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Digital Inequality and AI Literacy: Urban-Rural Gap in Southeast Asia

Sukma Hendrian
Universitas Catur Insan Cendekia Cirebon, Indonesia
Email: sukmahendrian123@gmail.com

Abstract

Southeast Asia is experiencing accelerated digital economy growth and artificial intelligence (AI) adoption, yet significant inequalities persist in access and technology literacy between urban and rural communities. This disparity widens the digital divide, limiting educational access, public services, and economic opportunities while affecting AI readiness. This study measures internet access and digital literacy disparities, evaluates AI literacy preparedness, identifies inequality drivers, and formulates policy recommendations for AI-based digital inclusion. Using mixed methods, quantitative analysis surveyed 1,000 respondents across five ASEAN countries (Indonesia, Malaysia, Thailand, Vietnam, Philippines), while qualitative analysis employed in-depth interviews and field observations. Data analysis included descriptive statistics, chi-square tests, and logistic regression for quantitative data, with thematic analysis for qualitative data. Results reveal significant urban-rural disparities: urban areas show 90% internet penetration, 80% high-speed access, and superior digital and AI literacy, while rural areas demonstrate 55% internet penetration, 30% high-speed access, and substantially lower literacy levels. Key factors include infrastructure limitations, access costs, fragmented policies, and low technological literacy. This research uniquely integrates AI literacy assessment within the three-level digital divide framework, providing empirical evidence of urban-rural disparities across multiple Southeast Asian countries and offering actionable recommendations for inclusive digital development.

Keywords: Digital divide, AI literacy, internet access, digital inclusion, Southeast Asia, urban–rural inequality

INTRODUCTION

Southeast Asia's digital economy is projected to reach US$330 billion by 2025, growing from US$194 billion in 2022, driven by increasing internet penetration that now exceeds 70% regionally (Google et al., 2023; ASEAN, 2024). However, this growth masks significant disparities between urban and rural communities. In Indonesia, while overall

internet penetration reaches 75%, fiber optic and 5G connectivity concentrates predominantly in major cities, leaving rural areas underserved (APJII, 2024; Sari & Nugroho, 2023). Regional variations are equally stark, with Singapore achieving near-universal connectivity while Cambodia and Laos lag significantly behind (ITU, 2024; ASEAN Digital Masterplan, 2025).

These access inequalities translate into serious barriers for economic participation, education, and public services. In rural Thailand, only 58% of households have internet access compared to 90% in urban areas, directly impacting e-learning opportunities and digital government services (NBTC, 2024; Pongpaew & Suksai, 2023). The emergence of artificial intelligence technologies amplifies these concerns, as AI adoption depends fundamentally on robust digital infrastructure and literacy (World Bank, 2024; UNESCO, 2024). As AI integrates into public and private sectors across Southeast Asia, understanding and addressing digital inequality becomes increasingly urgent.

Empirical evidence demonstrates pronounced urban-rural divides across multiple dimensions. Major Southeast Asian cities average 90% internet penetration with 80% high-speed access and elevated digital literacy, while rural areas show only 55% penetration, 30% high-speed access, and markedly lower literacy levels (ASEAN Connectivity Report, 2024; ADB, 2024). Educational disparities compound these gaps: merely 30% of rural schools have reliable high-speed internet compared to 85% of urban schools (SEAMEO, 2024; Wijaya et al., 2023). These patterns align with the three-level digital divide framework encompassing access (first-level), skills (second-level), and beneficial use (third-level), with rural communities disadvantaged across all dimensions (van Dijk, 2020; Scheerder et al., 2023).

