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A REVIEW PAPER ON STUDY OF SMART ROAD DRAINAGE SYSTEM

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ABSTRACT

The Smart Road Drainage System is designed to reduce waterlogging on roads during heavy rainfall. Traditional drainage systems may not remove excess water efficiently because drainage channels can become blocked or their capacity may be insufficient. Waterlogging can cause traffic congestion, road damage, accidents, and flooding in low-lying areas. To solve this problem, the proposed system uses a water-level sensor to monitor the amount of water collected in the drainage channel. The sensor sends information to an Arduino or controller, which activates a DC water pump when the water level reaches a predefined limit. An LED or buzzer provides a warning when the water level becomes high. The excess water is then pumped through pipes to a suitable storage or discharge location. This system aims to improve drainage efficiency, reduce manual monitoring, and increase road safety during heavy rainfall. In the future, the system can be improved by adding IoT technology, mobile notifications, and remote monitoring to provide a smarter and more reliable drainage solution.

Keywords: Smart road drainage system, Water-level sensor, Arduino, DC water pump, Waterlogging, Flood control, IoT, Automatic drainage

I. INTRODUCTION

Road drainage is an important part because it helps collect and remove rainwater from road surfaces. During heavy rainfall, water may accumulate on roads due to poor drainage, blocked channels, or insufficient drainage capacity. This condition is known as waterlogging. It can cause traffic congestion, damage road surfaces, increase the risk of accidents, and lead to flooding in low-lying areas. Traditional drainage systems mainly depend on road slopes, drainage channels, and gravity to carry away rainwater. However, these systems may not always manage excess water efficiently during heavy rainfall and often require manual inspection and maintenance.

The Smart Road Drainage System is a technology-based solution designed to monitor water levels and remove excess water automatically. It uses a water-level sensor to detect rising water, an Arduino or controller to process the sensor signal, and a DC pump to remove excess

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water when the level reaches a predefined limit. An LED or buzzer can also provide a warning when the water level becomes high. The main purpose of this project is to reduce road waterlogging, improve drainage efficiency, minimize manual monitoring, and enhance road safety. The system demonstrates how sensors and automation can be used to develop a smarter and more effective road drainage solution.



Fig. 1: Smart road drainage system

II. OBJECTIVES

1. To review previous research on smart drainage systems.
2. To compare traditional and modern drainage methods.
3. To study the applications of IoT in stormwater management.
4. To understand the role of automation in flood control.
5. To identify the limitations of existing drainage systems.
6. To study future improvements in smart drainage technology.
7. To study methods for controlling rainwater overflow on roads.
8. To reduce road accidents and traffic problems caused by waterlogging.

III. LITERATURE REVIEW

1. **Chris Sweetapple, Anna Hastings and Peter Melville-Shreeve (2026):** Developing Strategies for Real-Time Control of Stormwater Systems: A Review This review studies different methods used to control stormwater systems in real time. It explains how water-level sensors, rainfall forecasts, controllers and automated gates can help manage stormwater flow. The authors identify challenges in designing control strategies that work across different locations. This research is highly relevant to a smart

road drainage model because it supports monitoring water levels and controlling excess water before it floods the road.

