e-ISSN 2549-7472
Edumatic: Jurnal Pendidikan Informatika
Volume 10, Issue 1, **11-20.**
https://e-journal.hamzanwadi.ac.id/index.php/edumatic
DOI: 10.29408/edumatic.v10i1.32949

Machine Learning Approaches for Export Trend Classification: Evidence from Leading Commodities in Indonesia

Virasanty Muslimah [1,*], Rezki [1], Wildan Abdul Jabar [1]

[1] Universitas Muhammadiyah Sorong, Indonesia
[*] Corresponding author: Virasanty Muslimah, Universitas Muhammadiyah Sorong, Indonesia
✉ virasanty@um-sorong.ac.id

Received: 6 November 2025 | Revised: 23 October 2025 | Accepted: 9 January 2025 | Published: 18 February 2026

Abstract
Sorong City holds a strategic position in the export economy of Papua Barat Daya; however, its export performance remains volatile due to global price fluctuations, logistical constraints, and shifts in international demand. To address these challenges, this study applies machine learning-based classification to analyze and predict export trend dynamics of Sorong's leading commodities. Specifically, the study compares the performance of Naïve Bayes and Random Forest classifiers within a quantitative experimental framework. The dataset comprises 874 export records (2023–2025), including HS Codes, export values, destination countries, exporters, and export types. The methodological workflow encompasses data preprocessing, trend labeling, normalization, label encoding, class balancing using SMOTE, and model evaluation via 80:20 train-test split and 10-fold cross-validation. Performance metrics include accuracy, precision, recall, F1-score, and ROC-AUC. Experimental results reveal that Random Forest outperforms Naïve Bayes, achieving 74% accuracy compared to 57%, and more effectively captures nonlinear feature relationships. Despite a reduction in ROC-AUC during cross-validation, Random Forest demonstrates greater robustness in export trend prediction. Overall, the findings highlight the potential of machine learning to enhance regional trade forecasting, inform evidence-based policy formulation, and strengthen data-driven export management in emerging regional economies.

Keyword: export; machine learning; naïve bayes; random forest; sorong city

To cite this article: Muslimah, V., Rezki, R., & Jabar, W. A. (2026). Machine Learning Approaches for Export Trend Classification: Evidence from Leading Commodities in Indonesia. *Edumatic: Jurnal Pendidikan Informatika*, *10*(1), 11–20. https://doi.org/10.29408/edumatic.v10i1.32949

INTRODUCTION

Sorong City is a strategic economic hub in Southwest Papua and serves as the main gateway for international trade from eastern Indonesia due to its location on the western coast of Papua Island. Its economic strength is supported by abundant natural resources, including marine fisheries, processed wood, and plantation commodities such as nutmeg, coffee, and cocoa, which contribute significantly to regional income and national foreign exchange (Muzwardi & Nurhayati, 2025). Despite this potential, Sorong's export sector faces complex challenges amid intensifying global competition. Local governments and business actors are therefore required to adopt technology-driven and data-oriented strategies to remain competitive (Pratama & Hutajulu, 2022). Moreover, global price volatility, logistical disruptions, and shifting trade policies of partner countries continue to affect regional economic stability (Harjanto et al., 2023; Sarangi et al., 2025). Recent statistics even show short-term

growth accompanied by year-on-year decline, indicating unstable market dynamics that demand predictive and technology-based policy support (Harjanto et al., 2023).

Machine learning has emerged as a promising analytical approach to address export uncertainty because of its ability to process large-scale datasets, capture complex nonlinear relationships, and generate reliable forecasts (Hathikal et al., 2020; Özden, 2022; Qi et al., 2025; Ramadhani, 2022). Celik & Celik (2025) demonstrate that hybrid models such as LSTM, ARIMA, and GBM each have distinct advantages: LSTM excels during crises, ARIMA remains stable under low volatility, and GBM balances accuracy and risk, though their study is limited to seven major commodities. Dionissopoulos et al. (2024) highlight the effectiveness of AutoML with AutoKeras NN and TPOT based on Random Forest and GBM, achieving high accuracy with error rates of 0.29-9.8% and predicting price directions with success probabilities of 73-85%, though restricted to European Union data. He et al. (2021) propose a commodity classification framework using CNN and Transformer fusion, reaching 88-99% accuracy in HS-code classification, while Thaker et al. (2024) employ CNN with satellite imagery and weather data to forecast wheat prices, though performance declines due to crowding effects and weak generalization. Albanna & Diana (2025) further show that the Prophet method applied to forecasting staple food sales in traditional retail achieves an average accuracy of 94.09%, effectively capturing strong seasonal patterns such as demand surges before Ramadan and Eid al-Fitr.

