African FinTech and Digital Finance

Developing Low-Cost IoT Solutions for Environmental Monitoring in Urban Slums: A Methodological Approach in Namibia

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Abstract

Urban slums in Namibia face significant environmental challenges including air pollution, water scarcity, and waste management issues. Traditional monitoring methods are either too expensive or impractical for widespread deployment. The methodology involves designing a custom IoT platform using Arduino microcontrollers. Sensor data is aggregated through a Raspberry Pi server for real-time monitoring and analysis. Data privacy and security are ensured by implementing end-to-end encryption techniques. Sensor deployment across three urban slums in Namibia revealed that particulate matter concentrations exceeded WHO guidelines in all locations, with air quality index (AQI) readings averaging above the threshold of 40 AQI units for fine particulates. The custom IoT system successfully monitored environmental conditions and provided actionable insights to local authorities for improving urban slum living standards. Future work should focus on integrating machine learning algorithms for predictive maintenance and real-time health advisories. Developers should prioritise energy-efficient sensors and secure data transmission protocols, while policymakers can use the findings to inform public health and infrastructure development strategies in urban slums. Model estimation used $\hat{\{\theta\}} = argmin\{\theta\} sumiell(yi, f\theta(\xi)) + \lambda lVert\theta rVert 2^2$, with performance evaluated using out-of-sample error.

Keywords: *Geographic, Urbanization, Slums, Sensor Networks, Data Analytics, Remote Monitoring, Sustainable Technologies*

ABSTRACT-ONLY PUBLICATION

This is an abstract-only publication. The complete research paper with full methodology, results, discussion, and references is available upon request.

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