

Low-Cost Digital Decision Tools for Improving Traditional Rice Farming Practices in Indonesia Using a Simple Additive Weighting (SAW) Approach

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ABSTRACT

Smallholder rice farming in Indonesia is still largely characterized by experience-based decision-making, often leading to inconsistencies in cultivation practices. This study aims to develop and evaluate a low-cost digital decision support tool based on Microsoft Excel using the Simple Additive Weighting (SAW) method. The study employed a Research and Development approach with a quasi-experimental pre-post design involving 30 rice farmers in Entabuk Village, West Kalimantan. The system integrates five key variables, that is land size, crop age, growth stage, weather conditions, and rice variety, into a weighted scoring model that generates risk classifications and cultivation recommendations. Decision quality before and after system implementation was analyzed using a paired t-test. The results indicate a statistically significant improvement in decision consistency and quality ($p < 0.05$) after system use. The mean decision score increased substantially, accompanied by reduced variability among farmers. Usability evaluation also demonstrated high user acceptance, with an average score of 4.21 (84.3%). These findings demonstrate that integrating the SAW method into an accessible Excel-based platform provides a practical and affordable approach to supporting structured decision-making in smallholder rice farming.

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INTRODUCTION

Rice farming remains a fundamental pillar of food security in Indonesia. However, cultivation practices among smallholder farmers are still largely dominated by experience-based decision-making and habitual field practices. This approach often leads to uncertainty in determining planting schedules, fertilizer dosage, and the management of weather and pest risks. The Food and Agriculture Organization emphasizes that improving smallholder productivity is strongly influenced by the availability of practical and affordable digital technologies capable of supporting data-driven decision-making (Trendov et al., 2019).

The development of digital agriculture has introduced various data- and computation-based approaches, including decision support systems (DSS), mobile agricultural applications, and simple analytical tools. The integration of digital technologies in agriculture has been shown to improve operational efficiency and support sustainable production systems, especially in developing regions (Mushi et al., 2022). Scientific studies indicate that the use of decision support systems and digital analytics in agriculture contributes to improved input efficiency and production management quality, particularly when systems are designed according to end-user needs (Duckett et al., 2018).

In the context of smallholder farming, low-cost technological approaches are a key factor in successful implementation. Smartphone-based solutions and lightweight software are considered more realistic compared to expensive sensor systems and complex infrastructures, as they present lower entry barriers and shorter learning curves. Such approaches are specifically recommended for smallholder agricultural ecosystems in developing countries (Meddeb et al., 2021).

In Indonesia, opportunities for implementing digital decision-support tools are expanding in line with increasing digital technology penetration in rural and agricultural sectors. Nevertheless, national studies indicate that the adoption of agricultural technological innovations still faces constraints related to digital literacy, infrastructure readiness, and the availability of technical assistance. These factors significantly determine the success of digital technology implementation at the farmer level (Hidayati et al., 2025). Several community engagement programs have demonstrated that simple technological interventions accompanied by participatory training can enhance technology uptake and operational practices in rural communities. For example, a recent community service initiative (Azmi Fitrсія et al., 2025) focused on implementing basic digital strategies for local agricultural producers, showing that tailored digital guidance increased the capacity of community members to adopt and apply technology in their operational contexts.

The digitalization of agricultural information and extension services has also been shown to enhance farmers' readiness to adopt technology. The integration of digital media, information platforms, and decision-support tools can accelerate knowledge transfer and improve operational decision quality at the field level (Stepanovitch Sinurat et al., 2025). Several national studies have begun developing digital decision-support systems for agricultural contexts, including weather prediction platforms and operational cultivation recommendations. Previous studies have demonstrated that decision support tools tailored to smallholder farming systems can enhance structured decision-making and improve adaptation strategies, particularly when developed through participatory approaches (Thar et al., 2021). Findings suggest that simple DSS based on environmental data can assist farmers in determining planting schedules and mitigating climate risks more systematically.