Other studies reinforce the relevance of Random Forest and Naïve Bayes in trade and commodity contexts. Tiits et al. (2024) integrate gravity models with Random Forest to predict bilateral export values at the HS-6 digit level, while Zhang et al. (2022) apply Random Forest with the Gini Index to identify dominant factors in China's import-export economy, achieving $R^2 > 0.9$ though limited to Beijing. Yunita et al. (2025) how that Random Forest is more stable than SVM and Decision Tree in predicting local robusta coffee prices, despite small datasets. Suhadi (2025) applies Naïve Bayes for sentiment analysis of the Bisa Ekspor application, achieving 85.8% accuracy, 81.4% precision, and 92.7% recall. Danny & Muhidin (2025) report that optimized Random Forest achieves an almost perfect R^2 of 0.9984 in predicting global palm oil production, while Aprianto et al. (2024) and Elbasi et al. (2023) confirm Naïve Bayes consistency with accuracy above 80%. Fakhrizal et al. (2025) strengthen Random Forest's position with 96.65% accuracy in obesity classification, although static datasets remain a limitation. Meanwhile, Adi & Sudianto, (2022) emphasize the predictive strength of LSTM with low RMSE, though requiring significant computational resources.

Although research on machine learning in trade and commodities is expanding, most studies remain focused on global and national levels. Empirical applications that classify export trends of leading regional commodities, particularly in eastern Indonesia and Sorong City, are still scarce. Existing studies on export performance in this region are largely descriptive and retrospective, lacking predictive capabilities needed for proactive policy formulation (Suhadi, 2025; Yunita et al., 2025).

Therefore, this study employs machine learning-based classification to analyze and forecast the export trend dynamics of Sorong's key commodities, while comparatively evaluating the performance of Naïve Bayes and Random Forest algorithms. The findings are anticipated to contribute to the development of evidence-based policy frameworks, enhance regional economic resilience, and align with Indonesia's national strategic priorities, particularly Asta Cita 2, which emphasizes digital economic sovereignty, and Asta Cita 6, which focuses on village-centered and inclusive economic development.

METHOD

This study adopts a quantitative experimental design within an applied research framework that integrates machine learning to analyze and classify export trends of Sorong's

key commodities. The quantitative approach emphasizes numerical analysis and statistical algorithm testing for objective prediction, while the experimental component involves model development, training, and evaluation using Naïve Bayes and Random Forest to assess forecasting performance based on historical data. As an applied study, it aims to provide practical insights for mitigating export fluctuations and enhancing data-driven policy decisions among local governments and businesses. Sorong City, the primary export hub of Papua Barat Daya, was selected due to its leading commodities fisheries, processed wood, and agriculture. The research, conducted from April to November 2025, encompassed data collection, preprocessing, model construction, and performance assessment, as outlined in Figure 1, which depicts the complete research workflow.

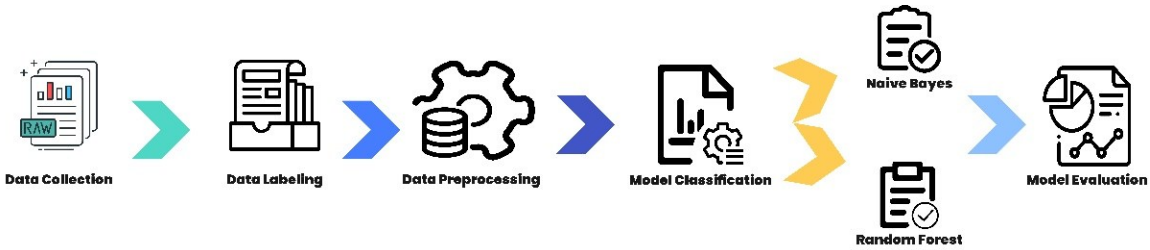


Figure 1. Research workflow

The study employs primary data obtained from KPPBC TMP C Sorong. This dataset includes export values in both IDR and USD, HS Codes, exporter names, destination countries, and export periods covering 2023 to 2025. Additional supporting information is collected from the Trade Office and BPS to enrich the analysis. Together, these sources provide a comprehensive basis for examining export dynamics in Sorong City. Table 1 provides a summary of the variables used in this study, and Table 2 presents the complete dataset analyzed.

