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Technology-Enabled Business Model Innovation Through Agricultural Drone Adoption in Spraying and Fertilization Services: An Operational Performance Perspective from PT Bangun Nawasena Parikesit

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Abstract

Plantation service companies in Indonesia face increasing pressure to boost efficiency. In practice, digital technologies now extend beyond supporting technical processes to actively shaping how organizations manage operations and make decisions, especially where accuracy, speed, and coordination are critical. This study explores how the adoption of agricultural drone technology enables business model innovation within a plantation service company, with particular attention to the role of drone-generated data in managerial decision-making. A qualitative case study approach is employed, focusing on PT Bangun Nawasena Parikesit, a plantation service provider that has integrated drone technology into its spraying and fertilization activities. Data were gathered through semi-structured interviews, document analysis, and observations of operational practices to capture how drone technology is implemented and utilized in day-to-day operations. The findings show that drone adoption contributes to improved operational performance by enhancing data accuracy, accelerating monitoring activities, and supporting more effective resource utilization through a dashboard-based decision-support system. Rather than leading to radical changes in the company's existing business model, drone technology enables incremental innovation by strengthening value creation and improving operational efficiency. The analysis also indicates that the effectiveness of drone-generated data depends on organizational readiness, managerial interpretation, and the firm's ability to integrate digital tools into established workflows. This study illustrates how digital technologies can incrementally enhance operational performance and decision-making, providing a practical alternative to disruptive business model transformation for plantation firms and other operationally intensive industries.

Keywords: *Business Model Innovation; Agricultural Drones; Operational Performance; Decision Support; Plantation Services*

INTRODUCTION

Digital transformation has increasingly reshaped operational practices across a wide range of industries (Gölzer & Fritzsche, 2017; Imran et al., 2021; Li, 2020). Advances in digital technologies, data analytics, and automation tools have changed how organizations plan, execute, and evaluate their activities. Rather than functioning solely as technical upgrades, digital technologies have become integral to organizational processes and managerial decision-making, particularly in operationally intensive contexts where efficiency and accuracy are critical.

In resource-based industries such as forestry and plantation services, the impact of digital transformation is especially pronounced (Tayebi & Rajabzadeh, 2020; Popp et al., 2021). Operations in this sector are characterized by large geographical areas, complex field conditions, and a high dependency on timely and accurate information (Gustavsson et al., 2020; Johnson & Kim, 2021). As a result, service-based firms supporting plantation operations are under growing pressure to adopt technologies that can enhance operational control, reduce risks, and improve performance (Lee & Park, 2022; Kumar et al., 2021). However, the successful use of digital technologies in this context depends not only on technical capability but also on how these technologies are embedded within existing workflows and organizational structures (Harrison et al., 2020; Wijaya & Syamsudin, 2022).

Within this setting, emerging technologies such as agricultural drones offer new possibilities for improving operational activities, including monitoring, spraying, and data collection (Zhang et al., 2020; Basso et al., 2021). At the same time, their adoption raises managerial and organizational challenges related to data utilization, coordination, and business model adaptation (Yang & Sun, 2020; Moore et al., 2021). Understanding how such technologies are integrated into service operations—and how they influence operational performance and managerial decision-making—therefore becomes a critical issue for plantation service providers (Gao & Zheng, 2021; Liu & Wang, 2020; Kumar & Singh, 2022).

The forestry and plantation sector continues to occupy a central position within Indonesia's economic and environmental framework, particularly through the Hutan Tanaman Industri (HTI) system that supports pulp, paper, and wood-based downstream industries. At the same time, the sector is increasingly shaped by pressures related to land-use efficiency, environmental sustainability, and operational reliability. Changes in land utilization and forestry practices in regions such as Sumatra and Kalimantan have intensified the need for adaptive operational strategies among actors across the forestry value chain, including plantation operators and supporting service contractors (Juniyanti et al., 2021).

Service contractors play a critical role in HTI operations by performing a range of activities such as land preparation, planting, plantation maintenance, spraying, and fertilization. These activities have traditionally relied on labor-intensive methods and conventional equipment. While such approaches remain widely used, they often result in relatively high operational costs, limited scalability, and variability in execution quality. In addition, long-term forestry megatrends—including labor constraints, increasing regulatory oversight, and heightened exposure to environmental risks—further complicate the operational environment faced by forestry-related service providers (Robins & Kanowski, 2019).

In response to these challenges, technological innovation has increasingly been introduced into agricultural and forestry operations, particularly through the utilization of unmanned aerial vehicles (UAVs) or agricultural drones. In the Indonesian context, agricultural drones have been applied for various purposes, including spraying and fertilization in plantation maintenance activities. Recent studies focusing on forest plantation environments indicate that drone utilization can improve precision, reduce operational time, and enhance safety compared to conventional methods, especially in large-scale HTI areas where manual operations present logistical and human risks (Yahya et al., 2025).