Based on these conditions, there remains a need for research specifically focused on designing accessible digital decision tools that are simple, user-friendly, and tailored to traditional rice cultivation

practices. Although various digital decision support systems have been developed for agricultural applications, many rely on advanced infrastructure, sensor integration, or complex computational platforms that are not easily accessible to traditional smallholder farmers. Existing studies rarely emphasize spreadsheet-based tools designed for low-infrastructure rural environments with limited digital literacy.

This study addresses this gap by developing and evaluating a low-cost Excel-based decision support system specifically designed for traditional smallholder rice farmers operating in low-infrastructure settings. The study aims to assess whether such a system can improve the quality and consistency of cultivation decision-making.

Accordingly, the research is guided by the following question: Can a low-cost Excel-based decision support system using the Simple Additive Weighting (SAW) method significantly improve decision consistency among smallholder rice farmers?

METHOD

Research Design

This study employed a Research and Development (R&D) approach focusing on the development and evaluation of a low-cost digital decision-support prototype based on Microsoft Excel to support traditional rice cultivation practices. Spreadsheet-based decision support systems remain relevant in applied contexts because they enable low-cost implementation without requiring advanced infrastructure (Yi et al., 2024). The R&D approach was selected because the study not only analyzes existing phenomena but also produces a practical decision-support system that can be directly used by farmers.

Research Site and Subject

The research was conducted in Entabuk Village, Belitang Hilir Subdistrict, West Kalimantan, Indonesia. Participants included local rice farmers, members of the indigenous community, and the research team. The site was selected because the majority of residents rely on small-scale traditional rice cultivation for their livelihoods. All participants were informed about the research objectives and provided consent to participate. Respondent data were kept confidential and used solely for research purposes.

Research Procedure

This study was implemented through a community engagement program (PKM) integrated with the development of a Microsoft Excel-based decision-support prototype. The process began with a direct visit to Entabuk Village to observe local rice cultivation practices and understand farmers' decision-making patterns.

Initial identification involved field observation focusing on fertilizer timing, weather risk management, and actions taken during different crop growth stages. These observations were used to determine relevant decision variables: land size, crop age, growth stage, weather conditions, and rice variety. Based on these variables, a decision-support model was designed using a Multi-Criteria Decision Making approach with the Simple Additive Weighting (SAW) method. Each variable was converted into numerical scores through a rule-based system developed based on agronomic considerations and local

cultivation practices. Criterion weights were then determined to reflect their relative importance in decision-making.

The prototype was developed as a Microsoft Excel file consisting of four main components: an input sheet (user interface), a rule base sheet (knowledge base), a calculation sheet (SAW computation), and a dashboard sheet (result visualization). The SAW calculation multiplies each criterion score by its respective weight and sums the results to obtain a weighted total score, which is classified into risk categories (low, medium, high) to generate automated cultivation recommendations.

The system was then implemented through demonstration and hands-on assistance. Farmers entered actual cultivation data into the system and evaluated the generated recommendations. The final stage involved evaluating decision consistency before and after system use and collecting user feedback through a questionnaire. The findings were used to refine rules, adjust weights, and improve dashboard design.

Decision Support Model and Weight Determination

The decision support model developed in this study employed a Multi-Criteria Decision Making (MCDM) approach using the Simple Additive Weighting (SAW) method. SAW was selected due to its computational simplicity, transparency, and suitability for implementation in low-resource environments such as spreadsheet-based systems. The SAW method has been widely applied in agricultural and decision-support contexts because of its ability to integrate multiple criteria into a single composite score while maintaining interpretability (Triantaphyllou, 2000) (Velasquez & Hester, 2013) (Liakos et al., 2018).

The mathematical representation of the SAW model is expressed as:

$$S_i = \sum_{j=1}^n (w_j \times r_{ij}) \quad (1)$$

Where:

S_i represents the final score of the alternative i ,

w_j denotes the weight of the criterion j , and

r_{ij} represents the score of the alternative i on criterion j .