2. **Shahrzad Hamidiaala et al. (2026):** A Review of Real-Time Control Approaches in Nature-Based Solutions for Enhanced Stormwater Management This study reviews real-time control methods for green roofs and blue-green infrastructure. It explains how temporary storage can reduce the amount of rainwater entering drainage networks during peak rainfall. It also discusses how automated control can improve the performance of nature-based stormwater systems. For a smart road drainage project, the same principle can be applied by collecting rainwater in a storage chamber and releasing it safely when the drainage network has sufficient capacity.
3. **Jiacheng Zhu et al. (2026):** Urban Flood Resilience in a Warming World: Evaluating Global Practices in Smart and Nature-Based Solutions This review compares flood-management practices across different regions and examines how climate change and rapid urbanization increase urban flood risks. It discusses technologies such as IoT sensors, artificial intelligence and remote sensing, alongside green infrastructure and nature-based solutions. The study highlights that combining intelligent monitoring with sustainable drainage infrastructure can improve flood prediction and resilience. For your project, this supports combining sensors with a storage tank, safe overflow pipe and conventional drains.
4. **Md Shike Bin Mazid Anik, Chunjiang An and S. Samuel Li (2025):** Evolution from the Physical Process-Based Approaches to Machine Learning Approaches to Predicting Urban Floods: A Literature Review This review examines how urban flood prediction has developed from traditional physical models to machine learning, GIS, remote sensing and data-driven methods. It explains how these technologies can improve flood mapping and prediction in rapidly changing urban areas. The research is useful for future development of your project because rainfall forecasts and previous waterlogging records could help identify locations at risk before flooding occurs.
5. **Abdulaziz Yasin Nageye, Abdukadir Dahir Jimale, Mohamed Omar Abdullahi and Mohamed Abdirahman Addow (2025):** Enhancing Urban Resilience: An IoT-Based Smart Drainage System for Flood Management in Mogadishu, Somalia This study develops an IoT-based drainage system that monitors water levels and flow rates using sensors. The collected data is processed through cloud services, and a web application displays drainage conditions and flood alerts. Pumps are used to help redirect excess water. The study is closely related to your project because it combines real-time monitoring, automated water management and early warning to reduce urban flooding
6. **Yi-Chen Ethan Yang and colleagues (2024):** Flood Risks of Cyber-Physical Attacks in a Smart Storm Water System This study examines cybersecurity risks in smart stormwater infrastructure. Smart drainage systems rely on electronic sensors, communication networks and controllers, so incorrect data or malicious interference

can affect system operation. The research highlights the need to protect monitoring and control systems against cyber-physical threats. For a student project, it demonstrates why sensor readings should be checked and why the system should include a safe manual operating method in case the controller or communication system fails.

7.Marlon Navia, Jessica Macías-Aguayo and Dennis Quiroz-Cordova (2024): IoT-Based Detection of Blockages in Stormwater Drains This paper explores the use of Internet of Things technology to detect blockages in stormwater drains. Monitoring drainage conditions can help identify problems that reduce the flow of water and increase the risk of waterlogging. The research is relevant to your project because blocked drains are a major concern during heavy rainfall. A future version of your model could use sensor readings to flag possible blockages for inspection and cleaning.

8.Shihui Ma, Tarek Zayed, Jiduo Xing and Yuyang Shao (2024): A State-of-the-Art Review for the Prediction of Overflow in Urban Sewer Systems This review examines methods used to predict overflow in urban sewer systems. It explains why predicting overflow in advance can help utilities prepare warnings, priorities maintenance and reduce the effects of flooding. The study is relevant to smart drainage because rising water levels and limited drain capacity can lead to overflow. A sensor-based system with an alert and a planned overflow route can help address these conditions.

9. **Chris Sweetapple and colleagues (2023):** Realizing Smarter Stormwater Management: A Review of the Barriers and a Roadmap for Real World Application This review explains the benefits and difficulties of implementing smart stormwater management in real cities. It examines technologies used for sensing, data analysis, remote communication and automatic control. The authors identify practical barriers such as installation costs, equipment reliability, security, limited knowledge and difficulties in adopting new technology. The paper recommends a step-by-step approach to implementation. This is useful for your project because it helps explain both the advantages of smart drainage and the practical problems that must be considered before large-scale installation.
10. **Chris Sweetapple, James L. Webber, Anna Hastings and Peter Melville-Shreeve (2023):** Realizing Smarter Stormwater Management: A Review of the Barriers and a Roadmap for Real World Application This paper discusses the challenges of implementing smart stormwater management systems. It explains how sensors, real-time monitoring and automated controls can improve drainage performance. It also highlights practical barriers such as cost, technology reliability and implementation. The study supports integrating water-level sensors and automated alerts into a smart road-drainage system.
11. **James L. Webber, Tim Fletcher, Raziye+ Farmani, David Butler and Peter Melville-Shreeve (2022):** Moving to a Future of Smart Stormwater Management: A Review and Framework for Terminology, Research, and Future Perspectives This paper

reviews smart stormwater technologies, including IoT sensors, real-time monitoring and automated control. It explains how connected drainage systems can respond to changing rainfall and water levels. The research supports an integrated approach combining physical drains, sensors, storage facilities and safe water discharge.

