Artificial Intelligence Literacy as the Foundation for Sustainable Business Transformation: An Analysis of Strategic Gaps and Governance Challenges in Indonesia

Arya Budi Sutopo [1*], Muhammad Davin Arya Syahputra [2]

[1,2] Sahid University of Surakarta, Indonesia
1 aryabudisutopo@usahidsolo.ac.id;
Correspondence: aryabudisutopo@usahidsolo.ac.id

Abstract
Artificial Intelligence (AI) literacy has emerged as a critical foundation for sustainable business transformation in Indonesia, encompassing the competencies necessary for individuals and organizations to effectively engage with AI technologies. This study aims to analyze the strategic gaps and governance challenges that hinder AI implementation in Indonesia's business ecosystem. Using a qualitative approach through systematic literature review, this research examines how AI literacy impacts business transformation, identifies key barriers to AI adoption, and proposes strategic recommendations for improvement. The findings reveal that 77% of Indonesian business leaders recognize AI as critical for economic growth, while 94% plan to increase sustainability investments. However, significant challenges persist, including infrastructure inadequacy (84%), cybersecurity concerns (55%), and skilled talent shortage (45%). Only 45% of businesses understand ethical AI usage, and merely 24% have clear governance processes. The study identifies critical gaps in human capital development, regulatory fragmentation, and regional disparities in AI adoption. Strategic recommendations include integrating AI literacy into national education curricula, adopting skills-based hiring practices, establishing ethical governance frameworks, and fostering multi-stakeholder cooperation. The research concludes that comprehensive AI literacy programs, coupled with robust governance mechanisms, are essential for Indonesia to harness AI's transformative potential while ensuring ethical and sustainable business practices.
Keywords : *Artificial Intelligence Literacy; Sustainable Business Transformation; AI Governance; Digital Transformation; Strategic Gap Analysis; Indonesia;*

INTRODUCTION

Artificial Intelligence (AI) has become one of the most transformative technologies in modern history, fundamentally reshaping business landscapes, industries, and society. In the era of Industry 4.0, the ability to understand, adopt, and leverage AI technology is no longer merely a competitive advantage but a prerequisite for business survival. Indonesia, as the largest economy in Southeast Asia with a population of over 270 million, faces unique challenges and opportunities in navigating this AI-driven transformation [1].

AI literacy is defined as a set of competencies that empower individuals to critically assess artificial intelligence technologies, communicate and collaborate effectively with AI systems, and utilize AI as a functional tool in various contexts including education, the workplace, and daily life. According to Ng et al. (2021), these competencies encompass not only technical skills but also a critical understanding of AI's implications, enabling users to make informed decisions about its application in their personal and professional environments [2].

The global AI market has experienced exponential growth, with market size projected to reach over $1.8 trillion by 2030. This growth is driven by advances in computing power, data availability, algorithm development, and increasing recognition of AI's potential to solve complex problems. Major economies are racing to establish AI leadership positions, investing heavily in research, talent development, and infrastructure. Indonesia must position itself strategically within this global landscape to capture economic benefits while managing associated risks.

In Indonesia, 77% of business leaders recognize that artificial intelligence and digital transformation represent critical opportunities for economic growth [3]. This sentiment reflects broader acknowledgment of AI's transformative potential across various sectors. Furthermore, a recent survey indicates that 94% of respondents plan to increase investments in sustainability initiatives, with 89% already allocating additional funds for green technologies in their 2025 budgets. This focus on sustainable practices is vital for aligning with global standards and addressing urgent challenges posed by climate change.

However, the journey toward comprehensive AI literacy and sustainable business

transformation in Indonesia faces considerable challenges. Barriers such as inadequate infrastructure, cybersecurity concerns, and lack of skilled talent hinder progress. Approximately 84% of business leaders cite infrastructure as a top barrier, followed by cybersecurity concerns (55%) and shortage of digital talent (45%). Moreover, ethical governance issues and regulatory fragmentation complicate the effective implementation of AI solutions [3].

The gap in AI literacy is also evident from data showing that only 45% of businesses understand how to use AI ethically, while only 24% have clear governance processes in place [3]. This condition underscores the urgent need for cohesive strategies that address these gaps and foster a collaborative environment among government, industry, and educational institutions to enhance AI literacy and promote ethical AI usage.

Regional disparities in AI familiarity and adoption are also noteworthy. A gap exists between leaders and employees, with 87% of leaders recognizing the importance of AI compared to only 56% of employees [4]. Addressing these disparities through localized strategies is essential to ensure that upskilling initiatives reach rural communities and marginalized groups, who are often left behind in digital transformation efforts.

The COVID-19 pandemic accelerated digital transformation globally, including in Indonesia. Remote work, e-commerce, and digital services saw dramatic growth, increasing demand for AI-powered solutions. This acceleration has created both urgency and opportunity for AI literacy development. Organizations that invested in digital capabilities during the pandemic have gained competitive advantages, while those that lagged face increasing pressure to catch up.

Based on this background, this research aims to comprehensively analyze the role of AI literacy as the foundation for sustainable business transformation in Indonesia, with specific focus on strategic gaps in AI implementation and governance challenges faced. Deep understanding of these issues is crucial for formulating actionable recommendations for relevant stakeholders.

RESEARCH METHODS

A. Research Design

This research uses a qualitative approach through systematic literature review (SLR) method. This approach was chosen to collect, analyze, and synthesize findings from various academic literature sources relevant to AI literacy, sustainable business transformation, and governance challenges in Indonesia. The SLR method allows researchers to identify, evaluate, and interpret all available and relevant research to specific research questions systematically and replicably [14].

Systematic literature review was chosen for several reasons. First, the topic of AI literacy and AI governance in Indonesia is relatively new and rapidly evolving, so comprehensive synthesis of existing literature is needed to build holistic understanding. Second, SLR allows identification of research gaps that can serve as the basis for future empirical research. Third, findings from SLR can provide evidence-based recommendations that can be directly applied by policymakers and business practitioners.

*B. **Data Sources and Search Strategy***

Data sources in this research consist of indexed journal articles, conference proceedings, industry reports, government publications, and white papers related to AI literacy, digital transformation, AI governance, and Indonesia context. Literature search was conducted through leading academic databases including Google Scholar, Scopus, Web of Science, and IEEE Xplore. Additionally, industry sources such as IBM, McKinsey, Deloitte, and World Economic Forum reports were consulted for contextual data on Indonesia's AI landscape.

The search strategy used a combination of keywords in English and Indonesian. Main keywords include: 'AI literacy', 'artificial intelligence education', 'sustainable business transformation', 'AI governance Indonesia', 'digital transformation Indonesia', 'AI skills gap', 'AI ethics', and 'AI regulation Southeast Asia'. Boolean operators (AND, OR) were used to combine keywords and expand or narrow search results as needed.

C. Selection Criteria and Analysis

Inclusion criteria applied in literature selection include: (1) publications within the 2019-2025 timeframe to ensure relevance to current conditions given rapid AI development; (2) relevance to Indonesia or Southeast Asian context; (3) focus on AI literacy, AI governance, or digital business transformation; (4) discussion of strategic gap or implementation challenge aspects; and (5) publication in peer-reviewed journals or other trusted sources.

Exclusion criteria include: (1) publications not available in full text; (2) opinion articles without strong empirical or conceptual basis; (3) publications in languages other than English or Indonesian; and (4) studies focusing on purely technical aspects without business or policy implications. Data analysis was conducted through thematic approach to identify patterns, themes, and inter-concept relationships emerging from reviewed literature.

RESULTS AND DISCUSSION

A. AI Literacy Conditions in Indonesia

Literature review results show that AI literacy conditions in Indonesia still face various challenges. Although there is broad recognition of AI's importance for economic growth, actual understanding and capability levels in utilizing AI remain limited. A survey conducted by IBM (2024) shows significant gaps between AI adoption aspirations and implementation reality among Indonesian businesses [3].

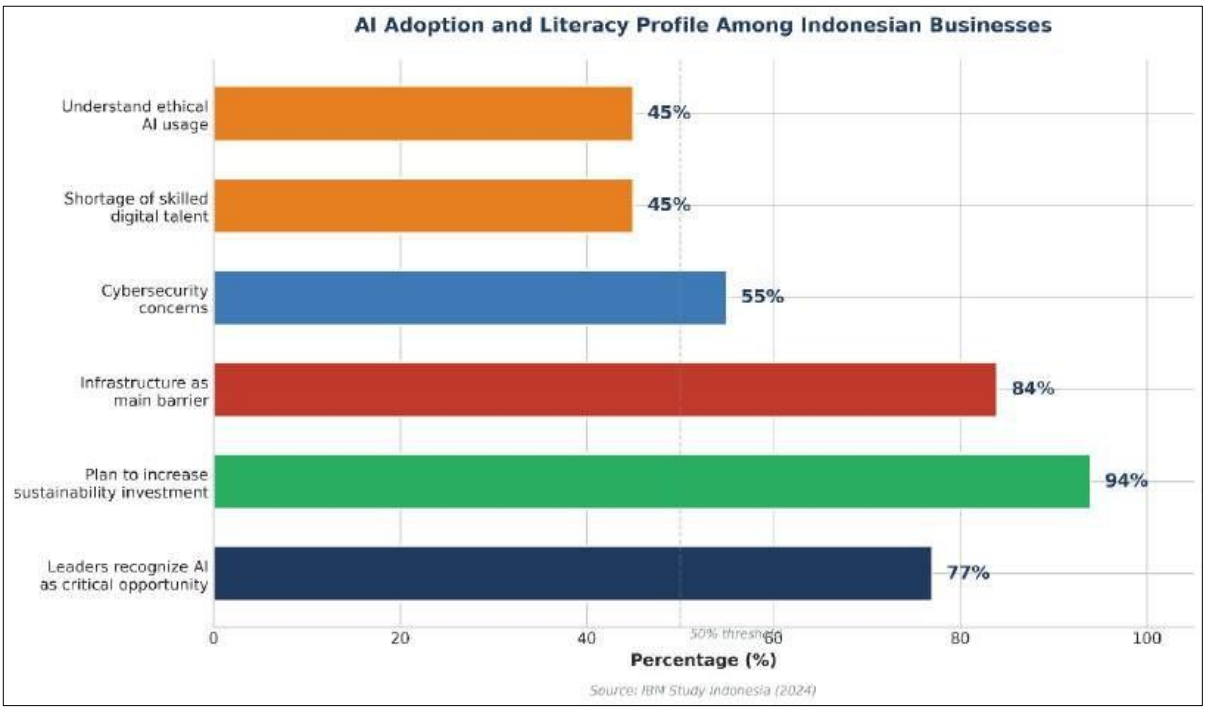
From an educational perspective, AI literacy integration into curriculum is still in early stages. Although the Indonesian government has recognized the importance of digital and AI literacy, implementation of comprehensive educational programs remains limited. Challenges include lack of AI-trained educators, limited technology infrastructure in educational institutions, and absence of clear national-level AI curriculum standards.

