How Can Deep Learning and Strategic Thinking Transform Agri-Business Research in Malaysian Academic Libraries?

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Abstract
This qualitative research investigates the confluence of strategic thinking and advanced deep learning algorithms in elevating the expertise of senior librarians in Malaysian agri-business research. It emphasizes the role of librarians specializing in agricultural information services and aims to uncover their strategic methodologies and adaptability to emerging technologies. Through extensive interviews, the study reveals the intricate aspects of librarians' strategic decision-making and their application of deep learning algorithms in supporting agri-business research. The paper critically assesses the employment of advanced deep learning techniques, including neural networks and machine learning, to enhance information retrieval and data analytics in the agri-business sector. It introduces the Agri-Business Integrated Framework (ARI Framework), an innovative strategy designed to advance agri-business research. This framework merges strategic thinking with effective deep learning applications, providing guidance for librarians and researchers in managing agri-business complexities and leveraging new technologies. The adoption of the ARI Framework is intended to improve decision-making processes, optimize resource management, and encourage sustainable practices in agri-business research, thereby making a significant contribution to the development of the field.
Keywords: Strategic Thinking, Deep Learning Algorithms, Agri-Business, Academic Library

Introduction

Agri-business research, an increasingly complex and dynamic field, necessitates a robust framework of strategic thinking to navigate its challenges effectively (Weick, 2001). However, within the context of Malaysian academic libraries, the application of such strategic approaches, particularly in managerial roles, often encounters institutional barriers and a notable deficit in strategic skills among personnel (Saravani & Haddow, 2018). This shortfall becomes more pronounced when considering the burgeoning necessity for advanced technological interventions, such as deep learning algorithms, which promise a paradigm shift in agri-business research (Kamilaris et al., 2020).

This study is poised to address the underutilized synergy between strategic thinking and deep learning algorithms in Malaysian academic libraries, with a special focus on enhancing agri-business research. The significant potential of these methodologies, though recognized, remains scarcely actualized within the realms of library practice. This gap in application is particularly pertinent given the escalating role of Malaysia's agricultural sector in the global context of food security (Arshad et al., 2016).

Malaysian academic libraries stand at the forefront of this challenge, serving as vital knowledge hubs that support an array of activities in agri-business, ranging from research facilitation to entrepreneurial and academic endeavors (Neal, 2011; Khoo et al., 2012). Their commitment to the integration of digital tools and strategic management principles (Mutula & Brakel, 2006) not only reinforces their role in propelling agri-business research but also aligns with the global agenda for sustainable development in agriculture, as highlighted in recent scholarly discourse (Panda et al., 2023). These studies underscore the transformative role of libraries in advancing Sustainable Development Goals (SDGs), particularly in agrarian economies.

The present research aims to delve deeper into the Malaysian context, exploring the strategic application of algorithms and innovative thinking processes in academic libraries. By drawing on insights from seasoned librarians at a premier Malaysian university renowned for its agri-business research, this study seeks to uncover the practical implementations of these advanced methodologies. The objective is to formulate strategies that not only elevate the standard of research but also align academic practices with the evolving needs of the agri-business sector. This research endeavors to contribute significantly to the discourse on the strategic role of academic libraries in supporting agri-business research, aligning with global trends while catering to local agricultural needs and aspirations.

Literature Review

Leveraging Deep Learning Algorithms for Strategic Advancement in Agri-Business Research
In the volatile realm of agri-business, characterized by significant risks and uncertainties, the role of strategic thinking is paramount. The sector's susceptibility to fluctuating climatic conditions and market volatility underscores the need for sophisticated decision-making frameworks (Meuwissen et al., 2001; Abraham, 2005). Strategic thinking extends beyond conventional risk management; it innovatively leverages uncertainties to drive disruptive advancements and develop pioneering market strategies (Mittal et al., 2016). In such a dynamic environment, the adept application of strategic thinking is not merely advantageous but essential for ensuring the long-term sustainability and success of agri-business ventures (Isaacs, 2018; Ireland & Webb, 2007).

The integration of strategic thinking with advanced deep learning algorithms represents a paradigm shift in agri-business. This powerful synergy not only boosts adaptability but also catalyzes the seamless adoption of cutting-edge technologies, addressing complex sector-specific challenges (LeCun et al., 2015; Ireland et al., 2002). Strategic thinking involves the creation, planning, and execution of far-sighted initiatives critical to navigating the ever-evolving agri-business landscape (Liedtka, 1998). Deep learning algorithms, particularly adept at deciphering and interpreting complex data patterns, are revolutionizing data management in agri-business, from nuanced crop health analysis to intricate supply chain optimization (Kamilaris & Prenafeta-Boldú, 2018; Garca et al., 2018). This amalgamation of strategic insight and algorithmic prowess is redefining agri-business, leading to more sustainable practices, enhanced farming methods, and competitive strategies attuned to the global food market's rapid evolution.

