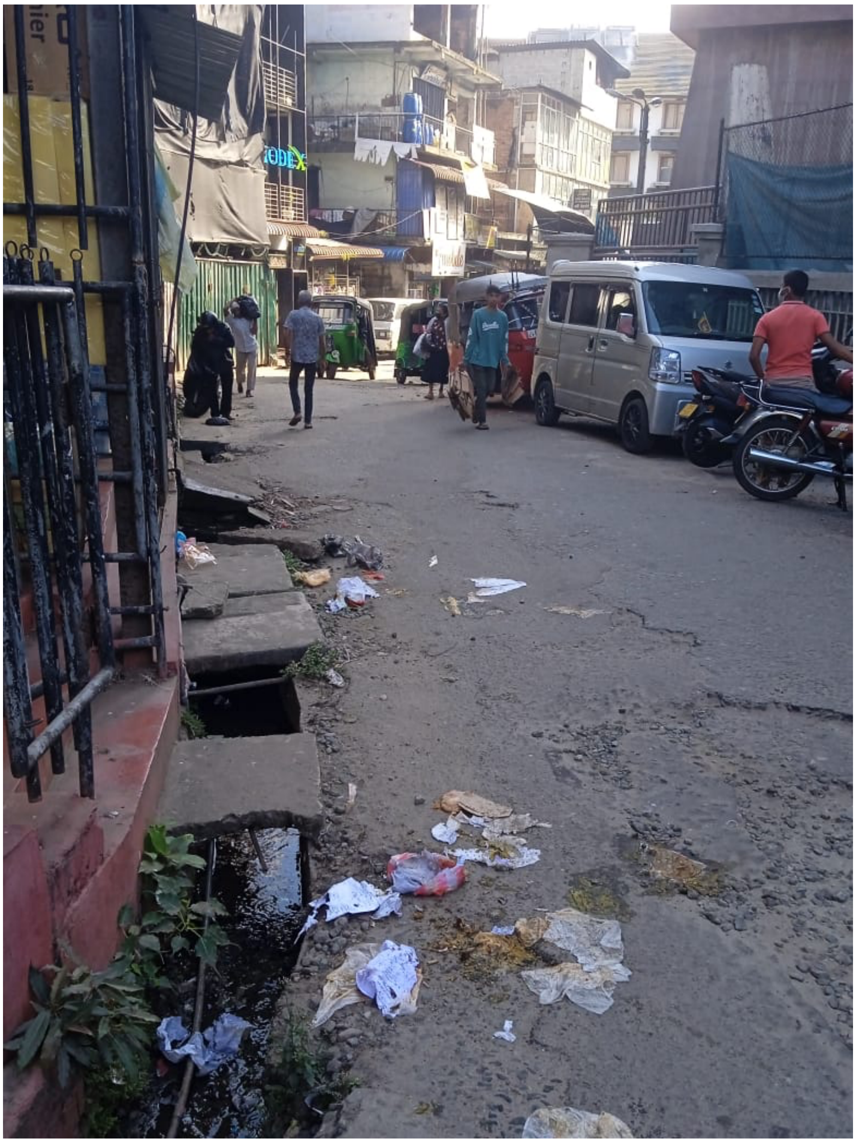

Figure 6: Ali Mudukkuwa is a congested urban area with improper storm drainage, highlighting a mix of development and inadequate infrastructure maintenance.

1.1 Objectives of the Study

I. **Identify and Analyse Drainage Challenges:**
   a. Conduct a comprehensive assessment of the unique drainage issues at the Sri Lanka Atomic Energy Board (SLAEB) and Ali Mudukkuwa sites of the Kandy Municipal Council (KMC), specifically focusing on stormwater disposal inefficiencies, silt deposition, and solid waste accumulation.
   b. Map the problem areas within these locations to establish a baseline for intervention.

II. **Develop and Customise the Retrofit Smart Drain Solution:**
   a. Design and build an advanced retrofit version of the Smart Drain system tailored to address the identified drainage inefficiencies.
   b. Integrate design features that enhance debris management and improve overall drainage performance in open drain systems.

