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Optimization of Prediction of Labor Percentage of Agricultural Information in NTB using Salp Swarm Algorithm

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Abstract: This research aims to develop an appropriate prediction model regarding the percentage of informal labor in the agricultural sector of West Nusa Tenggara (NTB) Province by utilizing the Salp Swarm Algorithm (SSA) within the framework of the third-order Autoregressive (AR) model. This quantitative approach with computational experiments uses secondary data on the percentage of informal labor in the agricultural sector in NTB from 2015 to 2024. The SSA algorithm is used to optimize the time series model parameters and evaluated using the Mean Squared Error (MSE) and Mean Absolute Percentage Error (MAPE) indicators. The results show that the resulting prediction model has high accuracy, with an MSE of 0.9353 and MAPE of 0.93%, as well as stable projections for the period 2025-2029 which are estimated to be between 97.19% to 98.41%. This study contributes to the development of agricultural employment policies and suggests further research by considering external variables to improve the accuracy of the model.

Keywords: Salp Swarm Algorithm (SSA), Informal Labor Prediction, NTB Agricultural Sector.

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A. INTRODUCTION

Informal labor plays an important role in employment in developing countries, including Indonesia. Informal workers are individuals without formal contracts, legal protection, or access to social security (Anisah & Damayanti, 2024). In the agricultural sector, especially in NTB, they play a significant role due to limited formal employment opportunities. Research on the informal workforce often focuses on variables such as demographic characteristics, type of employment, contribution to income, and structural challenges. With the increasing need for evidence-based planning, prediction of informal workforce trends is important for more targeted policies. Therefore, the application of metaheuristic algorithms, such as Salp Swarm Algorithm (SSA), is relevant to improve estimation accuracy in informal labor market analysis.

Various forecasting techniques have been applied to analyze informal workforce data, ranging from classical statistical models such as AutoRegressive Integrated Moving Average (ARIMA) to machine learning-based algorithms such as Artificial Neural Network (ANN) and Support Vector Machine (SVM) (Huang et al., 2018). Each of these methods has advantages and limitations in processing dynamic and unstructured data, such as informal workforce data which is influenced by various social, economic, and political factors (Sibagariang et al., 2023). In this case, Salp Swarm Algorithm (SSA), which is a metaheuristic optimization method, emerges as a promising approach to improve forecasting accuracy. Drawing inspiration from the swarming behavior of salps, SSA can optimize the parameters of the prediction model to

produce more accurate estimates, making it highly relevant to be applied in forecasting the informal workforce of the agricultural sector in NTB.

Salp Swarm Algorithm (SSA) is a metaheuristic algorithm inspired by the social behavior of salps in the ocean and proven effective in optimizing time series prediction models (Al-Shabi et al., 2021). SSA is commonly used to fine-tune parameters in neural networks such as Artificial Neural Networks (ANN) and Echo State Networks (ESN), thereby significantly improving prediction accuracy (Srivinay et al., 2022). For example, MBSSA-ESN successfully predicted the air quality index well, while SSA-ANN outperformed traditional methods such as ARIMA in stock price prediction. Compared to other algorithms such as Whale Optimization Algorithm (WOA) and Moth-Flame Optimizer (MFO), SSA shows competitive accuracy and stability, making it a reliable choice for complex and dynamic data (Wang et al., 2024).

informal employment makes an important contribution in understanding the dynamics of the unregulated employment sector (Houssein et al., 2020). The model is able to integrate various determinants, such as individual skill levels, quality of governance, as well as employment policies, so as to describe the complexity of the system more thoroughly (Sabillah et al., 2025). For example, the implementation of SSA in Brazil successfully identified a downward trend in informality rates over the period 2003-2012 and linked it to changes in the structure of the workforce (Pertanian & Muhammadiyah, 2024). Similar results were found in Mexico, where increased human capital accumulation was shown to impact the productivity of informal labor (Munthe et al., 2023). However, this model still has limitations, especially in accommodating socio-cultural aspects as well as global economic dynamics, which emphasizes the need for the development of more adaptive and contextual predictive models (Nasir et al., 2023).

Although the Salp Swarm Algorithm (SSA) has been widely used in various predictive studies, its specific application to informal labor in the agricultural sector, especially in regions such as West Nusa Tenggara (NTB), is still rare. Most previous studies have focused more on macro issues or the context of large countries, with limited attention to local dynamics and the agricultural sector as the mainstay of the informal economy. Therefore, this study makes a novel contribution by adopting the SSA approach in forecasting informal labor in the agricultural sector in NTB, by considering local variables such as education level, gender, and access to resources. This research aims to build a responsive and accurate prediction model based on SSA, in order to support the formulation of more targeted policies in improving the welfare of informal workers.