12.Rentachintala, Reddy, and Mohapatra (2022): Urban Stormwater Management for Sustainable and Resilient Measures and Practices: A Review Rentachintala, Reddy, and Mohapatra (2022) reviewed sustainable methods for managing stormwater in urban areas. The authors discussed how urbanisation, climate change, and the reduction of vegetation increase runoff and create drainage problems. They examined methods such as sustainable urban drainage systems, low-impact development, and water-sensitive urban design. This research is useful for a smart road drainage system because it supports combining modern monitoring technology with sustainable drainage methods to reduce waterlogging and improve stormwater management.

13. **Webber et al. (2022):** Moving to a Future of Smart Stormwater Management: A Review and Framework for Terminology, Research, and Future Perspectives Webber, Fletcher, Farmani, Butler, and Melville-Shreeve (2022) reviewed smart stormwater management systems using the Internet of Things (IoT). The authors explained how sensors, real-time monitoring, and automated control can improve stormwater management. They also identified research gaps, including the need for better coordination and practical implementation. This study is directly relevant to smart road drainage because it provides a framework for monitoring drainage conditions and responding to rising water levels before serious road flooding occurs.
14. **Omamageswari et al. (2021):** IoT Based Smart Drainage Monitoring and Cleaning System for Solid Waste Materials Omamageswari, Mohanraj, Carolin Jeeva, Kishore Reddy, Thilagam, and Penchalaiah (2021) proposed an IoT-based drainage monitoring and cleaning system to address the problem of solid waste blocking drains. The study focused on collecting and managing waste that can obstruct drainage flow. This research is useful for a smart road drainage system because monitoring and removing waste can improve water flow and reduce waterlogging during heavy rainfall.

15.Shishegar et al. (2021): A Smart Predictive Framework for System-Level Stormwater Management Optimization Shishegar, Duchesne, Pelletier, and Ghorbani (2021) developed a predictive framework for managing stormwater systems using real-time control and optimisation. Their approach aimed to reduce peak water flows and improve the use of stormwater storage basins. The study is relevant to smart road drainage because predictive control can help manage excess rainwater and reduce the risk of flooding in low-lying road areas.

16. **Manaye Teshome and Allu Revathi Devi (2020):** A Review of Recent Studies on Urban Stormwater Drainage System for Urban Flood Management This review examines research on urban stormwater drainage and pluvial flooding, which occurs

when rainfall overwhelms drainage systems. The authors review 78 journal papers covering research published from 1990 to 2018. They discuss drainage management, flood-disaster management and the difficulties of reducing urban flood risk. The review explains why drainage planning must consider both the capacity of infrastructure and the consequences of heavy rainfall. It is relevant to a smart road drainage system because early detection, sufficient drainage capacity and safe overflow routes are all important for preventing road flooding.

17. **Carolyn M. Rodak and colleagues (2020):** Urban Stormwater Characterization, Control, and Treatment This annual review summarizes research published in 2019 on stormwater runoff, its characteristics, control and treatment. It examines how rainfall runoff can be measured and managed through stormwater-control devices, green infrastructure and watershed-scale planning. The review also highlights the need for reliable models that can represent the complex physical and environmental processes affecting stormwater. For your project, it supports the use of storage tanks, properly designed drains and controlled water discharge rather than allowing rainwater to flow randomly onto roads and nearby properties.