The SAW method has been widely implemented in practical decision support system development due to its computational simplicity and transparency (Suryadi et al., 2025). This additive aggregation model allows proportional contribution of each criterion to the final decision score, consistent with established MCDM frameworks (Triantaphyllou, 2000). Recent agricultural digitalization studies confirm that transparent weighted aggregation models are particularly suitable for smallholder contexts where explainability and user trust are critical (Liakos et al., 2018; Ingram & Maye, 2020).

The determination of criterion weights was based on structured expert judgment combined with agronomic considerations derived from field observation and consultation with local agricultural practitioners. Expert-based weighting is a recognized approach in DSS development when empirical historical datasets are limited (Velasquez & Hester, 2013). Weather conditions were assigned the highest weight (0.30) due to their dominant influence on crop growth and climate-related risk exposure, consistent with climate-risk sensitivity findings in smallholder agriculture (Trendov et al., 2019); (Liakos et al., 2018). Other criteria, including crop growth stage (0.20), fertilization timing (0.20), land size (0.15), and rice variety (0.15), were weighted proportionally according to their relative agronomic contribution

to decision-making. The total weight was maintained at 1.0 to preserve internal consistency within the SAW framework.

Statistical Analysis

To evaluate the effectiveness of the developed decision support system, decision quality scores before and after system implementation were compared using a paired sample t-test. A paired samples t-test is a statistical method used to compare two related measurements taken from the same subjects under different conditions, such as before and after an intervention (Talikan et al., 2024). The paired sample t-test was selected because the same participants ($n = 30$) were measured under two conditions, resulting in dependent observations. The paired t-test is an appropriate parametric statistical method for comparing mean differences between two related measurements obtained from the same subjects, such as in pre–post quasi-experimental designs (Kim, 2015)(Bland & Altman, 1995).

The statistical hypothesis tested was:

$$H_0: \mu_{before} = \mu_{after} \quad (2)$$

$$H_1: \mu_{before} \neq \mu_{after} \quad (3)$$

The significance level was set at $\alpha = 0.05$, which is a conventional threshold for determining statistical significance in applied research (Kim, 2015). A statistically significant result ($p < 0.05$) indicates that the improvement in decision quality is unlikely to be due to random variation and can be attributed to the implementation of the decision support system. The use of quasi-experimental pre–post evaluation is consistent with evaluation designs in community-based agricultural innovation studies (Ingram & Maye, 2020).

Instrument Validity and Reliability

The usability of the system was evaluated using a four-item questionnaire measured on a five-point Likert scale, covering ease of use, output clarity, recommendation relevance, and perceived benefit to decision-making. Content validity was ensured through expert review involving two academic evaluators with expertise in digital agriculture and decision support systems.

Internal consistency reliability was assessed using Cronbach's Alpha, which measures the degree to which items in a scale consistently represent the same underlying construct (Taber, 2018). Cronbach's alpha is a widely used measure of internal consistency that assesses how well questionnaire items measure the same latent construct (Tavakol & Dennick, 2011). The Cronbach's Alpha coefficient obtained in this study was 0.82, indicating good reliability according to commonly accepted interpretation thresholds (Taber, 2018).

The reliability coefficient is calculated as:

$$\alpha = \frac{k}{k-1} \left(1 - \frac{\sum \sigma_i^2}{\sigma_t^2} \right) \quad (4)$$

Where:

k is the number of items,

σ_i^2 represents the variance of each item, and

σ_t^2 is the total variance of the summed scale.

A reliability coefficient above 0.70 is generally considered acceptable for exploratory and applied research contexts (Taber, 2018).

RESULTS

System Development Outcome

The study successfully developed a Microsoft Excel-based decision support system (DSS) prototype using the Simple Additive Weighting (SAW) method. The system integrates five key variables influencing rice cultivation decisions: land size, crop age, growth stage, weather conditions, and rice variety. Each variable was converted into numerical scores using rule-based criteria derived from agronomic considerations and field observations.

