ABSTRAK

***BENCHMARKING* ARSITEKTUR *HYBRID DOUBLE-STAGE* (ARIMAX-FNN DAN SVR-FNN) UNTUK PREDIKSI PERTUMBUHAN IKAN NILA PADA LINGKUNGAN AKUAKULTUR TERKONDISI BERBASIS IOT (2026: xiv + 136 Halaman + 20 Gambar + 16 Tabel + 68 Daftar Pustaka + Lampiran)**

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Sistem budidaya ikan nila memerlukan pemantauan kualitas air secara berkelanjutan untuk menjaga stabilitas lingkungan dan mendukung pertumbuhan optimal. Penelitian ini merancang sistem *smart aquaculture* berbasis *Internet of Things* (IoT) untuk memantau suhu, pH, dan *dissolved oxygen* (DO), serta membangun model prediksi pertumbuhan ikan nila menggunakan arsitektur *hybrid double-stage*. Data yang diperoleh diproses melalui sinkronisasi temporal, interpolasi linier, deteksi outlier dengan *Interquartile Range* (IQR), dan normalisasi *Min-Max Scaler*. Pemodelan dilakukan dengan membandingkan ARIMAX dan SVR sebagai *baseline*, kemudian dikombinasikan dengan *Feedforward Neural Network* (FNN) sebagai *residual error corrector*. Evaluasi menggunakan RMSE, MAE, MAPE, dan R^2 menunjukkan bahwa ARIMAX menghasilkan RMSE 0.3841, MAE 0.3429, MAPE 1.116%, dan R^2 0.9721, sedangkan ARIMAX-FNN meningkatkan performa menjadi RMSE 0.2737, MAE 0.2393, MAPE 0.776%, dan R^2 0.9858. Sebaliknya, SVR-FNN mengalami penurunan performa. Berdasarkan *benchmarking* dan *Error Reduction Rate* (ERR), ARIMAX-FNN menjadi model terbaik untuk prediksi pertumbuhan ikan nila dalam sistem akuakultur cerdas.

Kata kunci: *Smart aquaculture*, *Internet of Things* (IoT), ARIMAX, *Support Vector Regression* (SVR), *Feedforward Neural Network* (FNN), *Double-stage hybrid*, Prediksi pertumbuhan ikan nila.

ABSTRACT

BENCHMARKING OF DOUBLE-STAGE HYBRID ARCHITECTURES (ARIMAX-FNN AND SVR-FNN) FOR PREDICTING TILAPIA GROWTH IN A CONDITIONED IOT-BASED AQUACULTURE ENVIRONMENT (2026: xiv + 136 Pages + 20 Figures + 16 Tables + 68 References + Appendices)

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Tilapia aquaculture systems require continuous monitoring of water quality to maintain environmental stability and support optimal growth. This study designs a smart aquaculture system based on the Internet of Things (IoT) to monitor temperature, pH, and dissolved oxygen (DO), and develops a tilapia growth prediction model using a double-stage hybrid architecture. The collected data are processed through temporal synchronization, linear interpolation, outlier detection using the Interquartile Range (IQR), and Min-Max normalization. Modeling is conducted by comparing ARIMAX and SVR as baseline models, which are then combined with a Feedforward Neural Network (FNN) as a residual error corrector. Evaluation using RMSE, MAE, MAPE, and R^2 shows that ARIMAX achieves RMSE of 0.3841, MAE of 0.3429, MAPE of 1.116%, and R^2 of 0.9721, while ARIMAX-FNN improves performance to RMSE of 0.2737, MAE of 0.2393, MAPE of 0.776%, and R^2 of 0.9858. In contrast, SVR-FNN experiences a decline in performance. Based on benchmarking results and Error Reduction Rate (ERR) analysis, ARIMAX-FNN is identified as the best model for predicting tilapia growth in a smart aquaculture system.

Keywords: *Smart aquaculture, Internet of Things (IoT), ARIMAX, Support Vector Regression (SVR), Feedforward Neural Network (FNN), Double-stage hybrid, Tilapia growth prediction.*