18.Dejene Tesema Bulti and Birhanu Girma Abebe (2020): A Review of Flood Modeling Methods for Urban Pluvial Flood Application This review examines methods used to model urban flooding caused by rainfall. It explains how flood models can estimate water accumulation and identify locations where drainage capacity may be exceeded. The research is useful for identifying vulnerable road sections and planning suitable drainage infrastructure.

19. **Carolyn M. Rodak and colleagues (2019):** Urban Stormwater Characterization, Control, and Treatment This review summarizes more than 250 studies published in 2018 on urban stormwater. It covers runoff quantity and quality, stormwater-control measures and green infrastructure. It also discusses practices such as permeable pavements, rainwater harvesting, constructed wetlands and bioretention. The research emphasizes the importance of considering the entire drainage catchment rather than an individual drain alone. For your project, it supports combining conventional roadside drains with water collection, temporary storage and suitable outlets to improve the management of rainfall runoff.

20.Kendurkar et al. (2019): Smart Drainage System and Methods for Purifying and Recycling of Water Using Internet of Things Chinmay Kendurkar, Mayuresh Bahegavankar, Archis Basangar, and Milarepa Marachakkanavar (2019) presented an IoT-based smart drainage system designed to improve drainage management and explore water purification and recycling. The proposed approach uses connected technology to monitor drainage conditions and support more effective water management. This research is relevant to a smart road drainage project because it demonstrates how IoT technology can be applied to drainage monitoring and water reuse.

21. **Keung et al. (2018):** Smart City Application and Analysis: Real-Time Urban Drainage Monitoring by IoT Sensors: A Case Study of Hong Kong Keung, Lee, Ng, and Yeung (2018) developed a prototype IoT system for monitoring urban drainage. The researchers collected sensor data and used an artificial neural network to predict drainage conditions. Their results showed that the trained model could predict many of the tested drainage situations. This study is directly relevant to smart road drainage because it demonstrates how sensor monitoring and prediction can help identify potential drainage problems before they cause serious flooding.
22. **Urban Pluvial Flooding and Stormwater Management Researchers (2018):** Urban Pluvial Flooding and Stormwater Management: A Contemporary Review of China's Challenges and "Sponge Cities" Strategy This review explains how urban development, impermeable surfaces and extreme rainfall contribute to flooding. It examines China's sponge-city approach, which uses methods such as rainwater retention, infiltration, green infrastructure and improved drainage planning. The study also discusses implementation difficulties associated with technology and governance. Its main relevance to smart road drainage is the principle of slowing, storing and managing rainwater instead of depending only on conventional drains. A roadside storage chamber or detention tank can apply this principle on a small scale.

23.Mullapudi et al. (2018): Shaping Streamflow Using a Real-Time Stormwater Control Network Mullapudi, Bartos, Wong, and Kerkez (2018) investigated the use of a real-time stormwater control network to manage water flow in an urban watershed. The researchers coordinated the release of water from two internet-controlled stormwater basins to achieve specific flow objectives. Their study demonstrated how real-time control can improve stormwater management. This research is useful for smart road drainage systems that use sensors and automatic controls to manage excess rainwater

24. **Anne J. Jefferson (2017):** Stormwater Management Network Effectiveness and Implications for Urban Watershed Function: A Critical Review This review examines how stormwater-control measures influence the performance of urban drainage networks and the health of receiving water bodies. It highlights the importance of evaluating individual drainage measures as part of a wider watershed system. Its findings suggest that the combined performance of many small interventions matters when assessing urban runoff. For a smart road drainage project, this supports studying how roadside inlets, connecting drains, storage chambers and final outlets work together
25. **Mehran Niazi and colleagues (2017):** Storm Water Management Model: Performance Review and Gap Analysis This study reviews the performance, calibration and validation of the Storm Water Management Model (SWMM), a widely used tool for analysing urban drainage and runoff. It discusses the model's development and its use in drainage design and planning. Reliable models can help engineers estimate how much runoff a drainage system may receive during rainfall and identify locations where

capacity improvements are required. For your project, SWMM can be considered for future simulation of rainfall, runoff, drainage capacity and waterlogging.

