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Implementation of The Analytical Hierarchy Process (AHP) Algorithm to Support Decision Making For Determining Superior Orange Comodities Orange in Selorejo Village

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ABSTRACT

This study aims to explore the selection of orange varieties as the primary crop for farmers in Selorejo Village, Sengkaling, Malang Regency. Oranges have high economic value and are important for meeting the community's nutritional needs; however, selecting the right variety must take into account factors such as cultivation expertise, environmental influences, and income potential.The research question posed is: "Which orange variety is most suitable to be the primary crop in Selorejo Village?" The study employs the Analytical Hierarchy Process (AHP), enabling a systematic analysis of criteria and alternatives. The research findings are expected to provide new insights into the selection of optimal orange varieties and to integrate environmental and economic factors that are often overlooked. Data analysis using AHP includes initial data collection, applying AHP to define criteria and alternatives, determining the priority of criteria and alternatives, and ensuring consistency in the analysis. Focusing on Selorejo Village, this study aims to make a tangible contribution to strategies for more sustainable orange cultivation and to improve farmers' welfare. The results of the study indicate that income criteria are the primary factor in selecting orange varieties for farming in Selorejo Village, followed by cultivation practices and environmental influences, while the main orange varieties chosen are siem oranges, followed by mandarin oranges and sweet oranges.

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1. INTRODUCTION

Orange crops are a horticultural agricultural commodity with high economic value in Indonesia, including in Malang Regency. Orange serves as a source of income for farmers but also plays a crucial role in meeting the community's nutritional needs [1]. As public awareness of the importance of fruit consumption grows, market demand for orange continues to rise, both for fresh consumption and for processed products [2]. Selorejo Village, located in Dau Subdistrict, holds significant potential for orange cultivation due to its suitable climate and fertile soil conditions [3]. However, selecting the appropriate orange variety must consider various factors such as cultivation expertise, environmental influences, and income potential [4]. This study aims to explore the optimal orange variety selection for farmers in the village and provide data-driven recommendations to improve farmers' welfare.

The research question is: "Which orange variety is most suitable to be the primary crop in Selorejo Village based on the criteria of cultivation expertise, environmental influences, and income?" This question will be addressed through a systematic analysis using the AHP method, which allows for the comparison and evaluation of various alternatives [5]. Thus, the comprehensive results of this study can provide more detailed insights into the factors that play a role in selecting the optimal orange variety.

This study employs the AHP (Analytical Hierarchy Process), an effective decision-making method for problems involving multiple criteria and alternatives [6]. The AHP enables researchers to systematically organize information and assess the relative weights of various criteria. This method has proven effective in various studies in the field of agriculture and can provide more accurate results in decision-making [7]. Additionally, AHP also facilitates farmer participation in the decision-making process, which can enhance the acceptability of research findings [6].

This study contributes to the understanding of optimal orange variety selection in regions with specific conditions and provides new insights into the application of AHP in the context of agriculture in Indonesia [3]. The novelty of this study lies in its focus on Selorejo Village and the use of AHP to determine the most suitable orange variety [8]. Furthermore, this study will also integrate environmental and economic factors that have often been overlooked in previous research. Therefore, the results of this study can make a tangible contribution to the development and management of sustainable orange cultivation strategies based on farmers' preferences and experiences with orange farming in their region.

2. METHOD

The study was conducted from September 2024 to November 2025 in the main orange-growing area of Selorejo Village, Dau Subdistrict, Malang Regency. The study's respondents were orange farmers in the main orange-growing area of Selorejo Village, Dau, Malang. The primary research tools were questionnaires and in-depth interviews. The questionnaires were designed based on the research objectives and covered key topics related to the criteria for selecting orange varieties and the available alternatives or varieties at the research site. The criteria included the level of crop cultivation, environmental factors, and income. The alternatives identified were Siem oranges, Mandarin oranges, and sweet oranges.

Data collection from 30 farmers was conducted through random interviews. Data was gathered through face-to-face interviews and questionnaires administered to farmers with the assistance of the research team. An in-depth study was conducted to confirm and supplement information and data not covered in the questionnaire; the results of the in-depth study were recorded in the research diary. The data in the research diary included: side businesses other than orange farming, reasons for choosing specific orange varieties, orange cultivation practices, fertilizer use, pest, disease, and weed control, as well as the suitability of the environment for orange plants.