The weighted total score was calculated using the SAW formula:

$$S = \sum_{i=1}^n w_i x_i \quad (5)$$

Where:

S = total score

w_i = criterion weight

x_i = criterion score

The assigned weights were: weather (0.30), growth stage (0.20), fertilization timing (0.20), land size (0.15), and variety (0.15). The total weight equals 1.0 to ensure normalization consistency within the SAW framework. The final score generated by the system was classified into three risk categories (Low, Medium, High), each linked to automated cultivation recommendations.

Field Testing and Decision Accuracy

The field implementation was conducted as a single-session community service (PKM) activity involving 30 smallholder farmers. Decision quality was measured before and immediately after the introduction and demonstration of the DSS to evaluate short-term changes in decision consistency. The evaluation focused on three main indicators: fertilizer timing accuracy, fertilizer dosage consistency, and the ability to identify weather-related risks affecting crop growth. These three indicators were selected because they represent critical aspects of rice cultivation practices and directly influence productivity.

TABLE 1. Improvement in Decision Consistency

Parameter	Mean Before DSS	SD Before DSS	Mean After DSS	SD After DSS	Increase (Poin)	Increase (%)
Fertilizer timing accuracy	63.2	8.4	84.7	6.9	+21.5	34.0%
Fertilizer dosage consistency	61.5	9.1	83.1	7.3	+21.6	35.1%
Weather risk identification	59.8	8.7	81.9	7.5	+22.1	36.9%

From Table 1, it can be observed that the average decision score increased from 61.5 (Standard Deviation = 8.7) to 83.2 (Standard Deviation = 7.2) after implementation, representing an average

increase of 21.7 points or approximately 35.3%. The reduction in post-intervention standard deviation indicates decreased variability among farmers' decisions, suggesting improved consistency and partial standardization of cultivation practices. The measurement results indicate that there was an improvement in decision consistency across all indicators after the use of the DSS. This improvement was not only reflected in the average scores but also in the stability of decisions among farmers. Decision variability, which was previously relatively high, became more controlled after the use of the system, indicating a process of standardization in cultivation practices.

In addition to quantitative improvements, field observations showed that farmers became more systematic in considering risk factors before making decisions. Prior to using the DSS, most decisions were made based on personal experience and seasonal intuition. After using the system, decisions tended to simultaneously consider combinations of variables such as crop growth stage and weather conditions.

The results of the paired statistical test showed that the difference in scores before and after using the DSS was statistically significant ($p < 0.05$). This indicates that the observed improvement was not merely due to random fluctuation but was associated with the use of the developed decision support system.

Cohen's d is a standardized mean difference measure commonly used to quantify the magnitude of an effect by comparing the difference between two means relative to a standard deviation estimate, and it is widely accepted in experimental and applied research. To assess the practical significance of the decision-support intervention beyond statistical significance, Cohen's d was calculated as a standardized mean difference measure. Cohen's d expresses the difference between two means relative to a standard deviation and is widely used in experimental research to quantify the magnitude of effects. Common benchmarks suggest that Cohen's d values around 0.2 indicate a small effect, around 0.5 a medium effect, and ratios above 0.8 a large effect, although interpretation should consider the specific research context (Hedges, 2025).

To assess the magnitude of the improvement, Cohen's d was calculated using:

$$d = \frac{\overline{X}_{after} - \overline{X}_{before}}{SD_{pooled}} \quad (6)$$

The calculated effect size ($d = 2.71$) indicates a very large short-term effect of the DSS intervention. This value indicates a very large practical effect, demonstrating that the DSS substantially improved decision consistency beyond statistical significance alone.

In addition to the quantitative findings, field observations revealed changes in decision-making behavior. Before DSS implementation, decisions were primarily based on personal experience and seasonal intuition. After using the system, farmers systematically considered multiple variables simultaneously, particularly growth stage and weather conditions, before determining cultivation actions. Therefore, the implementation of the Excel-based DSS provided a tangible contribution to improving the quality and consistency of cultivation decision-making at the smallholder farmer level.