The Transformative Role of Academic Librarians in Fostering Strategic Thinking and Deep Learning in Agri-Business

Academic libraries, as integral components of the scholarly community, provide pivotal resources and services that support research, teaching, and learning. In the face of shifting academic landscapes, it is imperative for academic librarians to cultivate a robust repertoire of competencies, notably in strategic thinking. This involves not only developing a vision for the library's future but also establishing clear goals and devising effective strategies to achieve them. The role of policymakers and educational institutions is critical in nurturing these skills, underscoring the need for ongoing professional development and specialized training for librarians. It is equally important to recognize the divergent needs and priorities of public and private academic libraries, tailoring strategies to suit these variances (Sa'ari & Goulding, 2024). Further research is warranted to explore the unique facets of entrepreneurial and strategic thinking in private academic libraries, insights from which can guide the enhancement of librarians' adaptability and strategic acumen.

Librarians endowed with strategic thinking capabilities are at the vanguard of embracing innovative methods and adapting to technological advancements in agri-business research. By employing deep learning techniques, such as neural networks and machine learning algorithms, librarians are poised to revolutionize key aspects of agri-business research, including advanced information retrieval, nuanced data analysis, and the discovery of new knowledge. This recognition of the synergy between strategic thinking and deep learning empowers librarians to optimize library services and spearhead the effective dissemination of knowledge within the agricultural research sphere. Investing in the professional development of academic librarians is crucial, not only for enhancing their strategic capabilities but also for ensuring that academic libraries continue to be pivotal, adaptive, and impactful in the ever-changing academic and research landscape.

Theoretical Frameworks and Neuro-Strategic Fusion in Librarianship
The integration of strategic thinking competencies with deep learning algorithms in academic librarianship necessitates a nuanced understanding of various theoretical frameworks. While traditional models like the Resource-Based View (RBV) and Dynamic Capabilities Framework offer insights into leveraging resources and adapting to change (Barney, 1991; Teece et al., 1997), their direct application in librarianship must be carefully adapted to the unique

functions of libraries as facilitators of information and knowledge. Cognitive Mapping and the Cynefin Framework, though useful for strategic planning and problem categorization (Eden & Ackermann, 2004; Snowden & Boone, 2007), need to be reinterpreted to align with the libraries' role in managing complex information networks. This adaptation is crucial for academic libraries engaged in supporting agri-business research, where the interplay of diverse data types and research needs is common.

Central to this research is the application of Effectuation Theory (Liedtka, 1998), which aligns closely with the multifaceted nature of agri-business and the evolving role of academic libraries. This theory's emphasis on systems thinking, intent-focused approaches, and adaptability offers a robust framework for integrating strategic thinking with deep learning algorithms. Such integration is particularly relevant in deciphering complex agricultural data, enhancing predictive analytics, and fostering innovation in agri-business research practices.

The novel concept of Neuro-Strategic Fusion, merging strategic thinking with artificial neural networks (ANNs), represents a groundbreaking approach in academic librarianship. ANNs, inspired by biological neural networks, excel in pattern recognition and data analysis. By combining the analytical depth of strategic thinking with the computational efficiency of ANNs, this fusion promises to revolutionize decision-making processes in academic libraries. Figure 1 (NEMAN) illustrates this integration, highlighting its potential to enhance integrated approaches, drive innovation, and improve practical applicability and competitiveness in library services supporting agri-business research.

In summary, while traditional theoretical frameworks provide valuable perspectives, their adaptation and integration with advanced computational models like ANNs are essential for academic libraries to effectively support and advance agri-business research in today's data-driven landscape.
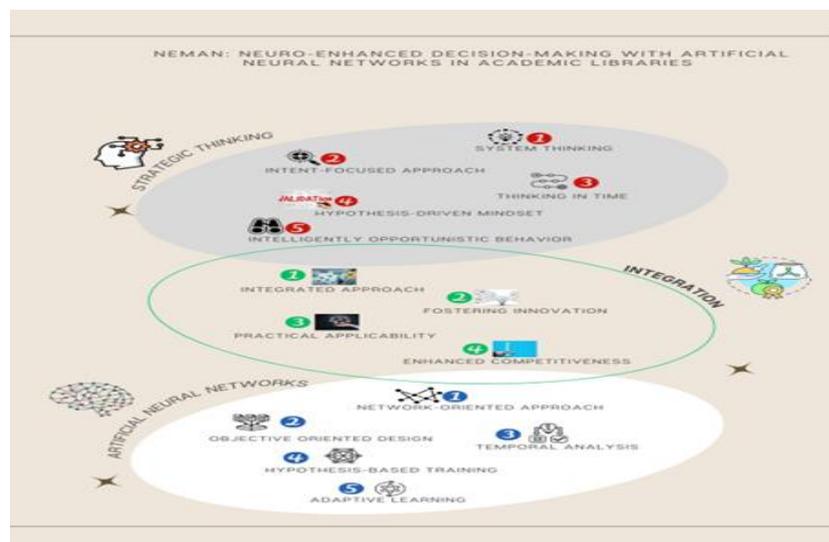

Figure 1: Theoretical Frameworks and Neuro-Strategic Fusion (developed by authors)

Research Design and Methodology
This study adopted a robust research design to ensure validity and reliability. Initiating with an extensive literature review, foundational knowledge was shaped, influencing the research

problem and methodology (Leite et al., 2019; Yin, 2009). Focused on a premier Malaysian public university, known for its agri-business specialization, the study leveraged its unique resources and expertise.