The Analytic Hierarchy Process (AHP) is used to analyze data from research findings. AHP is a method for decision-making based on multiple criteria [9], which begins by compiling a set of criteria, followed by compiling a set of alternatives. A pairwise comparison matrix is then constructed for the criteria and alternatives. Each criterion is evaluated on a 1–9 scale established [7]. These are then organized in a hierarchical structure to ensure a structured and systematic format. Respondent data is then entered into the AHP application, including priority data for both criteria and alternatives. AHP testing is conducted using the Expert Choice 11 software.

The testing procedures performed include:

1. Testing of criteria priorities and alternative priorities to determine the highest-ranked criteria and their order, as well as the highest-ranked alternatives and their order.
2. Consistency analysis testing to ensure the validity of the results, where the consistency ratio (CR) must be less than 0.1 to be considered consistent [9]. If the CR has a value greater than 0.1, then corrections or revisions must be made to the ratings given.
3. Two-dimensional (2D) sensitivity testing to evaluate the alternatives' performance under the influence of two criteria, thereby clearly identifying the alternatives' positions within the testing quadrants and confirming the selected alternative, as described in [3].

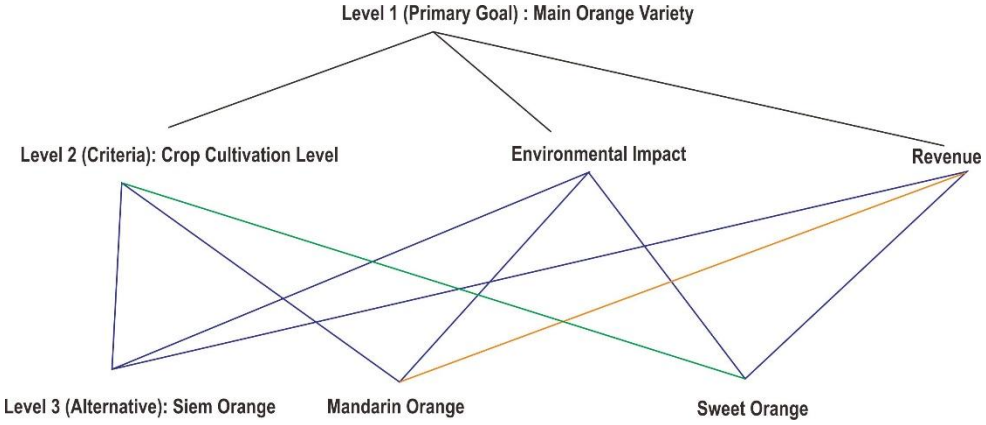

Figure 1. Testing Hierarchy Structure

The description of Figure 1 is as follows:

1. Level 1: Primary Goal: Main Orange Variety
    a. Selection of a orange variety as the primary crop for farmers in Selorejo Village.
2. Level 2: Selection Criteria
    a. Crop Cultivation Level
    b. Environmental Impact
    c. Revenue
3. Level 3: Alternative Orange Varieties
    a. Siem orange
    b. Mandarin orange
    c. Sweet orange

The operational steps of the AHP are explained as follows:

1. Hierarchy Formation: The problem is broken down into objectives, criteria, and alternatives. The criteria were established by integrating factors related to cultivation expertise, environmental suitability, and income, in accordance with study [9], which found that the competitiveness of local oranges is influenced by many factors, the most important of which are cultivation expertise, environmental suitability for the crop, and economic factors or income derived from the crop. Meanwhile, the alternatives are the types of oranges planted and cultivated by orange farmers in Selorejo Village, based on observations and interviews conducted prior to the research.
2. Pairwise Comparison:
    - Between Criteria: Experts or farmers will compare each criterion against one another to determine which is more important. For example, is “Income” more important than “Crop Cultivation Techniques”? Or is “Environmental Impact” more important than “Income”? These comparisons typically use a numerical scale (e.g., 1 = equally important, 3 = slightly more important, 5 = much more important, 7 = very much more important, 9 = absolutely more important).
    - Comparing Alternatives Against Each Criterion: Next, each type of orange (alternative) is compared against the others based on each criterion.
    - For example, based on the “Crop Cultivation Techniques” criterion, which is easier or more efficient to cultivate: Siamese oranges vs. Navel oranges? Siamese oranges vs. Sweet oranges? Navel oranges vs. Sweet oranges?
    - The same process will be applied to the “Environmental Impact” criterion (e.g., which is more resistant to pests/diseases or specific soil conditions?) and the “Income” criterion (e.g., which has a higher selling price or better market demand?).
3. Weight Calculation and Consistency:
    - Based on the results of the pairwise comparisons, AHP calculates priority weights for each criterion and each alternative. These weights indicate how important each element is within the hierarchy.
    - AHP also calculates the Consistency Ratio (CR) to ensure that the ratings given are not overly inconsistent. If the CR is too high (e.g., > 0.1), the comparisons need to be reviewed.
4. Priority Synthesis :
    - The priority weights of the alternatives will be combined with the priority weights of the criteria to obtain a final score for each type of orange.
    - The type of orange with the highest total score is the most recommended as the primary commodity.

