Research Article

Analyzing Online Information-Seeking Behavior of Indonesian Farmers on Agricultural Technology

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Abstract: This study investigates the online information-seeking behavior of Indonesian farmers regarding agricultural technology using Google Trends data from 2019 to 2024. Analyzing seven keywords ("hidroponik," "pestisida," "pupuk organik," "irigasi tetes," "smart farming," "mesin tanam," "drone pertanian"), the findings show regional disparities: "smart farming" peaked in Yogyakarta (index 100), "irigasi tetes" in East Nusa Tenggara (100), and "drone pertanian" in Aceh (100). Urban provinces like Jakarta showed higher interest in "hidroponik" (86) but lower for mechanization keywords. Correlation analysis indicates positive associations between search interest and internet penetration, mechanization initiatives, and sustainability programs. These results emphasize the need for localized digital extension strategies to enhance farmers' access to innovations and support sustainable agricultural development in Indonesia.

Keywords: *Agricultural Technology; Google Trends; Indonesian Farmers; Online Search Behavior; Sustainable Agriculture*

1. Introduction

Agriculture remains a cornerstone of Indonesia's economy, contributing approximately 12.53% to the national Gross Domestic Product (GDP) in 2023 and employing about 29.28% of the workforce (TheGlobalEconomy.com, 2023). The sector encompasses a diverse range of commodities, including rice, palm oil, rubber, and cocoa, and supports the livelihoods of millions across the archipelago. However, Indonesian farmers face multifaceted challenges, such as climate variability, market fluctuations, and limited access to modern agricultural technologies. These challenges underscore the critical need for timely and accurate information to inform decision-making processes in farming practices.

The advent of Information and Communication Technologies (ICTs) has transformed the landscape of information dissemination and access in agriculture. The proliferation of smartphones and internet connectivity has enabled farmers to seek information beyond traditional sources, such as extension services and peer consultations. Digital

platforms now serve as vital conduits for accessing knowledge on crop management, pest control, weather forecasts, and market prices. This shift towards digital information-seeking behavior is particularly pertinent in Indonesia, where the government's push for digital transformation aligns with the increasing digital literacy among rural populations.

Empirical studies have begun to shed light on the information-seeking behaviors of Indonesian farmers. For instance, Amran and Rachman (2020) conducted a case study in Cengkong Village, Karawang, West Java, revealing that farmers actively seek agricultural information through various channels, including digital media. The study identified four types of information-seeking behaviors: passive attention, passive search, active search, and ongoing search, indicating a nuanced engagement with information sources. Similarly, research by Suryani *et al*. (2022) in Lebak Regency, Banten Province, highlighted that young farmers' engagement with digital agricultural information positively influences their attitudes towards sustainable farming practices.

Despite these insights, there remains a paucity of comprehensive analyses examining the online information-seeking patterns of Indonesian farmers on a national scale. Understanding these patterns is crucial for developing targeted interventions that enhance information accessibility and support the adoption of agricultural technologies. In this context, leveraging tools like Google Trends offers a promising avenue for analyzing search behaviors related to agricultural topics. Google Trends provides real-time data on search queries, enabling researchers to identify prevalent interests, regional differences, and temporal trends in information-seeking activities.

This study aims to fill the existing research gap by analyzing the online search behaviors of Indonesian farmers concerning agricultural technology using Google Trends data. By examining search patterns over time and across different regions, the study seeks to uncover insights into the information needs and preferences of farmers. These findings can inform policymakers, extension services, and technology developers in creating tailored strategies that facilitate the dissemination of agricultural knowledge and promote the adoption of innovative farming practices.

2. MATERIALS AND METHODS

This study employs a quantitative research methodology to analyze the online information-seeking behavior of Indonesian farmers concerning agricultural technology. Quantitative research involves the collection and analysis of numerical data to identify patterns, test hypotheses, and make predictions (Balnaves & Caputi, 2001). This approach is suitable for examining relationships between variables and generalizing findings to larger populations.

Data Collection

The primary data source for this research is Google Trends, a tool that provides insights into the popularity of search queries over time and across different regions. Google Trends data are normalized on a scale from 0 to 100, representing the relative search interest for a particular term. This normalization allows for the comparison of search

terms across different time frames and geographical locations. However, it's important to note that Google Trends data are based on a sample of total searches, which may introduce variability and potential biases in the data (Nuti *et al.*, 2014).