B. METHOD

This research applies a quantitative approach with a type of computational experiment, which aims to build an accurate prediction model of the number of informal workers in the agricultural sector in West Nusa Tenggara (NTB) Province. This approach allows testing the effectiveness of the Salp Swarm Algorithm (SSA) algorithm in the process of optimizing the parameters of the time series data prediction model. This research is applied because it integrates mathematical modeling techniques with smart computing approaches to produce

data-based solutions that can be used as a basis for employment policy making. The general formula of Salp Swarm Algorithm is as follows:

1. Initialize the starting position of the salp
   Each salp has a position x_i in the dimension space D:

$$x_i^d \in [lb^d, ub^d] \; to \; i = 1,2 \ldots, N; \quad D = 1,2, \ldots, D$$

2. Leader position update (first salp):

$$x_1^d = \begin{cases} F^d + c_1\left(\left(ub^d - lb^d\right)c_2 + lb^d\right), & if \; c_3 \geq 0.5 \\ F^d - c_1\left(\left(ub^d - lb^d\right)c_2 + lb^d\right), & if \; c_3 < 0.5 \end{cases}$$

3. Updating the position of the follower (salp to-2 up to-N):

$$x_i^d = \frac{1}{2}(x_i^d + x_{i-1}^d) \;\; to \; i = 2,3, \ldots N$$

The data used in this study is secondary data in the form of the percentage of informal labor in the agricultural sector in NTB during the period 2015 to 2024. Data sources were obtained from official publications such as the Central Bureau of Statistics (BPS) and other government agencies. The research procedure includes several stages, namely data collection and initial processing, preparation of SSA-based prediction algorithms using MATLAB software, and implementation of the forecasting process. The prediction results are then analyzed to measure the model's performance in representing the historical data pattern.

To assess the accuracy of the prediction results, two evaluation indicators are used, namely Mean Squared Error (MSE) and Mean Absolute Percentage Error (MAPE). MSE is used to measure the average squared error between the actual value and the predicted value, while MAPE provides an overview of the average percentage error relative to the actual value. These two parameters are used to evaluate the extent to which the SSA model is able to provide estimates that are close to reality, as well as the basis for drawing conclusions on the effectiveness of the model in the context of informal employment in the agricultural sector in NTB. The following is a flowchart that represents the stages in the algorithm:

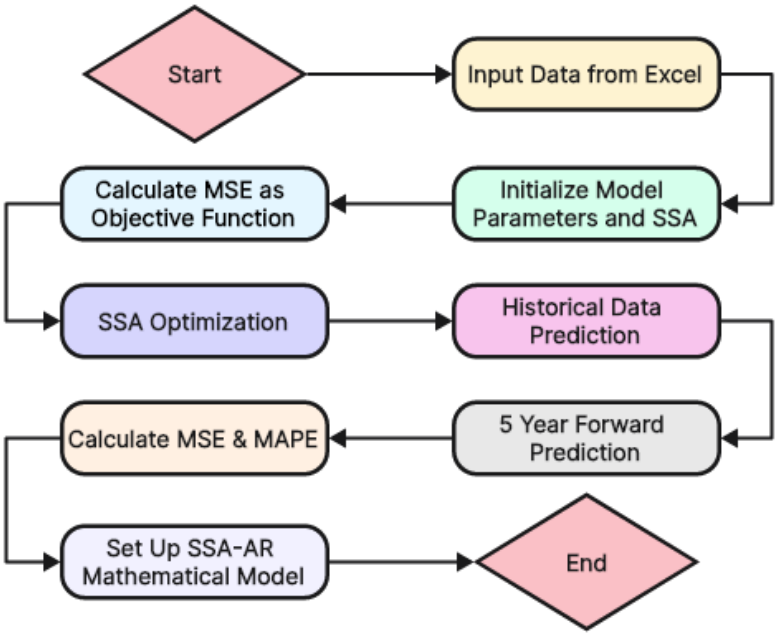

Figure 1. Salp Swarm Algorithm

C. RESULTS AND DISCUSSION

1. Data Description

The data trend of the percentage of informal labor in the agricultural sector in NTB from 2015 to 2024 shows stability with an average of 96.99%. The minimum value was recorded at 96.10% in 2015, while the maximum value reached 98.42% in 2024, with a standard deviation of 0.81, indicating a relatively small fluctuation around the average value. Overall, the data does not show any clear upward or downward trend, but rather tends to be stable within a high range, illustrating the consistency of informal labor utilization in the agricultural sector over the period.