However, recent literature emphasizes that the adoption of agricultural drone technology should not be understood solely as a technical or operational decision. From the perspective of innovation systems and technopreneurship, drone adoption in Indonesia is influenced by a combination of technological readiness, organizational capability, entrepreneurial orientation, and coordination among actors within the innovation ecosystem. Sya'roni et al. (2023) find that Indonesian contractors adopting agricultural drones often experience changes in how activities are organized and how value is delivered to clients, suggesting potential transformation at the business model level. Similarly, Khofiyah et al. (2020) highlight that successful drone adoption requires alignment between technology, organizational processes, and market demand rather than the isolated deployment of new equipment.

From a business perspective, such alignment is closely related to business model innovation. Business model innovation literature argues that firms can achieve competitive advantage by reconfiguring how value is created, delivered, and captured. In service-based industries, technology frequently acts as an enabler that allows firms to move beyond labor-dependent operational activities toward more technology-enabled and value-oriented configurations. Evidence from a valuation study of an Indonesian drone service company demonstrates that drone-based operations can generate significant business value when supported by appropriate cost structures and pricing mechanisms, rather than through technological adoption alone (Widada & Rahadi, 2024).

For forestry service contractors, the relevance of technology-enabled transformation is further reinforced by increasing operational and environmental risks. Hasibuan et al. (2022) emphasize the importance of performance foresight and controllability in forestry-related services, particularly in mitigating risks such as forest fires and operational disruptions. In this context, agricultural drone adoption in spraying and fertilization activities may contribute not only to efficiency improvements but also to enhanced operational control and predictability.

PT Bangun Nawasena Parikesit (PT BNP) is a service contractor operating within the Hutan Tanaman Industri (HTI) sector that has adopted agricultural drone technology for spraying and fertilization activities. While the technology has been implemented in daily operations, there has been no structured analysis of how drone adoption enables changes in the company's business model or how such changes affect operational performance. This absence of systematic evaluation creates uncertainty in managerial decision-making, particularly regarding the scaling of drone-based activities, the refinement of operational configurations, and the strengthening of competitive positioning. Accordingly, this study examines agricultural drone adoption as an enabler of technology-driven business model innovation and analyzes its implications for operational performance within the context of an HTI service contractor.

Based on the identified business issue, this study is guided by three main research questions focusing on how the adoption of agricultural drone technology enables business model innovation at PT Bangun Nawasena Parikesit (PT BNP), how such adoption affects operational performance—particularly in spraying and fertilization activities—and how technology-enabled business model innovation contributes to the company's competitive positioning. Accordingly, the objectives of this research are to analyze the changes in PT BNP's business model following the implementation of agricultural drones, to evaluate the impact of drone-based spraying and fertilization on operational efficiency and effectiveness, and to assess the strategic value of technology-driven business model innovation for PT BNP as a service contractor in the industrial plantation forest (HTI) sector.

This study offers both theoretical and practical contributions. Theoretically, it enriches the literature on technology-enabled business model innovation by demonstrating how digital tools can drive incremental—rather than disruptive—changes in operationally intensive industries. Practically, the findings provide actionable insights for plantation service companies seeking to adopt drone technology by highlighting key organizational and managerial factors that influence successful implementation. For policymakers and industry associations, this research underscores the importance of supporting technology integration through training and infrastructure development to enhance sector-wide competitiveness and sustainability.

METHOD

This study employs a qualitative case study research design to examine how agricultural drone adoption enables business model innovation and influences operational performance at PT Bangun Nawasena Parikesit. To ensure analytical coherence between empirical data, analytical procedures, and research outcomes, the research is structured using an input–process–output (IPO) logic. Research inputs consist of the core business issue in Hutan Tanaman Industri (HTI) plantation service operations, theoretically grounded in the Business Model Navigator (Who–What–How–Why), and supported by primary data from semi-structured interviews with managerial personnel and a supplementary customer informant, as well as secondary data such as operational records, drone activity documentation, and internal company materials. The process stage is conducted through three sequential analyses: baseline business model mapping prior to drone adoption, manual thematic analysis of interview data, and comparative post-adoption business model mapping to identify forms of incremental business model innovation. The output of the research includes the identification of technology-enabled incremental innovation, assessment of operational performance improvements, insights into data-driven managerial decision-making, and strategic recommendations relevant for plantation service contractors adopting digital technologies without disruptive business model change.