Selection Criteria for the Case
In examining the integration of strategic thinking and deep learning in academic libraries, a Malaysian public university, renowned for its agri-business acumen, was selected. This institution's resource base, faculty expertise, and project relevance were pivotal to aligning with the study's objectives. Additional dimensions, such as the university's establishment year and QS World University Ranking, enriched the analysis. Ten experienced academic librarians from this university, each with a decade or more of experience, were selected based on their seniority (Malaysian grade S41), degree qualifications, and involvement in strategic projects.
Ethical Considerations and Participant Selection

The study adhered strictly to ethical standards, ensuring academic integrity. Consent was obtained from the library's senior management and informants. Focus group interviews, crucial for data collection, were conducted with utmost professionalism and recorded for transcription accuracy, ensuring data richness and integrity. The selection of a single university and a small group of librarians was strategic, focusing on depth and quality of data rather than breadth.

Table 1
Elements of Sampling

Category	Details
Year of University Establishment / Year Granted Research University Status	1971/2017
QS World University Ranking (2024)	158
Core Specialization	Agriculture, Bioscience, Biotech, Food Science & Technology, and Forestry
Type of Institution	Public
Geographical Location (University)	Selangor, Malaysia
Library Staff Strength (University)	80-150
Library Size	Over 600,000 volumes of books and bound journals; more than 80,000 full-text articles
Location (Study Focus)	Central Peninsular Malaysia, Public University focused on Agri-business
Library Staff Strength (Study Focus)	170-180
Participants' Departmental Experience	Various Departments (Rotation Basis)
Number of Participants	10 (7 Females, 3 Males)
Key Performance Index (Last 3 Years)	90-95%
Years of Experience	10-15
Age Range	40-50

Category	Details
Qualifications	Degrees in Library Science/Information Management, Islamic Studies, Botany; Masters in Library Science
Current Position	Senior Librarian

Discussion of Findings
In this section, we present a thorough discussion of the findings by synthesizing the insights provided by the informants. The discussion is substantiated by pertinent source citations, with CSA serving as the primary source citation. Q2 denotes the specific question related to the domain, and E1 signifies the element or construct being addressed. The cited academic librarian or AL represents the individual who provided the referenced information.

Integration of System Thinking and Network-Oriented Approach: Advancing Research
During interviews with academic librarians, a key theme emerged: their dedication to advancing agri-business research through the integration of cutting-edge deep learning algorithms, state-of-the-art satellite imagery software, and a comprehensive system thinking approach. Librarians recognized the importance of thinking like farmers, who consider the well-being of their crops or livestock, to gain a comprehensive understanding of the agricultural domain. This mindset enabled them to analyze complex agricultural systems using satellite data, uncovering valuable insights into interdependencies among factors such as crop health, land use, and environmental conditions. Librarian A emphasized, "To support agricultural research, we need to think like farmers who deeply understand their crops or livestock. This allows us to analyze complex agricultural systems, identify patterns, and make informed decisions based on reliable data" (CSA, AL-A, Q2, E1).

The integration of advanced deep learning algorithms and sophisticated satellite imagery software optimized information management systems, resulting in streamlined processes and informed decision-making. By leveraging software applications like Google Earth Engine, librarians enhanced the user experience for faculty and students in agricultural disciplines by providing access to relevant satellite data and guidance in analysis. This empowered researchers to make data-driven decisions and advance their studies in agri-business. Librarian B stated, "Through integrating deep learning algorithms and satellite imagery software, we gain valuable insights into the dynamics of agricultural systems. This optimization streamlines information management systems and supports researchers in making informed decisions" (CSA, AL-B, Q2, E1).

Furthermore, the integration of deep learning algorithms and satellite imagery software supported efficient collection development in academic libraries. Librarians utilized analyzed satellite data to inform collection decisions, ensuring alignment with researchers' evolving needs in agri-business. They also facilitated access to valuable satellite data and guided analysis, enabling researchers to develop information literacy skills and navigate agricultural resources effectively. Librarian C emphasized the importance of efficient collection development by saying, "By using deep learning algorithms and satellite imagery software, we make informed decisions about collection development, ensuring alignment with the

changing needs of agri-business researchers and facilitating access to reliable and analyzed satellite data" (CSA, AL-C, Q2, E1).