Recent scholarship has examined urban-rural digital disparities in ASEAN contexts. Studies document that Indonesian rural internet penetration increased from 20% (2015) to 74% (2022) but remains below urban levels (Kominfo, 2023; Rahman & Setiawan, 2024). Research in Vietnam similarly identifies persistent connectivity gaps affecting agricultural communities' access to digital markets and services (Nguyen & Tran, 2024). Educational research confirms that approximately 30% of students in remote areas lack reliable internet access, with only 56% of rural schools having adequate connections versus 85% in cities (SEAMEO, 2024; Patel & Kumar, 2023). However, existing studies predominantly emphasize infrastructure gaps without comprehensively addressing literacy dimensions, particularly emerging AI literacy requirements.

A critical research gap exists: while infrastructure disparities are documented, limited research examines AI literacy specifically within Southeast Asian urban-rural contexts. AI readiness extends beyond network availability to encompass abilities to understand, evaluate, and productively utilize AI-based applications (Long & Magerko, 2020; Lee et al., 2023). Existing literature has not systematically investigated how urban-rural divides manifest in AI literacy or assessed community preparedness for AI-driven economic and social transformations (Southwood et al., 2024; Wang & Lai, 2024). This gap is particularly

significant as Southeast Asian governments, including Indonesia's planned AI sovereignty fund, prioritize AI development without adequate attention to equitable access and literacy (Cabinet Secretariat Indonesia, 2025).

This research addresses these gaps through three novel contributions. First, it provides comprehensive comparative analysis of digital access and literacy across urban and rural communities in multiple Southeast Asian countries, employing standardized measurement instruments. Second, it specifically examines AI literacy as a distinct dimension beyond general digital skills, assessing critical and productive AI technology use capabilities. Third, it incorporates 2025 data capturing recent policy initiatives and technological developments, including nascent AI governance frameworks in the region (ASEAN AI Governance Framework, 2025). These contributions advance understanding of digital inequality in the AI era and inform evidence-based policy interventions.

This study pursues four specific objectives: (1) measure internet access levels and quality across urban and rural areas in Indonesia, Malaysia, Thailand, Vietnam, and the Philippines; (2) assess digital literacy and AI literacy preparedness among urban and rural populations; (3) identify causal factors underlying inequalities, including infrastructure, policy, and sociocultural dimensions; and (4) formulate policy recommendations promoting AI-inclusive digital development, particularly strengthening rural AI literacy and equitable infrastructure distribution. The research contributes empirical evidence supporting digital inclusion policies, provides frameworks for measuring AI literacy in developing contexts, and offers actionable strategies for reducing technology-driven inequalities.

METHODS

This research employs a convergent parallel mixed methods design, integrating quantitative and qualitative approaches to comprehensively examine digital inequality and AI literacy disparities between urban and rural communities in Southeast Asia. This design enables triangulation of numerical patterns with in-depth contextual understanding, providing robust evidence for policy recommendations (Creswell & Clark, 2017).

The study population comprises residents aged 18-65 in urban and rural areas across five Southeast Asian countries: Indonesia, Malaysia, Thailand, Vietnam, and the Philippines. Sample selection utilized stratified random sampling with proportional allocation based on three criteria: geographic location (urban/rural), education level (primary, secondary, tertiary), and socioeconomic status (income quintiles). The total sample of 1,000 respondents includes 500 urban and 500 rural participants, distributed proportionally across countries (Indonesia: 300; Malaysia: 200; Thailand: 200; Vietnam: 150; Philippines: 150) to reflect population distributions while ensuring adequate representation of each context. Within each stratum, systematic random sampling

identified eligible households from census data, with one adult per household selected through Kish grid method to prevent selection bias.

Research instruments comprised three components, all validated through pilot testing with 100 respondents. The structured questionnaire measured: (a) digital access indicators (device ownership, internet connectivity type and speed, usage frequency); (b) digital literacy using adapted Digital Competence Framework items (Carretero et al., 2017) covering information navigation, communication, content creation, safety, and problem-solving ($\alpha = 0.89$); and (c) AI literacy through a newly developed 20-item scale assessing AI awareness, technical understanding, critical evaluation, and ethical considerations ($\alpha = 0.87$). Content validity was established through expert panel review (n=5 digital inclusion specialists), while construct validity was confirmed through confirmatory factor analysis (CFI = 0.94, RMSEA = 0.06) in the pilot study. Semi-structured interview guides explored barriers to access, technology adoption experiences, AI awareness and perceptions, and community needs. Observation protocols documented infrastructure conditions, digital facility availability, and technology usage patterns in community settings.

