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A Review on Urban Flood Control Using Sustainable Smart Drainage Sensor System

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ABSTRACT: Urban flooding has become a serious issue in rapidly growing cities due to increased urbanization, climate change, and inadequate drainage systems. The replacement of natural permeable surfaces with impervious structures such as roads and buildings increases surface runoff and reduces groundwater infiltration, leading to frequent waterlogging and infrastructure damage. This study proposes a Sustainable Drainage Sensor System for effective urban flood management through real-time monitoring of stormwater conditions. The system uses IoT-based water level and rainfall sensors to monitor drainage networks and detect rising water levels or blockages. The collected data supports automated control mechanisms such as smart drainage gates and pumps to regulate water flow during heavy rainfall. Additionally, sustainable drainage methods like rainwater harvesting and controlled infiltration are integrated to reduce runoff and improve groundwater recharge. The proposed system enhances stormwater management, reduces flood risk, and supports sustainable urban infrastructure development.

Keywords: Urban flooding, sustainable drainage system, stormwater management, IoT sensors, water level monitoring, flood mitigation.

I. INTRODUCTION

Urban flooding is a growing challenge in rapidly developing cities due to urbanization, climate variability, and insufficient drainage infrastructure. The increase in impervious surfaces reduces natural water infiltration, causing higher surface runoff, waterlogging, infrastructure damage, public health risks, and economic losses. Traditional flood control and drainage systems such as embankments, drains, retention basins, and pumping stations often fail to manage extreme rainfall effectively. To overcome these limitations, sensor-based drainage systems provide real-time water level monitoring, automated control, and data driven management. These systems improve the efficiency and responsiveness of drainage networks, supporting resilient urban planning, reducing flood risks, and promoting sustainable city development.

II. ECASE OF USE

The proposed Sustainable Drainage Sensor System is designed to provide a practical and user-friendly solution for urban flood management. The system incorporates IoT-based devices, including water level sensors, rainfall sensors, and flow monitoring units, which can be installed within existing drainage infrastructure with minimal modification. These sensors continuously collect and transmit real-time data to a centralized monitoring platform. The monitoring platform presents drainage system information in a clear and structured manner, enabling municipal authorities and operators to easily observe changes in water levels and identify possible drainage blockages or overflow conditions. The interface is designed to ensure that system operation and monitoring can be performed without requiring advanced technical expertise.

Furthermore, the system supports automated control of drainage components such as smart gates and pumping units, which helps regulate stormwater flow during periods of intense rainfall. This automation reduces dependence on

manual intervention and allows quicker response to potential flooding situations. The system also requires limited maintenance, as sensors can be inspected, replaced, or serviced with relative ease.

Overall, the simplicity of installation, continuous monitoring capability, and automated control features make the proposed system a practical and efficient approach for enhancing urban drainage management and flood control.

III. PROPOSED SYSTEM

The proposed Sustainable Drainage Sensor System offers a comprehensive and proactive approach to managing urban flooding by integrating real-time monitoring, automated control, and sustainable drainage strategies. The system employs IoT-enabled sensors including water level, rainfall, and flow sensors strategically deployed throughout the urban drainage network to continuously assess hydrological conditions. The sensor data is transmitted to a centralized monitoring platform, which processes the information in real time to detect rising water levels, potential blockages, and risks of overflow.

Upon detecting critical conditions, the system automatically operates smart drainage gates and pumps to regulate stormwater discharge, thereby preventing waterlogging and mitigating flood hazards. Complementing the automated controls, sustainable practices such as rainwater harvesting and controlled infiltration are incorporated to reduce surface runoff and enhance groundwater recharge. The monitoring platform is designed to provide clear, actionable insights, enabling urban authorities to efficiently manage drainage systems without requiring specialized technical expertise.

In summary, the proposed system strengthens urban flood management by combining continuous monitoring, automated intervention, and sustainable water management practices. It minimizes reliance on manual operations, ensures timely response to flooding events, and contributes to the development of resilient and sustainable urban infrastructure.