One academic librarian emphasized comprehensive support and expert guidance in utilizing the platform. She stated, "We assist researchers in account setup and provide expert guidance on utilizing the platform effectively. Our offerings include customized workshops and training sessions designed for utilizing the Google Earth Engine in agricultural research. Additionally, our dedicated research guide provides comprehensive instructions and real-life examples to help users leverage the software's capabilities" (CSA, AL-E, Q2, E1). Another informant highlighted the significance of subject guides in the library portal, attracting new users by disseminating specialized information. She said, "These guides support research in specific disciplines, guiding finding and using information in various formats, such as patents or dissertations. This proactive approach enhances research capabilities and demonstrates the commitment of academic librarians to supporting agricultural studies" (CSA, AL-H, Q2, E1). Similarly, Librarian D voiced his agreement on the paramount significance of the administrative innovation process and the integration of products that fortify the administrative structure. He highlighted, "I wholeheartedly concur on the paramount significance of the administrative innovation process, placing special emphasis on the integration of products that effectively bolster the administrative structure. These products play a pivotal role in providing the necessary support, especially for research and development (R&D) budgets. By allocating resources strategically and ensuring their optimal utilization, we can propel innovation and advance agri-business research to unprecedented heights" (CSA, AL-D, Q2, E1).

Integration of Intent-Focused Approach and Objective-Oriented Design: Tools and Technologies
In the realm of agri-business research support, academic librarians have embraced an integrated approach, recognizing the importance of fostering innovation, practical applicability, and enhanced competitiveness. To uphold these principles, librarians utilize various tools and technologies to effectively deliver services and resources to users.

Data mining tools like RapidMiner or KNIME have become indispensable assets. By harnessing the capabilities of these tools, librarians can extract valuable insights from vast datasets, enabling them to comprehend user needs and make data-driven decisions. This enhances library services and resources specifically tailored for agri-business research. One informant shared their transformative experience, stating, "Participating in Mendeley courses has been instrumental in my professional growth. It has equipped me with expertise in guiding library patrons through citation management and research organization. Sharing my knowledge and conducting courses for library patrons has been immensely rewarding. I take pride in being recognized as an expert in Mendeley within our academic community and derive joy from being the go-to person for citation management support" (CSA, AL-G, Q2, E2).

Another informant passionately emphasized the profound transformative impact of tools like Mendeley, underscoring their ability to revolutionize research productivity and streamline the complex process of citation management. With unwavering commitment, academic librarians excel in their specialty, equipping researchers with the essential tools and expertise needed to excel in their scholarly pursuits and elevate the quality of their work. Through their

dedicated guidance and support, researchers are empowered to maintain meticulous organization, ensure accurate citation of sources, and seamlessly collaborate with peers. This unwavering commitment to excellence not only contributes to the advancement of agri-business research as a whole but also propels it to new frontiers of innovation and impact. The informant passionately declared, "That's the unwavering specialty of academic librarians. We are catalysts for scholarly excellence, actively endorsing and wholeheartedly supporting the adoption of invaluable tools like Zotero or Mendeley. These citation management software programs are indispensable in efficiently organizing, managing, and flawlessly citing research references within the realm of agri-business. Through our expertise and dedication, we foster a vibrant culture of impactful and cutting-edge scholarship, elevating the field to unprecedented heights."(CSA, AL-D, Q2, E2)

Moreover, academic librarians wholeheartedly dedicate themselves to securing subscriptions to specialized online research databases, including esteemed platforms like Scopus, Web of Science, and AGRICOLA. These comprehensive databases house an extensive collection of scholarly articles, conference papers, and research reports that hold immense relevance for the field of agri-business. One informant enthusiastically affirmed, "Through unwavering commitment in meetings, discussions, and negotiations, librarians adeptly ensure unfettered access to these invaluable resources. By facilitating researchers' exploration of cutting-edge findings, keeping them at the forefront of advancements, and enabling comprehensive literature reviews, librarians empower scholars in their agri-business pursuits. The astute utilization of data mining tools, citation management software, and online research databases serves as a resounding testament to academic librarians' seamless integration of unwavering support for agri-business research. These indispensable tools not only empower librarians to analyze user data and refine citation practices but also substantiate persuasive evidence presented in reports to top management, advocating for requisite budget allocation to optimize and fully harness the potential of these databases. The commitment of academic librarians transcends the researcher's realm, encapsulating their devoted endeavors to ensure optimal resource utilization within the scholarly community at large" (CSA, AL-D, Q2, E2).