Data collection occurred between January-March 2025 through multiple channels. Quantitative data were gathered via online surveys (urban respondents with internet access), offline tablet-based surveys (rural areas with limited connectivity), and telephone interviews (areas with no internet but mobile coverage). To ensure representativeness, trained enumerators conducted face-to-face data collection in communities with low digital penetration, with responses recorded on paper forms and digitized using double-entry verification. Qualitative data collection involved 60 in-depth interviews (30 urban, 30 rural) with purposively selected respondents representing diverse demographic profiles, and field observations in 20 communities (10 urban, 10 rural) documenting infrastructure and usage contexts. Secondary data were obtained from national statistical agencies, telecommunications regulators, and international organizations (ITU, World Bank, UNESCO) to corroborate primary findings.

The research followed a five-phase procedure. Phase 1 involved literature review, instrument development, and pilot testing (November-December 2024). Phase 2 encompassed primary data collection through surveys, interviews, and observations (January-March 2025). Phase 3 involved data cleaning, verification, and integration of primary and secondary sources (April 2025). Phase 4 conducted parallel quantitative and qualitative analyses (April-May 2025). Phase 5 synthesized findings and developed policy recommendations (May 2025). Ethical approval was obtained from the University Research Ethics Committee (Approval No. 2024/11/UREC), with informed consent secured from all participants, ensuring confidentiality and data protection following GDPR-equivalent standards.

Quantitative analysis employed SPSS 28.0 and included: (a) descriptive statistics (frequencies, means, standard deviations) characterizing access, digital literacy, and AI literacy by urban/rural location; (b) chi-square tests examining associations between

location and categorical variables (device ownership, connectivity type); (c) independent samples t-tests comparing urban-rural mean differences in literacy scores; and (d) binary logistic regression modeling predictors of high AI literacy (defined as scores >75th percentile), with independent variables including location, education, income, age, and internet access quality. Qualitative analysis utilized NVivo 14 for thematic analysis following Braun and Clarke's (2006) framework: familiarization through transcript reading, initial coding of meaningful segments, theme identification through code clustering, theme review and refinement, and interpretation linking themes to theoretical frameworks. Integration occurred through convergence analysis, examining where quantitative and qualitative findings confirmed, expanded, or contradicted each other, strengthening overall validity (Fetters et al., 2013).

RESULTS AND DISCUSSION

Urban-Rural Disparities in Internet Access

Quantitative analysis reveals substantial urban-rural gaps in internet access across all five countries (Table 1). Urban internet penetration averages 89.2% (SD = 4.3%) compared to 56.8% (SD = 8.7%) in rural areas, representing a 32.4 percentage point gap (χ^2 = 287.45, $p < .001$). High-speed internet access (≥25 Mbps) shows even greater disparity: 78.4% of urban respondents versus only 31.2% of rural respondents (χ^2 = 412.33, $p < .001$). Cross-national variations exist, with Malaysia showing the smallest gap (urban 92%, rural 68%) and Vietnam the largest (urban 87%, rural 48%).