Disparity in AI literacy levels is also visible between various demographic and geographic segments. Employees and workers at operational levels tend to have lower AI literacy levels compared to leaders and managers. Similarly, there is a gap between urban areas with better access to educational and technological resources and rural areas that are still lagging behind.

Table I. AI Adoption And Literacy Profile Among Indonesian Businesses

Indicator	Percentage	Implication
Leaders recognize AI as critical opportunity	77%	High awareness at leadership level
Plan to increase sustainability investment	94%	Strong commitment to sustainable practices
Infrastructure as main barrier	84%	Need for digital infrastructure investment
Cybersecurity concerns	55%	Need for security strengthening and trust
Shortage of skilled digital talent	45%	Urgency of HR development programs
Understand ethical AI usage	45%	Need for broader AI ethics education

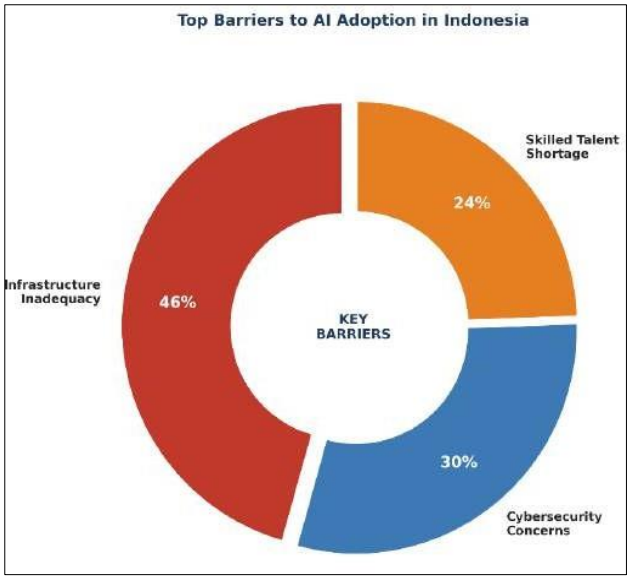
Source: Processed from IBM Study Indonesia (2024)



Pic I. AI Adoption And Literacy Profile Among Indonesian Businesses

B. Strategic Gaps in AI Implementation

Artificial intelligence implementation in Indonesia is hindered by several strategic gaps affecting both public and private sectors. Despite significant readiness to adopt AI technologies among businesses, notable challenges persist in education, infrastructure, and ethical governance areas.



Pic 2. TOP Barriers to AI Adoption in Indonesian

The first and most fundamental gap is the human capital and skills gap. Approximately 45% of Indonesian business leaders reported a deficiency in digitally skilled personnel as a primary obstacle to AI adoption [3]. Bridging this skills gap requires a collaborative approach among government, industry, and educational institutions. The National Strategy on AI emphasizes the need for education and training programs aligned with market demands, including the integration of AI-related curricula from secondary schools through universities [15].

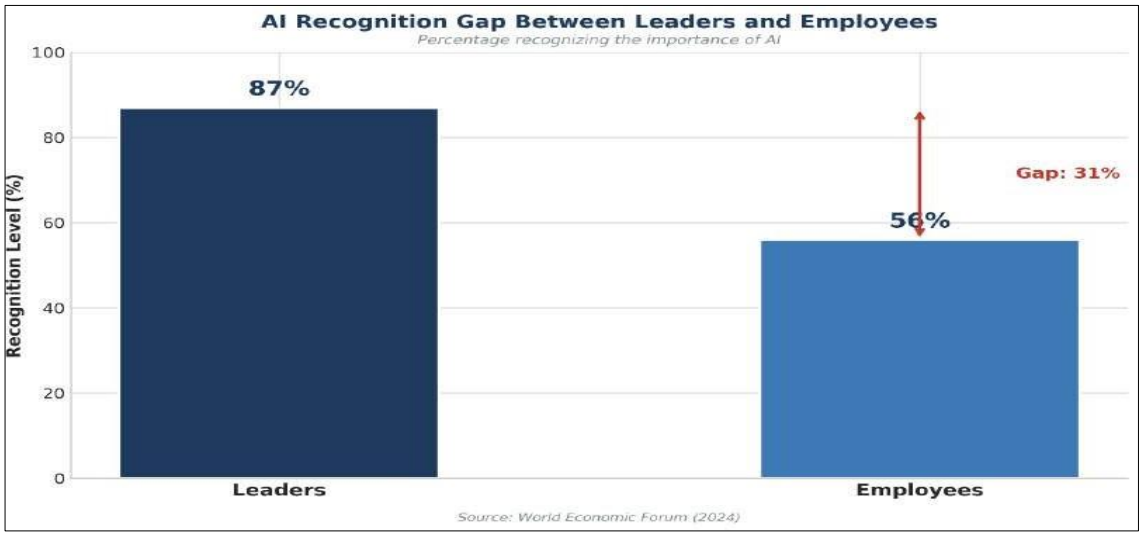
A Skills-based hiring approach that prioritizes competencies over traditional qualifications can

potentially expand the AI talent pool significantly, fostering an inclusive workforce prepared for the evolving demands of the future. However, this paradigm shift requires a mindset change among both employers and job seekers, as well as policy support that facilitates alternative education pathways.

B. The second gap is infrastructure challenges. Infrastructure remains a critical concern, with 84% of business leaders citing it as a top barrier to AI adoption [3]. The current state of digital infrastructure in Indonesia is insufficient to support widespread AI deployment, which is essential for maximizing its benefits across sectors such as banking, healthcare, and entertainment. Investments in robust and secure digital infrastructure are necessary to facilitate effective data management and AI applications, particularly in micro, small, and medium enterprises (MSMEs) that lack the resources to implement AI solutions independently.

The third gap relates to ethical governance and public trust. A study revealed that only 45% of businesses understood how to use AI ethically, while just 24% had clear governance processes in place [3]. Establishing a regulatory framework that provides clarity and builds trust in AI applications is crucial. The establishment of governance bodies, such as Lembaga Pengawas PDP, can help oversee personal data management and ensure ethical standards are met, fostering public confidence in AI technologies.

The fourth gap is regional disparities. There are notable regional disparities in AI familiarity and adoption. A gap exists between leaders and employees, with 87% of leaders recognizing the importance of AI compared to only 56% of employees [4]. Addressing these disparities through localized strategies is essential to ensure that upskilling initiatives reach rural communities and marginalized groups, who are often left behind in digital transformation efforts.



C. AI Governance Challenges in Indonesia

Indonesia faces significant governance challenges in implementing artificial intelligence across various sectors. These challenges are primarily linked to regulatory fragmentation, ethical concerns, and the necessity for a cohesive national strategy that aligns with global standards while addressing local needs.

One of the foremost obstacles is the existing regulatory fragmentation surrounding AI governance. Currently, Indonesia lacks a dedicated AI law, relying instead on existing frameworks pertaining to electronic information, transactions, and data protection [12]. This reliance can complicate the enforcement of regulations and may hinder the effectiveness of AI governance. Critics have called for the government to expedite regulatory frameworks to mitigate potential rights violations stemming from AI use, highlighting the urgency for comprehensive legislation that can directly address AI challenges.

Ethical governance of AI presents another critical challenge. Stakeholders, including members of a multi-stakeholder cooperation model, emphasize the importance of addressing biases and discrimination inherent in AI systems [16]. The need for ethical anchoring in AI governance is paramount, as it ensures that AI tools are developed and deployed in a human-centered manner, sensitive to local contexts and cultural nuances. The ongoing drafting of the National AI Roadmap and Ethical Guidelines reflects Indonesia's commitment to fostering ethical AI practices, although these guidelines must be effectively integrated into existing regulatory frameworks to be impactful.

Indonesia's approach to AI governance adopts a multi-stakeholder cooperation model, which aims to bring together government, industry, academia, and civil society in the regulatory process [13]. This approach seeks to create an inclusive and practical AI governance framework. However, ensuring effective collaboration among diverse stakeholders remains a significant challenge. The integration of various perspectives into cohesive policies can be complex, particularly in addressing the different interests and capabilities of stakeholders involved in the governance process.

Additionally, the Indonesian government is engaged in broader digital transformation initiatives aimed at improving bureaucratic efficiency and enhancing public services [17]. However, bureaucratic inertia and inefficiencies can impede the swift implementation of AI-related policies and regulations. Initiatives to simplify bureaucratic processes indicate recognition of these challenges, yet the success of such reforms is still in progress and requires sustained commitment from all levels of government.