Table 1. Dataset description

Variable	Data Type	Description
Year	Numeric	Export period (2023-2025)
Destination Country	Categorical	Export destination country code
Exporter	Categorical	Name of the exporting company
HS Code	Categorical	Harmonized System code for exported commodities
Export Value (IDR)	Numeric	Export value in Indonesian Rupiah
Export Value (USD)	Numeric	Export value in United States Dollars
Export Type	Categorical	Regular Export / Temporary Export-Import
Trend Label	Categorical	Increasing or Decreasing trend generated during labeling

Table 1 outlines the dataset variables, encompassing both numerical and categorical attributes such as export period, destination country, exporter, HS code, export values (IDR and USD), and export type. A trend label variable, derived during data labeling, indicates increasing or decreasing export patterns and serves as the classification target. Table 2 presents a sample dataset (2023–2025) containing year, destination country, exporter, HS code, and export values, distinguishing between regular and temporary export-import activities, thus illustrating the dataset structure used for analysis.

Data preprocessing involved trend label generation, label encoding for categorical attributes, feature normalization via Min–Max Scaler, and class imbalance correction using SMOTE. Classification experiments utilized Naïve Bayes for computational efficiency and

Random Forest for robustness in handling high-dimensional data. Model training adopted an 80:20 train-test split with 10-fold cross-validation to ensure reliable evaluation. Performance was assessed using accuracy, precision, recall, F1-score, and visualized through confusion matrix and ROC–AUC. All analyses were implemented in Python using scikit-learn, pandas, numpy, and matplotlib, resulting in stable and accurate export trend prediction models for Sorong City.

Table 2. Dataset

Year	Destination Country	Exporter	HS Code	Export Value (IDR)	Export Value (USD)	Description
2023	SG	Maritel Bahtera Logistik	85159090	15,013	1	Temporary Export-Import
2023	AU	Snepac Shipping	89011070	38,557,500,000	2,500,000	Temporary Export-Import
2023	MY	Kerapu Emas Papua	03028918	4,501,500	300	Regular Export
…	…	…	…	…	…	…
2025	JP	Dwi Bina Utama	03061711	5,752,493,186	341,928	Regular Export
2025	CN	Dwi Bina Utama	03061790	7,670,775,853	462,352	Regular Export

RESULTS AND DISCUSSION

Results

The dataset comprising 874 export records from Sorong City (2023–2025) exhibits distinct trade patterns. Export activities were primarily directed toward Malaysia, Singapore, Japan, China, and Taiwan, showing notable year-to-year fluctuations in both value and volume. Analysis based on HS Code classifications reveals that machinery-related products and marine commodities dominate the export structure, while the differentiation between regular and temporary export-import activities reflects varying degrees of market stability. Exploratory visualizations indicate pronounced volatility in export values, particularly marked surges and declines in shipments to Singapore and Malaysia, suggesting high sensitivity to external demand shocks. These insights establish the empirical basis for assessing the performance of machine learning models in export trend classification. Figure 2 illustrates the distribution of export trend labels.

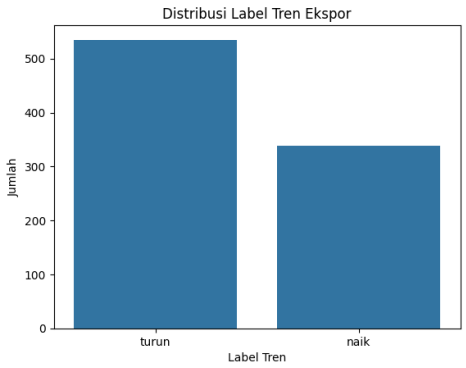


Figure 2. Distribution of export trend labels

Figure 2 illustrates the distribution of export trend labels and shows that the “decrease” category is more dominant than the “increase” category. This condition indicates the presence of class imbalance within the dataset. Such imbalance can influence the performance of classification models, particularly algorithms that are sensitive to unequal class proportions. As a result, models may become biased toward the majority class during training. Therefore, addressing class imbalance is important to improve the reliability of export trend classification results. Figure 3 displays the total export value (USD) based on destination country and HS Code.