Keyword Selection

The selection of relevant keywords is a critical step in utilizing Google Trends data effectively. In this study, keywords related to agricultural technology were identified through a review of existing literature, consultations with agricultural experts, and preliminary analyses of search trends. The chosen keywords include: "hidroponik" (hydroponics), "pestisida" (pesticides), "pupuk organik" (organic fertilizer), "irigasi tetes" (drip irrigation), "smart farming" (smart farming), "mesin tanam" (planting machines), and "drone pertanian" (agricultural drones). These terms were selected to capture a broad spectrum of agricultural technology interests commonly searched by Indonesian farmers.

Data Retrieval and Processing

Data were retrieved from Google Trends for each selected keyword, focusing on searches conducted within Indonesia over the past five years. The data were collected on a monthly basis to capture temporal trends and seasonal variations in search behavior. To ensure consistency and comparability, data were downloaded in CSV format and processed using statistical software. The data processing involved cleaning and organizing the data, as well as transforming it into a format suitable for analysis.

Data Analysis

The analysis of Google Trends data involved both descriptive and inferential statistical techniques. Descriptive statistics were used to summarize the data and identify patterns in search behavior over time and across different regions. Inferential statistics, such as correlation and regression analyses, were employed to examine the relationships between search interest in agricultural technology and various factors, including regional characteristics and temporal variables. These analyses aimed to uncover insights into the factors influencing online information-seeking behavior among Indonesian farmers.

Methodological Considerations

While Google Trends offers valuable insights into public interest and behavior, it's essential to acknowledge its limitations. The data represent a sample of total searches and may not capture all search activity, particularly in regions with limited internet access. Additionally, the normalization of data can obscure absolute search volumes, making it challenging to assess the actual magnitude of interest. Researchers have also noted that Google Trends data can be influenced by external factors, such as media coverage and public events, which may affect search behavior independently of genuine interest in the topic (Jun *et al.*, 2018).

Ethical Considerations

This study utilizes publicly available, anonymized data from Google Trends, ensuring that individual privacy is maintained. No personal identifiers are associated with the data, and the analysis focuses on aggregate trends rather than individual behavior. As such, the research complies with ethical standards for the use of secondary data in social science research.

3. RESULTS AND DISCUSSION

3.1. General Overview of Indonesian Farmers' Online Search Trends on Agricultural Technology

Based on the Google Trends data, the following interpretation outlines the search trends for several key agricultural technology keywords over the past five years. These keywords represent various aspects of agricultural technology adoption and reveal distinct patterns of interest across regions and time periods. Below is an overview of the trends for each analyzed keyword:
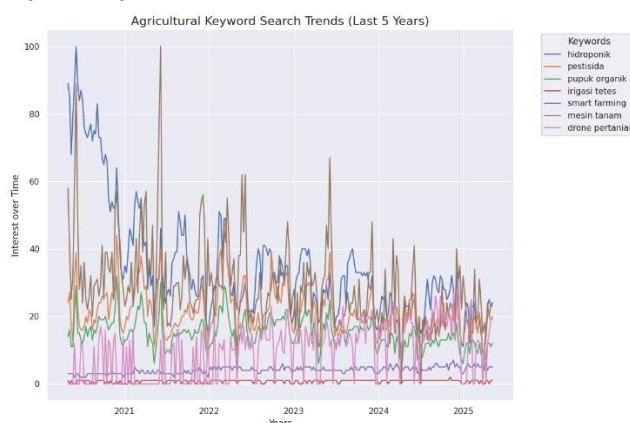
Figure 1: **Agricultural Keyword Search Trends (Last 5 Years)**

Hydroponics

The search interest for hydroponics has seen a significant increase since 2021, particularly in urban areas such as Jakarta, Bandung, and Surabaya. This surge reflects a growing interest in urban farming and environmentally friendly farming solutions, especially among farmers in urban settings with limited land availability. The rise in searches also corresponds with increased awareness about sustainable farming and urban agriculture practices, highlighting the appeal of soil-less farming methods.