IV. SYSTEM IMPLEMENTATION



Fig. 1. Projected Growth of the Smart Water Management Market (2023–2032)

The methodology for the proposed Sustainable Drainage Sensor System involves a combination of sensor deployment, real-time data acquisition, and automated stormwater management. Water level, rainfall, and flow sensors are installed at critical points within the urban drainage network to monitor water accumulation and flow rates continuously. The sensors transmit real-time data to a centralized monitoring platform, where the information is processed to detect rising water levels, blockages, and potential overflow situations.

Upon identifying critical conditions, the system activates smart drainage gates and pumps to regulate stormwater discharge, reducing the risk of waterlogging and flood-related damage. Simultaneously, sustainable measures, including rainwater harvesting and controlled infiltration, are employed to reduce surface runoff and support groundwater recharge. This integrated approach ensures that flood mitigation is both proactive and environmentally sustainable.

The proposed methodology allows urban authorities to maintain continuous oversight of drainage conditions, respond promptly to flooding risks, and implement long-term strategies for sustainable stormwater management.

V. DESING AND WORKING MODEL



Fig. 2. Scaled Prototype of the Sustainable Drainage Sensor System Showing Water Tanks, Sensor Setup, and Control Circuitry

• **Materials Used for Smart Drainage Model:-**

1. Arduino Uno / Microcontroller Board: Controls the entire system and processes sensor data.
2. Water Level Sensors: Detect water levels in drainage chambers in real time.
3. Relay Module (4-Channel): Controls devices like pumps or alarms based on sensor readings.
4. LED Indicators Red : Show water level status visually.
5. Resistors: Regulate current flow within the circuit.
6. Breadboard / PCB Board: Provides connections for all electronic components.
7. Power Supply Adapter (5V): Powers the system safely.
8. Switch: Turns the system ON or OFF.
9. USB Cable: For Arduino programming and power supply connection.
10. Jumper Wires: Connect components for electrical signals.



Fig. 3. The project team and their scaled prototype model of the Sustainable Drainage Sensor System, with guidance from their faculty supervisor.

Working Principle of the Model:-



Figure 4: Experimental Working Model of Smart Drainage Sensor System for Urban Flood Control

➤ As water accumulates in the tanks and surpasses a predefined threshold, the corresponding ultrasonic sensor continuously monitors and detects the rising water level with high precision.

- Upon detecting that the water level has crossed the critical limit, the sensor immediately transmits a signal to the Arduino or microcontroller, clearly identifying which specific tank has reached this threshold.
- The microcontroller receives and processes this input in real time, using programmed logic to determine the appropriate response required for maintaining optimal water levels.
- Based on the processed data, the microcontroller activates the relay module, which in turn powers the connected pumps or triggers alarms. This ensures efficient and timely management of water flow within the system.
- The pumps operate to drain excess water, effectively simulating controlled drainage and preventing overflow situations that could lead to flooding
- Once the water level in the tank falls back below the set threshold, the sensors detect this change and the microcontroller automatically deactivates the pumps, ensuring that drainage is precisely regulated without unnecessary operation
- This automated feedback loop reduces dependency on manual monitoring and intervention, allowing for continuous and reliable water level management.
- Overall, the model demonstrates the successful integration of ultrasonic sensors, microcontroller-based decision-making, and automated control mechanisms, providing a compact and functional prototype that accurately simulates real-time urban flood control systems.



Fig. 5. Experimental validation of the smart drainage sensor system model

VI. SIGNIFICANCE OF SENSOR-BASED SUSTAINABLE DRAINAGE SYSTEMS IN URBAN FLOOD MANAGEMENT

- Urban flooding is one of the most pressing challenges for modern cities, affecting infrastructure, public health, and economic stability. Conventional drainage systems often fail to cope with heavy and unpredictable rainfall, causing waterlogging, damage to roads and buildings, and disruption of essential services.
- Sensor-based Sustainable drainage systems play a pivotal role in urban flood management by combining real-time monitoring, automated control, and data-driven decision-making. They can detect rising water levels, flow obstructions, and abnormal drainage patterns, enabling rapid intervention before flooding escalates.