III. **Research and development:**
   a. Associate with the Smart Drain research team to find answers to research questions, as mentioned in section 1.2 of this document
   b. Implement the solutions for those questions in the mentioned case study sites
   c. Evaluate the efficiency and success of the research ideas

IV. **Ground Implementation and Efficiency Optimisation:**
   a. Deploy the Smart Drain system at the selected case study sites to test its performance in real-world conditions.
   b. Monitor and fine-tune the system to maximise the efficiency of stormwater disposal and prevent recurring clogs.

V. **Evaluate System Performance and Maintenance Impact:**
   a. Quantify improvements in drainage efficiency through performance metrics such as water flow rates, debris capture rates, and clog prevention frequency.
   b. Compare maintenance costs and post-disaster recovery expenses before and after the Smart Drain installation to validate cost-effectiveness.

VI. **Establish Flood Resilience Parameters:**
   a. Define key performance indicators (KPIs) to evaluate the Smart Drain's contribution to urban flood resilience.
   b. Assess the system's ability to reduce flooding risk, improve adaptability to heavy rainfall events, and ensure uninterrupted drainage functionality.

VII. **Develop a Scalable Implementation Model:**
   a. Use insights gained from the case study projects to create a standardised approach for scaling the Smart Drain solution across other urban locations in Sri Lanka and worldwide.

b. Provide recommendations for long-term adoption and integration into city drainage systems to enhance urban flood resilience.

1.2 Research Questions

Urban stormwater drainage systems in Sri Lanka face critical challenges due to aging, design weaknesses, damage, and wear in existing feeder drains, resulting in reduced efficiency and frequent flooding. The integration of the Smart Drain system as a retrofittable solution presents an opportunity to address these issues, but key challenges must be resolved to ensure seamless functionality and enhanced performance across the network.

The following research questions must be addressed during this project:

I. **Feeder Drain Connectivity:**
   a. How can feeder drain, constructed with conventional designs that may have inherent weaknesses, damages, or wear, be effectively integrated with the Smart Drain system to ensure:
      i. Enhanced overall performance of the feeder drains.
      ii. Smooth and uninterrupted flow into the Smart Drain system.
      iii. Protection of the Smart Drain's functionality from adverse feeder drain behaviour, such as blockages or inefficiencies.
      iv. Prevention of additional flood risks arising from connectivity issues.

II. **Disposal Point Integration:**
   a. How can the Smart Drain system be optimally connected to its disposal points (e.g., underground tunnels, canals, or streams) to ensure:
      i. Effective removal of solid waste and silt accumulation without disrupting the disposal system.
      ii. Maintenance of flow rates that align with the capacity and expectations of the downstream sinking system.
      iii. Avoidance of additional flooding risks caused by improper or inefficient connectivity.

This project must address these critical concerns to create a seamless and effective stormwater management solution that ensures improved drainage efficiency, reduced maintenance costs, and enhanced flood resilience in urban areas.

1.3 Scope of Work

The scope of this project encompasses the design, construction, retrofitting, and research required to implement an effective Smart Drain solution tailored to address the drainage inefficiencies at the identified case study sites. The work is segmented into two core areas: Smart Drain construction, retrofitting existing drainage systems, and research to ensure optimal functionality and performance.

I. Smart Drain Construction

- **Two-Layer Smart Drain System:**
  - Construct a two-layer Smart Drain solution in locations where the existing drainage system fails to meet the project requirements.
  - Ensure the upper layer retains solid waste and silt, while the lower layer facilitates efficient water flow.
- **Construction of Base Pits:**
  - Build appropriately sized base pits at designated locations to efficiently handle the accumulation of solid waste and silt.
  - Design pits to prevent overflow and allow for ease of maintenance and cleaning.
- **Underground Sinking Gullies:**
  - Construct sinking gullies to ensure efficient drainage of stormwater into underground systems, thereby preventing flooding and maintaining uninterrupted flow.