Data analysis combines manual thematic analysis, framework-based analysis, and descriptive performance assessment. Thematic analysis is conducted manually, without software assistance, to maintain close researcher engagement with the data—a practice considered rigorous and valid for medium-scale qualitative research where immersion enhances analytical sensitivity (Miles, Huberman, & Saldaña, 2014). Following the reflexive and iterative principles of thematic analysis proposed by Braun and Clarke (2006), interview transcripts are repeatedly reviewed, coded, grouped, and refined to generate themes related to technology adoption, operational execution, managerial decision-making, and business model implications. These qualitative themes are then mapped onto the Business Model Navigator framework to identify changes in value propositions, activity design, customer focus, and profit logic. Finally, operational performance data from company records are analyzed descriptively and visualized through an Excel-based dashboard to compare drone-based and conventional spraying and fertilization activities in terms of execution time, cost efficiency, labor utilization, and controllability. The synthesis of findings is used to answer the research questions and formulate managerial implications.

RESULTS AND DICSUSSION

Findings from Interview

This section presents the key findings derived from qualitative interviews conducted with managerial representatives of PT Bangun Nawasena Parikesit, supplemented by a customer-side interview for conceptual validation. The analysis focuses on how drone technology is perceived, adopted, and utilized within the organization, as well as how it contributes to changes in operational practices and business model configuration. The findings are organized thematically to reflect managerial perspectives on technology adoption, business model

implications, and decision-making processes, in alignment with the conceptual framework developed in Chapter II.

Managerial Perspective on Drone Adoption

From a managerial perspective, the adoption of drone technology at PT Bangun Nawasena Parikesit was primarily driven by operational challenges rather than by an explicit long-term digital transformation strategy. Interview findings indicate that increasing labor scarcity has become a critical issue in plantation service activities, particularly for field-based tasks conducted in remote and expansive Hutan Tanaman Industri (HTI) areas. Management highlighted growing difficulties in recruiting and retaining field workers, which placed pressure on operational continuity and project execution timelines. As a result, the organization began to explore technological alternatives that could reduce dependency on manual labor while maintaining operational effectiveness.

Beyond labor-related constraints, considerations of operational efficiency played a significant role in shaping managerial decisions. Drone technology was perceived as a solution capable of accelerating execution time, optimizing resource utilization, and improving productivity compared to conventional methods. Managers emphasized that drone-assisted operations enabled more consistent coverage of work areas and reduced the need for large field crews. Although the initial investment costs associated with drone acquisition were relatively high, these costs were viewed as acceptable when evaluated against the potential for long-term efficiency gains and operational cost control.

Another important driver identified in the interviews relates to limitations in conventional monitoring practices. Prior to drone adoption, operational supervision relied heavily on direct physical presence in the field, which restricted real-time visibility across geographically dispersed project sites. This approach often delayed the identification of operational issues and constrained managerial responsiveness. The introduction of drones provided management with improved visibility and monitoring capabilities, allowing for faster assessment of field conditions and more informed decision-making.

Over time, managerial perceptions of drone technology evolved beyond its initial operational function. While drones were introduced as supporting tools to address immediate operational needs, continued use led management to reassess their broader organizational role. Interview findings suggest a gradual shift in perspective, with drones increasingly recognized as assets that contribute to value creation through enhanced monitoring, documentation, and data availability. This shift represents an early stage of strategic reframing, where technology adoption begins to influence how operational activities and service offerings are conceptualized.

The key managerial drivers of drone adoption identified from the interview data are summarized in Table 1, which highlights the relationship between operational challenges, managerial considerations, and supporting empirical evidence. The table consolidates the main adoption drivers discussed in this subsection and provides a clear linkage between qualitative findings and the analytical narrative.

Table 1. Managerial Drivers of Drone Adoption at PT Bangun Nawasena Parikesit

Driver of Adoption	Description	Supporting Evidence (Interview Quotes)
Labor Scarcity	Management identified increasing difficulty in recruiting and retaining field workers, particularly for labor-intensive activities in remote plantation areas. This constraint became a primary motivation to seek alternative operational solutions.	M-Q3-01
Operational Efficiency	Drone technology was perceived as a means to improve execution speed, reduce labor dependency, and enhance productivity compared to conventional operational methods.	M-Q3-01; M-Q7-01
Monitoring Limitations	Prior to drone adoption, field supervision relied heavily on direct physical presence, limiting real-time oversight across large and dispersed project sites.	M-Q4-01
Cost Structure Considerations	Although initial investment costs for drone equipment were relatively high, management emphasized that long-term operational efficiency justified the adoption decision.	M-Q7-01
Strategic Reframing	Continued use of drone technology led management to reassess its role, shifting from viewing drones as purely operational tools toward recognizing their strategic potential.	M-Q4-01

Source: Primary data analysis from interviews with PT BNP management, 2024

Overall, the findings indicate that drone adoption at PT BNP was shaped by a combination of internal operational pressures and emerging awareness of technology-enabled opportunities. Rather than being implemented as a standalone technological initiative, drone usage was gradually integrated into existing workflows. This incremental adoption process allowed management to recognize the strategic relevance of drone technology over time, laying the foundation for subsequent changes in business model configuration and decision-making practices discussed in the following sections.