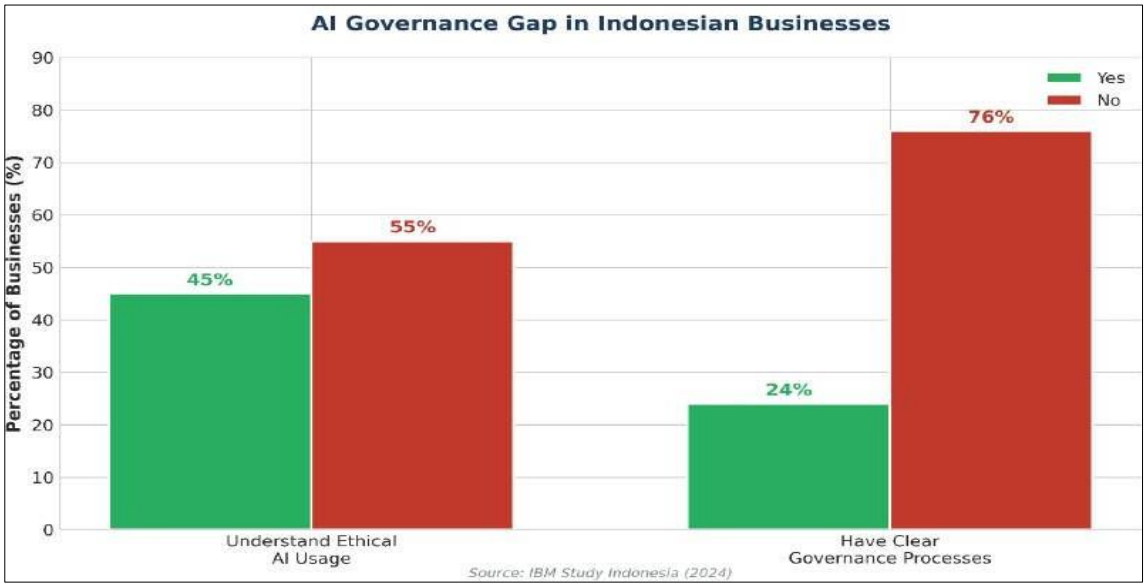


Table II. AI GOVERNANCE CHALLENGES AND THEIR IMPLICATIONS

Challenge	Description	Implication
Regulatory Fragmentation	No dedicated AI law, relies on existing regulations	Legal uncertainty and weak enforcement
Ethics Gap	Only 45% businesses understand AI ethics	Risk of misuse and rights violations
Weak Governance	Only 24% have clear governance processes	Lack of accountability and transparency
Multi-stakeholder Coordination	Complex integration of diverse perspectives	Non-cohesive policies
Bureaucratic Inertia	Slow bureaucratic reform process	Delayed AI policy implementation

Source: Processed from various sources (2024)

D. Impact of AI Literacy on Business Transformation

Literature analysis shows that AI literacy has a significant impact on organizational capabilities in conducting business transformation. Organizations with higher AI literacy levels tend to be more successful in identifying AI opportunities, implementing AI solutions, and managing associated risks. The positive relationship between AI literacy and AI technology adoption has been confirmed in various contexts, both educational and business [5][6].

In Indonesia's context, the impact of AI literacy on business transformation can be observed through several dimensions. First, organizations with better AI literacy show higher capability in identifying AI use cases relevant to their business needs. They can separate hype from reality regarding AI capabilities, so AI investments are more targeted and have clearer return on investment. Second, AI literacy at the leadership level correlates with more coherent and integrated digital transformation strategies. Leaders who understand AI can make more informed decisions about technology investment priorities, resource allocation, and transformation roadmaps. They are also better able to communicate AI vision to the entire organization and gain buy-in from various stakeholders.

Third, AI literacy at the operational level enables smoother implementation and faster adoption of AI solutions. Employees who understand AI are more ready to work alongside AI systems, provide constructive feedback for improvement, and identify potential problems before they become critical. They are also more likely to develop hybrid workflows that optimize human-AI collaboration. Fourth, AI literacy contributes to better risk management. Organizations that understand AI limitations and risks can develop appropriate controls, avoid over-reliance on AI systems, and ensure adequate human oversight. This is particularly important given the potential negative consequences of wrong AI decisions, especially in high-stakes applications like healthcare and finance.

E. Strategies for Enhancing AI Literacy

Based on gap and challenge analysis that has been identified, several strategies can be recommended to enhance AI literacy in Indonesia. These strategies include interventions at various levels, from national policy to organizational initiatives. The first strategy is integrating AI literacy into the national education curriculum. Investing in AI literacy is essential to empower individuals and organizations. Integrating AI literacy into the national education curriculum is essential to prepare future generations for a tech-driven economy [9]. A staged approach to AI literacy, which gradually introduces students to basic concepts before advancing to more complex skills, has proven effective in other contexts and should be adopted in Indonesia.

Furthermore, mandatory AI literacy programs should focus on equipping educators with both technical skills and pedagogical strategies to ensure responsible teaching and application of AI in classrooms [18]. This will create a robust foundation for future workforce development that is not only capable of using AI but also understands its ethical and social implications. The second strategy is adopting skills-based hiring practices. A shift towards skills-based hiring practices is recommended to expand Indonesia's AI talent pool. By prioritizing competencies over traditional qualifications, employers can access a broader talent base and better adapt to evolving market demands [4]. Governments can play a pivotal role by incentivizing businesses to adopt these practices and supporting alternative education pathways such as micro-credentials and online learning platforms.

The third strategy is fostering a culture of continuous learning. Fostering a culture of continuous learning within organizations is essential for maintaining a competitive edge in an AI-driven economy. Companies are encouraged to identify existing talent that can be upskilled in areas such as AI and cybersecurity, leading to productivity gains and innovation [19]. Reskilling and upskilling programs should be an integral part of organizational talent management strategies. The fourth strategy is strengthening multi-stakeholder cooperation. A crucial element in fostering sustainable business transformation is enhancing AI literacy among the workforce through cross-sector collaboration that integrates efforts from government bodies, educational institutions,

industry stakeholders, and civil society organizations [20]. This collaboration can produce programs that are more comprehensive and relevant to labor market needs.

F. Recommendations for Strengthening AI Governance

To facilitate the effective integration of artificial intelligence into various sectors in Indonesia, it is crucial to develop comprehensive strategies that address both the technological and ethical dimensions of AI implementation. The following are recommendations for improving AI governance. The first recommendation is leveraging AI for real-time insights and proactive policymaking. One significant recommendation is to leverage agentic AI to provide real-time, cross-sectoral insights that can inform policymakers [21]. Utilizing AI can transform traditional reactive governance into a more proactive model by automatically detecting emerging trends and patterns, thereby enabling timely and data-driven policy responses. This shift not only enhances the effectiveness of governance but also ensures that policy measures reflect real-world conditions.

The second recommendation is establishing an ethical AI governance framework. Establishing a framework for ethical AI governance is paramount. This involves drafting policies that ensure AI tools are developed and deployed in a manner that is inclusive, accountable, and responsive to local contexts [16]. The ongoing efforts in Indonesia to create a National AI Roadmap and Ethical Guidelines are steps in the right direction but require further enhancement through robust redress mechanisms and monitoring systems to maintain public confidence in AI applications. The third recommendation is accelerating comprehensive AI regulation. The government needs to accelerate the drafting of comprehensive AI regulations to provide legal certainty and clear guidance for business actors. This regulation should be flexible enough to accommodate rapid technological developments, yet strong enough to protect individual rights and public interests. A regulatory sandbox approach can be considered to allow controlled experimentation with new AI technologies.

The fourth recommendation is strengthening oversight and enforcement capacity. Regulatory bodies tasked with overseeing AI implementation need to have their capacity strengthened, both in terms of human resources, technology, and authority. This includes the ability to conduct algorithm audits, investigate AI-related complaints, and enforce sanctions against violations. Transparency and accountability should be the main principles in AI oversight.

G. Managerial Implications

Based on this research findings, several managerial implications can be identified to help organizations optimize AI literacy and support sustainable business transformation. These implications are relevant for both private and public sectors. First, organizations need to treat AI literacy as a strategic capability that must be developed systematically. This means allocating adequate resources for AI training programs, creating career paths that encourage AI expertise development, and making AI literacy a criterion in performance evaluation and promotion. Investment in AI literacy should be viewed not as a cost but as an investment in longterm competitiveness.

Second, organizational leadership must play an active role in shaping a culture that supports responsible AI adoption. This includes demonstrating commitment to AI ethics through concrete actions, encouraging experimentation and learning from failures, and ensuring that ethical considerations are integrated into every AI-related decision. Tone at the top is crucial in shaping organizational attitudes toward AI. Third, organizations need to develop clear and effective internal AI governance mechanisms. This includes establishing committees or boards responsible for AI oversight, developing policies and procedures for AI development and deployment, and implementing monitoring and audit systems to ensure compliance. Good governance not only reduces risk but also builds stakeholder trust. Fourth, organizations should actively participate in the broader AI ecosystem, including collaboration with educational institutions, industry associations, and government bodies. This participation can provide access to talent, knowledge, and resources that may not be available internally. Additionally, organizations can contribute to the formation of standards and best practices that benefit the entire ecosystem.

H. Case Studies: AI Literacy Initiatives in Indonesia

Several AI literacy initiatives that have been conducted in Indonesia provide valuable lessons about effective strategies and challenges faced in enhancing national AI capabilities. Analysis of these initiatives can inform the development of more comprehensive AI literacy programs in the future. One prominent initiative is the Digital Talent Scholarship (DTS) program organized by the Ministry of Communication and Information Technology. This program provides free training in various technology fields including AI and machine learning to thousands of participants each year. Evaluation of this program shows success in increasing AI awareness and basic skills, although challenges remain in post-training follow-up and connection to real job opportunities.