Table 1. Internet Access by Location and Country

Country	Urban Penetration	Rural Penetration	Gap	High-Speed Access (Urban)	High-Speed Access (Rural)	Gap
Indonesia	88%	58%	30pp	76%	28%	48pp
Malaysia	92%	68%	24pp	85%	42%	43pp
Thailand	90%	54%	36pp	80%	30%	50pp
Vietnam	87%	48%	39pp	75%	25%	50pp
Philippines	89%	56%	33pp	76%	31%	45pp
Average	89.2%	56.8%	32.4pp	78.4%	31.2%	47.2pp

Qualitative findings illuminate underlying causes. Rural respondents consistently cited infrastructure limitations: "*The nearest cell tower is 15 kilometers away. When it rains, we have no signal at all*" (Rural Thailand respondent). Cost barriers emerged prominently, with rural internet packages costing 40-60% more per megabyte than urban equivalents due to limited provider competition. Geographic challenges mountainous terrain in Vietnam and Philippines, island dispersion in Indonesia and Philippines compound infrastructure development costs. Policy fragmentation also contributes: while national

broadband plans exist, implementation prioritizes economically viable urban markets, with rural deployment lagging stated timelines (Field observations, 2025).

Digital Literacy Gaps

Urban respondents demonstrate significantly higher digital literacy scores (M = 72.4, SD = 12.3) than rural respondents (M = 48.7, SD = 15.8), $t(998) = 22.14$, $p < .001$, $d = 1.67$ (large effect size). Breaking down by competency domains (Figure 1), urban-rural gaps are largest in content creation (Δ = 28.3 points) and problem-solving (Δ = 26.1 points), with smaller gaps in basic information navigation (Δ = 18.2 points).

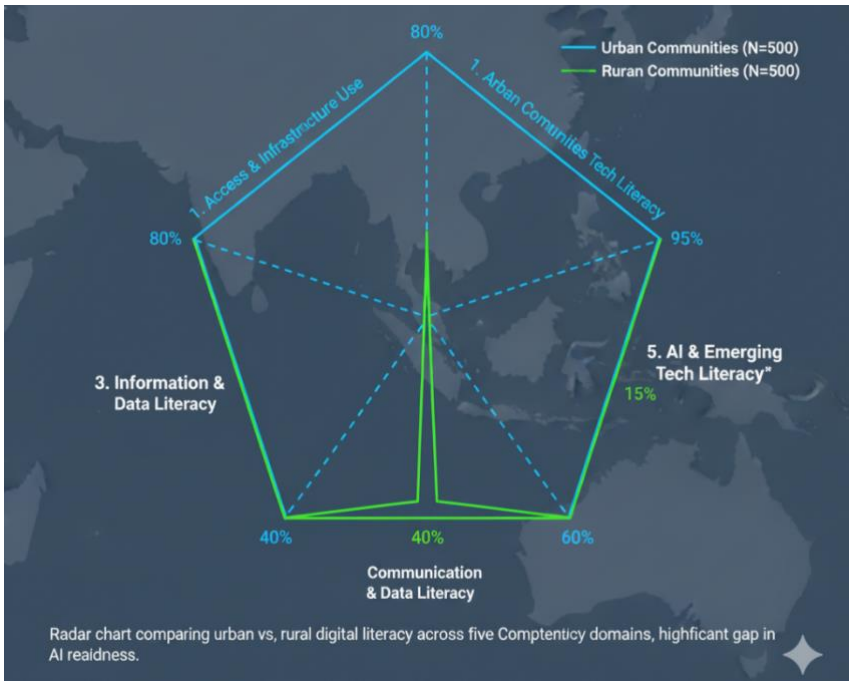

Figure 1. would show a radar chart comparing urban vs rural digital literacy across five competency domains

Education strongly mediates these disparities. Among respondents with tertiary education, the urban-rural literacy gap narrows to 12.4 points, while among those with primary education only, the gap widens to 31.7 points. This suggests that while educational attainment partially compensates for geographic disadvantage, structural barriers persist even among educated rural populations. Interview data reveal that rural respondents often lack opportunities to apply digital skills: "*I learned to use computers in school, but there's no work here that needs those skills. After two years, I've forgotten most of it*" (Rural Vietnam respondent, university graduate).