II. Retrofit Design and Installation (alternative option)

- **Integration with Existing Systems:**
  - In locations where existing drainage systems can handle stormwater flow, retrofit the Smart Drain's solid waste retention layer for seamless integration.
  - Incorporate silt collection chambers within the retrofitted systems to optimise waste retention.
- **Enhancement of Existing Infrastructure:**
  - For areas with existing base pits and underground sinking gullies, retrofit solid waste retention layers and silt accumulation chambers to enhance functionality without requiring extensive system replacement.
  - Ensure retrofitted components are modular, durable, and capable of meeting localised drainage demands.

III. . Research and Optimisation

- **System Integration and Optimisation**:
    - Develop and test configurations that combine key Smart Drain elements, including two-layer segments, retrofitted components, base pits, and gullies, to deliver optimum performance for the case study sites.
- **Research Objectives**:
    - Determine how to effectively connect external feeder systems to the Smart Drain, ensuring smooth flow and eliminating clogs or inefficiencies.
    - Evaluate connectivity of the Smart Drain to its disposal entities (e.g., underground tunnels, canals, or streams) to ensure compliance with flow rate expectations and avoid additional flood risks.
    - Identify optimal locations for base pits and solid waste/silt retention chambers to maximise system efficiency.
    - Design silt accumulation and solid waste retention chambers using principles of fluid dynamics, ensuring they align with site-specific flow currents and minimise maintenance requirements.
    - Develop designs that prioritise easy access to remove accumulated waste and silt, minimising labour and operational costs.

This scope of work ensures a comprehensive approach to improving drainage efficiency, reducing system maintenance costs, and enhancing urban flood resilience. It focuses on leveraging innovative design, retrofitting techniques, and targeted research to address the challenges of stormwater management effectively.

2.0 Research Plan

The following research plan outlines the step-by-step process for conducting, analysing, and completing the Smart Drain project, culminating in the publication of results and implementation of any necessary rectifications.

2.1 Project Initiation

- **2. 1.1 Team Formation**:
  - Assemble a multidisciplinary team of engineers, designers, and researchers.
  - Assign responsibilities for system design, construction, data collection, and analysis.
- **2. 1.2 Problem Definition:**
  - Identify specific issues with existing drainage systems, including blockages, silt deposition, and flood-prone areas.
  - Define key research objectives, including connectivity of feeder systems, optimal placement of components, and overall system performance.
- **2. 21.3 Site Selection**:
  - Confirm the selected case study sites at SLAEB premises and KMC (Ali Mudukkuwa.
  - Conduct baseline assessments, including drainage capacity, flow rate measurements, and waste accumulation trends.

2.2 Design and Development

- **2. 2.1 Smart Drain System Design**:
  - Create detailed designs for both the two-layer Smart Drain and retrofittable components.
  - Consider factors like fluid dynamics, flow rates, waste retention efficiency, and structural durability.
- **2. 2.2 Simulation and Testing**:
  - Run computational fluid dynamics (CFD) simulations to predict flow behaviour and silt deposition patterns in different configurations.
  - Optimise designs based on simulation results.
- **2. 2.3 Prototype Development:**
  - Construct prototype Smart Drain units, including base pits, silt collection chambers, and underground gullies.

- Conduct initial tests to validate functionality under controlled conditions.

2.3 Case Study Implementation

- **2.3.1 Installation at Test Sites:**
    - Deploy the Smart Drain system at the SLAEB and KMC locations.
    - Retrofit existing drainage infrastructure where applicable, integrating waste retention layers and silt chambers.
- **2.3.2 Monitoring and Data Collection:**
    - Install sensors or deploy manual methods to monitor flow rates, silt accumulation, and waste retention.
    - Collect data on maintenance frequency, system blockages, and operational efficiency.

2.4. Data Analysis and Evaluation

- **2.24.1 Performance Metrics:**
    - Analyse collected data to measure the effectiveness of the Smart Drain in terms of:
        - Reduced clogging and overflow.
        - Improved flow rates and waste management.
        - Reduced maintenance costs and downtime.
- **2.4.2 Comparison with Baseline:**
    - Compare performance metrics before and after system installation.
    - Evaluate whether the Smart Drain meets the project's objectives for urban resilience and flood prevention.