IBM Indonesia has also launched various AI literacy initiatives, including free training programs for youth and women. These programs focus on building practical skills in using AI tools and understanding the business applications of AI technology. Partnerships between global technology companies and local stakeholders demonstrate a replicable model for accelerating AI literacy development. In the higher education sector, several leading universities have begun integrating AI curricula into their study programs. Universitas Indonesia, Institut Teknologi Bandung, and several other universities have launched special programs in AI and data science. However, capacity to produce graduates with AI expertise is still far from meeting market demand, indicating the need to expand and accelerate AI education initiatives.

The experience from these initiatives underscores several critical success factors: the importance of multi-stakeholder partnerships, the need for sustained programs rather than one-off events, the importance of connecting training with real application opportunities, and the need to customize content to local contexts and needs. These lessons can inform the design of more effective AI literacy programs in the future. Additionally, private sector companies have increasingly invested in internal AI training academies. Large corporations in banking, telecommunications, and manufacturing sectors have established corporate universities with dedicated AI curricula. These investments reflect recognition that AI capabilities are becoming essential for competitive advantage. The materials and methodologies developed in these corporate programs offer potential for broader dissemination through partnerships with educational institutions.

I. The Role of Private Sector in AI Literacy Development

The private sector plays a crucial role in AI literacy development in Indonesia, both as users of AI technology, developers of AI solutions, and contributors to the AI education and training ecosystem. Indonesian companies need to take greater responsibility in building AI capabilities, not only for their internal needs but also for contribution to national human resource development. Large companies such as banks, telecommunications, and conglomerates have the capacity to invest significant resources in internal AI training programs. Many of these companies have established corporate academies or learning centers that include AI curricula. The experience and materials from these internal programs can be shared more broadly through partnerships with educational institutions and non-profit organizations.

Indonesian AI startups also play an important role in the AI literacy ecosystem. Many startups provide learning platforms, tools that facilitate access to AI technology, or solutions that enable businesses to adopt AI without requiring deep technical expertise. A dynamic startup ecosystem can accelerate the diffusion of AI literacy to various economic segments. The main challenge for the private sector is balancing short-term competitive needs with investment in long-term capability development. Companies often face trade-offs between recruiting already skilled talent versus developing internal talent. Policy incentives such as tax benefits for training investments can help shift this calculation toward supporting AI literacy development. Furthermore, private sector engagement in shaping AI policy and regulation is increasingly important. Business associations and industry groups can provide valuable input to government on practical implementation challenges and opportunities. This engagement ensures that regulatory frameworks are both protective and enabling of innovation.

Cross-border knowledge transfer also represents a significant opportunity. Multinational companies

operating in Indonesia can serve as conduits for global AI best practices and cutting-edge methodologies. Strategic partnerships between Indonesian firms and international technology leaders can accelerate capability building and provide access to world-class training resources.

J. Future Trends and Prospects

The AI landscape in Indonesia is expected to continue evolving rapidly in the coming years. Several key trends that organizations and policymakers need to pay attention to include technological developments, regulatory changes, and workforce transformation. From a technological perspective, generative AI such as ChatGPT and other large language models will become increasingly integrated into daily business operations. This technology will change how organizations interact with customers, generate content, and automate processes. MSMEs that previously did not have access to advanced AI capabilities will be able to leverage generative AI tools that are increasingly affordable and easy to use.

From a regulatory perspective, Indonesia is expected to accelerate the development of a more comprehensive AI legal framework. Pressure from international trading partners, the need to protect consumers, and the desire to position Indonesia as a regional AI hub will drive progress in this area. Organizations need to prepare for an increasingly strict yet clearer regulatory landscape. From a workforce perspective, demand for professionals with AI expertise will continue to increase, while traditional roles will undergo transformation. AI literacy will no longer be a competitive advantage but a basic requirement for employability. Education and training programs must adapt quickly to meet these evolving needs.

Indonesia has great potential to become an AI leader in Southeast Asia given its economic size and young population. However, realizing this potential requires sustained commitment to AI literacy development, infrastructure building, and formation of a governance ecosystem that supports innovation while protecting public interests. The emergence of AI agents and autonomous systems presents both opportunities and challenges. These systems can handle increasingly complex tasks with minimal human intervention, potentially transforming business processes across industries. However, they also raise new governance questions around accountability and control that regulators must address. Edge AI and distributed computing will enable AI capabilities in remote and underserved areas, potentially helping bridge the digital divide. Indonesian organizations and policymakers should monitor these developments and plan for their integration into national AI strategy.

K. Comparative Analysis with Regional Peers

Understanding Indonesia's position in AI literacy and governance relative to regional peers provides valuable context for strategy development. Singapore, Malaysia, Thailand, Vietnam, and the Philippines each offer different models and lessons that Indonesia can learn from. Singapore has established itself as the regional leader in AI governance and literacy. The Model AI Governance Framework, first released in 2019 and updated in 2020, provides a principles-based approach that has been widely referenced globally. Singapore's investment in AI research through AI Singapore and the National AI Strategy demonstrates sustained government commitment. Indonesia can learn from Singapore's emphasis on practical guidance and industry collaboration.

Malaysia's National AI Roadmap launched in 2021 focuses on developing AI talent and fostering an AI ecosystem. The country has invested significantly in AI education, including dedicated AI degrees at public universities. Malaysia's approach to public-private partnerships in AI development offers lessons for Indonesia in mobilizing resources across sectors. Thailand has taken a sector-focused approach, prioritizing AI applications in healthcare, agriculture, and smart cities. The Thai government's coordination mechanisms for AI development across ministries provide a model for inter-agency collaboration. Indonesia's larger and more diverse economy may require similar sector-specific strategies. Vietnam's rapid emergence as a technology hub has been accompanied by growing attention to AI. The country's young and tech-savvy population, combined with strong manufacturing base, creates unique opportunities for AI adoption. Vietnam's success in attracting foreign investment in technology provides lessons for Indonesia in positioning

itself in global AI value chains. The Philippines' approach emphasizes AI for social good and inclusive development. Programs targeting underserved communities and focusing on AI applications for development challenges offer a model for Indonesia's aspirations to ensure AI benefits reach all segments of society.

L. Implementation Roadmap

Based on the analysis presented in this study, a phased implementation roadmap for enhancing AI literacy and governance in Indonesia can be proposed. This roadmap addresses short-term, medium-term, and long-term priorities while recognizing the need for flexibility as the AI landscape evolves. In the short term (1-2 years), priority should be given to foundational activities. These include completing the National AI Roadmap and Ethical Guidelines, establishing baseline assessments of AI literacy across different sectors and demographics, launching pilot AI literacy programs in selected educational institutions, and creating platforms for multi-stakeholder dialogue on AI governance.

In the medium term (3-5 years), focus should shift to scaling and institutionalization. This includes integrating AI literacy into national education curricula at all levels, establishing certification systems for AI competencies, strengthening regulatory frameworks with dedicated AI legislation, building AI centers of excellence in partnership with leading research institutions, and developing sector-specific AI adoption guidelines.

In the long term (5-10 years), Indonesia should aim for leadership and innovation. This includes positioning Indonesia as a regional hub for responsible AI development, achieving widespread AI literacy across the workforce, establishing robust AI governance mechanisms that balance innovation and protection, contributing to international AI standards and norms, and leveraging AI for national development priorities including sustainable development goals. Success metrics should be established for each phase, including quantitative indicators such as percentage of workforce with AI literacy certifications, number of AI-related regulations enacted, AI adoption rates across sectors, and qualitative measures such as stakeholder satisfaction with AI governance and international recognition of Indonesia's AI ecosystem. Regular review and adjustment of the roadmap will be essential given the rapid pace of AI advancement. An agile governance approach that can respond to emerging challenges and opportunities should be embedded in implementation structures.

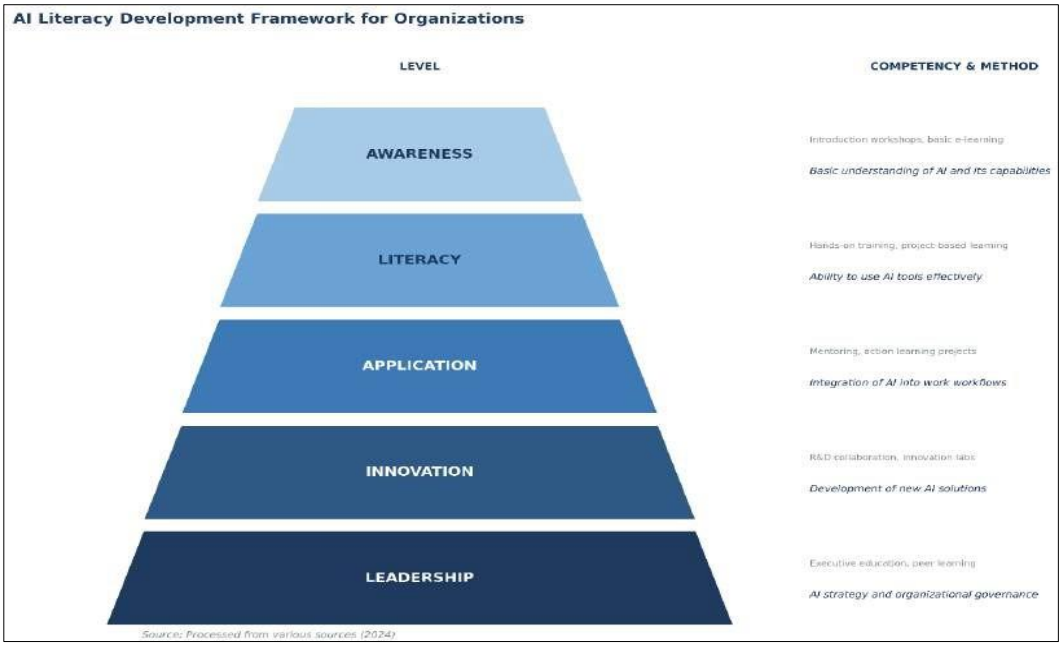


Table III. AI LITERACY DEVELOPMENT FRAMEWORK FOR ORGANIZATIONS

Level	Competency	Development Method
Awareness	Basic understanding of AI and its capabilities	Introduction workshops, basic e-learning
Literacy	Ability to use AI tools effectively	Hands-on training, project-based learning
Application	Integration of AI into work workflows	Mentoring, action learning projects
Innovation	Development of new AI solutions	R&D collaboration, innovation labs
Leadership	AI strategy and organizational governance	Executive education, peer learning