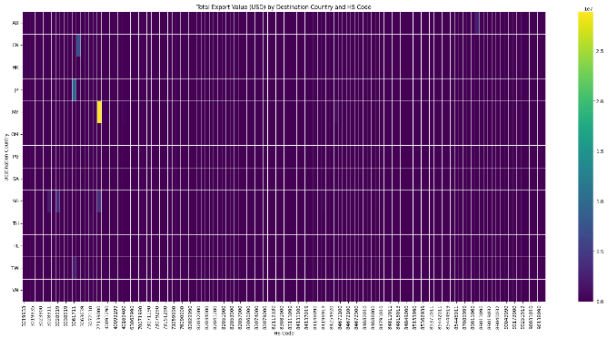


Figure 3. Total export value (usd) by destination country and hs code

Figure 3 illustrates the variations in export values, where lighter areas represent higher values and darker areas indicate lower ones. This visualization provides a clear overview of how different commodities, identified by HS Codes, contribute to specific destination markets. It highlights which commodities dominate Sorong City’s export activities and reveals the concentration of trade flows. The patterns observed also suggest a reliance on certain markets, such as those with consistently high shipment volumes. These insights emphasize the importance of diversifying both commodities and markets to ensure greater stability in regional export performance.

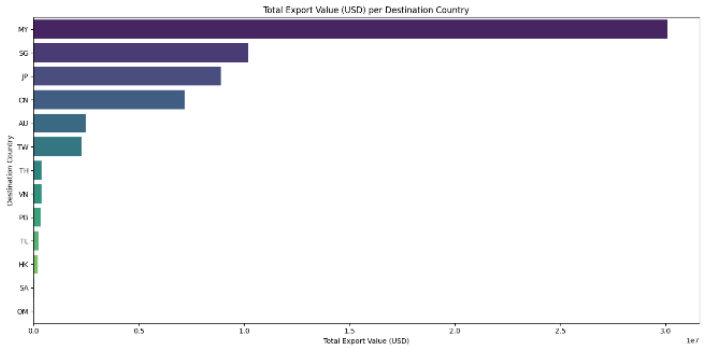


Figure 4. Total export value (usd) by destination country

Figure 4 presents the total export value by destination country and indicates that Malaysia recorded the highest export value among all trading partners. Singapore, Japan, and China follow as the next major export destinations. This distribution highlights the concentration of Sorong City’s export activities in specific international markets. The variation in export values also reflects differing levels of demand and trade intensity across partner countries. Overall, the figure provides an overview of Sorong’s dominant export markets and their relative economic importance. Figure 5 presents total export value (USD) by year and destination country.

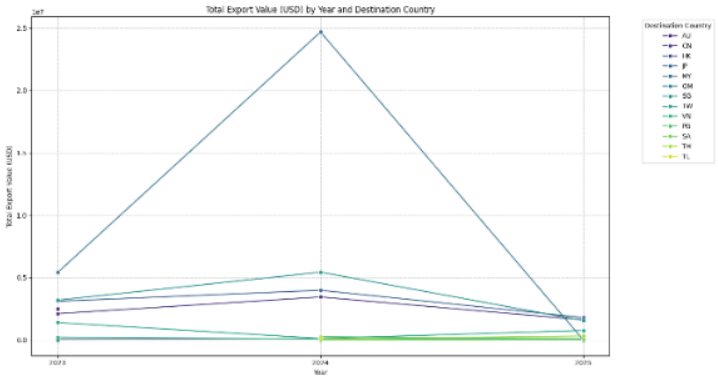


Figure 5. Total export value (usd) by year and destination country

Figure 5 illustrates the export value trends from 2023 to 2025 across different destination countries. The figure shows noticeable fluctuations, including periods of significant increases and declines in export performance. These variations indicate that export activities are not stable over time and differ between markets. The visualization helps capture temporal dynamics in Sorong City's export performance. Overall, Figure 5 supports the identification of time-based patterns and market-specific changes that are important for export trend forecasting.

The preprocessing phase involved structuring and preparing the dataset through label generation based on year-to-year export value comparisons, conversion of categorical variables using Label Encoding, and feature normalization with Min-Max Scaler to maintain consistent feature scaling. SMOTE was applied to address class imbalance, while 10-fold cross validation ensured robust model evaluation across multiple data partitions.