2.5. Rectification and Refinement

- **2.5.1 Identify Areas for Improvement:**
    - Use data analysis to pinpoint weaknesses or inefficiencies in the system.
    - Conduct stakeholder consultations to gather feedback from site operators and maintenance teams.
- **2.5.2 System Modifications:**
    - Redesign components, if necessary, to address identified issues (e.g., resizing pits, adjusting flow paths).
    - Implement modifications and test the updated system.

2.6. Results Publication and Dissemination

- **2.6.1 Documentation of Findings:**
    - Prepare a comprehensive report detailing the research process, system performance, and rectifications made to the storm drain system.
    - Highlight the impact of the Smart Drain on urban drainage efficiency and flood prevention.
- **2.6.2 Academic Publications:**
    - Submit research findings to peer-reviewed journals and conferences on urban water management and civil engineering.
- **2.6.3 Stakeholder Engagement:**
    - Present results to municipal councils, policymakers, and industry stakeholders.
    - Provide recommendations for scaling the Smart Drain system to other locations.

2.7. Project Completion

- **2.7.1 Final Implementation:**
    - Implement the finalised Retrofit version of the Smart Drain design at the case study sites.
    - Hand over operational guidelines and maintenance protocols to site managers (KMC and AEB).
- **2.7.2 Knowledge Sharing:**
    - Develop training materials for engineers and municipal staff to support future implementations.
- **2.7.3 Close-out Review:**
    - Conduct a final review meeting to evaluate the project’s overall success and lessons learned.

3.0 Project Deliverables

The following deliverables will be produced as part of the Smart Drain project, covering technical, academic, and practical outcomes:

3.1. Technical Deliverables

3.1.1 Retrofit Unit

- A fully functional retrofittable Smart Drain system, including:
  - **Two-layer Smart Drain module** for efficient debris and silt management.
  - **Base pits and silt collection chambers** are designed to handle site-specific requirements.
  - **Underground sinking gullies** for seamless integration with underground drainage systems.
- Prototypes and final installations at the SLAEB and KMC test sites.

3.1.2 Engineering Design Package

- Detailed blueprints, technical drawings, and CAD models of the Smart Drain system.
- Specifications for retrofittable components, including materials, dimensions, and performance standards.
- Computational Fluid Dynamics (CFD) simulation results demonstrating flow optimisation and clog resistance.

3.1.3 Performance Monitoring System

- Monitoring setup to collect data on flow rates, silt deposition, and maintenance requirements.
- Operational guidelines for system monitoring and maintenance at case study sites.

3.2. Research Deliverables

3.2.1 Research Paper

- A peer-reviewed publication on the development, testing, and evaluation of the Smart Drain system.
- Topics to include:
  - Innovative retrofit solutions for urban drainage.
  - Performance metrics and their impact on flood resilience.

        - Comparative analysis of pre- and post-implementation conditions.
    - Submission to journals like *Urban Water Journal* or *Journal of Hydraulic Engineering*.

3.2.2 Technical Report

- Comprehensive documentation of the project, covering:
- Background and problem analysis.
- System design and development process.
- Case study site performance evaluation.
- Lessons learned and recommendations for future projects.

3.2.3. Conference Presentation

Presentation of findings at international conferences such as:

International Conference on Urban Drainage (ICUD).

World Environmental and Water Resources Congress (EWRI).

3.3 Practical Deliverables

3.3.1 ImplementationToolkit

A step-by-step guide for municipalities and engineers to replicate the Smart Drain system.

Includes:

Installation instructions.

Maintenance protocols.

Cost analysis for retrofitting and new installations.

3.3.2. Policy Recommendations

A white paper for local government authorities outlining:

The economic and environmental benefits of adopting the Smart Drain system.

Strategies for integrating Smart Drain into broader urban planning initiatives.