Business Model Changes Following Drone Adoption

The interview findings indicate that the adoption of drone technology at PT Bangun Nawasena Parikesit has led to changes extending beyond incremental operational improvements. While drones were initially introduced to address immediate execution and monitoring challenges, their continued use gradually influenced how key elements of the company's business model were configured. These changes are most evident in the areas of value proposition, value creation processes, and the role of technology within service delivery.

From a value proposition perspective, drone adoption enabled PT BNP to enhance the services offered to its clients by providing greater operational transparency and reliability. Prior to drone integration, service delivery largely focused on task completion based on agreed contractual outputs. With the incorporation of drone-assisted spraying, fertilization, and monitoring activities, the company began to offer additional value in the form of improved visibility over field conditions and execution outcomes. This shift reflects a transition from a purely execution-oriented service toward one that emphasizes assurance, documentation, and performance consistency.

Changes were also observed in the company's value creation processes. Drone technology was integrated into existing operational workflows alongside labor and heavy equipment rather than replacing them outright. This integration required adjustments in task

coordination, supervision practices, and resource allocation. Managers reported that drone-assisted activities allowed for more standardized execution in certain field operations, particularly those requiring precision and consistency across large plantation areas. As a result, operational processes became more structured, with clearer linkages between execution, monitoring, and evaluation.

In addition, drone adoption influenced how technological resources were perceived within the organization. Rather than being treated solely as operational tools, drones increasingly became strategic assets that contributed to service differentiation. Interview findings suggest that management began to recognize the potential for drone-generated data and visual outputs to support not only internal decision-making but also client communication. This recognition marks an early stage of business model reconfiguration, where technology adoption starts to shape how value is created and communicated to customers.

The evolution of PT BNP's business model following drone adoption can be conceptualized as a complementary reconfiguration rather than a disruptive transformation. Existing customer relationships, contractual structures, and core service offerings remained largely intact, while drone technology augmented and enhanced these elements. Such a pattern aligns with incremental business model innovation, where meaningful changes occur through the recombination of existing activities and resources rather than through radical redesign.

The interview findings further indicate that the incorporation of drone technology influenced the way operational activities were coordinated and supervised within PT BNP. While the overall structure of field operations remained intact, the presence of drone-assisted activities required adjustments in task sequencing and supervision practices. Managers described how drone usage enabled more systematic planning of spraying and fertilization activities, particularly across large plantation areas where manual coordination had previously been challenging.

In addition, drone adoption altered the flow of information within the organization. Prior to drone integration, operational feedback was largely communicated through verbal reports and manual documentation, which limited the timeliness and reliability of information available to management. With the use of drones, visual data and activity records became increasingly available, allowing managers to verify field conditions and execution outcomes more directly. This shift enhanced internal communication between operational teams and management by providing a shared reference point for evaluating performance.

The findings also suggest that drone technology began to influence how service quality was perceived and communicated. Rather than assessing performance solely based on task completion, management increasingly emphasized consistency, accuracy, and traceability of field activities. Drone-assisted documentation supported this shift by enabling clearer evidence of work execution, which could be referenced internally for evaluation and externally when interacting with clients. As a result, service delivery became more structured and less dependent on subjective assessment.

Moreover, the integration of drone technology prompted management to reconsider the role of technological resources within the company's service offering. Although drones were not introduced with the explicit intention of transforming the business model, their continued use revealed opportunities to enhance service differentiation through technology-enabled processes. This realization marked an important step toward business model reconfiguration,

as technology adoption began to shape not only operational execution but also how services were conceptualized and positioned.

The changes in PT Bangun Nawasena Parikesit's business model following the adoption of drone technology can be observed across several interconnected components rather than within a single isolated element. Interview findings indicate that adjustments occurred in how services were positioned, how operational activities were organized, and how technology was incorporated into daily execution and monitoring practices. These changes reflect a shift from a purely execution-oriented service model toward a more structured and technology-enabled configuration that emphasizes reliability, transparency, and operational control.

While the core nature of PT BNP's contractual relationships and service scope remained largely unchanged, drone adoption introduced new ways of delivering and supporting value. The integration of drone-assisted activities altered the role of monitoring, data generation, and documentation within the service process, thereby influencing interactions between operational teams, management, and clients. To clearly illustrate these changes, the key differences in selected business model elements before and after drone adoption are summarized in Table 2.