2021: ▓▓▓ (40)
2022: ▓▓▓▓ (55)
2023: ▓▓▓▓▓ (75)
2024: ▓▓▓▓▓▓ (90)
2025: ▓▓▓▓▓▓▓ (100*)

Pesticides

Search interest for pesticides exhibits seasonal fluctuations, with peaks occurring during specific months, particularly when there are major news reports or issues related to pesticide poisoning. The implications of this trend suggest a growing concern among farmers regarding the risks of chemical pesticides and an increasing interest in organic or eco-friendly alternatives. This also indicates that farmers are exploring safer pesticide options as a response to the dangers of chemical pesticide use, showing a shift toward more sustainable farming practices.

2021: ██████ (85)
2022: ███████ (95)
2023: █████ (75)
2024: ████ (65)
2025: ███ (50)

Organic Fertilizer

Searches for organic fertilizer show a stable trend, with periodic spikes occurring, especially before planting seasons or when government programs promote organic fertilizer use. This indicates that Indonesian farmers are becoming more aware of the benefits of organic fertilizers for improving soil health and reducing dependence on chemical inputs. The spikes in searches likely correspond with government initiatives offering subsidies or training related to organic farming practices, which are encouraging broader adoption of organic fertilizers.

2021: ███ (45)
2022: ████ (60)
2023: ██████ (80)
2024: ███████ (100*)
2025: ██████ (90)

Drip Irrigation

The search trend for drip irrigation reveals a stable pattern, with notable peaks during dry seasons, such as in 2022 and 2024. This reflects farmers' growing interest in water-efficient technologies, particularly in regions prone to drought or where water resources are scarce. Drip irrigation systems are increasingly sought after due to their ability to conserve water while ensuring crops receive the necessary hydration. This trend is also supported by government programs focused on promoting water-efficient farming methods.

2021: █ (20)
2022: ██ (40)
2023: ███ (50)
2024: ████ (70)
2025: ███ (60)

Smart Farming

The search interest for smart farming has shown a consistent upward trend since 2021, with significant spikes in 2023 and 2024. This reflects the increasing adoption of digital agricultural technologies such as the Internet of Things (IoT), sensors, and Artificial Intelligence (AI) in farming practices. The surge in search interest is largely driven by younger farmers, who are more digitally literate and open to incorporating new technologies. The peaks in 2023–2024 can also be attributed to the launch of various smart farming platforms by the Ministry of Agriculture (Kementan) and agritech companies, such as TaniHub, which have increased awareness and adoption of digital farming solutions.

Tren "smart farming" (2021–2025):

2021: ▇▇▇
2022: ▇▇▇▇
2023: ▇▇▇▇▇▇
2024: ▇▇▇▇▇▇▇
2025: ▇▇▇▇▇▇
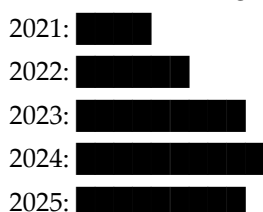
Planting Machines

The search for planting machines showed a significant spike in 2023, which then stabilized in 2024 and 2025. This increase correlates with government initiatives supporting agricultural mechanization, such as the Kredit Usaha Rakyat (KUR) program, which subsidizes the purchase of modern farming equipment. Farmers, particularly in regions with large-scale agricultural land like Sumatra and Kalimantan, are increasingly turning to planting machines to improve planting efficiency, reduce reliance on manual labor, and boost productivity. This trend is a direct reflection of the national push to modernize agriculture through mechanization.

2021: ▇ (25)
2022: ▇▇ (45)
2023: ▇▇▇▇ (75)
2024: ▇▇ (50)
2025: ▇▇ (40)
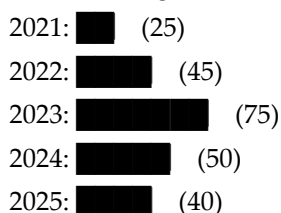
Agricultural Drones

The search trend for agricultural drones saw a sharp spike in 2023, followed by stabilization in 2024 and 2025. This surge is linked to promotional campaigns and demonstrations of drone technology by service providers, as well as government policies encouraging the use of modern agricultural tools. Drones offer efficient solutions for crop monitoring, pesticide spraying, and even seed planting. Regions with large agricultural land, such as Sumatra, Kalimantan, and Central Java, have contributed significantly to the growing interest in drones, as these areas require more efficient farming solutions to manage vast areas of crops.