Source: Processed from various sources (2024)

M. Sectoral Analysis of AI Adoption

AI adoption patterns and literacy requirements vary significantly across Indonesia's key economic sectors. Understanding these sectoral differences is essential for developing targeted strategies and allocating resources effectively. In the financial services sector, AI adoption is relatively advanced, driven by applications in fraud detection, credit scoring, customer service automation, and algorithmic trading. Major banks have established dedicated AI teams and invested significantly in building internal capabilities. However, challenges remain in ensuring AI systems comply with regulatory requirements and maintaining customer trust. AI literacy in this sector requires strong emphasis on risk management and ethical considerations.

The manufacturing sector presents significant opportunities for AI-driven efficiency gains through predictive maintenance, quality control, and supply chain optimization. However, adoption levels remain uneven, with large manufacturers more advanced than SMEs. AI literacy initiatives in manufacturing should focus on practical applications that demonstrate clear ROI and address the specific skill gaps among technical staff and production managers. Healthcare represents a promising frontier for AI in Indonesia, with applications in diagnostic imaging, drug discovery, patient management, and public health surveillance. The COVID-19 pandemic accelerated interest in AI-powered health solutions. However, regulatory uncertainties, data privacy concerns, and limited digital infrastructure in many healthcare facilities constrain adoption. AI literacy for healthcare professionals must emphasize both clinical applications and ethical considerations around patient data.

The agricultural sector, crucial for Indonesia's economy and food security, can benefit from AI applications in crop monitoring, yield prediction, pest management, and supply chain optimization. However, adoption is limited by infrastructure gaps, low digital literacy among farmers, and lack of locally relevant AI solutions. AI literacy initiatives targeting agriculture must be designed for audiences with limited technical backgrounds and delivered through accessible channels.E-commerce and digital services have emerged as rapid adopters of AI, leveraging recommendation engines, dynamic pricing, chatbots, and logistics optimization. Companies like Tokopedia, Bukalapak, and Gojek have built sophisticated AI capabilities. This sector serves as a model for other industries and a source of AI talent development. AI literacy in this sector focuses on cutting-edge applications and continuous innovation.

The public sector represents both a major opportunity and a significant challenge for AI adoption. Government agencies can leverage AI for service delivery, fraud detection, resource allocation, and policy analysis. However, bureaucratic culture, legacy systems, and procurement processes often impede adoption. AI literacy for public servants must address not only technical skills but also change management and ethical considerations in public service delivery.

N. Digital Infrastructure Requirements

Robust digital infrastructure is a fundamental prerequisite for AI adoption and effective AI literacy programs. Indonesia's current infrastructure presents both opportunities and constraints that must be addressed in national AI strategy. Telecommunications infrastructure has improved

significantly with 4G coverage now reaching most urban and many rural areas. The ongoing 5G rollout will further enhance connectivity, enabling more sophisticated AI applications particularly in areas requiring low latency such as autonomous systems and real-time analytics. However, significant coverage gaps remain in remote and underserved areas, creating digital divides that affect AI access.

Data center capacity is expanding rapidly in Indonesia, with major investments from both domestic and international players. This growth supports the computational requirements for AI training and deployment. However, data localization requirements and energy costs present challenges that must be addressed through policy coordination and infrastructure investment. Cloud computing adoption is accelerating, providing organizations with scalable access to AI capabilities without requiring large upfront investments. Major cloud providers including AWS, Google Cloud, Microsoft Azure, and local players like Biznet have established presence in Indonesia. Cloud-based AI services democratize access to sophisticated capabilities, enabling even small organizations to leverage AI.

Edge computing infrastructure will become increasingly important as AI applications move closer to data sources. This is particularly relevant for Indonesia's archipelagic geography, where centralized processing may face latency and connectivity challenges. Investment in edge infrastructure can enable AI applications in remote locations including agricultural monitoring, environmental sensing, and healthcare delivery. Digital identity infrastructure, including the national e-KTP system and growing digital identity services, provides foundation for AI applications requiring verified identity. However, interoperability challenges and privacy concerns must be addressed to fully leverage this infrastructure for AI-powered services. Open data initiatives and data sharing frameworks are essential for AI development. Indonesia has made progress with the One Data Indonesia initiative, but significant work remains in improving data quality, standardization, and accessibility. AI literacy programs should include data literacy components that prepare individuals to work with and contribute to data ecosystems.

O. International Cooperation and Knowledge Transfer

International cooperation plays a vital role in accelerating AI literacy and governance development in Indonesia. Strategic engagement with global partners can provide access to knowledge, resources, and best practices while positioning Indonesia in the global AI ecosystem. Bilateral cooperation with leading AI nations offers opportunities for knowledge transfer and capacity building. Indonesia has engaged with Singapore, Japan, South Korea, China, the United States, and European countries on various AI-related initiatives. These partnerships can support AI research collaboration, talent development programs, and policy dialogue.

Regional cooperation through ASEAN provides a framework for harmonized AI governance and collective action. The ASEAN Guide on AI Governance and Ethics offers principles that member states can adapt to their national contexts. Cooperation on cross-border data flows, AI standards, and talent mobility can benefit the entire region while addressing shared challenges. Multilateral engagement through organizations such as the OECD, G20, UNESCO, and ITU enables Indonesia to participate in shaping global AI norms and standards. Active participation in these forums ensures that Indonesian perspectives and interests are represented in international AI governance discussions.

Academic and research partnerships with leading international institutions can accelerate AI research capacity in Indonesia. Collaborative research programs, joint degree offerings, and researcher exchanges provide pathways for knowledge transfer and talent development. Indonesian universities should actively seek such partnerships while building their own research capabilities. Private sector engagement with multinational technology companies offers another channel for knowledge transfer. Technology companies operating in Indonesia can contribute to local ecosystem development through training programs, startup incubation, and technology partnerships. Policy frameworks should encourage such contributions while ensuring appropriate knowledge retention. Development partner support from organizations such as the World Bank, Asian Development Bank, and bilateral aid agencies can provide resources for AI-related capacity

building. Indonesia should strategically leverage these resources for priority areas including education, governance, and infrastructure development.

P. Risk Assessment and Mitigation

Effective AI adoption and governance require systematic assessment and mitigation of associated risks. Indonesia must develop capabilities for identifying, evaluating, and managing AI-related risks across technical, ethical, economic, and social dimensions. echnical risks include system failures, security vulnerabilities, and performance degradation. AI systems can produce incorrect or biased outputs that lead to harmful decisions. Organizations must implement rigorous testing, monitoring, and validation processes. AI literacy programs should include components on understanding AI limitations and implementing appropriate safeguards.

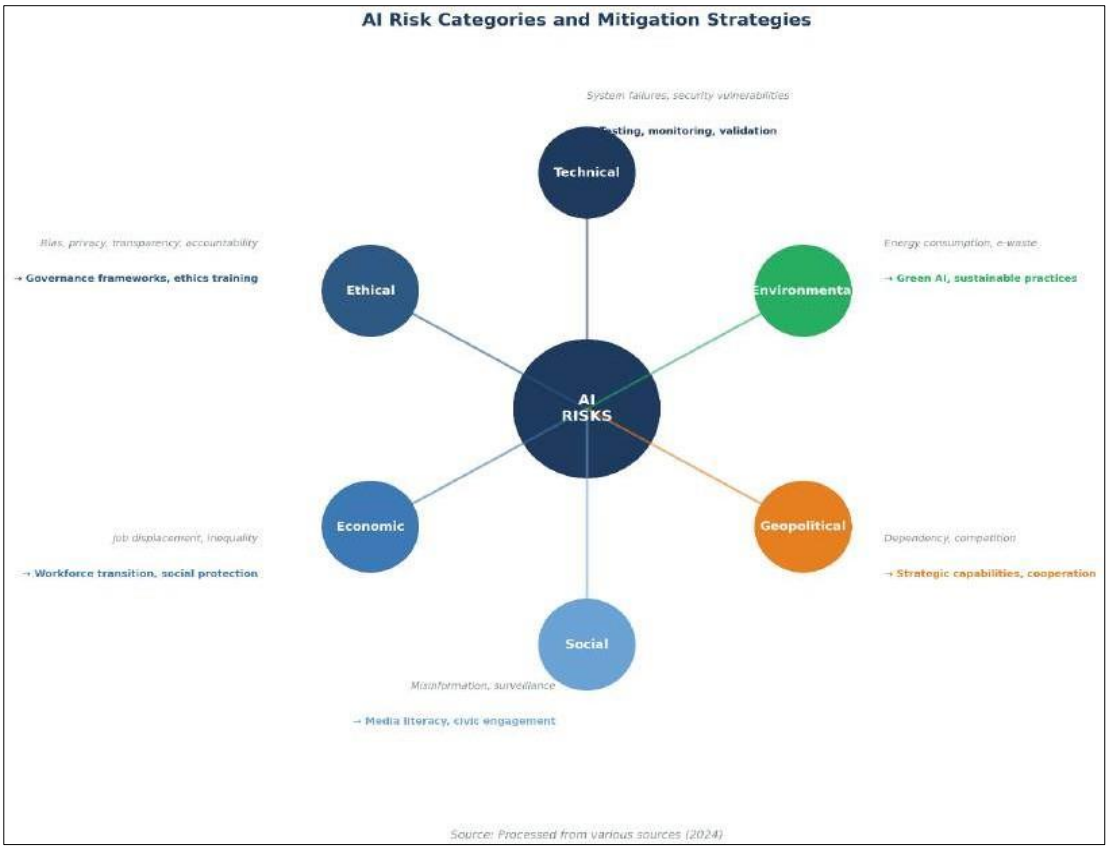
Ethical risks encompass issues of fairness, privacy, transparency, and accountability. AI systems may perpetuate or amplify existing biases, infringe on privacy, operate as black boxes, or make decisions without clear accountability. Governance frameworks must address these risks through principles, guidelines, and enforcement mechanisms. Ethical AI literacy is essential for all stakeholders involved in AI development and deployment. Economic risks include job displacement, market concentration, and economic inequality. While AI creates new opportunities, it may also eliminate certain jobs and concentrate economic power among those with AI capabilities. Policy responses should include investment in workforce transition, support for affected communities, and measures to ensure competitive markets.