Usability and Acceptance Level

The evaluation of system acceptance was conducted using a Likert-scale questionnaire ranging from 1 to 5, measuring four main dimensions: ease of use, output clarity, recommendation relevance, and the system's usefulness in supporting decision-making.

TABLE 2. Usability Evaluation Results

Indicator	Mean Score	Percentage
Ease of use	4.18	83.6%
Output clarity	4.25	85.0%
Recommendation relevance	4.12	82.4%
Benefit to decision-making	4.31	86.2%

The evaluation results show that the system achieved an average usability score of 4.21 (84.3%), which falls into the very good category. The highest score was obtained for the indicator “benefit to decision-making,” at 4.31 (86.2%), indicating that users perceived a direct impact on their decision-making processes. The ease-of-use score of 83.6% demonstrates that the Excel-based interface did not become a barrier for users. This is particularly important considering that most farmers are not accustomed to complex digital applications. The simple input structure and the use of dropdown menus helped reduce data entry errors.

The clarity of system output (85%) indicates that the visualization of risk categories and cultivation recommendations was well understood by users. The dashboard, which displays the total score and risk category, helped farmers quickly understand their cultivation condition status. The relatively high recommendation relevance score (82.4%) also indicates the system’s potential sustainability. Several farmers stated that the system helped them understand the relationships among cultivation factors in a more structured manner compared to their previous approach.

Overall, the high acceptance level indicates that the low-cost digital decision tool based on Excel can be well received within the smallholder farming context without requiring complex technical training.

Activity Documentations



FIGURE 1. Implementation of the community engagement program and system field



FIGURE 2. Field observation and evaluation of rice cultivation practices



FIGURE 3. Assistance and demonstration of the Excel-based DSS to rice farmers.

DISCUSION

Field testing results indicate that the implementation of the Excel-based decision support system (DSS) using the SAW method produced both statistically significant and practically meaningful improvements in decision consistency. The increase in mean scores, combined with the reduction in post-intervention standard deviation, suggests not only enhanced individual decision quality but also reduced variability among farmers. The very large effect size (Cohen's $d = 2.71$) further confirms that the intervention had a substantial practical impact rather than merely statistical significance. Because the evaluation was conducted within a single-session PKM implementation, these findings reflect immediate cognitive and procedural improvements in decision-making.

One notable finding is that a simple spreadsheet-based system generated a large short-term effect. This effectiveness can be explained by three interacting factors: accessibility, familiarity, and cognitive structuring. First, Microsoft Excel is widely available and does not require additional software installation or advanced technical skills. In low-infrastructure rural contexts, such accessibility reduces technological barriers. Second, many farmers are already indirectly familiar with spreadsheet-style interfaces through

exposure to basic administrative tools, making the learning curve relatively shallow compared to mobile apps or sensor-integrated platforms. Third, the structured format of Excel (input cells, dropdown menus, automated calculations) forces explicit consideration of multiple variables simultaneously. This cognitive structuring effect likely contributed to the observed reduction in decision variability across participants.

The system's positive usability score (4.21; 84.3%) can be interpreted through the lens of the Technology Acceptance Model (TAM), which posits that perceived usefulness and perceived ease of use are primary determinants of technology adoption. In this study, the highest usability rating was obtained for perceived decision-making benefit (4.31), indicating strong perceived usefulness. Similarly, the relatively high ease-of-use score (4.18) suggests low cognitive and technical barriers. The alignment between high perceived usefulness and improved decision scores strengthens the argument that the DSS did not merely appear functional but was meaningfully integrated into users' reasoning processes. In smallholder contexts, perceived usefulness often outweighs technological sophistication in influencing adoption decisions.