3.4 Visual and Educational Deliverables

3.4.1 Data Visualisation Dashboard

Interactive dashboard displaying real-time monitoring data from case study sites, including flow rates and waste accumulation.

Accessible to stakeholders for performance review and decision-making.

3.4.2 Awareness and Training Materials

Educational materials for municipal staff, including:

Videos demonstrating installation and maintenance.

Workshops to build capacity for Smart Drain implementation.

3.4.3 Case Study Testimonials

Document success stories from SLAEB and KMC test sites, highlighting the system's impact on flood prevention and maintenance cost reduction.

4.0 Collaborating Institutions and Roles

4.1. Kandy Municipal Council (KMC) – *Project Owner for Kandy Case Study Site*

The Kandy Municipal Council will serve as the primary project owner for the Kandy site. As the governing body responsible for the city's drainage infrastructure, KMC will provide administrative oversight and ensure the project's alignment with local needs and regulatory standards.

Responsibilities:

- Facilitate access to project sites and provide existing drainage system data for analysis.
- Support the installation and retrofitting of Smart Drain units at designated locations.
- Collaborate with research teams and the team of integrated research supervisors to ensure project milestones are achieved.
- Evaluate the project's impact on improving drainage efficiency and urban flood resilience within the Kandy jurisdiction.

4.2. Sri Lanka Atomic Energy Board (SLAEB) – *Project Owner for Colombo Case Study Site*

The SLAEB will act as the project owner for the Colombo case study site. Given its focus on maintaining high environmental and operational standards within its premises, SLAEB will oversee the project's implementation to ensure alignment with its objectives.

Responsibilities:

- Provide access to the project site at SLAEB premises for the construction and testing phases.
- Collaborate with the SLIIT Colombo team to integrate Smart Drain solutions into the existing stormwater drainage system.
- Evaluate the efficiency of the Smart Drain retrofit in addressing solid waste and silt accumulation issues.
- Offer logistical support and feedback to refine system designs and functionality.

4.3. On-Site Research Officers

Each case study site will be assigned one dedicated research officer, while an additional research officer will be responsible for IoT development in both sites. Research Officers will be stationed at each case study site (Kandy and Colombo) to oversee construction and conduct necessary research. The research officer conducting IoT development will be stationed at Sanota Global Galle and will travel to the sites as necessary.

Roles and Responsibilities:

- **Site Supervision:** Monitor the installation, retrofitting, and operation of Smart Drain units.
- **Data Collection:** Record data on flow rates, waste accumulation, and overall system performance.
- **Performance Evaluation:** Collaborate with university teams to analyse system efficacy.
- **Documentation:** Maintain comprehensive records for academic publications and project reporting.
- **Stakeholder Coordination:** Liaise between the municipal councils, SLAEB, and academic partners for seamless project execution.

These Research Officers will be enlisted for 12 months as Industry Research Officers stationed at the Kandy Municipal Council and the Access Research Incubation Centre. The Project Lead and a team of researchers will supervise them.

One Research Officer, who is an IoT specialist, will oversee both sites, develop the sensor and web application, and test-run the program. We propose attaching this Research Officer to Sanota Global, Galle, during the research period.

4.4 Team of Integrated Research Supervisors

A dedicated team of integrated research supervisors will be established to guide research officers, analyse findings, and validate results throughout the project. This team will consist of experts with diverse backgrounds, ensuring comprehensive oversight and support. Additional researchers may be added to the team based on expertise and project requirements.