In recognition of their efforts, academic librarians have earned notable accolades and awards. Flashing back to the records, the "Creation of a Fast Gluing Process for Conservation Work" received the Emerald Group Publishing High Usage Award in 2012, while the Library Portal Service was honored with the Springer e-book and e-journal High Usage Award in 2012/2013. These esteemed accolades highlight the effectiveness and impact of the tools and technologies integrated by academic librarians in supporting lecturers, students, and researchers with specialized information in the field of agri-business. Through the seamless integration of an intent-focused approach and objective-oriented design, academic librarians have revolutionized agri-business research support by incorporating cutting-edge tools and technologies. Their unwavering commitment to continuous learning and the utilization of innovative resources enables them to meet the evolving needs of the agri-business community, ultimately contributing to advancements in the field.

The Integration of Thinking in Time and Temporal Analysis: Promoting Participation and Collaboration

The integration of temporal analysis and thinking in time in agri-business has proven highly beneficial, supported by specific examples, statistical data, and user testimonials. Academic librarians recognize the advantages of utilizing software tools such as Climate FieldView and AgriWebb in practical agri-business scenarios. Academic librarian J highlights that Climate FieldView, a digital agriculture platform, effectively integrates real-time and historical data to support decision-making processes, optimize farming practices, and enhance productivity, resource management, and decision-making capabilities. "The software's temporal analysis features enable farmers to achieve higher crop yields and reduce environmental impact" (CSA, AL-J, Q2, E3).

The integration of these data platforms extends beyond the platforms themselves and includes retailers who have a last-mile relationship with farmers. Establishing exclusive relationships with retailers in this highly fragmented market is challenging. Integrated data platforms like Climate or others provide a solution by reducing barriers and allowing companies to develop stronger relationships with retailers. Adopting an all-inclusive solution through an integrated platform is more favorable to retailers and end-users compared to purchasing separate imagery and analytics services. This shift has the potential to transform the relationship between farmers and academic librarians, fostering enhanced collaboration and information exchange.

By fostering collaboration between farmers, academic librarians, and data platform providers, a robust and efficient agri-business ecosystem can be created. The integration of temporal analysis and thinking, supported by advanced software tools and data platforms, has the potential to revolutionize decision-making, improve resource management, and drive sustainable agricultural practices. Academic Librarian D emphasizes the importance of continuous adaptation and mastery of new tools in the ever-changing agricultural landscape. "As technologies evolve, academic librarians must continuously adapt and master new tools to provide valuable support to farmers. We need to stay updated and proficient in various software technologies as they become essential tools for our work" (CSA, AL-D, Q2, E3).

Statistical data serves as additional evidence reinforcing the value of integrating temporal analysis and thinking in agri-business. It supports the positive impact of this approach on productivity, resource utilization, and financial outcomes. However, the absence of feedback and shared experiences from agricultural businesses or farmers makes it difficult to conduct a thorough evaluation of the benefits realized. Additionally, the absence of compulsory documentation or official agreements between academic librarians and agri-business entities poses limitations on establishing successful partnerships. Academic librarian F emphasized the significance of addressing the lack of official partnership and ongoing collaboration between the agricultural industry and libraries. "One of the key challenges is the lack of partnership and collaboration between the agricultural industry and libraries. This gap hampers the potential for cooperation and knowledge exchange, limiting the advancement of research and support in the field. To overcome this challenge, it is crucial to leverage the role of academic librarians as repositories of specialized information. By building upon past accomplishments, such as The Excellent Library Award 2011, and actively seeking

partnerships, we can reinforce our contributions and establish stronger connections with the agricultural industry" (CSA, AL-F, Q2, E3).

Another informant supported this and added, "Encouraging their active participation, feedback, and shared experiences while implementing compulsory documentation and official agreements is essential to achieving a comprehensive evaluation and realization of the benefits. Addressing these challenges necessitates collaboration among various stakeholders, including researchers, farmers, policymakers, and other relevant parties. By fostering partnerships, sharing knowledge, and developing innovative solutions together, we can overcome these obstacles and foster a more resilient and sustainable agri-business ecosystem. This collective effort will not only meet the increasing global demand for food but also minimize environmental impacts and promote equitable practices" (CSA, AL-A, Q2, E3).

The Integration of Hypothesis-Driven Mindset and Hypothesis-Based Training: Enabling Access to Specialized Resources
During the interview, it became evident that academic librarians play an indispensable role in driving agri-business research. Their support and expertise in providing access to specialized resources are vital for researchers in the field. In the digital age, the integration of technology has revolutionized the way academic librarians meet the evolving needs of the agri-business community. The amalgamation of critical thinking and discernment has emerged as a potent force in this context. The integration of a hypothesis-driven mindset and hypothesis-based training lies at the heart of analytical thinking and informed decision-making in agri-business research. Academic librarians serve as invaluable guides, assisting researchers in selecting appropriate software tools and emphasizing the significance of conducting comprehensive and contextually grounded research. Academic librarian G highlighted the adaptability of the profession, stating, *"It's similar to the referral service concept. We adapt our conventional concepts to the current situation"* (CSA, AL-G, Q2, E4).