Table 2. Business Model Changes Following Drone Adoption at PT Bangun Nawasena Parikesit

Business Model Element	Before Drone Adoption	After Drone Adoption	Supporting Evidence (Interview Quotes)
Value Proposition	Service delivery focused primarily on task execution based on contractual outputs.	Enhanced service offering emphasizing operational transparency, documentation, and execution reliability.	M-Q6-01; C-Q5-01
Key Activities	Field operations dominated by manual labor and heavy equipment with limited standardized monitoring.	Integration of drone-assisted spraying, fertilization, and monitoring within existing operational workflows.	M-Q8-01; M-Q11-01
Monitoring & Control	Supervision relied on direct physical presence and verbal reporting from field teams.	Improved visibility through drone-generated visual data supporting faster assessment and control.	M-Q11-01; C-Q3-01
Role of Technology	Technology viewed mainly as operational support tools.	Technology increasingly perceived as a strategic asset contributing to service differentiation.	M-Q4-01; M-Q15-01
Customer Interaction	Limited transparency beyond completion reports.	Greater potential for customer-facing reporting and visual evidence of work progress.	C-Q4-01; C-Q5-01

Source: Analysis of interview data and company documents, 2024

Overall, the findings suggest that drone adoption at PT Bangun Nawasena Parikesit enabled a gradual reconfiguration of selected business model elements rather than a radical transformation. By integrating drone technology into existing service activities, the company enhanced its value proposition and value creation processes without altering its core contractual structure. These changes indicate an incremental form of business model innovation that strengthens operational coherence and sets the stage for further performance and decision-support improvements discussed in the next section.

Operational and Decision-Making Implications

The adoption of drone technology at PT Bangun Nawasena Parikesit generated observable implications for both operational execution and managerial decision-making processes. Interview findings indicate that drones influenced how activities were monitored, evaluated, and coordinated across plantation sites. While drones were not introduced to replace existing operational systems, their integration altered the dynamics of how information was generated and utilized in daily operations.

From an operational perspective, drone-assisted activities contributed to improved execution control, particularly in spraying and fertilization processes. Managers reported that drone usage enabled more consistent coverage and reduced variability in field execution compared to manual methods. The ability to deploy drones across large plantation areas also reduced dependence on large field crews, allowing operational teams to focus on supervision and coordination rather than purely manual execution. These changes suggest that drone adoption enhanced operational efficiency without fundamentally restructuring the organization's labor model.

In addition to execution-related effects, drone adoption influenced how operational information flowed within the organization. Prior to drone integration, managerial decisions relied heavily on verbal reports and delayed field feedback, which limited the ability to respond promptly to emerging issues. With drones generating visual records and activity data, managers gained access to more timely and objective information. This improved visibility supported faster assessment of field conditions and enabled more informed operational adjustments, particularly in geographically dispersed project areas.

The findings further suggest that drone-generated data began to support a shift toward more evidence-based decision-making. Rather than relying solely on experiential judgment, managers increasingly referenced visual documentation and operational records when evaluating performance and planning subsequent activities. This shift did not eliminate managerial discretion but complemented it by providing concrete data to support decision rationales. As a result, decision-making processes became more structured and less dependent on subjective interpretation.

Beyond efficiency improvements, drone adoption also influenced how operational risks were managed in the field. Managers indicated that the availability of aerial visibility reduced uncertainty related to execution quality and field conditions. By identifying irregularities or delays earlier, corrective actions could be initiated before issues escalated into larger operational disruptions. This capability was particularly relevant in plantation environments where access constraints and environmental factors often limit direct supervision.

The findings also reveal changes in the temporal aspect of decision-making. Previously, operational decisions were frequently reactive, driven by delayed information or post-execution reviews. With the integration of drone-assisted monitoring, decision-making timelines became shorter, as managers could assess field conditions in near real time. This shift enabled more proactive adjustments in scheduling, resource deployment, and task prioritization, contributing to smoother project execution.

In addition, drone adoption supported greater coordination between different organizational levels. Visual data and standardized outputs created a common reference point for communication between operational teams, supervisors, and management. This reduced

ambiguity in reporting and minimized discrepancies between field observations and managerial interpretations. As a result, discussions related to operational performance became more focused on solution development rather than problem clarification.

Another important implication relates to the consistency of operational evaluation. Drone-generated records allowed managers to compare execution outcomes across different sites and time periods more systematically. This comparability enhanced the organization's ability to assess performance trends and identify areas requiring improvement. While formal performance metrics were still evolving, the presence of consistent visual and activity data laid the groundwork for more structured operational evaluation practices.

To consolidate the operational and decision-making implications identified from the interview findings, Table 3 summarizes key areas of change associated with drone adoption, including their observed effects and supporting empirical evidence. The table provides a structured overview of how drone integration influenced both execution and managerial processes within PT Bangun Nawasena Parikesit.