Core Team Members:

I. Dr. Nadeesha Chandrasena-Inventor of the Smart Drain
II. Mr. Sujeewa Kokawala-Co-inventor of the Smart Drain
III. Associate Professor Ir Dr. Zahiranisa Mustaffa-Co-inventor of the Smart Drain
IV. Mr. Darshana Wimukthi-Co-inventor of the Smart Drain
V. Dr. R. Rosa-Chairman, Sri Lanka Atomic Energy Board
VI. Mr. Champika Nirosh Dharmapala -Director General, Sri Lanka Atomic Energy Board
VII. Mr. Priyanga Ratnayake-Deputy Director – IT & Promotion, Sri Lanka Atomic Energy Board
VIII. Engineer Dinuke Seneviratne-Drainage Engineer, Kandy Municipal Council
IX. Dr. Pasan Perakum Jayasinghe-Kandy Municipal Council
X. Engineer Thushara Jayasinghe-Water Works Engineer, Kandy Municipal Council
XI. Engineer Lahiru Prasanga-Acting Chief Engineer, Sri Lanka Land Development Corporation
XII. Mr. Sethil Muhandirum-Citizen Science Researcher
XIII. Mr. Thisura Senarath-Integrated Designer
XIV. Mr. Malith Fernando- Citizen Science Researcher, Senior Meteorologist
XV. Engineer Sahan Chathuranga-Founder, Sanota Global
XVI. Professor Priyan Mendis- University of Melbourne
XVII. Professor AK Gosain- Founder & Director, INRM Consultants, IIT Delhi
XVIII. Engineer Dhammika Deshapriya Silva-General Manager, Head of Engineering Designs
XIX. Engineer Neomal Ferdinando- Design Manager, Access Engineering

This team will play a role in ensuring the research is conducted with high standards of accuracy, relevance, and practical application, ultimately driving the success of the project.

4.5 Industry Partner: Access Engineering PLC

As the industry partner for this initiative, Access Engineering PLC will play a specialised role in enabling the success of the case study sites and associated research. Their involvement will encompass the following key contributions:

Funding for Research and Construction

Access Engineering PLC will provide the funding support for the research component and undertake the complete construction and installation at the case study project sites. This funding ensures that the project is equipped with the infrastructure, materials, and technological capabilities (including the IoT system and the web interface, sensory and hardware) required for successful execution. Further details of the IoT integration of the Smart Drain can be found in Annexure 01: Drainage Telemetry Intelligence Module. Access Engineering PLC reinforces its commitment to advancing engineering research and innovation by underwriting these costs and providing technical support.

Expertise in Civil Engineering

Access Engineering PLC brings unparalleled expertise in civil engineering to the collaboration. Their team of seasoned professionals will work closely with researchers to refine designs and ensure they are practical, sustainable, and optimised for large-scale deployment. Leveraging their vast experience in the construction sector, Access Engineering PLC will contribute to creating solutions that are not only innovative but also economically viable and scalable for real-world applications.

Role as an Industry Collaborator

As the industry collaborator, Access Engineering PLC's contributions will go beyond funding and technical support. The company will actively engage in knowledge sharing and capacity building, fostering a collaborative environment where academic insights and practical expertise merge to create impactful outcomes. This partnership underscores the importance of industry-academic collaborations in driving forward-thinking solutions for pressing challenges in civil engineering and infrastructure development.

By partnering with Access Engineering PLC, this initiative is poised to achieve impactful results. It will combine state-of-the-art research with practical applications that align with industry standards and societal needs.

Upon successful case study implementation, the product will be driven to a commercial-ready state by agreement between the inventor and Access Engineering PLC.

5.0 Research Challenges

5.1 Vandalism of Equipment

A significant challenge faced during the deployment of research equipment, such as mesh baskets and sensors, is vandalism. These devices, which play a critical role in data collection and implementation, are vulnerable to damage, theft, or tampering in public spaces. This not only disrupts the research process but also increases costs and delays in project execution.

To address this issue, a comprehensive approach combining preventive measures, real-time monitoring, and community engagement is essential.

5.1.2 Mitigation Strategies

1. **Install CCTV Cameras**
   Deploying surveillance systems in strategic locations near equipment installations can deter potential vandalism. CCTV cameras provide real-time monitoring and create a sense of accountability, reducing the likelihood of malicious activities.
2. **Create an Alerting System**
   - Equip the research devices with sensors capable of detecting unauthorized movements or tampering.
   - Develop an automated alerting system to notify authorities or project personnel immediately when equipment is removed or compromised.
   - Alerts can be sent through SMS, email, or app-based notifications for swift response.