Encouraging researchers to directly engage with agricultural environments fosters a holistic and pragmatic approach to agri-business studies, enriching their research with firsthand insights and practical knowledge. This aligns with the hypothesis-driven mindset, emphasizing the importance of conducting grounded research and gaining firsthand experience in the agri-business field. By integrating technology and specialized knowledge, academic librarians enable researchers to make informed decisions and enhance productivity.

One of the informants shared a valuable perspective, stating, *"No matter how advanced deep learning offers, more importantly, academic librarians must leverage it in a way that aligns with their work nature, passion, and responsibility"* (CSA, AL-I, Q2, E4). This emphasizes the importance of academic librarians leveraging technology in alignment with their roles and responsibilities. Through their expertise and guidance, academic librarians contribute to efficient collection development strategies that meet the evolving needs of agri-business researchers. While software tools enhance the practical applicability of library services, strategic decisions ultimately rely on the librarians' expertise. Librarians must remain critical and relevant by continuously adapting to new technologies and user needs and avoiding complacency.
Another informant suggested the establishment of a categorized databank that includes references to common issues faced by farmers and researchers. This recommendation

highlights the practicality and benefits of integrating technology and specialized knowledge to support the agri-business community. She stated, *"By providing quick access or quick reference to relevant information, academic librarians can facilitate the research process and enhance the productivity of farmers and researchers. It also helps in addressing the needs of researchers promptly"* (CSA, AL-A, Q2, E4).

Through the integration of a hypothesis-driven mindset, comprehensive research strategies, and the use of technology, librarians contribute to the success and productivity of researchers in the field. The need for continuous adaptation and proactive engagement serves as a guiding principle to ensure that academic librarians remain relevant and effective in supporting the evolving needs of the agri-business community.

The Integration of Intelligently Opportunistic Behavior and Adaptive Learning: Bridging Knowledge and Innovation
Insights gleaned from interviews with academic librarians shed light on the pivotal role that deep learning algorithms play in effectively harnessing the extensive information embedded within Malaysia's diverse biodiversity. These librarians, with their specialized expertise in library and information management, bring forth a unique array of skills and knowledge to the realm of agro-business. Their multidisciplinary educational backgrounds in library sciences, botany, and agriculture equip them with the acumen to bridge disciplinary boundaries and adeptly deploy deep learning algorithms in agro-business research.

Academic librarians possess a rich tapestry of educational backgrounds, encompassing library sciences, botany, and agriculture, endowing them with an intricate understanding of the profound significance of deep learning algorithms in the agro-business sphere. For instance, one librarian eloquently elucidated the impact of their educational foundation in botany, stating, *"My primary degree in botany science has been pivotal in comprehending the intricacies of knowledge customization within this domain"* (CSA, AL-G, Q2, E5).

Furthermore, the active involvement of academic librarians across various departments confers upon them an invaluable firsthand exposure to the complexities and nuances of the agro-business landscape. Through their dynamic engagement in departments such as cataloging and reference, they cultivate a holistic comprehension of the specific information needs and challenges that underpin agro-business research. One informant poignantly expressed, *"My immersion in the cataloging and reference departments has endued me with a unique vantage point to assimilate the intricacies of this field, assimilate novel terminologies and jargon, and grasp the precise information requisites and conundrums that arise in agro-business research"* (CSA, AL-B, Q2, E5).

Academic librarians are not oblivious to the latent potential of deep learning algorithms to contribute to the agricultural and pharmaceutical sectors, inextricably intertwined with agro-business. The splendid panorama of Malaysia's biodiversity presents an unparalleled opportunity for these algorithms to facilitate the identification of novel medicinal plants, agricultural practices, and crop protection strategies. The continuous refinement of adaptive learning strategies within these algorithms propels their performance to new heights, furnishing invaluable recommendations to enhance agro-business productivity, sustainability, and innovation. Moreover, academic librarians underscore the paramount importance of

systematic collection and analysis of biological samples in agro-business research. Leveraging the technique of "biological prospecting," deep learning algorithms discern economically valuable compounds, bioactive substances, and natural ingredients that can be judiciously harnessed in agro-business practices. A discerning librarian aptly emphasized Malaysia's biodiversity, remarking, *"Malaysia stands among the world's megadiverse countries, boasting over 170,000 species. However, this estimate is likely conservative, as numerous species remain undiscovered and unexplored"* (CSA, AL-E, Q2, E5).

