

# Methodological Evaluation and Multilevel Regression Analysis of Industrial Machinery Fleet Reliability in Senegal

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## ABSTRACT

**Background:** Industrial machinery fleets are critical for economic development, yet systematic reliability assessments in West African operational contexts are scarce. Existing methodologies often fail to account for the hierarchical structure of fleet data and region-specific operational stressors.

**Purpose and objectives:** This study aims to develop and apply a robust methodological framework for evaluating the reliability of industrial machinery fleets. The primary objective is to quantify the influence of multilevel factors—machine-level, operational, and environmental—on system failure rates.

**Keywords:** *Industrial machinery reliability, Multilevel modelling, West Africa, Fleet management, Maintenance methodology, Sub-Saharan Africa, Regression analysis*

### Article Highlights

- Multilevel modelling isolates nested operational and environmental stressors.
- Airborne particulate concentration linked to 15% increase in hazard rate.
- Depot-level maintenance practices account for significant reliability variance.
- Framework enables contextualised benchmarks for West African fleets.

### Core Statistical Model

Two-level hierarchical linear model:  $\lambda_{ij} = \beta_{0j} + \beta_{1j}X_{1ij} + \varepsilon_{ij}$ , where  $\beta_{0j} = \gamma_{00} + \gamma_{01}Z_j + u_{0j}$ . Parameters estimated via restricted maximum likelihood.

*This study advances methodological rigour for reliability assessment in region-specific operational environments.*

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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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