26. **Trisha L. Moore, Carolyn M. Rodak and Jason R. Vogel (2017):** Urban Stormwater Characterization, Control, and Treatment The authors review 246 studies published in 2016 related to urban stormwater runoff. The review covers runoff quantity and quality, engineered control systems, green roofs, permeable pavements, rainwater harvesting and watershed-level management. It demonstrates that urban stormwater can be controlled through a combination of structural and nature-based approaches. This literature is useful for designing a drainage model that combines roadside drains with temporary storage and sustainable rainwater management.
27. **Abhiram Mullapudi, Brandon P. Wong and Branko Kerkez (2017):** Research on smart stormwater control and sensing. This research examines smart stormwater management through monitoring and control technologies. It demonstrates the importance of using data from drainage infrastructure to improve water management decisions. The findings are relevant to developing drainage systems that monitor water conditions and respond to potential overflow.

28.-Bharath et al. (2017): Drainage Monitoring System Using IoT (DMS) Sriram Venkata Sai Bharath, T. Sidharth, Sravani Kavita, and Bhuvaneswari Balachander (2017) proposed an Internet of Things (IoT)-based drainage monitoring system using an ultrasonic sensor. The system monitors water levels and helps identify possible blockages in underground drainage systems. The collected information can help authorities detect drainage problems and take action in time. This study is useful for a smart road drainage project because it demonstrates how sensors can be used to monitor water levels and reduce the risk of road waterlogging.

29. **Jason R. Vogel and colleagues (2016): Urban** Stormwater Characterization, Control, and Treatment This review summarizes 181 journal articles published during 2015. It discusses runoff measurement, stormwater-control structures, treatment systems and watershed-scale modelling. The review highlights the importance of improving the design and operation of stormwater practices to manage runoff quantity and quality. For your smart road drainage system, it provides background for designing the physical drainage network and adding sensor-based monitoring to improve its operation.
30. **Branko Kerkez, Cyndee Gruden, Matthew Lewis, Luis Montestruque, Marcus Quigley, Brandon Wong, Alex Bedig, Ruben Kertesz, Tim Braun, Owen Cadwalader, Aaron Poresky and Carrie Pak (2016):** This paper explains how sensors, communication networks and automated controls can improve traditional stormwater systems. It discusses how monitoring and control can help drainage infrastructure respond to changing rainfall conditions. The research provides a foundation for a smart road-drainage model using sensors, a controller and a water-storage facility.

31.L. García, J. Barreiro-Gomez, E. Escobar, D. Téllez, N. Quijano and C. Ocampo-Martinez (2015): Modeling and Real-Time Control of Urban Drainage Systems: A Review This paper reviews mathematical modelling and real-time control methods for urban drainage systems. It explains how monitoring and control strategies can improve the management of water flowing through drainage networks. The study is relevant to designing systems that detect rising water levels and manage drainage operations efficiently.

32. **Yazdan far and Sharma (2015) :** Urban Drainage System Planning and Design—Challenges with Climate Change and Urbanization: A Review Yazdan far and Sharma (2015) reviewed the challenges involved in planning and designing urban drainage systems under climate change and urbanization. Their research explains how increasing urban development and changing rainfall patterns can affect drainage performance. The study highlights the importance of improving drainage design and adapting infrastructure to future flood risks. It is relevant to smart road drainage because it supports better planning for roads that experience waterlogging during heavy rainfall.
33. **Roshni Jose, Rebecca Wade and Chris Jefferies Smart SUDS: Recognizing the Multiple-Benefit Potential of Sustainable Surface Water Management Systems (2015):** The authors studied smart sustainable drainage systems to manage rainwater and surface runoff. The study explained how improved drainage management can reduce waterlogging, control flooding and improve urban water management
34. **Zhou, Q. (2014):** A Review of Sustainable Urban Drainage Systems Considering Climate Change and Urbanization Impacts Zhou (2014) reviewed sustainable urban drainage systems and examined how climate change and urbanization affect stormwater management. The study explained that increasing construction and paved surfaces reduce natural water infiltration and increase surface runoff. It highlighted sustainable drainage methods that can reduce flooding and improve stormwater management. This research is useful for a smart road drainage system because it supports combining proper drainage design with modern monitoring technology to reduce road waterlogging during heavy rainfall.