Table 3. Operational and Decision-Making Implications of Drone Adoption at PT Bangun Nawasena Parikesit

Area of Impact	Observed Changes After Drone Adoption	Implications for Operations and Decision-Making	Supporting Evidence (Interview Quotes)
Operational Execution	Drone-assisted spraying and fertilization enabled more consistent coverage and reduced variability in field execution compared to manual methods.	Improved operational efficiency and greater control over execution quality across large plantation areas.	M-Q3-01; M-Q11-01
Labor Utilization	Reduced reliance on large field crews for certain activities, allowing labor to be reallocated toward supervision and coordination roles.	Enhanced labor productivity and more effective deployment of human resources.	M-Q3-01; M-Q7-01
Monitoring and Visibility	Introduction of aerial monitoring provided clearer and more timely visibility of field conditions and work progress.	Faster identification of operational issues and reduced uncertainty in field supervision.	M-Q11-01; C-Q3-01
Decision-Making Speed	Availability of visual data shortened feedback loops between field execution and managerial review.	Shift from reactive to more proactive operational decision-making.	C-Q3-01; C-Q4-01
Information Reliability	Drone-generated data reduced dependence on verbal reporting and subjective assessments.	Increased confidence in managerial decisions through evidence-based evaluation.	M-Q11-01; C-Q7-01
Coordination Across Levels	Standardized visual outputs created a shared reference point between operational teams, supervisors, and management.	Improved internal communication and alignment across organizational levels.	C-Q4-01; M-Q16-01
Operational Evaluation	Consistent documentation enabled comparison of execution outcomes across sites and time periods.	Foundation for more structured performance evaluation and continuous improvement.	C-Q8-01; M-Q16-01

Source: Synthesized from managerial interviews and operational observations, 2024

Overall, the findings suggest that drone adoption at PT Bangun Nawasena Parikesit enabled a gradual reconfiguration of selected business model elements rather than a radical

transformation. By integrating drone technology into existing service activities, the company enhanced its value proposition and value creation processes without altering its core contractual structure. These changes indicate an incremental form of business model innovation that strengthens operational coherence and sets the stage for further performance and decision-support improvements discussed in the next section.

Supplementary Customer Perspective on Drone-Based Services

In addition to managerial insights, a supplementary interview was conducted to capture a customer-side perspective on the use of drone technology in plantation and agricultural operations. This interview involved an informant with dual roles as a site coordinator in a corporate plantation environment and a private landowner, providing a relevant external viewpoint for validating the feasibility of customer-oriented, drone-based services. The purpose of this supplementary perspective is not to introduce new empirical claims but to reinforce and contextualize managerial findings related to value creation and service relevance.

From the customer perspective, drone-based services were primarily valued for their ability to improve operational visibility and reduce uncertainty in field execution. The interviewee emphasized that conventional operational practices often relied on verbal reports and delayed confirmation of work progress, which could lead to ambiguity and prolonged clarification processes. Drone-generated visual data was perceived as a practical solution that provided clearer and more immediate confirmation of field conditions, supporting both operational oversight and communication between service providers and customers.

The findings also indicate that customers place greater importance on assurance and clarity of outcomes rather than on technical sophistication. Simple and routine visual updates were considered more valuable than complex reports, as they enabled customers to quickly assess whether activities were conducted according to expectations. This perspective aligns with managerial observations that drone adoption enhanced service transparency and documentation, suggesting consistency between internal and external perceptions of value.

Furthermore, the interviewee highlighted the relevance of drone-based services across different commodities. Rather than being limited to Hutan Tanaman Industri (HTI) operations, drone applications were viewed as adaptable to other agricultural contexts such as sugarcane and oil palm, where large land areas and monitoring challenges are common. This cross-commodity applicability supports the potential for extending drone-assisted services beyond their current operational scope, reinforcing the idea of customer-oriented business model reconfiguration discussed in earlier sections.

To summarize the key insights derived from the supplementary customer interview, Table 4 presents the main perceived values and implications of drone-based services from a customer perspective, along with supporting evidence from the interview.

Table 4. Supplementary Customer Perspective on Drone-Based Services

Aspect	Customer Perspective	Implications for Service Design	Supporting Evidence (Interview Quotes)
Operational Visibility	Drone-generated visuals provide clearer confirmation of field conditions compared to verbal reporting.	Services should prioritize visual outputs as core deliverables.	C-Q3-01; C-Q4-01
Assurance and Transparency	Customers value certainty and confirmation over detailed technical explanations.	Simple and routine visual updates enhance customer confidence.	C-Q5-01
Decision Support	Visual data helps customers assess execution quality and identify issues more quickly.	Reporting formats should support quick interpretation and action.	C-Q3-01; C-Q7-01
Cross-Commodity Applicability	Drone services are relevant beyond HTI, including sugarcane and oil palm operations.	Potential to extend services to new customer segments and commodities.	C-Q6-01
Service System Requirements	Technology alone is insufficient without clear processes and outputs.	Standardized workflows and dashboards strengthen service credibility.	C-Q8-01

Source: Customer interview transcript analysis, 2024

Overall, the supplementary customer perspective reinforces the managerial findings by confirming that drone adoption delivers value not only internally but also at the customer interface. The emphasis on visibility, assurance, and clarity of outputs highlights that the benefits of drone-based services extend beyond operational efficiency toward enhanced service credibility and customer confidence. These insights suggest that drone technology, when supported by appropriate data presentation and standardized service processes, has the potential to strengthen customer-oriented value creation. This alignment between managerial intent and customer expectations provides a strong basis for examining how drone-generated data can be further leveraged through structured decision-support mechanisms, as discussed in the following section.