Digital literacy plays a critical moderating role in agricultural technology adoption. Complex digital platforms often fail in smallholder settings due to high technical demands. The success of the Excel-based DSS in this study may therefore be attributed to contextual fit rather than technological advancement. By minimizing interface complexity and avoiding real-time integration requirements, the system matched the existing digital capacity of farmers. The reduction in decision variability observed in the results also suggests that structured digital guidance can compensate for heterogeneous experiential knowledge levels among farmers. In other words, the DSS acted as a cognitive equalizer, narrowing decision gaps within the group.

Several studies indicate that although digital decision support systems (DSS) have strong potential to enhance productivity and resource use efficiency, their adoption in real-world farming remains constrained by barriers such as limited digital literacy, infrastructural gaps, and concerns about practical effectiveness under field conditions (Petraki et al., 2025). Previous DSS implementations in agriculture often report moderate improvements in decision quality and gradual adoption patterns, particularly when systems involve mobile apps or sensor integration. Compared to such studies, the large effect size observed in this research may be influenced by the immediate structured guidance provided during PKM facilitation. While many digital agriculture interventions emphasize technological sophistication, the present findings suggest that simplicity and contextual relevance may generate stronger short-term decision improvements. However, it should be noted that this study measured immediate decision consistency rather than long-term productivity outcomes. Therefore, direct quantitative comparison with multi-season DSS impact studies must be interpreted cautiously.

The SAW model enables the integration of multiple criteria simultaneously into a composite score that is transparent and easily traceable. Transparency is essential in the context of technology adoption, as users can understand the calculation logic underlying the system's recommendations. Literature (Liakos et al., 2018) indicates that digital systems that are simple, transparent, and accessible have higher adoption potential in smallholder farming compared to complex and expensive systems. Although the SAW model provided transparency and interpretability, the weighting scheme remains a methodological limitation. The weights were determined conceptually based on agronomic reasoning and structured consultation, but they were not validated using formal methods such as Delphi procedures, sensitivity analysis, or historical yield data optimization. This introduces potential subjectivity in the relative importance assigned to criteria. Nevertheless, the Excel platform presents limitations in terms of scalability, multi-user collaboration, and real-time data integration, such as automated weather information or field sensors. Previous studies indicate that effective technology adoption typically occurs gradually, beginning with low-cost prototypes, followed by pilot implementation, and eventually

transitioning toward more integrated digital platforms. Within this continuum, the present system may be positioned as an entry-level or transitional decision-support tool rather than a fully integrated digital agriculture solution.

From a social adoption perspective, field observations indicate that initial adoption success depends strongly on extension support and contextual format suitability. Short assistance sessions provided by the PKM team played a critical role in enabling farmers to quickly understand and operationalize the system. This observation aligns with broader evidence suggesting that digital extension services and simplified training interventions significantly enhance early-stage technology adoption among smallholder farmers. These outcomes have direct implications for agricultural extension systems. Rather than prioritizing high-cost digital transformation initiatives, extension agencies may adopt phased digitalization strategies beginning with low-cost, spreadsheet-based decision tools. Such tools can function as transitional technologies that foster digital confidence and structured decision-making habits before introducing more advanced digital platforms.

Importantly, although the intervention was conducted in a single-session PKM setting, it generated a large short-term improvement in decision consistency. This suggests that structured, low-complexity decision tools can be effectively embedded into extension training modules. Integrating simple DSS applications into routine farmer group meetings may enhance collective decision standardization without imposing substantial infrastructural or financial burdens.

In addition, the evaluation design focused on short-term decision consistency measured immediately after system implementation. Long-term agronomic outcomes, productivity gains, and income impacts were not assessed. Consequently, while the results demonstrate strong short-term cognitive and procedural improvements, the sustainability of these effects over multiple planting seasons remains uncertain. Future research employing longitudinal and multi-season designs is therefore necessary to evaluate economic and agronomic impacts more comprehensively, as also emphasized in previous agricultural DSS studies (Marpaung, 2022).

Despite these limitations, the study provides evidence that structured, low-cost digital tools can generate substantial short-term improvements in decision consistency among smallholder farmers operating in low-infrastructure environments.