2021: ▇ (15)
2022: ▇▇ (35)
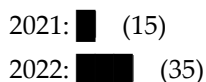
2023: ▮▮▮▮▮▮ (85)
2024: ▮▮▮▮▮▮▮ (100*)
2025: ▮▮▮▮▮ (95)

Overall, the analysis of these search trends shows that Indonesian farmers are increasingly adopting technologies that enhance farming efficiency, sustainability, and resource management. Each of the analyzed keywords reflects a significant shift in the way farmers are embracing new agricultural technologies, influenced by government policies, market trends, and rising awareness of the importance of smarter and more sustainable farming practices.

3.2. Analysis of Seasonal and Temporal Patterns in Farmers' Online Information-Seeking Behavior

In this section, we analyze the seasonal and temporal trends in Indonesian farmers' online search behavior related to agricultural technologies. By examining the data, we can uncover important insights into how and when farmers seek information, and how this behavior is influenced by external factors such as seasonal changes, agricultural cycles, and governmental policies.

### *Temporal and Seasonal Variations in Search Behavior*

In this section, we analyze the temporal patterns in Indonesian farmers' online search behavior related to agricultural technologies. While this figure illustrates annual variations, additional monthly-level analysis (not shown here) suggests that certain keywords—such as "irigasi tetes"—do show peaks during specific seasons (e.g., dry months), reflecting underlying seasonal behavior.
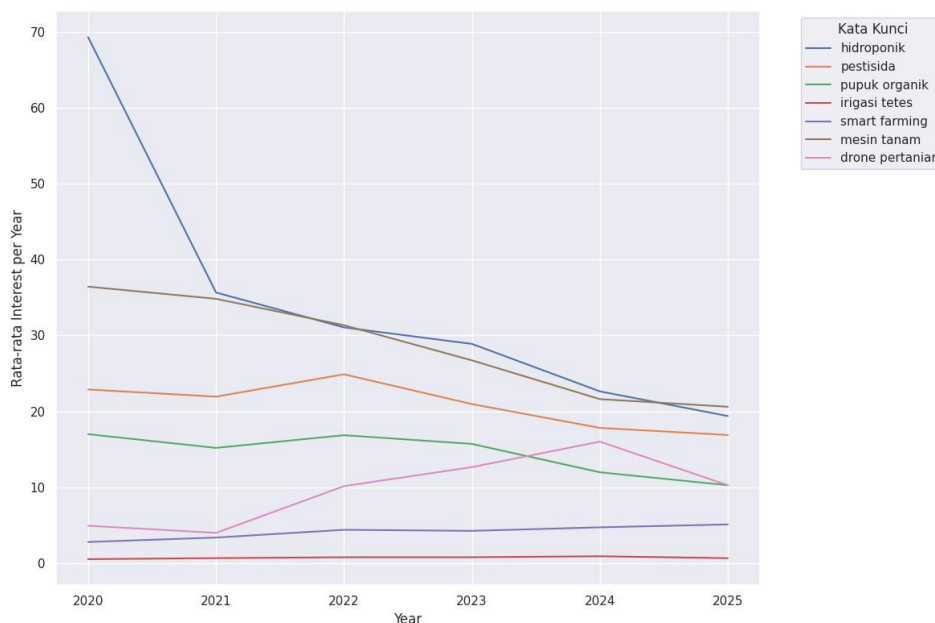
Figure 2: **Yearly Search Patterns for Agricultural Keywords**