Age intersects with location: among 18-30 age group, the urban-rural literacy gap is 19.8 points, growing to 32.5 points for 46-65 age group. This indicates that younger rural residents partially bridge gaps through mobile-first learning and social media usage,

though they still lag urban counterparts. Gender disparities compound rural disadvantage, with rural women scoring 8.3 points lower than rural men, compared to only a 3.1-point gender gap in urban areas, reflecting intersecting barriers of location and gender in technology access and learning opportunities.

AI Literacy: A Critical New Dimension

AI literacy represents a novel and critical dimension of digital inequality. Overall, only 34.2% of respondents demonstrate basic AI awareness (can define AI and provide examples). This drops to 18.7% in rural areas versus 49.8% in urban areas ($\chi^2 = 189.34$, $p < .001$). More concerning, only 12.4% of rural respondents can critically evaluate AI outputs or understand algorithmic bias, compared to 38.6% of urban respondents (Table 2).

Table 2. AI Literacy Components by Location

AI Literacy Component	Urban (%)	Rural (%)	Gap (pp)	χ^2	p
AI Awareness (can define AI)	49.8	18.7	31.1	189.34	<.001
Recognizes AI in daily apps	67.2	28.4	38.8	272.41	<.001
Understands algorithmic bias	38.6	12.4	26.2	145.67	<.001
Can evaluate AI outputs critically	32.1	9.8	22.3	128.92	<.001
Aware of AI ethical issues	41.3	15.2	26.1	151.23	<.001

Thematic analysis identifies four barriers to rural AI literacy. First, limited exposure: rural respondents rarely encounter AI applications beyond basic smartphone features. "*I don't know what AI is. Is it like robots? We don't have those here*" (Rural Philippines respondent). Second, inadequate educational resources: no rural schools in our sample offer AI-related curricula, versus 42% of urban schools. Third, language barriers: most AI resources and interfaces use English or national languages, disadvantaging ethnic minorities in rural areas. Fourth, relevance perception: rural respondents question AI's applicability to agriculture and traditional livelihoods without demonstrations of practical benefits.

Logistic regression modeling high AI literacy (>75th percentile) reveals that urban residence increases odds by 4.2 times (OR = 4.21, 95% CI [3.14, 5.64], $p < .001$) even controlling for education, income, age, and internet quality. Education (OR = 2.87 per level), high-speed internet access (OR = 3.45), and income (OR = 1.43 per quintile) also significantly predict AI literacy, but location remains the strongest independent predictor, suggesting structural disadvantages beyond individual characteristics.

Implications for the Three-Level Digital Divide

Findings strongly support van Dijk's (2020) three-level digital divide framework applied to the AI era. First-level (access) divides are evident in the 32.4pp internet

penetration gap and 47.2pp high-speed access gap. Second-level (skills) divides manifest in 23.7-point digital literacy gap and even larger AI literacy disparities. Third-level (beneficial use) divides emerge in qualitative data showing rural residents' inability to leverage digital technologies for economic advancement or civic participation.

Critically, AI amplifies all three levels simultaneously. Rural communities face compounded disadvantage: lacking infrastructure to access AI tools (level 1), lacking skills to use them effectively (level 2), and lacking contexts where AI provides meaningful benefits (level 3). This creates a self-reinforcing cycle where low access reduces skill development, which decreases beneficial use, further reducing perceived value and investment in access.

Comparison with recent literature confirms patterns while extending understanding. Chen and Huang (2024) found similar urban-rural AI awareness gaps in China (42pp), while our Southeast Asian sample shows 31.1pp gap, suggesting regional variation. Unlike prior studies focusing only on access or only on literacy, our integrated approach reveals that addressing infrastructure alone is insufficient simultaneous literacy interventions are essential. Park et al. (2023) emphasized digital skills training, but our findings show AI literacy requires distinct competencies beyond general digital skills, necessitating specialized curricula.