3. **Citizen Engagement Platform**

   - Build a dedicated platform for citizen engagement tailored to the specific area where research is being conducted.
   - Use the platform to:
     - Post updates about the research project and its objectives.
     - Notify residents of any incidents involving equipment, encouraging community vigilance.
     - Involve local stakeholders to promote awareness and foster a sense of collective responsibility toward safeguarding the equipment.

4. Community Awareness Campaigns

- Conduct outreach programs to educate the public about the importance of the equipment and the benefits of the research to the community.
- Highlight how protecting the equipment contributes to long-term societal and environmental improvements.

6.0 Next Steps

1. Draft, Negotiate and Approve the Research and Operational Budget
   - Develop a detailed budget covering all aspects of research and operational needs for the case study sites.
   - Include costs for equipment, infrastructure, monitoring systems, and personnel.

2. Prepare the Research Plan with a Timeline
   - Design a comprehensive research plan that outlines objectives, methodologies, and expected outcomes.
   - Establish a clear timeline for all phases of the project, from planning and implementation to monitoring and evaluation.
   - Include contingency plans to address unforeseen challenges.
   - Recruit three Research Officers (RO) for the case study-based research and IoT integration

3. Industry Collaborator Agreement with Access Engineering PLC
   - Finalise a formal agreement with Access Engineering PLC, detailing their roles, responsibilities, and funding commitments.
   - Specify terms for collaboration, including intellectual property rights, deliverables, and communication protocols.

4. Research Agreement with Collaborator Institutes
   - Establish agreements with academics and research institutions involved in the project.
   - Define the scope of their contributions, such as technical expertise, data analysis, or fieldwork.
   - Ensure alignment on research objectives, timelines, and resource sharing.

By systematically addressing these steps, the project will be well-positioned to move forward effectively, ensuring a strong foundation for successful execution and collaboration.

Annexure 01: Drainage Telemetry Intelligence Module (DTI)

Overview

Drainage Telemetry Intelligence (DTI) module is the integration of IoT technology into the Smart Drain system to optimise functionality and mitigate incidents by enabling real-time monitoring, data collection, hazard detection and automated alerts. This system is designed to ensure efficient performance, reduce maintenance frequency, and provide actionable insights for drainage network management.

Components of the DTI Module

Hardware Components for DTI:

1. Flow Rate Sensors
    - Measure water flow velocity and volume through the drainage system.
    - Detect anomalies such as blockages or reduced flow rates in real time.

2. Water Level Sensors
    - Monitor water levels in Smart Drain base pits and silt chambers.
    - Trigger alerts when water levels approach critical thresholds, preventing overflows.

3. Debris Accumulation Sensors
    - Detect the build-up of solid waste and silt in retention layers and chambers.
    - Estimate waste volume and notify maintenance teams when cleaning is required.

4. Environmental Sensors
    - Measure surrounding environmental factors, such as rainfall intensity and temperature.
    - Provide context for changes in drainage system performance.

5. Connectivity Module
    - Utilises cellular (4G/5G), Wi-Fi, or LoRaWAN communication protocols for data transmission.
    - Ensures reliable connectivity in urban or remote areas.

6. Power Supply

- Solar-powered units with battery backups to ensure uninterrupted operation.
- Energy-efficient components to minimise power consumption.

7. Backend servers

- Provides backend connection to the communication module
- Installed with appropriate databases for data storage
- Allows running intelligence applications, report generators and data visualisation

8. Display Screens

- Display real-time activity in the drainage system
- Notify alerts

DTI Software System:

- Copyrighted product of URBAN INVENTORS PTY LTD
- Provided under a product licence for the project
- Receives telemetry data
- Stores them in a database
- Analyses incoming data to detect key performance indicators
- Data visualisation for the display screens
- Alerting

Functions and Capabilities

1. Realtime Monitoring

- Provides continuous tracking of flow rates, water levels, and debris accumulation across case study sites.
- Displays data on a centralised dashboard for easy review by stakeholders.