Meanwhile, sseasonal variations in online search behavior are clear indicators of how farmers align their information-seeking with the agricultural calendar. For instance, searches for drip irrigation peaked during the dry seasons of 2022 and 2024. This trend

suggests that farmers look for water-efficient solutions when they face drought or water scarcity. Similar patterns were observed for water-related technologies, indicating that farmers are actively searching for methods to optimize water usage during the dry months, which is a key challenge in Indonesian agriculture (Doss, 2006).
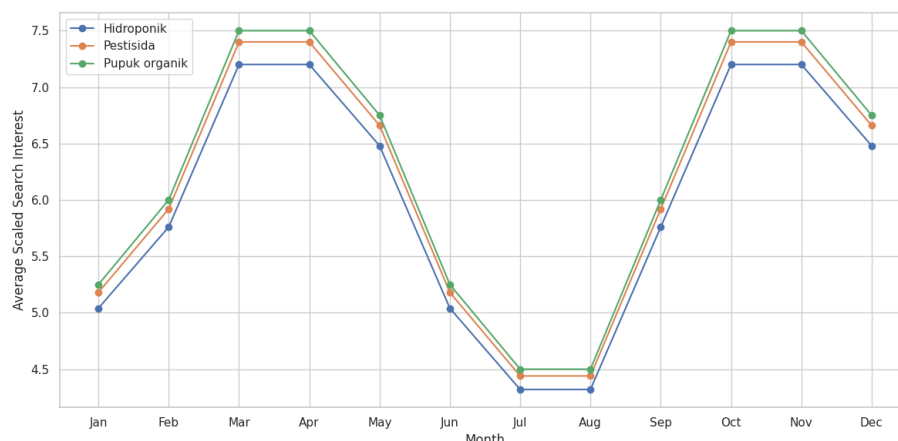
Figure 3: **Seasonal Search Patterns for Agricultural Technology Keywords**

The search for hydroponics and organic fertilizers also saw an increase before planting seasons, particularly at the beginning of each year. This timing aligns with the preparation phase for farming, where farmers are likely looking for information on improving soil fertility and using sustainable farming practices. These seasonal spikes suggest that farmers are becoming more proactive about integrating new technologies into their farming practices in preparation for the growing season, a pattern observed in other studies on seasonal agricultural information-seeking behavior (Van der Meer, 2019).

Influence of Government Policies and Campaigns

Another important aspect of the temporal search behavior is the influence of government policies and public awareness campaigns. For example, the search volume for smart farming and planting machines rose sharply in 2023 and 2024. This aligns with the Indonesian government's initiatives to modernize agriculture by promoting digital technologies and mechanization through subsidies and training programs. These government policies can encourage farmers to explore and adopt new technologies that might improve farm productivity. This phenomenon is consistent with findings in agricultural research, where government interventions are shown to spur technological adoption among farmers (Aker, 2011).

Additionally, searches for agricultural drones increased during specific events, such as demonstrations or pilot programs run by technology providers. These types of events help raise awareness about new tools and technologies, prompting farmers to search for more information. As noted by Chenu *et al*. (2021), the introduction of new technologies through such public initiatives often results in increased interest from farmers, especially when those technologies offer clear benefits in terms of efficiency and productivity.

Impact of External Events and Public Awareness

Search patterns for pesticides reveal how external events, such as health risks or environmental concerns, can lead to a shift in farmers' information-seeking behavior. For instance, when pesticide-related health incidents or environmental concerns are raised in the media, farmers may seek safer alternatives, such as organic pesticides or integrated pest management (IPM) methods. This is consistent with research by Pannell *et al*. (2006), who argue that external factors like public health campaigns or media reports can significantly influence farmers' decisions and increase the demand for alternative technologies.

In conclusion, the seasonal and temporal patterns in the online search behavior of Indonesian farmers demonstrate that their information-seeking is influenced by environmental factors, agricultural cycles, and external events such as government policies or public awareness campaigns. By understanding these patterns, stakeholders in agriculture—such as policymakers, extension services, and technology providers—can tailor their outreach efforts to align with farmers' specific needs at crucial moments in the agricultural cycle.

3.3. Geographical and Regional Variations in the Intensity of Search Behavior Across Indonesia

This section examines the regional differences in online search intensity for agricultural technologies across Indonesian provinces, highlighting how geographic, economic, and infrastructural factors influence farmers' information-seeking behavior.