To improve the efficiency and sustainability of decision-making for farmers and agricultural extension workers, this study also proposes a software-based decision support system (DSS) design that automates the calculations of the Analytical Hierarchy Process (AHP) method [10], thereby enabling its use for further development.

The system architecture is designed using an n-tier model that separates the user interface, processing logic, and data storage. The main components of this architecture include:

1. User Interface (Frontend): Functions to receive pairwise comparison ratings from farmers or experts via mobile devices or the web.
2. AHP Logic Service (Backend): The main engine that automatically performs matrix calculations, normalization, and consistency ratio (CR) checks. If the CR value is > 0.1, the system will automatically alert the user to revise the input.
3. Database: Stores criterion weights (Cultivation Level, Environmental Impact, Income) and alternative values for each type of orange (Siem, Mandarin. Sweet) for future historical analysis.

3. RESULTS AND DISCUSSION

The selection of the primary/preferred orange variety in Selorejo Village was based on income criteria (42.4%) as the top priority, followed by cultivation level (31.4%), while environmental impact (26.2%) was the final criterion. The result of the selection of the main/preferred orange variety in Selorejo Village is Siem oranges (40.2%), followed by tangerines (32.9%), and sweet oranges (27%) as the last choice. The complete analysis results are shown in Figure 2. This study provides AHP results consistent with the study [2], indicating that Siem oranges are the preferred choice as the primary commodity to support the development of flagship fruit commodities in Selorejo Village.

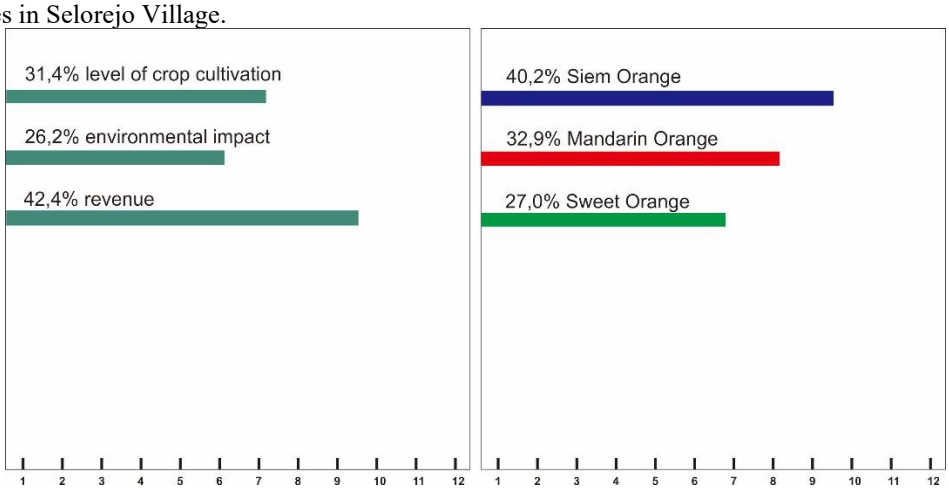

Figure 2. Results of the Analysis to Determine the Type of Oranges Grown by Farmers in Selorejo Village

The result of the consistency check for the criteria is 0.0055, as shown in Figure 3. This value is below the threshold of 0.1, indicating that the data from the pairwise comparisons of the criteria are consistent and valid. According to [11], consistency must be satisfied as a prerequisite for the validity of an analysis using the Analytical Hierarchy Process.