The classification stage compared the performance of Naïve Bayes and Random Forest in predicting increasing and decreasing export trends. Naïve Bayes produced 57 percent accuracy with unbalanced precision and recall values, and its mean accuracy decreased under 10-fold cross validation, indicating limited generalization. In contrast, Random Forest achieved 74 percent accuracy and more stable evaluation metrics in both the 80-20 split and cross-validation, demonstrating stronger capability in capturing complex trend patterns. Performance comparisons are summarized in Table 3, which shows that Random Forest outperformed Naïve Bayes across all metrics.

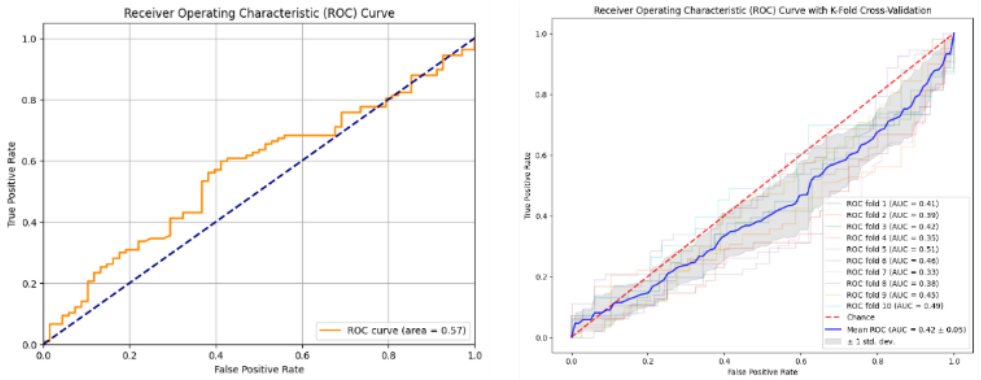
Table 3. Comparison of evaluation results of naïve bayes and random forest models

Model	Label	Accuracy	Precision	Recall	F1-Score
Naive Bayes	Naik	57%	0.46	0.63	0.53
	Turun		0.69	0.52	0.60
Random Forest	Naik	74%	0.67	0.63	0.65
	Turun		0.67	0.80	0.79

Table 3 presents a comparative evaluation of the Naïve Bayes and Random Forest models in classifying export trend labels. The results show that Random Forest achieves higher overall accuracy than Naïve Bayes. In addition, Random Forest demonstrates more balanced precision, recall, and F1-score for both increasing and decreasing trend classes. By contrast, Naïve Bayes shows lower accuracy and less consistent performance across classes. These findings indicate that Random Forest is more reliable for predicting export trends in this study.

Overall, the classification results indicate that Random Forest outperforms Naïve Bayes in predicting export trends of Sorong City's leading commodities. Its higher accuracy and more balanced evaluation metrics make Random Forest the recommended model for export trend analysis in this context. To assess the robustness of both algorithms, ROC-AUC analysis was

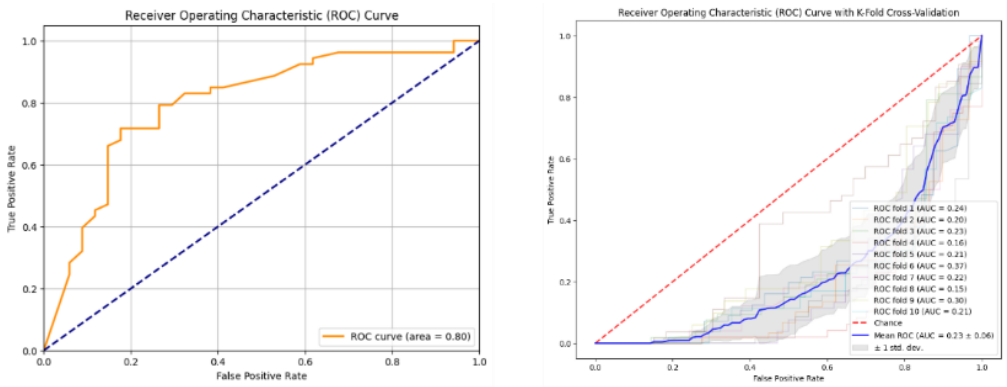
also conducted. Figure 6 presents the ROC-AUC performance of the Naïve Bayes model using both the 80-20 data split and 10-fold cross validation. In Figure 6(a), the model achieves an AUC of 0.57, reflecting moderate ability to differentiate between increasing and decreasing export trends. However, Figure 6(b) shows a decrease in mean AUC to around 0.42 under cross validation, indicating weaker generalization across resampled folds. This decline demonstrates the model's sensitivity to data variability, particularly given interdependent features such as HS Code, destination country, and export value.