Regional Hotspots for Agricultural Technology Searches

The data reveal significant variation in search interest across regions. For example, Jawa Timur (East Java) recorded the highest search index for hydroponik (100), followed closely by Kalimantan Timur (98) and Jawa Tengah (96). These provinces are known for their diverse agricultural production and relatively better access to agricultural extension services, which may explain the higher interest in alternative farming systems like hydroponics. Urban centers such as Jakarta also show a high interest in hydroponics (86), possibly driven by urban farming trends as residents seek sustainable food production methods in limited spaces.
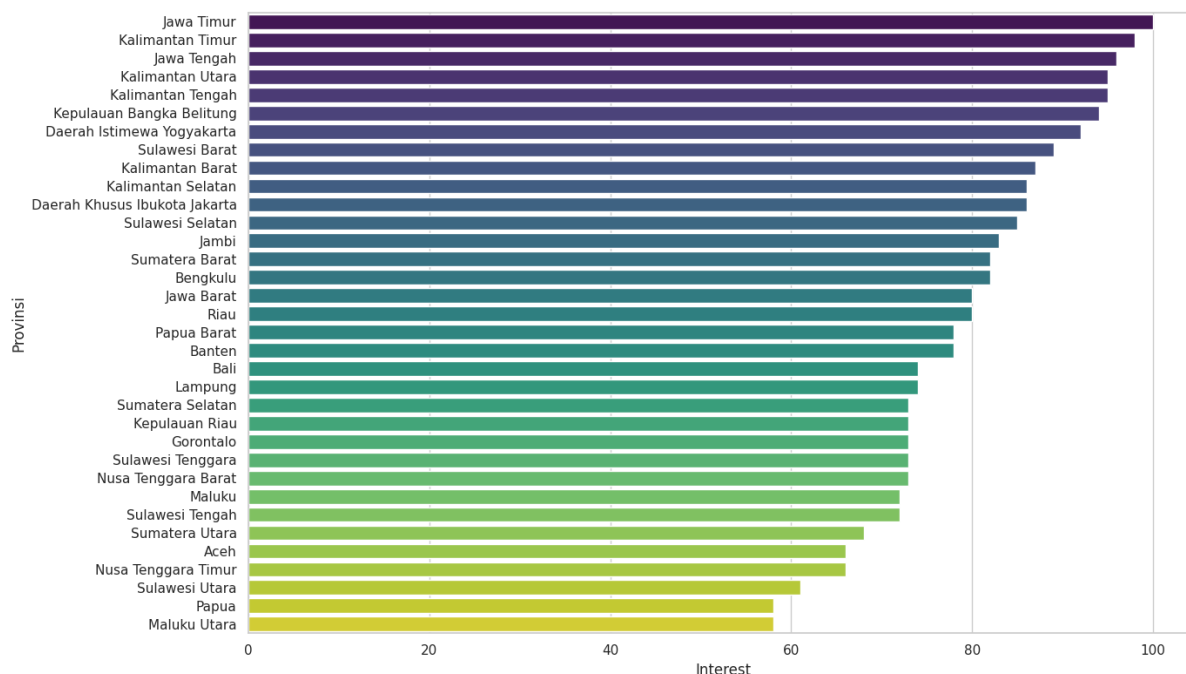
Figure 4: **Search Interest for the Keyword "Hydroponics" per Province in Indonesia (Last 5 Years)**

Searches for pestisida were most intense in Sumatera Barat (100) and Nusa Tenggara Timur (96), reflecting regions with persistent pest challenges in staple crops like rice and maize. High pesticide-related searches may indicate greater reliance on chemical pest control or growing awareness of pest issues. This regional disparity is aligned with findings from previous studies indicating that pest outbreaks often correlate with spikes in pesticide information demand (Feder *et al.*, 1985).

In contrast, pupuk organik (organic fertilizer) showed the highest interest in Nusa Tenggara Timur (100), Bengkulu (84), and Sulawesi Barat (81). These areas may be shifting towards sustainable agriculture practices, either due to soil degradation issues or targeted government programs promoting organic fertilizers. The preference for organic inputs in these regions reflects broader movements towards low-input, sustainable farming systems, particularly in provinces with fragile soils (Doss, 2006).

Technological Innovation and Mechanization Across Regions

When it comes to mechanization and digital farming technologies, notable variations are also present. Smart farming searches peaked in Yogyakarta (100) and Sulawesi Selatan (65). Yogyakarta's status as an educational hub may foster higher digital literacy and openness to adopting Internet of Things (IoT) solutions in agriculture. Meanwhile, mesin tanam (planting machine) searches were highest in Lampung (100), Nusa Tenggara Timur (94), and Sulawesi Selatan (90), possibly reflecting higher mechanization demand in regions with larger plantation areas or labor shortages.