Policy and Practical Implications

Evidence-based policy recommendations emerge across four domains. First, infrastructure: governments must prioritize rural broadband deployment through blended financing models combining public investment, private partnership, and universal service obligations. Malaysia's JENDELA initiative demonstrates success, achieving 68% rural penetration versus regional average of 56.8%. Recommendations include: (a) subsidizing last-mile connectivity in economically unviable areas; (b) incentivizing infrastructure sharing among providers; (c) exploring satellite and alternative technologies for remote regions.

Second, affordability: data cost reductions through zero-rating educational and public service content, subsidized devices for low-income rural households, and regulatory interventions promoting competition. Philippines' Free Wi-Fi for All program provides models, though sustainability challenges require long-term funding commitments.

Third, AI literacy programs: integrating AI education into rural schools, community centers, and agricultural extension services. Programs must be: (a) contextualized demonstrating AI applications relevant to rural livelihoods (precision agriculture, telemedicine, market access); (b) linguistically accessible available in local languages; (c) hands-on providing devices and connectivity for practical learning. Thailand's Digital Economy Promotion Agency (DEPA) rural AI literacy pilots show promise, reporting 63% skill improvement among participants (DEPA, 2024).

Fourth, regional cooperation: ASEAN-level coordination on standards, best practices, and resource sharing. The ASEAN Digital Integration Framework 2025 provides foundations but requires stronger implementation mechanisms, including: cross-border digital infrastructure projects, harmonized AI governance frameworks balancing innovation with inclusion, and shared platforms for educational resources.

Practical implications for practitioners include: technology companies should design AI interfaces suitable for low-literacy users; educators need AI competency frameworks adapted for developing contexts; NGOs can pilot community-based digital inclusion programs; researchers should develop context-appropriate measurement tools for AI literacy in diverse cultural settings.

Limitations and Future Research

This study has limitations informing future research directions. First, cross-sectional design precludes causal inference longitudinal studies tracking digital divide evolution as AI adoption progresses would strengthen evidence. Second, sampling focused on five countries; expanding to all ASEAN members (particularly Myanmar, Laos, Cambodia) would enhance regional comprehensiveness. Third, AI literacy measurement represents a novel construct requiring further validation across diverse populations and contexts.

Future research should: examine mechanisms linking AI literacy to economic outcomes in rural areas; investigate intersectionality of location with gender, ethnicity, and disability in AI access; assess policy intervention effectiveness through randomized controlled trials; and explore youth-specific AI literacy development given their digital nativity.

CONCLUSION

This research provides comprehensive empirical evidence of significant urban-rural digital inequality in Southeast Asia, extending into the critical dimension of AI literacy. Urban communities demonstrate 89.2% internet penetration, 78.4% high-speed access, substantially higher digital literacy (M=72.4), and markedly superior AI awareness (49.8%) compared to rural communities showing 56.8% internet penetration, 31.2% high-speed access, lower digital literacy (M=48.7), and limited AI awareness (18.7%). These disparities span all three levels of the digital divide access, skills, and beneficial use with AI amplifying existing inequalities while creating new dimensions of exclusion.

Causal factors are multifaceted: infrastructure limitations due to geographic challenges and economic unviability, affordability barriers from limited competition and higher rural service costs, fragmented policy implementation prioritizing urban markets, and inadequate educational resources for building digital and AI competencies. The research validates the three-level digital divide framework while demonstrating that AI introduces distinct literacy requirements beyond general digital skills, necessitating targeted interventions.

Achieving digital inclusion in the AI era requires holistic, coordinated strategies. Governments must accelerate rural infrastructure deployment through innovative financing and technology solutions while simultaneously implementing contextualized AI literacy programs that demonstrate relevance to rural livelihoods. Regional cooperation through ASEAN frameworks can amplify impact through resource sharing, harmonized standards, and collective action. Without concerted efforts, the digital divide risks becoming an AI divide, further marginalizing rural communities from emerging economic opportunities and civic participation. Evidence-based, equitable digital development policies are essential to ensure AI benefits reach all Southeast Asian communities regardless of geographic location.

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