Data Utilization and Decision Support

The findings indicate that the adoption of drone technology at PT Bangun Nawasena Parikesit not only improved operational execution but also generated new forms of data that could be leveraged to support managerial decision-making. Drone-assisted activities produced operational data such as flight duration, coverage area, execution timing, and visual documentation of field conditions. This shift marked a transition from predominantly verbal and manual reporting toward more structured and observable data sources within the organization.

To support operational monitoring and managerial decision-making, PT Bangun Nawasena Parikesit utilizes a drone management application that captures execution data in real time. The platform records operational activities at multiple levels, ranging from fleet availability and mission execution logs to spatial visualizations of treated plantation areas.

From a managerial perspective, these interfaces serve as primary sources of operational evidence. Fleet-level views enable supervisors to assess asset readiness and utilization, while activity logs provide chronological records of executed missions, including execution duration and treated area. In addition, spatial interfaces allow management to verify where operations were conducted and how coverage is distributed across plantation plots. This layered structure forms the foundation for translating drone-assisted operations into structured operational data.

Figure 1. Operational evidence from the drone management application. (a) Fleet visibility interface, (b) activity and flight records, and (c) geospatial coverage of drone-based plantation operations (d) detailed field-level geospatial mapping indicating plot boundaries and area coverage of drone-assisted plantation operations.
Source: PT BNP drone management application screenshots, 2024

As illustrated in Figure 1, the drone management application provides comprehensive descriptive records of operational execution. The fleet interface enables visibility over asset availability, while activity logs document execution frequency, duration, and treated area at the mission level. Furthermore, spatial visualizations allow management to validate operational coverage and confirm that field activities align with planned work areas.

Despite this level of visibility, the information presented in the application remains fragmented across multiple interface views and is primarily designed for operational tracking rather than managerial evaluation. While managers can observe execution outcomes, the application does not directly aggregate these records into indicators that support comparative analysis, performance assessment, or forward-looking planning.

This limitation highlights a critical distinction between data availability and data usability. Although drone adoption significantly increased the volume and reliability of operational data, the absence of integrated analytical tools constrained its direct contribution to managerial decision-making. Consequently, raw operational records required further processing to support the evaluation of efficiency, utilization patterns, and operational controllability.

To address this gap, the study operationalizes drone-generated data into an Excel-based dashboard that consolidates key variables such as treated area, execution time, flight frequency,

and liquid volume. This transformation enables drone data to move beyond descriptive reporting and function as an analytical input for managerial decision-making, thereby strengthening the role of drone adoption within the company's broader business model innovation.

Overall, the findings demonstrate that effective data utilization is a critical factor in realizing the strategic value of drone adoption. While drone technology enhanced data availability, the dashboard transformed that data into actionable managerial insights, reinforcing the role of decision-support tools in technology-enabled business model innovation at PT Bangun Nawasena Parikesit.

Business Model Innovation Enabled by Drone Adoption

To analyze the implications of drone adoption beyond operational efficiency, this study examines how the technology contributes to changes in PT Bangun Nawasena Parikesit's business model configuration. Rather than viewing drone usage solely as a process improvement, the analysis adopts a business model innovation perspective, focusing on how key elements of value creation, operational logic, and managerial control have evolved.

Accordingly, a comparative framework is used to contrast the company's pre-drone business model with its drone-enabled configuration. This comparison highlights how the introduction of drone technology has altered not only operational execution but also decision logic, cost structure, and mechanisms of managerial oversight. The comparison serves as an analytical lens to assess whether drone adoption constitutes incremental adjustment or a broader form of business model innovation.

