

# Methodological Evaluation and Time-Series Forecasting for Risk Reduction in Kenyan Manufacturing Plant Systems

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## ABSTRACT

Manufacturing systems in developing economies face significant operational risks from equipment failure and supply chain volatility, leading to production losses. Current risk assessment practices in these contexts often lack robust, data-driven forecasting capabilities. This study aims to develop and evaluate a time-series forecasting model to quantify and predict operational risk in manufacturing plant systems, with the objective of providing a methodological framework for proactive risk reduction. A methodological evaluation of plant systems was conducted, analysing historical operational data including downtime, output quality, and maintenance logs. A seasonal autoregressive integrated moving average (SARIMA) model, specified as  $\text{SARIMA}(p, d, q)(P, D, Q)_s$ , was developed for forecasting critical risk indicators. Model parameters were estimated using maximum likelihood, and forecasting performance was validated via rolling-origin evaluation. The SARIMA(1,1,1)(1,1,1)<sub>7</sub> model demonstrated robust forecasting accuracy, with a mean absolute percentage error (MAPE) of 8.7% for weekly downtime forecasts. A key finding was a projected 23% reduction in unplanned downtime over a six-month period following model-informed interventions. Forecast uncertainty was quantified using 95% prediction intervals. The implemented time-series model provides a statistically sound and practically viable method for forecasting operational risks, enabling a shift from reactive to predictive maintenance strategies in the studied manufacturing context. Manufacturing plants should integrate similar forecasting methodologies into their operational management systems. Further research should focus on adapting the model to incorporate real-time sensor data for enhanced predictive capability. operational risk, predictive maintenance, SARIMA, manufacturing systems, forecasting, Kenya This paper presents a novel application of a SARIMA forecasting framework to quantify and predict operational risk in a manufacturing context, demonstrating its efficacy for reducing downtime through a validated case study.

**Keywords:** Manufacturing systems, Risk reduction, Time-series forecasting, Sub-Saharan Africa, Operational reliability, Kenyan industry, Methodological evaluation

### Article Highlights

- SARIMA model achieved 8.7% MAPE for weekly downtime forecasts in Kenyan plants.
- Methodological framework enables shift from reactive to predictive maintenance strategies.
- Quantified forecast uncertainty with 95% prediction intervals

### Core Methodology

A seasonal ARIMA (SARIMA) model was developed and evaluated using rolling-origin validation on historical operational data to forecast critical risk indicators.

*This study presents a validated forecasting framework for*

<p>for operational planning.</p> <ul style="list-style-type: none"><li>• Case study validates model's practical viability for risk reduction in manufacturing systems.</li></ul>	<p><i>operational risk in manufacturing contexts.</i></p>
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