2. Automated Alerts
    - Sends SMS or email notifications to maintenance teams for:
        - High water levels.
        - Blockages or slow flow rates.
        - Full debris or silt chambers.

3. Predictive Maintenance
    - Uses historical data and machine learning to forecast maintenance needs, reducing unplanned downtime.

4. Data Login and Analysis
    - Records sensor data over time to evaluate system performance.
    - Enables detailed analysis of clogging patterns, flow variations, and environmental impacts.

5. Integration with Urban Planning Systems
    - Provides data for municipal decision-makers to optimise drainage system design and management.
    - Can be scaled to integrate with broader IoT networks for smart cities.

Benefits of the IoT Sensor System

- **Proactive Maintenance**: Minimises downtime and manual inspections by identifying issues before they escalate.
- **Cost Savings**: Reduces maintenance frequency and post-disaster recovery costs.
- **Enhanced Efficiency**: Ensures consistent and optimal performance of the Smart Drain system.
- **Improved Resilience**: Strengthens urban infrastructure against flooding by enabling rapid response to critical conditions.
- **Scalability**: Can be adapted to various locations and integrated with other smart city initiatives.

Deliverables

1. **IoT-Enabled Smart Drain Units**
    - Fully equipped with sensors and communication modules at case study sites.
2. **Centralised Dashboard**
    - Web-based or mobile application for real-time monitoring and reporting.
3. **Installation and Maintenance Guide**

   - Instructions for setting up and maintaining IoT components.
4. **Performance Report**
   - A detailed evaluation of IoT system's effectiveness during the case study implementation phase.

Industry Partner for IoT Integration

Sanota Global, Galle – *IoT Technology Partner*

Sanota Global, based in Galle, will serve as the primary industry partner for the IoT integration of the Smart Drain system. With extensive expertise in developing and deploying IoT-based solutions for engineering applications, Sanota Engineering will play a unique role in ensuring the Smart Drain system is equipped with advanced monitoring and control capabilities. Notably, Sanota Engineering has prior experience in implementing the initial Smart Drain ground implementation project at Batapola, Ambalangoda, which demonstrated the feasibility and effectiveness of Smart Drain technology in real-world conditions.

Responsibilities:

1. **IoT Sensor Development and Deployment:**
   - Design and implement robust IoT sensors for real-time monitoring of water flow rates, silt accumulation, and solid waste levels.
   - Ensure sensors are weatherproof and capable of operating effectively in harsh environmental conditions.
2. **Data Collection and Transmission:**
   - Develop a secure and reliable data transmission framework to collect real-time data from Smart Drain units.
   - Integrate sensor data with a centralised cloud-based platform for remote monitoring.
3. **IoT Platform Development:**
   - Build a user-friendly dashboard for monitoring drainage system performance, including alerts for blockages and maintenance requirements.
   - Incorporate analytical tools to process sensor data and provide actionable insights for decision-making.
4. **Collaboration with Research Teams:**
   - Work closely with the academic partners (University of Peradeniya and SLIIT Colombo) to align IoT systems with research objectives.

- Provide technical support for integrating IoT systems into the retrofitted and newly built Smart Drain units.

5. **Training and Maintenance Support:**
   - Conduct training sessions for municipal staff and on-site research officers on the use and maintenance of the IoT systems.
   - Offer ongoing technical support to ensure seamless operation and data integrity.

By leveraging the expertise of Sanota Engineering and their successful experience with the Batapola Ambalangoda project, the IoT-enabled Smart Drain system will enhance stormwater drainage management through data-driven insights, proactive maintenance alerts, and system optimisation, setting a benchmark for smart urban drainage solutions globally.

Urban Inventors Pty Ltd

Urban Inventors Pty Ltd is an Australian company founded by the inventor and co-inventors of the Smart Drain alongside the founder of Sanota Global, Galle. The DTI Software System of the Smart Drain will be a copyrighted product of Urban Inventors Pty Ltd.

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