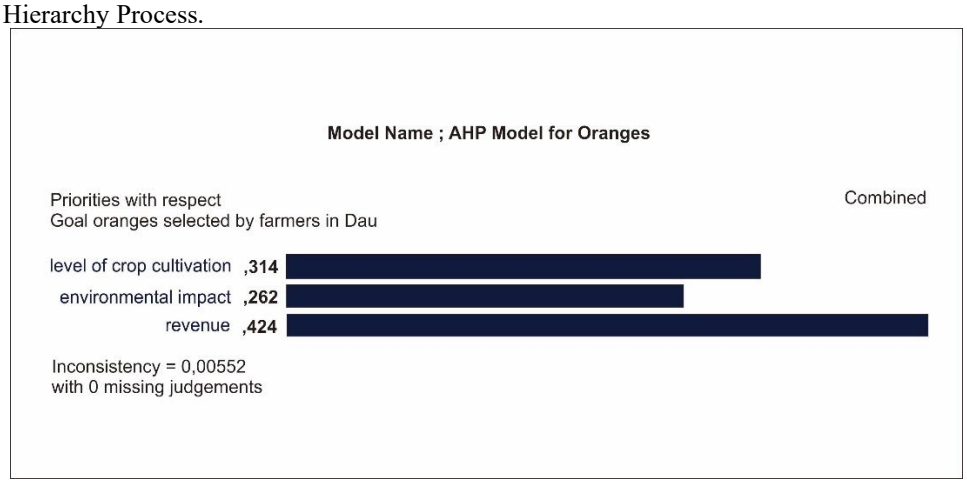

Figure 3. Results of the Criteria Inconsistency Check

The result of the consistency check for Alternative 0.00, shown in Figure 4, indicates that this value is below the threshold of 0.1, which means, in accordance with [6] and [5], that the data from the pairwise comparison of the Alternatives is consistent or valid.

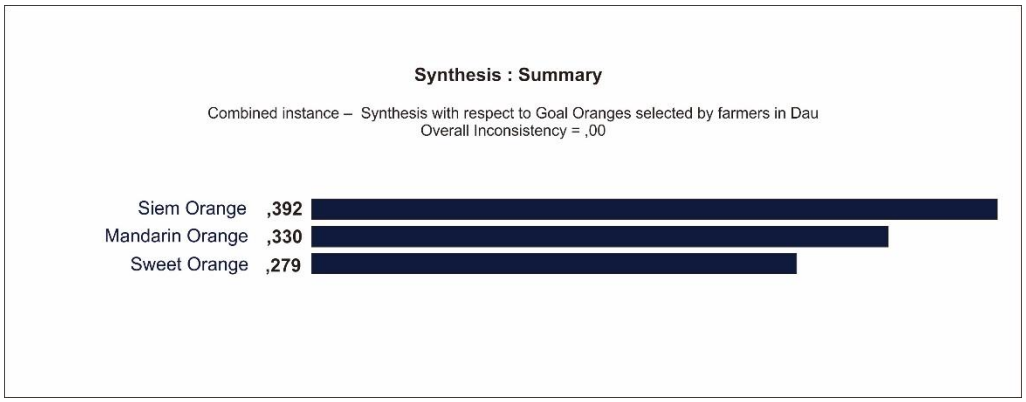

Figure 4. Results of the Alternative Inconsistency Check

Based on the results of the consistency test for the criteria and alternatives, which demonstrated consistency to ensure the validity of the results, the consistency ratio (CR) must be less than 0.1 to be considered consistent [9]. If the CR has a high value exceeding 0.1, this requires a revision of the assessment provided.

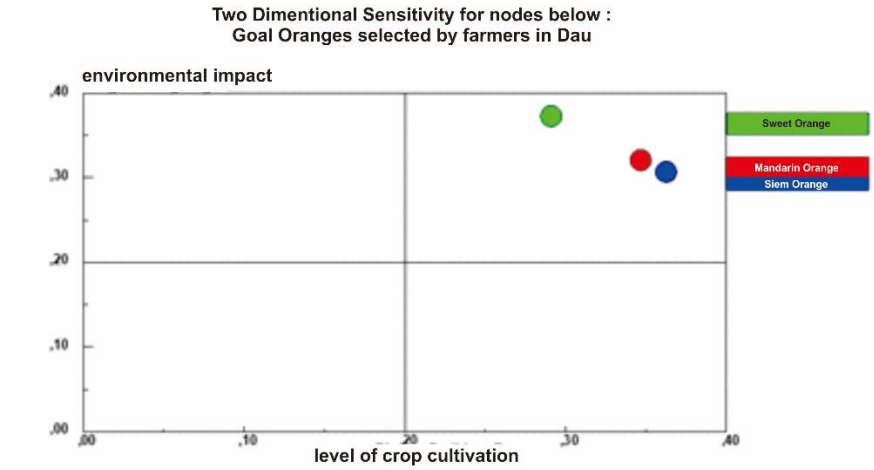

Figure 5. Results of Two-Dimensional (2D) Sensitivity Analysis on the Effects of Environmental Factors and Crop Cultivation Levels

Based on the results of the analysis of alternative orange crops using two criteria (environmental factors and cultivation practices), all three orange varieties fall into the highest quadrant in terms of both environmental factors and cultivation practices; therefore, based on these results, all three orange varieties are worthy of consideration as important options.