Social risks involve impacts on social cohesion, democratic processes, and human autonomy. AI-powered misinformation, surveillance, and manipulation can undermine social trust and democratic institutions. Robust governance, media literacy, and civic engagement are essential for mitigating these risks. Geopolitical risks relate to AI competition and dependence. Reliance on foreign AI technologies and platforms may create vulnerabilities. Indonesia should develop strategic capabilities while maintaining international cooperation. Balanced approaches to AI sovereignty and openness are needed. Risk mitigation requires multi-stakeholder collaboration, combining government regulation, industry self-regulation, civil society oversight, and individual responsibility. Building risk assessment capabilities across sectors should be a priority in AI literacy and governance programs.

Table Iv. AI RISK CATEGORIES AND MITIGATION STRATEGIES

Risk Category	Key Concerns	Mitigation Approach
Technical	System failures, security vulnerabilities	Testing, monitoring, validation
Ethical	Bias, privacy, transparency, accountability	Governance frameworks, ethics training
Economic	Job displacement, inequality	Workforce transition, social protection
Social	Misinformation, surveillance	Media literacy, civic engagement
Geopolitical	Dependency, competition	Strategic capabilities, cooperation
Environmental	Energy consumption, e-waste	Green AI, sustainable practices

Source: Processed from various sources (2024)



Q. Monitoring and Evaluation Framework

A robust monitoring and evaluation (M&E) framework is essential for tracking progress in AI literacy development and governance effectiveness. This framework should incorporate both quantitative and qualitative indicators, enabling evidence-based adjustments to strategies and programs. Key performance indicators for AI literacy should span multiple dimensions. Input indicators measure resources allocated, such as training budgets, educator development, and infrastructure investments. Output indicators track direct results, including number of individuals trained, certifications awarded, and programs implemented. Outcome indicators assess behavioral and capability changes, such as AI tool adoption rates, job placements in AI-related roles, and innovation outputs.

Impact indicators evaluate broader effects on economic and social outcomes. These include productivity gains from AI adoption, competitiveness improvements, and equity in AI access and benefits. Long-term impact assessment requires sustained data collection and analysis capabilities. Governance effectiveness can be monitored through indicators such as regulatory compliance rates, incident reporting and resolution, stakeholder satisfaction, and international rankings on AI governance. Regular governance audits and reviews should complement quantitative monitoring. Data collection mechanisms should leverage both traditional surveys and emerging digital methods. Administrative data from educational institutions, professional certification bodies, and government agencies provides baseline information. Surveys and assessments can capture perception and capability data. Digital analytics can track online learning engagement and AI tool usage patterns.

Evaluation approaches should combine formative and summative methods. Formative evaluation during implementation enables real-time adjustments. Summative evaluation at program completion assesses overall effectiveness. Rigorous impact evaluation using experimental or quasi-experimental designs provides evidence for scaling effective interventions. Transparency and accountability require regular public reporting on AI literacy and governance progress. Annual reports, dashboards, and stakeholder consultations ensure that progress and challenges are visible

and subject to public scrutiny. Independent evaluation by external parties adds credibility to assessment findings.

R. Funding and Resource Mobilization

Sustained and adequate funding is critical for achieving AI literacy and governance objectives. Indonesia must mobilize resources from diverse sources while ensuring efficient allocation and use of available funds. Government budget allocation for AI-related programs should reflect the strategic importance of AI for national development. This includes funding for education and training, research and development, infrastructure, and governance institutions. Budget coordination across ministries is essential to avoid duplication and ensure comprehensive coverage.

Private sector investment represents the largest potential source of AI-related funding. Corporate training budgets, R&D investments, and technology adoption spending all contribute to AI capability building. Policy incentives such as tax benefits, matching grants, and regulatory facilitation can encourage private investment in priority areas. Development partner support provides supplementary resources for capacity building. Indonesia should strategically engage with multilateral institutions, bilateral donors, and foundations to access funding for AI literacy and governance programs. Alignment with partner priorities and effective program implementation are essential for sustained support.

Innovative financing mechanisms can expand available resources. Public-private partnerships, social impact bonds, and blended finance approaches can mobilize additional capital. Revenue from AI-related services and data monetization may provide sustainable funding sources over time. Resource efficiency requires robust planning, procurement, and management processes. Competitive procurement, performance-based contracting, and rigorous monitoring help ensure that resources are used effectively. Knowledge sharing and coordination among implementing agencies can reduce costs and improve outcomes. Long-term sustainability requires building domestic funding capacity. As Indonesia develops its AI ecosystem, private sector growth and increased tax revenues can progressively replace external funding sources. Strategic planning should incorporate sustainability considerations from the outset.

S. Stakeholder Engagement Strategy

Effective AI literacy and governance development requires sustained engagement with diverse stakeholders. A comprehensive stakeholder engagement strategy ensures that perspectives are heard, capabilities are leveraged, and commitment is secured. Government stakeholders span multiple ministries and agencies with AI-related mandates. Coordination mechanisms such as inter-ministerial committees and dedicated coordination units help align efforts across government. Regular engagement with legislative bodies ensures that AI governance receives appropriate attention and resources. Private sector engagement should encompass large corporations, SMEs, and startups. Industry associations provide platforms for collective engagement on policy issues and standards development. Individual company engagement enables tailored collaboration on specific initiatives.

Educational institutions at all levels are critical stakeholders in AI literacy development. Universities contribute through research, curriculum development, and talent production. Schools implement foundational AI literacy programs. Vocational institutions prepare workers for AI-transformed industries. Civil society organizations provide important perspectives on AI impacts and governance. Consumer groups advocate for user protection. Human rights organizations monitor AI-related rights issues. Environmental groups address AI sustainability concerns. Academic researchers contribute independent analysis and evaluation. International stakeholders include foreign governments, international organizations, multinational companies, and global civil society. Engagement with these stakeholders positions Indonesia in global AI discussions and provides access to international resources and expertise.

Effective engagement requires multiple channels and formats. Formal consultation processes gather

structured input on policy and program development. Ongoing dialogue through working groups and advisory bodies enables sustained engagement. Public communication builds broader awareness and support. Engagement outcomes should be tracked and communicated. Stakeholders should see how their input influences decisions. Transparent feedback loops build trust and encourage continued participation in the national AI development journey.

T. Emerging Technologies and Future AI Developments

The AI landscape continues to evolve rapidly, with emerging technologies presenting new opportunities and challenges for Indonesia's AI literacy and governance frameworks. Understanding these developments is essential for future-proofing national AI strategy. Large Language Models (LLMs) and generative AI have dramatically expanded AI capabilities and accessibility. Tools like ChatGPT, Claude, and Gemini enable natural language interaction with AI systems, lowering barriers to AI adoption. However, they also raise new concerns about misinformation, copyright, and the changing nature of knowledge work. AI literacy programs must address both the opportunities and risks of generative AI.

Multimodal AI systems that process text, images, audio, and video together are becoming increasingly sophisticated. These systems enable applications from content creation to medical diagnosis. Their complexity poses challenges for explainability and governance that must be addressed through evolving frameworks. AI agents and autonomous systems capable of taking actions in the real world represent a significant frontier. From self-driving vehicles to automated trading systems, these technologies require robust governance mechanisms to ensure safety and accountability. Indonesia should monitor developments and develop appropriate regulatory responses. Edge AI and embedded intelligence enable AI processing at the device level, reducing latency and enhancing privacy. This technology is particularly relevant for Indonesia's diverse geography and connectivity challenges. Applications in agriculture, healthcare, and industrial monitoring can benefit from edge AI deployment.

Quantum computing promises to dramatically enhance certain AI capabilities, potentially enabling breakthroughs in optimization, simulation, and cryptography. While practical quantum AI remains years away, Indonesia should begin building foundational knowledge and exploring potential applications. Neuromorphic computing inspired by brain architecture offers potential for more efficient and capable AI systems. This technology may enable new applications and reduce the energy footprint of AI. Awareness of these developments should be incorporated into advanced AI literacy programs. Responsible AI technologies including explainability tools, bias detection methods, and privacy-preserving techniques are advancing rapidly. These technologies support ethical AI implementation and should be promoted as part of AI governance frameworks.