CONCLUSION

This study developed and implemented a Microsoft Excel-based decision support system using the Simple Additive Weighting (SAW) method as a low-cost solution to support traditional rice cultivation practices among smallholder farmers. The system successfully integrated key cultivation variables into a structured and operational decision model that is both transparent and accessible.

Field implementation results demonstrated a statistically significant improvement in decision consistency, with an average increase of 35.3% in decision scores and a very large practical effect size (Cohen's $d = 2.71$). The system also achieved a high usability rating (84.3%), indicating strong perceived usefulness and ease of use among farmers. These findings suggest that even a single-session implementation of a structured digital tool can generate meaningful short-term improvements in cultivation decision-making.

From a practical standpoint, the results highlight the potential of low-cost spreadsheet-based decision tools as entry-level digitalization strategies within agricultural extension systems. Rather than prioritizing high-cost and infrastructure-intensive technologies, policymakers and extension agencies may consider phased digital transformation pathways, beginning with accessible tools that build digital

confidence and structured decision habits among farmers.

Future development may focus on expanding the current Excel-based prototype into mobile or web-based applications with enhanced scalability, real-time data integration, and multi-user capabilities. Longitudinal studies across multiple planting seasons are recommended to evaluate sustained productivity and economic impacts. Overall, this study demonstrates that contextually appropriate, low-cost digital decision tools can serve as effective transitional technologies in supporting smallholder rice farming modernization.

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REFERENCES

- Azmi Fitsria, Friyatmi, & Oktaviani. (2025). Digital Marketing Strategies for Nagari Lawang Cane Sugar: Bridging Traditional Products and Online Markets. *ABDIMAS: Jurnal Pengabdian Masyarakat*, 8(4), 2443–2453. <https://doi.org/10.35568/abdimas.v8i4.7274>
- Bland, J. M., & Altman, D. G. (1995). Multiple Significant Tests: the Bonferroni Method. *The BMJ*. <https://doi.org/10.1136/bmj.310.6973.170>
- Duckett, T., Pearson, S., Blackmore, S., & Grieve, B. (2018). Agricultural Robotics: The Future of Robotic Agriculture. UK-RAS White Papers: Robotics & Autonomous Systems. <https://doi.org/10.48550/arXiv.1806.06762>
- Hedges, L. V. (2025). Interpretation of the Standardized Mean Difference Effect Size When Distributions Are Not Normal or Homoscedastic. *Educational and Psychological Measurement*, 85(2), 245–257. <https://doi.org/10.1177/00131644241278928>
- Hidayati, F., Syahni, R., Suliansyah, I., & Tanjung, H. B. (2025). Adopsi Inovasi Teknologi Pertanian Di Indonesia: Tantangan Dan Alternatif Solusi. In *Jurnal Ilmu dan Teknologi Pertanian* (Vol. 12, Number 1).
- Ingram, J., & Maye, D. (2020). What Are the Implications of Digitalisation for Agricultural Knowledge? *Frontiers in Sustainable Food Systems*, 4. <https://doi.org/10.3389/fsufs.2020.00066>
- Kim, T. K. (2015). T test as a parametric statistic. *Korean Journal of Anesthesiology*. <https://doi.org/http://dx.doi.org/10.4097/kjae.2015.68.6.540>
- Liakos, K. G., Busato, P., Moshou, D., Pearson, S., & Bochtis, D. (2018). Machine learning in agriculture: A review. In *Sensors (Switzerland)* (Vol. 18, Number 8). MDPI AG. <https://doi.org/10.3390/s18082674>
- Marpaung, D. S. S. (2022). Strategi Peningkatan Produktivitas Padi melalui Sistem Salibu. *Jurnal Sumberdaya Lahan*, 16(1), 1. <https://doi.org/10.21082/jSDL.v16n1.2022.1-7>