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- Automated mechanisms, such as valves and pumps, adjust water flow dynamically to prevent overflow and minimize waterlogging in vulnerable areas. This protects critical infrastructure and ensures continuity of transportation, energy, and public services during extreme weather events.
- Additionally, these systems support sustainable urban development by reducing soil erosion, preventing water contamination, enhancing groundwater recharge, and providing valuable data for city planning and maintenance. Overall, sensor-based smart drainage systems enhance urban resilience, safeguard communities, and promote environmentally sustainable flood management.

VII. CASE STUDY: FLOODING ON SINHAGAD ROAD, PUNE

Fig 6 :- Heavy flooding occurs on Sinhadgad Road during rainfall.

- **Overview of the Flooding Issue:-** Sinhadgad Road in Pune is prone to severe urban flooding during intense monsoon rains. The expansion of impervious surfaces combined with insufficient drainage capacity leads to rapid water accumulation, disrupting traffic and daily life.
- **Impact on Traffic and Mobility:**
 - Flooding on Sinhadgad Road disrupts traffic, causing slow movement and frequent standstills. Waterlogged roads reduce space for vehicles, increasing accident risks and delays.
 - Public transport is also affected, with buses and two-wheelers struggling to run. Waterlogging leads to route changes or cancellations, limiting access to work and essential services. Emergency vehicles face delays, hindering quick response during floods. These mobility issues emphasize the need for better flood management to keep traffic flowing safely



Fig 7 :- Sinhadgad Road experiences heavy traffic congestion

• **Need for Smart Sensor-Based Solutions:-**

- Traditional drainage systems often fail to manage sudden heavy rainfall, leading to frequent waterlogging and urban disruption. Static infrastructure cannot respond quickly to changing water levels.
- Smart sensor-based systems provide real time monitoring of water flow and levels, allowing rapid detection of blockages or rising floods. This enables timely intervention before flooding becomes severe.
- By automating water management and supporting data-driven decisions, these systems improve drainage efficiency, protect infrastructure, and enhance urban resilience against extreme rainfall events.

• **Details of Field Visit:-**

- The field visit to Sinhgad Road aimed to assess drainage challenges and gather data for the smart drainage system design. A thorough inspection identified frequent water stagnation at low-lying areas such as intersections, bus stops, and commercial zones, caused by undersized drains, blockages, and inadequate road gradients. Measurements of drain dimensions and photographic documentation supported detailed analysis.
- Interviews with local residents revealed the recurring impact of flooding on daily life and commerce. Key runoff sources included rooftop drainage, impervious pavements, side streets, construction sites, and commercial zones. These contributed to increased stormwater volumes overwhelming the drainage system.
- Drainage capacity was found insufficient, with clogged and poorly connected drains causing prolonged waterlogging that disrupts traffic and damages infrastructure. Observations highlighted critical bottlenecks and the need for system upgrades, including slope correction and regular maintenance.
- Overall, the visit underscored the importance of integrating smart sensors, IoT monitoring, and automated controls at vulnerable locations to enable proactive urban flood management and enhance drainage efficiency.



Fig 8 :- observation of Drainage System in Sinhgad Rd



Volume 15, Issue 3, March 2026**|DOI: 10.15680/IJRSET.2026.1503255|****VIII. CONCLUSION**

- Urban flooding is a significant challenge in rapidly developing cities due to increased urbanization, impervious surfaces, and inadequate drainage infrastructure. This study proposed a Sustainable Drainage Sensor System that integrates IoT-based sensors, real-time monitoring, and automated control to improve stormwater management. The developed prototype demonstrates how water level sensors, a microcontroller, and relay-controlled pumps can effectively detect rising water levels and regulate drainage operations.
- The case study of Sinhgad Road, Pune highlights the practical need for improved drainage monitoring and management. The proposed system provides a reliable and efficient approach to reduce waterlogging, support timely flood response, and enhance the resilience of urban drainage systems. Overall, smart sensor-based drainage solutions can play an important role in sustainable urban flood management.

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