35.Hamel, Daly, and Fletcher (2013): Source-Control Stormwater Management for Mitigating the Impacts of Urbanization on Baseflow: A Review Hamel, Daly, and Fletcher (2013) reviewed stormwater management methods that control runoff near the location where rainfall occurs. Their study examined how urbanization affects water infiltration and groundwater-related baseflow. The authors discussed source-control methods that can reduce runoff volume and improve stormwater management. This research is relevant to a smart road drainage system because it supports combining drainage monitoring with infiltration and runoff-control methods to reduce waterlogging.

36. **K. Arnbjerg-Nielsen, P. Willems, J. Olsson, S. Beecham, A. Pathirana, I. Bülow Gregersen, H. Madsen, and V.-T.-V. Nguyen (2013):** Impacts of Climate Change on Rainfall Extremes and Urban Drainage Systems: A Review This study reviews how

climate change affects heavy rainfall and urban drainage systems. Heavy rainfall can overload drains and cause waterlogging and flooding on roads. The research explains why drainage systems should be designed to handle extreme rainfall. It is useful for planning an effective smart road drainage system.

37.Perrine Hamel, Edoardo Daly, and Timothy D. Fletcher (2013): Source-Control Stormwater Management for Mitigating the Impacts of Urbanization on Baseflow: A Review This study examines methods for managing rainwater near the place where it falls. It explains how infiltration systems can reduce surface runoff and help maintain the natural water cycle. These methods can help reduce excess rainwater on roads and improve stormwater management.

38.A. E. Barbosa, J. N. Fernandes, and L. M. David (2012): Key Issues for Sustainable Urban Stormwater Management This research discusses the main problems in managing rainwater in urban areas. It explains that rainwater can carry waste and pollutants, and poor drainage can lead to flooding and environmental problems. The authors highlight the need for proper planning and sustainable drainage methods. This study is useful for designing a smart road drainage system that manages rainwater effectively.

39. **Matthew Burns, Timothy D. Fletcher, Christopher Walsh, Anthony R. Ladson, and Belinda E. Hatt (2012):** Hydrologic Shortcomings of Conventional Urban Stormwater Management and Opportunities for Reform **This** study explains the limitations of traditional urban drainage systems. Conventional systems often focus on quickly removing rainwater but may not protect the natural water cycle. The authors suggest better ways to manage rainwater and reduce the effects of urban development. This research is relevant to improving road drainage and reducing waterlogging during heavy rainfall.
40. **Carol R. Jacobson (2011):** Identification and Quantification of the Hydrological Impacts of Imperviousness in Urban Catchments: A Review This research reviews how urbanization and hard surfaces, such as roads and buildings, affect rainwater flow. These surfaces prevent water from entering the ground, increasing surface runoff and the risk of flooding. The study is useful for understanding why proper road drainage systems are needed to manage rainwater and reduce waterlogging.

IV. CONCLUSION

The Smart Road Drainage System is a modern and effective solution for controlling road waterlogging and urban flooding. This system uses sensors and smart technology to monitor the water level in drainage chambers. When the water level increases, the system provides an alert and helps in taking immediate action. It also helps to identify drainage blockages and directs excess rainwater towards a storage tank or safe outlet. This reduces water overflow on roads and protects nearby properties. The system can reduce traffic problems, road damage and

maintenance work. Overall, the Smart Road Drainage System is a useful, economical and sustainable approach for improving urban drainage management and developing smart cities.

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