U. Environmental Sustainability of AI

The environmental impact of AI is an increasingly important consideration that must be integrated into AI literacy and governance frameworks. AI systems consume significant energy and resources, with implications for Indonesia's sustainability commitments. AI training and inference require substantial computational resources, resulting in significant energy consumption and carbon emissions. Large language models in particular have drawn attention for their environmental footprint. Organizations adopting AI should consider energy efficiency and carbon impact in their technology choices. Data centers supporting AI workloads consume large amounts of electricity and water for cooling. As AI adoption grows, so does data center demand. Indonesia's data center development should prioritize renewable energy sources and efficient cooling technologies to minimize environmental impact.

Electronic waste from AI hardware including GPUs, servers, and edge devices poses disposal and recycling challenges. Lifecycle considerations should inform procurement decisions, and responsible disposal mechanisms should be developed. AI can also contribute positively to environmental sustainability through applications in energy optimization, environmental monitoring, climate modeling, and sustainable resource management. These applications should be promoted as part of Indonesia's green economy strategy. Green AI practices including model

efficiency, hardware optimization, and carbon-aware computing should be incorporated into AI development standards and literacy programs. Organizations should measure and report on the environmental impact of their AI systems. International cooperation on sustainable AI standards and practices can help align Indonesia's approach with global best practices. Participation in forums addressing AI sustainability ensures that Indonesian perspectives are represented.

V. Social Inclusion and Equity Considerations

Ensuring that AI benefits are distributed equitably across Indonesian society is a fundamental principle that should guide AI literacy and governance development. Without intentional efforts, AI adoption may exacerbate existing inequalities. Geographic disparities between urban and rural areas in AI access and capabilities require targeted interventions. Infrastructure investment, localized content development, and delivery mechanisms appropriate for underserved areas can help bridge the digital divide. Gender gaps in AI participation persist globally and likely in Indonesia. Women are underrepresented in AI education, careers, and leadership roles. Programs specifically targeting women's participation in AI can help address this imbalance. Youth engagement in AI is critical for Indonesia's demographic dividend. Young people are often quick adopters of new technologies but may lack critical evaluation skills.

AI literacy programs for youth should balance enthusiasm with responsible use. Persons with disabilities may face barriers to AI access and may be disproportionately impacted by AI-driven decisions. Accessibility standards for AI systems and inclusive design practices should be promoted. Small and medium enterprises may lack resources to adopt AI independently. Support programs including shared services, training, and financing can help SMEs participate in the AI economy. Informal sector workers and gig economy participants face particular challenges as AI transforms work. Social protection mechanisms and transition support should address the needs of these vulnerable groups. Indigenous communities and minority groups may have distinct perspectives and needs regarding AI. Engagement with these communities should inform AI literacy and governance development to ensure cultural sensitivity and appropriate participation.

W. Research Priorities and Knowledge Gaps

Advancing AI literacy and governance in Indonesia requires addressing significant knowledge gaps through targeted research. Understanding current limitations and priorities can guide resource allocation and international collaboration. Empirical research on AI literacy levels and determinants in Indonesia remains limited. Comprehensive baseline studies using validated instruments would enable tracking of progress and identification of priority interventions. Longitudinal research designs can capture changes over time. Impact evaluation of AI literacy programs is essential for evidence-based policy. Rigorous evaluation designs including randomized controlled trials where appropriate can identify what works and inform program scaling. Cost-effectiveness analysis can guide resource allocation decisions.

Research on AI governance effectiveness in Indonesian context is needed. This includes studies of regulatory implementation, compliance behaviors, and governance outcomes. Comparative research with other countries can identify transferable practices. Sector-specific AI adoption research can inform targeted strategies. Understanding barriers and enablers of AI adoption in key sectors like manufacturing, healthcare, and agriculture enables customized support programs. Social science research on AI impacts including employment effects, social attitudes, and behavioral changes can inform policy responses. Interdisciplinary approaches combining technical and social perspectives are particularly valuable. Research capacity building within Indonesian institutions should be a priority. Investment in research infrastructure, researcher development, and international collaboration can strengthen the knowledge base for AI policy and practice. Open research practices including data sharing, preregistration, and open access publication can maximize the value of research investments and enable cumulative knowledge building.

X. Policy Coherence and Coordination Mechanisms

Achieving effective AI literacy and governance requires policy coherence across government

agencies and alignment with broader national development objectives. Coordination mechanisms must address the cross-cutting nature of AI while respecting institutional mandates. AI policy touches multiple ministerial portfolios including communication and information technology, education, industry, trade, labor, and finance. Each ministry brings relevant expertise but may have different priorities and perspectives. Horizontal coordination mechanisms are essential for coherent policy development. The relationship between national AI strategy and sectoral policies requires careful management. AI applications in healthcare, agriculture, manufacturing, and other sectors must align with both AI governance principles and sector-specific regulations. Policy coherence analysis can identify conflicts and gaps.

Local government implementation of national AI policies requires attention. Provinces and districts vary in capacity and priorities. Guidance, capacity building, and incentive mechanisms can support effective local implementation while accommodating contextual differences. Parliamentary engagement ensures democratic oversight of AI policy and governance. Legislative committees should develop expertise on AI issues and provide scrutiny of executive policies and programs. Public hearings and inquiries can raise awareness and gather diverse perspectives.Judicial system preparation for AI-related disputes is important as adoption grows. Judges and court officials may need training on AI issues to handle cases involving AI systems. Legal frameworks should clarify liability and dispute resolution mechanisms. International policy coherence requires alignment with global norms and commitments. Indonesia's positions in international forums should be informed by domestic policy and vice versa. Trade agreements and international cooperation mechanisms should support rather than constrain domestic AI development.

Y. Communication and Public Awareness

Effective communication and public awareness strategies are essential for building broad support for AI literacy and governance initiatives. Public understanding of AI opportunities and risks shapes the environment for policy and investment. Public perception of AI in Indonesia appears to be generally positive but may lack depth. Many people have encountered AI through consumer applications but may not understand underlying technologies or implications. Communication strategies should address different levels of awareness and interest. Media engagement can shape public discourse on AI. Journalists and content creators need access to accurate information and expert sources. Media literacy initiatives should include AI-specific components to support quality reporting. Social media and digital channels offer opportunities for broad reach but also risks of misinformation. Official communication through verified channels should provide authoritative information. Monitoring of AI-related discourse can identify and address misinformation.

Community engagement approaches can reach populations not well served by digital channels. Local leaders, community organizations, and extension services can convey AI information in accessible formats. Two-way communication enables feedback and local perspective gathering. Education system communication ensures alignment between formal curricula and public messaging. Parents and community members should understand and support AI literacy education. Career guidance should incorporate AI-related opportunities. Crisis communication preparedness is important given potential AI-related incidents. Clear protocols for communicating about AI failures, misuse, or controversial applications can help maintain public trust and provide accurate information.

Z. Long-term Vision and Strategic Direction

Indonesia's AI journey requires a clear long-term vision that guides immediate actions while remaining adaptable to evolving circumstances. This vision should articulate aspirations for AI's role in national development and Indonesia's position in the global AI ecosystem. The vision should encompass economic objectives including productivity growth, innovation capacity, and competitive positioning. AI can contribute to Indonesia's ambition to become a high-income country by enhancing value-added across sectors and enabling participation in knowledge-intensive global value chains. Social objectives should emphasize inclusive development that ensures AI benefits reach all Indonesians. This includes quality employment, improved public services, and enhanced quality of life. AI should reduce rather than exacerbate inequalities across

regions, genders, and socioeconomic groups.

Sustainability objectives should position AI as a tool for environmental protection and climate action. Green AI practices and AI applications for sustainability can contribute to Indonesia's environmental commitments and natural resource stewardship. Sovereignty and security considerations should ensure that AI development protects national interests and citizen rights. This includes developing strategic capabilities, ensuring data security, and maintaining appropriate autonomy in critical systems. The vision should be supported by measurable goals and milestones that enable tracking of progress. Regular review and updating ensures relevance as circumstances evolve. Scenario planning can prepare for alternative futures and build adaptive capacity. Broad stakeholder ownership of the vision builds commitment to implementation. Inclusive visioning processes ensure that diverse perspectives are reflected. Communication of the vision inspires action across society toward shared AI aspirations for Indonesia.

TABLE V. IMPLEMENTATION ROADMAP TIMELINE

Phase	Timeframe	Key Activities
Foundation	2024-2025	National roadmap, baseline assessment, pilot programs
Scaling	2026-2028	Curriculum integration, certification systems, AI legislation
Leadership	2029-2035	Regional hub positioning, international standards contribution

Source: Proposed framework based on analysis (2024)

AA. Lessons from Global Best Practices

Analysis of global best practices in AI literacy and governance provides valuable insights that can inform Indonesia's approach. Countries and organizations that have successfully developed AI capabilities offer transferable lessons, while recognizing the need for adaptation to local context. Finland's Elements of AI course represents a successful model for mass AI literacy education. Originally developed by the University of Helsinki and Reaktor, this free online course has reached millions of learners globally. Key success factors include accessible content design, strong partnerships, and clear communication of practical benefits. Indonesia could develop similar nationally branded courses adapted to local context and languages.

Singapore's AI governance approach demonstrates effective balance between enabling innovation and protecting public interests. The Model AI Governance Framework provides practical guidance that has been widely adopted by organizations. Singapore's emphasis on implementation toolkits and industry collaboration offers lessons for translating principles into practice. The European Union's comprehensive AI Act provides a model for risk-based regulation that categorizes AI systems and applies proportionate requirements. While Indonesia's context differs, the EU

approach to stakeholder consultation, impact assessment, and phased implementation offers relevant lessons.