Table 1. Data Description

Data Descriptive Statistics	Values
N (Number of Years)	10
Minimum	96,10
Maximum	98,42
Mean	96,99
Standard Deviation	0,81

2. Computing System Design

Before presenting the flowchart, the following is a brief description of the stages of the Salp Swarm Algorithm (SSA) used in predicting the percentage of labor information in the agricultural sector. The process starts with loading data from an Excel file, followed by determining the model parameters and optimization process using SSA. After that, predictions are made on historical and future data, followed by an evaluation of the error rate using the Mean Squared Error (MSE) and Mean Absolute Percentage Error (MAPE) indicators. The final

stage of this process is the preparation of a mathematical model of optimization results, which is then presented along with graphical and tabular visualization of prediction results.

3. Forecasting Results and Decision Making

The following presents the prediction results of the percentage of information workers in the agricultural sector in West Nusa Tenggara Province for the next five-year period, namely from 2025 to 2029, obtained through a modeling process using the Salp Swarm algorithm (SSA).

Table 2. Forecasting Results

Year	5 Year Forward Prediction
2025	98.41
2026	97.19
2027	97.63
2028	98.21
2029	97.59

The following figure shows a comparison between actual data, historical prediction results, and predictions for the next five years regarding the percentage of labor information in the agricultural sector in West Nusa Tenggara Province. This visualization shows the performance of the prediction model based on the Salp Swarm algorithm (SSA) as well as the trend of changes in values during the observation and projection periods.

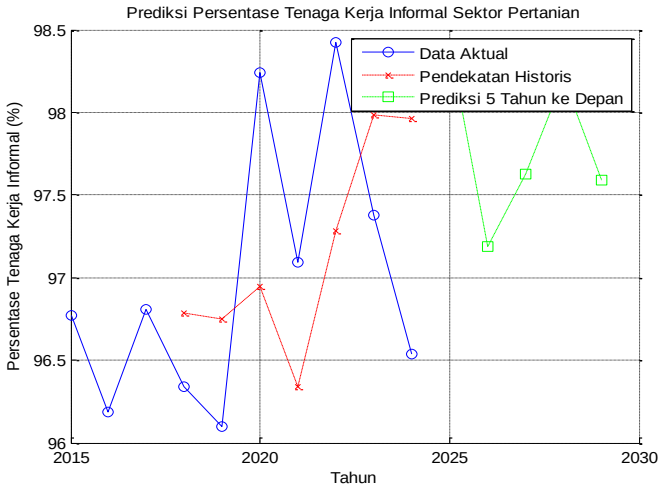

Figure 1. Prediction Chart for the Next 5 Years

The prediction of the percentage of information labor in the agricultural sector of West Nusa Tenggara Province for the period 2025 to 2029 shows a relatively stable pattern, with values ranging from 97.19% to 98.41%. Evaluation of model performance was carried out using two indicators, namely Mean Squared Error (MSE) of 0.9353 and Mean Absolute Percentage Error (MAPE) of 0.93%, which indicates a high level of prediction accuracy with low relative error. The mathematical model generated through the optimization process using the Salp

Swarm algorithm (SSA) in the third-order Autoregressive (AR) framework is formulated as follows $y(t) = -0{,}0917.y(t-2) + 0{,}6333.y(t-3)$. This model shows that the predicted value in year t is linearly influenced by the value in the previous three periods with a certain coefficient.

D. CONCLUSIONS AND SUGGESTIONS

Based on the analysis, it can be concluded that the percentage of information labor in the agricultural sector of West Nusa Tenggara Province shows a relatively stable trend throughout the 2015-2024 period, with minimal fluctuations around the average value of 96.99%. The prediction model developed using the Salp Swarm algorithm (SSA) in a third-order Autoregressive (AR) framework shows an excellent ability to project the trend of the next five years, with a high level of accuracy, as seen from the MSE value of 0.9353 and MAPE of 0.93%. The results of this prediction indicate that the percentage of the information workforce is expected to remain in a high and stable range until 2029.

As a recommendation, the results of this prediction can be used as a basis by local governments and stakeholders in designing employment policies in the agricultural sector, especially in terms of competency development and protection for information workers. In addition, it is recommended that future research include other relevant external variables to increase the complexity and adaptability of the prediction model to changes in socio-economic dynamics that occur.

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