(a) (b)

Figure 6. ROC-auc curve of naïve bayes (a) Data split 80-20 and (b) 10-Fold cross validation

Figure 7 presents the ROC-AUC curves for the Random Forest model under both evaluation methods. In Figure 7(a), the model attains an AUC of 0.80 in the 80-20 data split, demonstrating strong capability in identifying export trend patterns. In contrast, Figure 7(b) shows a substantial decrease in mean AUC to around 0.23 under 10-fold cross validation, indicating potential overfitting on certain folds caused by pronounced variations in export data across years, destination countries, and HS Codes. This discrepancy offers important academic insight into the behavior of ensemble models when applied to trade-related datasets and underscores the necessity of rigorous model validation for real-world policy applications.



(a) (b)

Figure 7. ROC-auc curve of random forest (a) Data split 80-20 and (b) 10-Fold cross validation

Figure 8 presents the visualization of model performance through the confusion matrices of both algorithms. This figure offers a clear comparison between misclassified and correctly predicted labels, supporting the quantitative results obtained earlier. Collectively, these visualizations enhance the academic value of the study by illustrating the behavior of export

trend classification models under varying validation schemes and providing methodological insights that can guide future machine learning applications in trade forecasting and regional economic analysis.

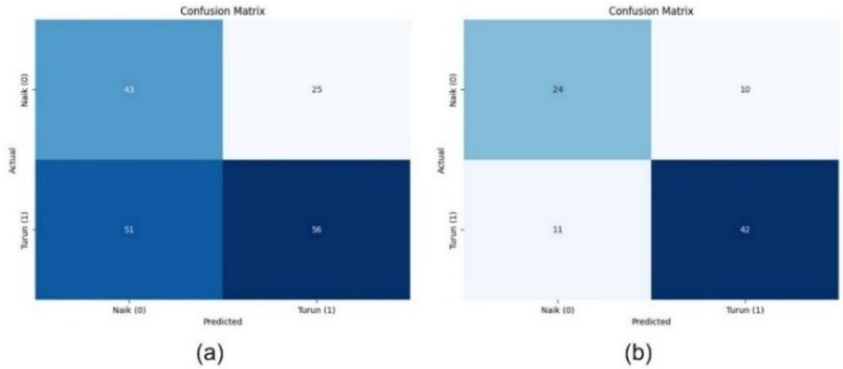


Figure 8. Confusion matrix evaluation of models (a) Naïve bayes and (b) Random forest

Discussion

This study demonstrates clear differences in the performance of Naïve Bayes and Random Forest when applied to the classification of export trend dynamics in Sorong City. Naïve Bayes achieved relatively low accuracy (57 percent) with moderate precision and recall, confirming its limitations in handling heterogeneous and correlated trade data. In contrast, Random Forest produced stronger results with 74 percent accuracy and more balanced evaluation metrics, consistent with its theoretical strength in managing nonlinear relationships and class imbalance. These findings directly address the research objective of identifying suitable machine learning approaches for dynamic regional trade data.

The comparative analysis also shows alignment with earlier studies. The weak performance of Naïve Bayes echoes the conclusions of Akhter et al. (2024) and Purnama & Putra (2024), while the stronger performance of Random Forest is consistent with Danny & Muhidin (2025), Sarangi et al. (2025), and Waleed et al. (2021). However, the sharper divergence observed in Sorong highlights the influence of local export volatility and sudden shifts in shipment volumes to markets such as Singapore and Malaysia. Unexpectedly, Random Forest exhibited weaker performance in terms of ROC-AUC under cross-validation, contradicting previous findings that consistently reported its stability. This anomaly may be explained by Sorong's extreme export fluctuations and uneven class distribution, which reduce the discriminative ability of ensemble models despite their overall accuracy.

Scientifically, the study contributes by clarifying the comparative suitability of machine learning algorithms for regional trade analysis, strengthening empirical evidence that ensemble methods are generally more effective in volatile contexts, while Naïve Bayes remains relevant as a computationally efficient baseline. Practically, the findings suggest that policymakers and exporters in Sorong should prioritize ensemble-based approaches such as Random Forest, while remaining cautious about potential instability in ROC-AUC. At the same time, the study acknowledges its limitations, particularly the restricted dataset and short observation period, which may affect generalizability. Future research should expand the dataset, integrate global price indices and logistical variables, and explore hybrid models combining ensemble learning with deep learning to further enhance predictive accuracy.