Estonia's digital government achievements show how small countries can leverage technology for transformation. Estonia's emphasis on digital identity, interoperability, and citizen-centric services provides lessons applicable to Indonesia's e-government AI aspirations. Private sector leaders including Google, Microsoft, and IBM have developed extensive AI ethics frameworks and responsible AI practices. Their experience with implementation challenges, governance structures, and stakeholder engagement informs corporate AI governance approaches. International organizations including OECD, UNESCO, and the World Economic Forum have developed AI principles and guidelines through inclusive multi-stakeholder processes. Indonesia's participation in these processes and adoption of their outputs supports global alignment while preserving national sovereignty.

AB. Critical Success Factors

Synthesis of analysis across sections reveals several critical success factors that will determine Indonesia's achievement of AI literacy and governance objectives. These factors require sustained attention from all stakeholders. Political will and leadership at the highest levels is essential for prioritizing AI development and allocating necessary resources. Presidential and ministerial commitment signals importance and enables coordination across government. Sustained leadership through political transitions requires institutionalization of AI priorities. Institutional capacity determines ability to implement policies and programs effectively. This includes human resources, organizational structures, processes, and technical systems. Capacity building should be a cross-cutting priority in AI initiatives.

Financial sustainability requires diverse funding sources and efficient resource use. Over-reliance on external funding creates vulnerability. Building domestic funding capacity through economic growth and taxation supports long-term sustainability. Multi-stakeholder collaboration brings together complementary capabilities and ensures broad ownership. Trust-building among stakeholders enables effective collaboration. Clear roles and coordination mechanisms prevent duplication and gaps. Adaptive management approaches enable response to rapid change and emerging challenges. Monitoring, learning, and adjustment cycles should be built into all programs. Scenario planning and contingency preparation enhance resilience.

Public trust and social license provides the foundation for AI adoption and governance. Transparent communication, inclusive engagement, and demonstrable benefits build public support. Addressing concerns about jobs, privacy, and fairness is essential for maintaining trust. International engagement positions Indonesia favorably in the global AI ecosystem. Active participation in international forums, strategic partnerships, and openness to knowledge transfer accelerate capability development while protecting national interests.

AC. Call to Action

The findings of this research underscore the urgency of coordinated action to advance AI literacy and governance in Indonesia. Delay will result in missed opportunities and potentially harmful outcomes as AI adoption accelerates without adequate preparation. All stakeholders must recognize their roles and take concrete steps. For government, priorities include finalizing the National AI Roadmap and Ethical Guidelines, accelerating regulatory development, increasing budget allocation for AI literacy programs, strengthening coordination mechanisms across ministries, and actively engaging in international AI governance discussions. For the private sector, priorities include investing in workforce AI literacy development, implementing responsible AI governance frameworks, collaborating with educational institutions on talent development, sharing best practices across industry associations, and engaging constructively in policy development processes.

For educational institutions, priorities include integrating AI literacy across curricula at all levels, developing educator capacity for AI instruction, strengthening research programs on AI topics, partnering with industry on applied learning opportunities, and contributing expertise to public

policy discussions. For civil society, priorities include advocating for inclusive AI policies that protect vulnerable groups, monitoring AI impacts and raising concerns, contributing diverse perspectives to governance discussions, building public awareness of AI opportunities and risks, and holding all stakeholders accountable for commitments. For international partners, priorities include supporting capacity building aligned with Indonesia's priorities, sharing knowledge and best practices from other contexts, facilitating access to global resources and networks, collaborating on research and innovation initiatives, and respecting Indonesian sovereignty in AI governance choices.

CONCLUSION

Based on the systematic literature review conducted, it can be concluded that artificial intelligence literacy is a critical foundation for sustainable business transformation in Indonesia. AI literacy encompasses not only technical skills in using AI technology but also critical understanding of the implications, limitations, and ethical considerations of AI. In Indonesia's context, where 77% of business leaders recognize AI as a critical opportunity for economic growth, comprehensive AI literacy development becomes highly urgent. This research identifies several strategic gaps hindering effective AI implementation in Indonesia. Human capital and skills gaps (with 45% of businesses reporting shortage of digital talent), infrastructure challenges (84% of businesses citing it as main barrier), ethical governance weaknesses

(only 45% understand ethical AI use and 24% have clear governance processes), and regional disparities in AI adoption, all require serious attention and coordinated intervention from various stakeholders. AI governance challenges in Indonesia primarily stem from regulatory fragmentation, where there is no dedicated AI law and reliance on existing legal frameworks not designed for AI technology. The complexity of multi-stakeholder coordination and bureaucratic inertia also add to challenges in building an effective AI governance ecosystem. Efforts in drafting the National AI Roadmap and Ethical Guidelines represent positive steps, yet implementation and enforcement remain challenges that need to be addressed through sustained commitment and adequate resource allocation.

The analysis reveals that sectoral variations in AI adoption require tailored approaches. Financial services, manufacturing, healthcare, agriculture, e-commerce, and public sector each present distinct opportunities and challenges. Understanding these sectoral differences enables more effective resource allocation and program design. International comparison with regional peers including Singapore, Malaysia, Thailand, Vietnam, and the Philippines provides valuable benchmarks and lessons. Each country offers different models that Indonesia can adapt to its unique context and priorities.

Strategic recommendations include integrating AI literacy into national education curricula at all levels, adopting skills-based hiring practices that prioritize competencies over traditional qualifications, fostering a culture of continuous learning within organizations, and strengthening multi-stakeholder cooperation across government, industry, education, and civil society. For AI governance strengthening, recommendations include leveraging AI itself for real-time policy insights, establishing robust ethical frameworks with clear accountability mechanisms, accelerating comprehensive AI regulation while maintaining flexibility for innovation, and building strong oversight and enforcement capacity.

Implementation success will depend on adequate and sustained funding from diverse sources, effective stakeholder engagement strategies, robust monitoring and evaluation frameworks, and adaptive management approaches that can respond to rapid technological change. Environmental sustainability considerations must be integrated into AI development and governance. Green AI practices, energy-efficient computing, and AI applications for environmental protection should be promoted as part of Indonesia's sustainable development commitments. Social inclusion and equity must be central to AI literacy and governance strategies. Targeted interventions for underserved areas, gender-responsive programming, youth engagement, accessibility for persons with disabilities, and protection for vulnerable workers can help ensure that AI benefits are broadly shared.

In conclusion, Indonesia is at a critical crossroads in its digital transformation journey. Success in harnessing AI's transformative potential while managing risks and ethical implications will heavily depend on commitment to comprehensive AI literacy development and building a robust governance ecosystem. Coordinated efforts from government, private sector, educational institutions, and civil society are needed to build a solid foundation for the AI era in Indonesia. The window of opportunity is open, but decisive action is needed to ensure Indonesia realizes its AI potential. Future research is recommended to explore quantitative empirical studies measuring the impact of AI literacy programs on business performance and individual outcomes, evaluation of AI governance model effectiveness in Indonesian context, longitudinal studies tracking AI literacy development over time, sector-specific adoption studies, and comparative research with regional peers. Such research will provide the evidence base for continued improvement of AI literacy and governance approaches.

REFERENCES

Chui, M., Manyika, J., & Miremadi, M. (2023). What AI can and can't do (yet) for your business.

McKinsey Quarterly, *2023*(1), 1–12.

Deloitte. (2024). *AI-driven educational transformation in Indonesia*. Deloitte Insights.

Floridi, L., & Cowls, J. (2019). A unified framework of five principles for AI in society. *Harvard Data Science Review*, *1*(1), 1–15.

Government of Indonesia. (2024). *Indonesia to use agentic AI for smarter, faster policy analysis* [Press release].

Herbert Smith Freehills. (2024). *Indonesia AI regulation update*. Herbert Smith Freehills.

IBM. (2024a). *IBM provides free AI training for youth and women learners in Indonesia*. IBM Corporate Social Responsibility.

IBM. (2024b). *IBM study: Indonesia businesses primed for AI, but face gaps in skills and infrastructure*.

IBM Newsroom Indonesia.

Jang, M. (2024). The mediating role of perceived usefulness in AI adoption behavior: A study of text-based generative AI. *Journal of Educational Technology*, *42*(3), 215–232.

Ke, F., Chen, Y., Wang, L., & Zhang, H. (2025). AI literacy as a predictor of perceived usefulness: The mediating role of performance and effort expectancies. *Computers & Education*, *189*, Article 104589.

Kitchenham, B., & Charters, S. (2007). *Guidelines for performing systematic literature reviews in software engineering* (EBSE Technical Report). Keele University.

Laupichler, M. C., Ber, R., Raupach, T., & Schaper, E. (2022). Artificial intelligence literacy in higher and adult education: A scoping review. *Computers and Education: Artificial Intelligence*, *3*, Article 100101.

Long, D., & Magerko, B. (2020). What is AI literacy? Competencies and design considerations. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (pp. 1–16). ACM. https://doi.org/10.1145/3313831.3376727

McKinsey Global Institute. (2024). *The state of AI in 2024: Generative AI's breakout year*. McKinsey & Company.

Ministry of Communication and Information of the Republic of Indonesia. (2024). *Law and policy on AI utilization for good governance in Indonesia*. Government of Indonesia.

MIT Technology Review. (2025). *The cognitive debt of AI reliance in education*. MIT Technology Review Insights.

Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). Conceptualizing AI literacy: An exploratory review. *Computers and Education: Artificial Intelligence*, *2*, Article 100041.

PS Engage. (2024). *Indonesia's AI national roadmap white paper*. PS Engage.

Public First. (2024). *Indonesia – The AI opportunity: Harnessing AI for economic growth*. Public First.

UNESCO. (2021). *Recommendation on the ethics of artificial intelligence*. UNESCO.

World Economic Forum. (2024a). *The future of jobs report 2024*. World Economic Forum.

World Economic Forum. (2024b). *Realising AI's potential for Southeast Asia's workforce: Spotlight on Indonesia* [White paper]. World Economic Forum.