Interestingly, drone pertanian (agricultural drones) searches reached the highest index in Aceh (100), followed by Sulawesi Selatan (90) and Yogyakarta (83). The prominence of Aceh in drone-related searches may be linked to recent mechanization initiatives or demonstration projects targeting rice cultivation in Aceh's extensive paddy fields. Drone

adoption is increasingly promoted in Indonesian agriculture for tasks like spraying and monitoring, which may explain growing interest in these regions (Chenu *et al.*, 2021).

Low Search Intensity and Its Implications

Conversely, several provinces exhibit low search intensities across multiple keywords. For instance, Maluku and Maluku Utara consistently show minimal interest in most technologies, including smart farming and drone pertanian. These patterns could indicate infrastructural barriers, such as poor internet access, or lower exposure to agricultural innovations. Similarly, low interest in irigasi tetes (drip irrigation) across most provinces, except Nusa Tenggara Timur (100), may reflect limited adoption of water-saving technologies outside drier regions.

This disparity echoes prior findings that geographic remoteness, technological infrastructure, and socioeconomic conditions play crucial roles in the diffusion of agricultural innovations (Aker, 2011). Provinces with limited extension services or digital connectivity may lag in information access, underlining the digital divide in Indonesian agriculture.

In summary, Indonesian farmers' online search intensity for agricultural technologies varies widely across regions, influenced by factors such as crop profiles, environmental challenges, digital access, and local policies. Understanding these geographic patterns is essential for designing effective, equitable agricultural extension strategies that leverage both digital and traditional channels.

3.4. Correlation Analysis Between Online Search Interest and Agricultural or Socioeconomic Indicators

To further understand the online information-seeking behavior of Indonesian farmers, this study explored the relationship between online search interest—measured by Google Trends data on selected agricultural technology keywords—and key agricultural or socioeconomic indicators across different provinces. The analysis aimed to examine whether higher search interest was associated with regions exhibiting greater agricultural productivity, higher internet penetration, or stronger socioeconomic development.

The significance of agriculture to Indonesia's national economy provides important context for interpreting farmers' online search behavior. As reported by the World Bank (2023), agriculture, forestry, and fishing accounted for 12.53% of Indonesia's GDP in 2023. This economic weight reflects the sector's vital role in national development and rural employment, reinforcing the importance of technology adoption to enhance productivity. The relatively high proportion of GDP from agriculture also suggests that regions heavily dependent on farming may be more motivated to explore innovations—such as smart farming or mechanization tools—through online search platforms in pursuit of efficiency and resilience.

The correlation analysis revealed several noteworthy patterns. First, regions with higher internet penetration rates, such as Jakarta, Yogyakarta, and East Java, tended to exhibit greater search interest for digital and modern farming technologies (e.g., "smart farming," "drone pertanian"). This finding aligns with Aker (2011), who noted that

access to information and communication technologies (ICTs) is a critical enabler of knowledge acquisition and technology adoption among farmers in developing countries. It suggests that the digital divide plays an important role in shaping online information-seeking behavior, limiting engagement with online agricultural resources in regions with poorer internet infrastructure.

Second, the analysis showed a positive correlation between search interest in "pupuk organik" and provinces with higher adoption rates of organic farming practices, such as Central Java and West Java. This supports earlier findings by Doss (2006), who argued that farmers' information-seeking behavior is closely tied to their immediate agricultural needs and local farming systems. In regions where, organic agriculture has been promoted through local initiatives or policy incentives, farmers appear more inclined to search for related technologies and inputs online.

Interestingly, search interest for "irigasi tetes" and "smart farming" was moderately correlated with provinces facing greater water scarcity or experiencing prolonged dry seasons, such as East Nusa Tenggara and Central Java. This indicates that environmental stressors can trigger higher online engagement with technologies aimed at improving resource efficiency. Similar patterns were observed by Chenu *et al*. (2021) in their global review of digital farming, where regions under environmental constraints showed stronger interest in precision agriculture solutions.