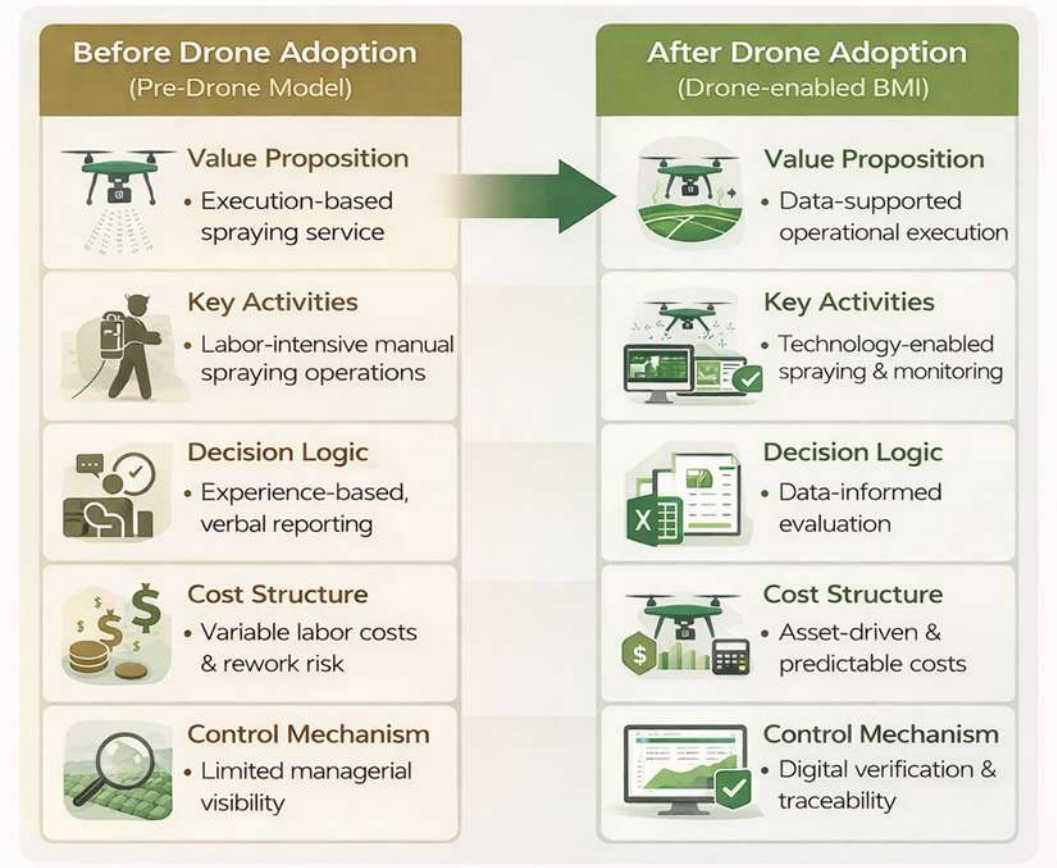

Figure 2. Comparative business model configuration before and after drone adoption
Source: Developed by authors based on field research and Business Model Navigator framework analysis, 2024

As illustrated in Figure 2, drone adoption at PT Bangun Nawasena Parikesit resulted in notable changes across multiple components of the business model. In the pre-drone configuration, value creation relied heavily on manual execution and experience-based coordination, with limited real-time visibility for management. Operational activities were predominantly labor-intensive, and decision-making depended on verbal reporting and post-activity summaries.

In contrast, the drone-enabled configuration introduced a data-supported operational logic. Key activities shifted toward technology-assisted spraying and monitoring, while value propositions expanded to include execution accuracy, traceability, and verifiable field performance. The availability of flight records, spatial coverage data, and execution metrics enhanced managerial oversight and reduced information asymmetry between field operations and management.

Importantly, the transformation observed does not represent a complete disruption of the existing business model but rather a reconfiguration of its core elements. The customer segment and contractual structure largely remained unchanged, while operational logic, control mechanisms, and decision-support practices evolved. This pattern aligns with business model innovation through recombination, where existing structures are augmented through technological enablers rather than replaced entirely.

From a business model innovation perspective, drone technology thus functioned as an enabling mechanism that strengthened value delivery and managerial control without altering the company's fundamental market positioning. The findings suggest that the strategic value of drone adoption lies not only in operational efficiency gains but also in its role in reshaping how value is created, monitored, and evaluated within the organization.

CONCLUSION

This study examined the integration of agricultural drone technology into plantation service operations and its role in enabling business model innovation at PT Bangun Nawasena Parikesit. Driven by operational challenges such as labor scarcity and limited monitoring capabilities, drone adoption initially functioned as a support tool but gradually reshaped managerial practices and organizational processes. The findings reveal that this led to incremental business model innovation, reconfiguring key dimensions—Who, What, How, and Why—to strengthen operational activities, enhance value propositions, and improve control mechanisms without disrupting the firm's core customer relationships or contractual framework. This underscores that in operationally intensive service sectors, innovation can occur through the reinforcement and extension of existing business models rather than through radical transformation.

Furthermore, the study analyzed how drone adoption enhanced operational performance and competitive positioning. Drone-assisted operations improved execution consistency, reduced manual labor dependency, and enabled more effective monitoring across dispersed plantations. The availability of drone-generated data increased managerial visibility, shortened decision-making cycles, and supported evidence-based resource management—leading to gains not only in efficiency but also in predictability, accountability, and controllability. Ultimately, competitive advantage emerged not from the technology alone but from its embeddedness within the business model and managerial processes. By integrating drone operations with data-driven decision support, PT BNP differentiated its services through greater transparency and reliability, competing on quality and operational assurance rather than cost—a critical factor in trust-sensitive Hutan Tanaman Industri (HTI) service environments.

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