- Meddeb, R., Handforth, C., Desai, G., Lee, L., Bovarnick, A., Siranart, A., O-In, A., Odusola, A., Panyasevanamit, K., Florey, C., Srinivasaraghavan, K., Nirannoot, N., Ducrocq, Ni., & Kolluri, S. (2021). Precision Agriculture for Smallholder Farmers. United Nations Development Programme. <https://doi.org/https://creativecommons.org/licenses/by-nc-sa/3.0/igo/legalcode>
- Mushi, G. E., Serugendo, G. D. M., & Burgi, P. Y. (2022). Digital Technology and Services for Sustainable Agriculture in Tanzania: A Literature Review. In *Sustainability (Switzerland)* (Vol. 14, Number 4). MDPI. <https://doi.org/10.3390/su14042415>
- Petraki, D., Gazoulis, I., Kokkini, M., Danaskos, M., Kanatas, P., Rekkas, A., & Travlos, I. (2025). Digital Tools and Decision Support Systems in Agroecology: Benefits, Challenges, and Practical Implementations. In *Agronomy* (Vol. 15, Number 1). Multidisciplinary Digital Publishing Institute (MDPI). <https://doi.org/10.3390/agronomy15010236>
- Stepanovitch Sinurat, F., Fitriati Samputri, D., & Noor Azizah, D. (2025). Digitalisasi Penyuluhan Pertanian dalam Upaya Pemberdayaan Masyarakat di Desa Teluk Jame Timur. *Indonesian Journal of Public Administration Review*, (2). <https://doi.org/10.47134/par.v2i4.4943>
- Suryadi, A., Adam Muiz, A., & Alpan Hidayat, A. (2025). Implementation of a Decision Support System for Selecting the Best Supplier Using the SAW Method. *Bit-Tech*, 7(3), 928–935. <https://doi.org/10.32877/bt.v7i3.2255>
- Taber, K. S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education*, 48(6), 1273–1296. <https://doi.org/10.1007/s11165-016-9602-2>
- Talikan, A. I., Salapuddin, R., Aksan, J. A., Rahimulla, R. J., Ismael, A., Jimlah, R., Idris, N., Dammang, R. B., Jamar, D. A., Sarahadil, E., & Ajan, R. A. (2024). On Paired Samples T-Test: Applications, Examples and Limitations. *International Journal for Multidisciplinary Research*. <https://doi.org/10.5281/zenodo.10987546>
- Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. In *International journal of medical education* (Vol. 2, pp. 53–55). <https://doi.org/10.5116/ijme.4dfb.8dfd>
- Thar, S. P., Ramilan, T., Farquharson, R. J., & Chen, D. (2021). Identifying potential for decision support tools through farm systems typology analysis coupled with participatory research: A case for smallholder farmers in Myanmar. *Agriculture (Switzerland)*, 11(6). <https://doi.org/10.3390/agriculture11060516>
- Trendov, N. M., Varas, S., & Zeng, M. (2019). *Digital Technologies In Agriculture and Rural Areas* (1st ed.). Food and Agriculture Organization of the United Nations (FAO). <http://www.fao.org/3/ca4985en/ca4985en.pdf>
- Triantaphyllou, E. (2000). Multi-Criteria Decision Making Methods. In: *Multi-criteria Decision Making Methods: A Comparative Study*. Springer, 44. https://doi.org/https://doi.org/10.1007/978-1-4757-3157-6_2
- Velasquez, M., & Hester, P. T. (2013). An Analysis of Multi-Criteria Decision Making Methods. *International Journal of Operations Research*, 10(2), 56–66. <https://api.semanticscholar.org/CorpusID:6891121>
- Yi, D., Jun, L., Haodi, G., Xing, Z., Li, Y., Maidin, S. S., Ishak, W. H. W., & Wider, W. (2024). Transforming Agriculture: An Insight into Decision Support Systems in Precision Farming. *Journal of Applied Data Sciences*, 5(4), 1614–1624. <https://doi.org/10.47738/jads.v5i4.274>