The establishment and perpetuation of seed banks emerge as a salient facet in the preservation of biodiversity. One informant ardently underscored the imperativeness of amassing and safeguarding traditional varieties within seed banks to preclude the erosion of biodiversity, an alarming trend afflicting crops on a global scale. They fervently stressed the need for proactive collaborations with other agricultural departments to compile a comprehensive seed bank database, citing the laudable example of the United States endeavors to assemble a database encompassing staple food species. *"Since 2007, the United States has diligently assembled a comprehensive database of staple food species in anticipation of prospective food shortages. In light of this, our esteemed library should actively forge alliances with agricultural counterparts such as FAMA and MARDI to embark on a similar undertaking. The progression of crops through centuries of selective cultivation has yielded a copious assortment of varieties. Regrettably, the advent of modern high-yielding varieties in recent decades has precipitated a precipitous decline in local variants across most nations. Hence, it behooves us to amass and safeguard traditional varieties within seed banks to avert the loss of biodiversity, an alarming phenomenon plaguing crops worldwide"* (CSA, AL-H, Q2, E5).

Confronting the challenges posed by the burgeoning global population and its reverberations on food production necessitates proactive measures. Academic librarians acutely recognize the urgency of raising awareness and disseminating critical information on pertinent issues such as rice research and plantation soil utilization. They assume a pivotal role in informing the public and engaging stakeholders in these pressing concerns. One informant cogently expounded on the need for resolute action, articulating, *"The deluge in Thailand unleashed a momentous impact on rice supplies in Malaysia several years ago, engendering an imperative for decisive measures. Academic librarians ought not to confine their purview to rice research alone but also to proactively document and disseminate vital information about plantation soil utilization in Malaysia"* (CSA, AL-B, Q2, E5). Echoing this sentiment, academic librarian H accentuated the exigency of overhauling the global food system to ensure the sustenance of livelihoods for farmers, provision of nutritionally rich products for consumers, and minimization of the environmental footprint of food production. *"By 2050, the global population is slated to burgeon to a staggering 9.7 billion individuals, consequently engendering a staggering 70% increase in food demand vis-à-vis contemporary consumption patterns. This prodigious upsurge poses an unprecedented challenge in catering to the nutritional and sustainable requisites of this amplified populace. Does Malaysia stand prepared to confront this prodigious conundrum? I ardently contend that substantial enhancements to the global food system are an imperative, more so within our national context, to engender viable livelihoods for farmers, provision nutritionally rich products for consumers, and assuage the environmental burden entailed in food production"* (CSA, AL-H, Q2, E5).

The valuable insights gleaned from academic librarians and informants underscore the indomitable role of deep learning algorithms in agro-business research. Harnessing Malaysia's bountiful biodiversity, these algorithms unmask priceless insights, contribute to the agricultural and pharmaceutical domains, and expedite the discovery of innovative solutions. Collaborative endeavors, temporal analysis, and visionary outlooks stand indispensable in tackling the challenges posed by a burgeoning global population, ensuring the enduring sustainability of agri-business. Academic librarians, researchers, and stakeholders ought to forge symbiotic alliances, propounding ingenious solutions and implementing sustainable practices, thus erecting a robust and egalitarian food system for posterity.

Transformative Impact of Strategic Thinking and Deep Learning in Agri-Business Research
Based on the analysis, Table 2 highlights the transformative impact of strategic thinking and deep learning in agri-business research at a Malaysian academic library, covering key areas like System Thinking/Network Approach, Intent-Focused/Objective Design, Temporal Analysis, Hypothesis-Driven Mindset, and Adaptive Learning. These areas represent innovative practices and transformative impacts that are critical in reshaping agri-business research.

Table 2
Transformative Impact of Strategic Thinking and Deep Learning in Agri-Business Research

Criteria	Strategic Thinking Innovations	Deep Learning Innovations	Transformative Impact in Agri-Business Research	Broader Implications for the Field
System Thinking and Network-Oriented Approach	Integration of system thinking for comprehensive analysis of agricultural systems.	Utilization of satellite imagery and advanced analytics software.	Enhances decision-making based on holistic understanding of agricultural ecosystems.	Sets a precedent for sophisticated data analytics in agricultural research libraries.
Intent-Focused Approach and Objective-Oriented Design	Development of strategic information dissemination plans and user-focused services.	Adoption of data mining tools and citation management software.	Streamlines library processes, leading to more efficient and targeted research support.	Demonstrates the potential of integrating technology in library service delivery.
Thinking in Time and Temporal Analysis	Emphasis on dynamic, time-sensitive decision-making and resource management.	Application of real-time data analysis tools in agri-business research.	Facilitates adaptive decision-making, optimizing resource management and farming practices.	Encourages the adoption of temporal analysis in agricultural studies.
Hypothesis-Driven Mindset and Hypothesis-Based Training	Promotion of critical thinking, evidence-based research practices, and	Leveraging technology to support research and enhance library services.	Promotes in-depth, evidence-based research practices in agri-business.	Highlights the need for continuous skill development and adaptation in

Criteria	Strategic Thinking Innovations	Deep Learning Innovations	Transformative Impact in Agri-Business Research	Broader Implications for the Field
	comprehensive research strategies.			evolving research fields.
Intelligently Opportunistic Behavior and Adaptive Learning	Foster multidisciplinary knowledge integration for practical agricultural applications.	Use of deep learning algorithms for biodiversity analysis and agricultural trend identification.	Contributes to innovative solutions and data-driven strategies in agri-business.	Illustrates the integration of multi-disciplinary knowledge for practical agricultural applications.