CONCLUSION

This study demonstrates that machine learning can be effectively applied to predict export trends of Sorong City's leading commodities using historical export data from 2023 to 2025, with Random Forest outperforming Naïve Bayes by achieving 74 percent accuracy and

more balanced precision, recall, and F1-score values, while Naïve Bayes, despite its computational efficiency, shows limited capability in capturing the complex and correlated patterns characteristic of export data. These results indicate that ensemble-based algorithms are more suitable for analyzing heterogeneous trade datasets and can support data-driven decision-making in regional export management. Nevertheless, the study is constrained by a relatively small dataset, imbalanced trend classes, and the exclusion of macroeconomic variables that influence global trade dynamics. Future research should therefore expand the dataset, incorporate external economic indicators, and explore more advanced methods such as Gradient Boosting, XGBoost, or deep learning models to improve predictive performance and strengthen the role of machine learning in supporting export policy formulation and economic stability in Sorong City.

REFERENCES

Adi, R. M. S., & Sudianto, S. (2022). Prediksi Harga Komoditas Pangan Menggunakan Algoritma Long Short-Term Memory (LSTM). *Building of Informatics, Technology and Science (BITS)*, *4*(2), 1137–1145. https://doi.org/10.47065/bits.v4i2.2229

Akhter, T., Siddiqua, T., Ahmed, F., Babu, A., & Hossain, S. F. A. (2024). Forecasting and unveiling the impeded factors of total export of Bangladesh using nonlinear autoregressive distributed lag and machine learning algorithms. *Heliyon*, *10*(17), 1–17. https://doi.org/10.1016/j.heliyon.2024.e36274

Albanna, H. T., & Diana, D. (2025). Forecasting Penjualan Sembako berbasis Model Prophet : Strategi Efisiensi Stok pada pada Ritel Tradisional. *Edumatic: Jurnal Pendidikan Informatika*, *9*(3), 698–707. https://doi.org/10.29408/edumatic.v9i3.32251

Aprianto, P. R., Lestari, N., & Wulandari, C. (2024). Klasifikasi Data Mining Pada Bibit Pertanian Dengan Menggunakan Algoritma Naïve Bayes. *RESOLUSI : Rekayasa Teknik Informatika Dan Informasi*, *5*(1), 30–39.

Celik, B. A., & Celik, S. (2025). Hybrid forecasting of agricultural commodity prices : Integrating machine learning , time series, and stochastic simulation models. *Borsa Istanbul Review*, *25*(6), 1440–1462. https://doi.org/10.1016/j.bir.2025.10.004

Danny, M., & Muhidin, A. (2025). Optimasi Algoritma Random Forest untuk Prediksi Eksport Kelapa Sawit Global. *Bulletin of Computer Science Research*, *5*(5), 1129–1138. https://doi.org/10.47065/bulletincsr.v5i5.744

Dionissopoulos, I., Assimakopoulos, F., & Spiliotopoulos, D. (2024). Predicting Agricultural Product and Supplies Prices Using Artificial Intelligence. *16th Intenational Conference on Khowledge Management and Information System*, *3*, 371–379. https://doi.org/10.5220/0013071600003838

Elbasi, E., Zaki, C., Topcu, A. E., Abdelbaki, W., Zreikat, A. I., Cina, E., Shdefat, A., & Saker, L. (2023). Crop Prediction Model Using Machine Learning Algorithms. *Applied Sciences*, *13*(16), 9288. https://doi.org/10.3390/app13169288

Fakhrizal, D., Ananda Sutrisno, A., Afza Zain, N., Angga Mukti, G., & Setiawan, A. (2025). Implementasi Algoritma Machine Learning Menggunakan Model Random Forest Untuk Klasifikasi Obesitas. *JATI (Jurnal Mahasiswa Teknik Informatika)*, *9*(5), 7579–7584. https://doi.org/10.36040/jati.v9i5.14667

Harjanto, S. A., Sa'adah, S., & Wulandari, G. S. (2023). Export Commodity Price Forecasting in Indonesia Using Decision Tree, Random Forest, and Long Short-Term Memory. *Jurnal Ilmiah Teknik Elektro Komputer Dan Informatika (JITEKI)*, *8*(4), 660–669. https://doi.org/10.26555/jiteki.v8i4.25242