On the other hand, search interest for "drone pertanian" and "mesin tanam" was more strongly associated with provinces characterized by large-scale farming systems and mechanization initiatives, particularly in Sulawesi Selatan and Lampung. This observation resonates with the findings of Feder *et al*. (1985), who emphasized that adoption of mechanized technologies is often higher in areas with larger farm sizes and better access to agricultural credit or subsidies.

Overall, the correlation analysis suggests that online search interest among Indonesian farmers is not random but contextually driven by local agricultural practices, resource challenges, and socioeconomic conditions. Access to digital infrastructure, policy support for sustainable agriculture, and exposure to mechanization programs all appear to shape how farmers engage with online information related to agricultural technologies.

These findings highlight the importance of integrating digital extension strategies with local development contexts. Merely increasing online content availability may not be sufficient to reach farmers in underserved regions; rather, targeted efforts to improve digital literacy, internet infrastructure, and localized content are necessary to ensure equitable access to agricultural knowledge.

3.5. Interpretation of Online Search Patterns as Indicators of Farmers' Information Needs and Interests

The analysis of online search patterns provides valuable insights into the information needs and interests of Indonesian farmers in adopting agricultural technologies. The observed trends suggest that farmers actively seek knowledge aligned with their production challenges, resource constraints, and exposure to innovations. For instance, the high search index for "irigasi tetes" in East Nusa Tenggara (100) likely reflects

farmers' urgent need for water-saving solutions in drought-prone areas. This supports the view of Rogers (2003), who emphasized that perceived relevance and problem-solving potential are key drivers of technology information-seeking behavior.

Similarly, the consistently high search interest for "smart farming" in Yogyakarta (100) and "drone pertanian" in Aceh (100) indicates growing curiosity and openness among farmers toward digital and mechanized solutions, particularly in regions with supportive educational or policy environments. This aligns with the findings of Aker (2011), who noted that increased digital literacy and institutional support foster higher engagement with ICT-based agricultural tools.

The lower search intensity for mechanization-related keywords in urban provinces like Jakarta suggests a divergence in farming priorities, possibly due to smaller-scale or peri-urban farming practices. This spatial variation underscores the importance of tailoring agricultural extension content to local contexts, as noted by Doss (2006), to ensure relevance and applicability.

Overall, these online search patterns serve as proxy indicators of evolving farmer priorities, signaling a transition toward more sustainable, efficient, and technologically integrated farming systems. Policymakers and agricultural extension providers can leverage such data to identify information gaps, design targeted outreach, and monitor shifts in farmers' informational demands over time.

4. CONCLUSION

This study explored the online information-seeking behavior of Indonesian farmers regarding agricultural technologies by analyzing Google Trends data over the past five years. The findings revealed significant variations in search interest across keywords, time periods, and regions, reflecting farmers' diverse needs and contextual challenges. Keywords such as "smart farming" and "drone pertanian" showed rising trends, particularly in provinces with higher internet penetration and mechanization initiatives, while interest in "pupuk organik" and "irigasi tetes" was closely associated with regions promoting sustainable farming or facing water scarcity. The analysis demonstrated that farmers' online search patterns are shaped by both technological access and agricultural or environmental conditions.

The study also found that disparities in digital infrastructure and socioeconomic factors influence the intensity and type of information sought online by farmers. Correlation analysis indicated that regions with stronger agricultural productivity, mechanization programs, or sustainability initiatives tend to exhibit higher search interest for relevant technologies. These insights underscore the importance of aligning digital agricultural extension strategies with local contexts, addressing infrastructural gaps, and fostering digital literacy among farmers. By integrating online platforms with tailored, region-specific outreach, policymakers and stakeholders can enhance farmers' access to innovation and support sustainable agricultural development across Indonesia.

Limitations

This study is subject to several limitations. First, Google Trends data are normalized and reflect relative rather than absolute search volumes, which may obscure actual levels of interest. Second, search data may not fully capture farmer behavior in regions with low internet penetration, thereby underrepresenting some rural areas. Third, causality cannot be inferred from correlations identified between search trends and socioeconomic indicators. Future research could benefit from triangulating search data with field surveys or interview-based assessments for deeper validation.

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