Agri-business Integrated Framework (ARI Framework)
Building on the insights from Table 2, we propose the Agri-business Integrated Framework (ARI Framework), as illustrated in Figure 2. This framework synthesizes the strategic thinking innovations and deep learning applications outlined in Table 2 into a cohesive model. It serves as a strategic roadmap, integrating these key competencies and approaches to address challenges and leverage opportunities in agri-business. The ARI Framework aims to foster collaboration, knowledge exchange, and innovation, driving sustainable practices in agri-business.

The ARI Framework, therefore, embodies the principles and innovations detailed in Table 2, illustrating how they converge to empower stakeholders in agri-business research. By adopting this framework, researchers and practitioners are equipped to navigate complexities, optimize resource management, and achieve excellence in their research endeavors. It emphasizes interdisciplinary collaboration and the generation of transformative solutions, underlining the importance of integrating strategic thinking and deep learning for effective decision-making, fostering partnerships, and contributing to the sustainable development of agri-business.

Figure 2: Agri-business Integration (ARI) Framework: Bridging Competencies and Approaches
(developed by authors)

Conclusion

In conclusion, the integration of strategic thinking and deep learning algorithms in agri-business research promises transformative change for Malaysian academic libraries and the broader agricultural sector. These libraries, by their roles, are central to the industry's growth, sustainability, and innovation. However, the journey towards this dynamic integration isn't without its complexities. Libraries face potential obstacles such as limited awareness of strategic thinking, the need for quality data, and infrastructure requirements. Yet, when addressed proactively, these challenges become stepping stones toward greater innovation. By understanding and addressing these intricacies, academic libraries can more effectively respond to the talent shortage in the Malaysian agri-business sector, cultivating a fresh cohort of agricultural professionals and optimizing practices using insights from deep learning algorithms. Moreover, Malaysian academic libraries, by leveraging deep learning, hold a unique opportunity to champion conservation strategies and ecosystem-centric approaches, given the country's rich biodiversity. To ensure the successful fusion of strategic thinking and deep learning in agri-business research, it's pivotal for academic libraries to champion continuous professional development, establish synergistic collaborations with industry stakeholders and governmental bodies, and continually invest in a solid technological backbone. The potential economic reverberations of such integration are profound – driving productivity, championing sustainable methodologies, and pioneering novel approaches that spur sector growth and buoy economic vitality. Libraries, in this transformative landscape, are instrumental in uplifting small-scale farmers and budding agri-businesses. They also uphold the ethics of data governance, ensuring responsible and meaningful use of deep learning algorithms. Furthermore, the merging of nascent technologies like IoT and remote sensing with deep learning heralds a fresh era of research possibilities in precision agriculture, resource allocation, and supply chain fine-tuning. Collaborative efforts, judicious investments in state-of-the-art technology, and a commitment to fostering the next generation of talents position academic libraries at the forefront of agri-business research. These institutions, by holding the torch of transformative thinking and sustainable agricultural paradigms, not only shape the trajectory of Malaysian agri-business research but also extend their influence globally, presenting a model of resilience and innovation for the world to follow.

Theoretical and Contextual Contributions of the Research

This research provides significant theoretical and contextual contributions to the field of agri-business research, particularly within the realm of Malaysian academic libraries. Theoretically, the study enriches existing literature by exploring the integration of strategic thinking and deep learning algorithms in academic libraries, a relatively underexplored area. It presents the Agri-Business Integrated Framework (ARI Framework), a novel conceptual model that combines strategic thinking with advanced technological applications. This framework extends the theoretical boundaries of library science and information management, specifically in their roles to support and enhance agri-business research.

Contextually, the study's insights are particularly valuable for Malaysian academic libraries and the broader agricultural sector. By focusing on the unique challenges and opportunities within Malaysia's agri-business landscape, this research highlights the pivotal role of libraries in supporting and advancing the sector. It addresses specific local needs, such as talent development, conservation strategies, and ecosystem-centric approaches, providing a blueprint for how libraries can leverage deep learning and strategic thinking to foster

sustainable agricultural practices and innovation. Furthermore, the study contributes to global discourses on sustainable development in agriculture, aligning with the Sustainable Development Goals (SDGs). It showcases how academic libraries can serve as catalysts for change, driving productivity and sustainable methodologies that resonate beyond Malaysia, offering a model of resilience and innovation for the global community.

In essence, this research not only augments the theoretical understanding of the synergies between strategic thinking and deep learning in academic libraries but also provides practical and contextual insights that are instrumental in shaping the future of agri-business research in Malaysia and potentially global.

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Conflict of Interest

The authors declare no conflict of interest about the content discussed.

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