Hathikal, S., Chung, S. H., & Karczewski, M. (2020). Prediction of ocean import shipment lead time using machine learning methods. *SN Applied Sciences*, *2*(7), 1272. https://doi.org/10.1007/s42452-020-2951-5

He, M., Wang, X., Zou, C., Dai, B., & Jin, L. (2021). A Commodity Classification Framework Based on Machine Learning for Analysis of Trade Declaration. *Symmetry*, *13*(6), 964. https://doi.org/10.3390/sym13060964

Muzwardi, A., & Nurhayati, N. (2025). Examining Sorong Special Economic Zone and its Implications for the Region. *Papua Journal of Diplomacy and International Relations*, *5*(1), 86–98. https://doi.org/10.31957/pjdir.v5i1.4319

Özden, E. (2022). The Dynamics Affecting the Export-Import Ratio in Turkey: A Hybrid Model Proposal with Econometrics and Machine Learning Approach. *Journal of Economic Policy Researches / İktisat Politikası Araştırmaları Dergisi*, *9*(2), 265–291. https://doi.org/10.26650/JEPR1088322

Pratama, N. K., & Hutajulu, D. M. (2022). Pengaruh Harga Bahan Kebutuhan Pokok Terhadap Inflasi di Kota Sorong. *Jurnal Wira Ekonomi Mikroskil*, *12*(1), 9–20. https://doi.org/10.55601/jwem.v12i1.821

Purnama, P. A. W., & Putra, T. A. (2024). Klasifikasi Penjualan Produk Menggunakan Algoritma Naive Bayes pada Konter HP Bayu Cell. *Remik: Riset Dan E-Jurnal Manajemen Informatika Komputer*, *8*(1), 286–292.

Qi, L., Zhang, Q., Lin, X., Zhang, J., & Liao, M. (2025). Attribute knowledge and KBGAT for predicting the accuracy of the harmonized system code for classifying import and export commodities. *Scientific Reports*, *15*(43504), 1–20. https://doi.org/10.1038/s41598-025-16580-7

Ramadhani, L. K. (2022). Prediksi Ekspor & Impor Komoditas Pertanian Menggunakan Metode Jaringan Syaraf Tiruan Radial Basis Function. *Joined Journal (Journal of Informatics Education)*, *5*(1), 36-44. https://doi.org/10.31331/joined.v5i1.2131

Sarangi, P. K., Singh, E., Kaushal, A., Sharma, B., Dutta, M., & Dubey, V. P. (2025). Analysing the Fluctuations in Commodity Prices and Forecasting the Future Directions Using Machine Learning Techniques. *Procedia Computer Science*, *259*, 1827–1836. https://doi.org/10.1016/j.procs.2025.04.138

Suhadi, E. (2025). Analisis Sentimen Aplikasi Bisa Ekspor Pada Ulasan Pengguna di Google Play dengan Naive Bayes. *JIKA (Jurnal Informatika)*, *9*(1), 93. https://doi.org/10.31000/jika.v9i1.12876

Thaker, A., Chan, L. H., & Sonner, D. (2024). Forecasting Agriculture Commodity Futures Prices with Convolutional Neural Networks with Application to Wheat Futures. *Journal of Risk and Financial Management*, *17*(143), 1–15. https://doi.org/10.3390/jrfm17040143

Tiits, M., Kalvet, T., Ounoughi, C., & Yahia, S. Ben. (2024). Relatedness and product complexity meet gravity models of international trade. *Journal of Open Innovation: Technology, Market, and Complexity*, *10*(2), 100288. https://doi.org/10.1016/j.joitmc.2024.100288

Waleed, M., Um, T. W., Kamal, T., & Usman, S. M. (2021). Classification of agriculture farm machinery using machine learning and internet of things. *Symmetry*, *13*(3), 1–16. https://doi.org/10.3390/sym13030403

Yunita, Y., Yulisa, N., Putri Sekar Mayasari, D., & Pujianto, P. (2025). Prediksi Harga Kopi Robusta Kabupaten Muara Enim Tahun 2025 Menggunakan Metode Random Forest, SVM & Tree. *Prosiding Seminar Nasional Teknologi Informasi Dan Bisnis*, 1602–1609. https://doi.org/10.47701/f9r5fm79

Zhang, R., Xie, Q., & Xu, Y. (2022). A study on the identification of economic contribution of import and export based on random forest algorithm under Gini index. *BCP Business & Management*, *23*, 206–215. https://doi.org/10.54691/bcpbm.v23i.1352