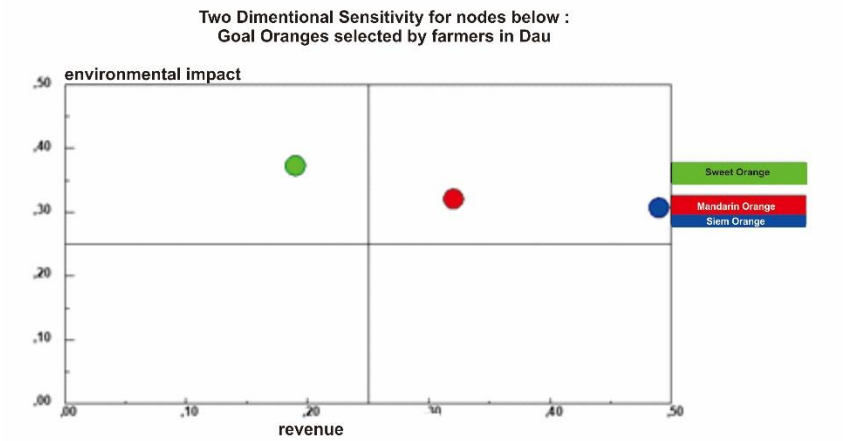

Figure 6. Results of the Two-Dimensional (2D) Sensitivity Analysis of the Effects of Environment and Income

Based on the results of the analysis of alternative orange crops using two criteria (environmental impact and income), two types of orange—mandarins and siem oranges—fall into the highest quadrant, which corresponds to the highest values for both environmental impact and income. Therefore, based on these results, mandarins and siem oranges are worthy of consideration as key options.

Based on the 2D sensitivity analysis of the criteria for orange shown in Figures 4, 5, and 6—which provide detailed explanations of the AHP analysis results displayed in Figure 1— Siem oranges are highly suitable as the primary choice for orange farmers in Selorejo Village, with the strong rationale that Siem oranges provide high income while also exhibiting environmental suitability and cultivation techniques that are well-mastered by Selorejo Village farmers compared to the other two orange varieties. This aligns with [8], which states that Siem oranges have become the flagship commodity for Selorejo orange farmers because they generate high income. It is crucial to maintain oranges as a flagship commodity in Dau Subdistrict to support the tourism area; this aligns with [12], which emphasizes that the sustainability of orange farming must be supported by the belief that these oranges can provide sufficient income to support family livelihoods.

Therefore, to strengthen the process of selecting orange commodities in the future, this study also proposes a software-based decision support system (DSS) [10] that automates the calculations of the Analytical Hierarchy Process (AHP) method, so that it can be utilized for further development in the form of a flowchart, which is expected to serve as a basis for future research. The following is the result of the flowchart proposed as the system to be designed.

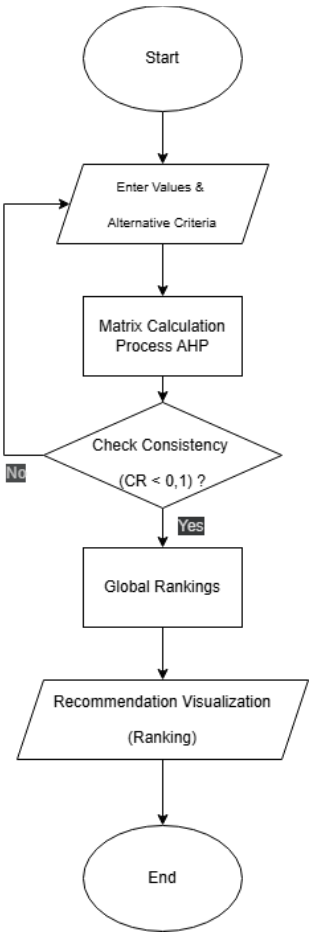

Figure 7. Flowchart of the Decision Support System for Selecting Orange Crops

4. CONCLUSION

The following are the conclusions drawn from the research that has been conducted.

1. Income is the primary criterion for selecting orange varieties in Selorejo Village, Dau, Malang. The next criterion is the level of cultivation, followed by environmental factors, which are the final criteria in selecting orange varieties for farming in Selorejo Village.
2. Siem oranges are the variety chosen as the primary crop in the orange farming industry in Selorejo Village, Dau, Malang. The second most popular variety is the mandarin orange, and the least preferred is the sweet orange.

3. Siem oranges and Mandarin oranges consistently rank in the highest quadrant in the two-dimensional sensitivity analysis.
4. The development of a Decision Support System application for selecting orange varieties is expected to be implemented in future research.

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