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Rethinking Digital Inclusion Priorities through a Predictive Analysis of Infrastructure Accessibility Factors for E-Services Provision

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ABSTRACT

Digital inclusion has evolved from a binary concern with access to a multi-dimensional challenge encompassing skills, usage, and outcomes. While infrastructure accessibility is widely recognized as foundational to digital participation, the specific mechanisms through which access-based factors influence usage depth remain underexplored, particularly among vulnerable populations in low-income contexts. This study examined the influence of infrastructure access-based factors on digital usage levels among vulnerable users in Kenya. Drawing on Sen's Capability Approach and the Unified Theory of Acceptance and Use of Technology (UTAUT), the study employed a quantitative, cross-sectional survey design with data collected from 292 respondents in rural central Kenya. Infrastructure access factors were operationalized through three constructs: System Infrastructure Accessibility, Perceived Cost of Access, and Alternative Access. A composite Digital Inclusion Index (DII) was developed using six usage levels with rank-sum weights, revealing a statistically significant progressive decline with increasing service complexity ($\chi^2(5) = 142.834$, $p < .001$). Multiple regression analysis revealed that System Infrastructure Accessibility emerged as the strongest access-based predictor ($\beta = 0.390$, $p < .001$), while Perceived Cost of Access showed a significant but substantially smaller negative influence ($\beta = -0.093$, $p = .030$). Contrary to common policy assumptions, Alternative Access through borrowed devices failed to reach statistical significance ($p = .465$). The study concludes that access-centric measures are insufficient for evaluating digital inclusion, and that physical proximity and service point density outweigh cost reduction in predicting usage depth. The findings challenge prevailing policy assumptions about device-sharing programs and suggest a fundamental policy shift from access-centric to capability-based digital inclusion strategies, prioritizing infrastructure density and service point availability over cost subsidies alone.

Keywords **-**Digital inclusion, infrastructure access, digital divide, vulnerable populations, capability approach, Kenya

I. INTRODUCTION

Information and Communication Technology (ICT) continues to exert a profound and transformative influence on modern society, reshaping cultural norms, economic structures, and governance models [1], [2]. The evolution into a digital information society is increasingly characterized by ICT's central role as a facilitator of socio-economic activities, with the provision of electronic services (E-services) widely recognized for its cost-effectiveness for governments [3], [4] and private enterprises [5], while simultaneously enhancing convenience for consumers [6]. Governments globally are accelerating the adoption of E-governance frameworks to enhance service efficiency and strengthen citizen-state relationships [7].

However, in the widespread provision of e-services, a persistent and complex form of disadvantage—digital exclusion—has emerged, barring those unable to access or effectively use digital technologies from critical socio-economic benefits [8]. This disparity, often termed the "digital divide," reflects profound global and regional inequalities in infrastructure, affordability, and digital literacy [9]. The irony of the digital age is that it often reinforces existing inequalities, as those already included are best positioned to reap technology's benefits. The poor, people with disabilities, those with lower formal education, and residents of remote areas frequently face significant limitations in accessing and meaningfully using ICT [10].

Kenya has made significant progress in expanding access to digital services through innovations such as M-Pesa, eCitizen, and online banking platforms. However, despite widespread access to digital technologies, many users continue to engage only in basic activities such as sending or receiving money, while very few utilize advanced services like online purchases, remote banking, or digital credit. This pattern points to the existence of a functional digital divide or usage gap, where users have access but lack the skills, trust, or conducive environment to fully participate in the digital economy. Existing digital inclusion initiatives have largely prioritized physical access, connectivity, and device ownership, with limited attention to the quality and extent of digital services usage for sustained adoption [11], [12].

While studies on technology adoption in Kenya have predominantly examined infrastructural and socio-economic factors, there remains a gap in understanding how infrastructure access-related features interact with security usability to shape digital service usage patterns. This study addresses this gap by examining the influence of infrastructure access-based factors on digital usage levels among vulnerable users in Kenya. Specifically, the study sought to: (1) establish infrastructure access-based factors that affect digital usage levels among users; (2) examine the relationship between these access factors and digital inclusion; and (3) provide empirical evidence to inform policy interventions for bridging the functional digital divide.

II. LITERATURE REVIEW

A. *Conceptualizing Digital Exclusion and Inclusion*

Digital marginalization is being on the lacking side of the digital divide, characterized by inability to benefit or participate in the information society [13]. The digital divide has been defined as the inequality in accessing ICTs and internet between individuals, households, enterprises and regions at different socio-economic levels [14], [15]. Digital exclusion manifests at three interconnected levels: access, use, and benefit [10]. Access barriers include the prohibitive cost of devices and data, a lack of robust ICT infrastructure in poor or remote regions, and the absence of secondary necessities like reliable electricity [16].

According to Sen's Capability Approach [17], the welfare of human life can be analyzed in terms of individual capabilities and functioning [18]. While functionings are achievements, capabilities are the abilities to achieve them [19]. ICT and related technologies have given rise to new capabilities to the human race. Functionings are states of being and doing—what an individual is doing such as owning a mobile phone, transacting an e-service, or being e-skilled. Capability, on the other hand, is the set of valuable functioning that a person has effective access to. This distinction is crucial for understanding digital inclusion, as it moves beyond mere access to consider the real freedoms individuals have to benefit from digital services.

B. *Access Versus Use in Digital Inclusion*

The foundation research on digital exclusion and marginalization mainly focused on the difference between the haves and the have-nots, with exclusion largely evaluated based on level of access or lack thereof to ICT [15]. Providing access to ICT was hailed as the solution to both digital and social exclusion. However, access alone could not solve the inclusion/exclusion problem. Availability and affordability was just the beginning of the solution. The next phase of divide was between those who used the technology and those who did not. Individuals who could not use the technology missed out on opportunities that came with technologies [20].

The inclusion debate had to go beyond mere access to actual usage and benefiting from the technology. From Sen's capability approach, inclusion goes beyond access—it stretches all the way to use and benefit. Several scholars have highlighted that digital inclusion approaches should target not merely physical access but also the ability to derive meaningful benefits from digital engagement [21], [22], [23]. This shift in perspective has important implications for measuring digital inclusion and designing interventions.

C. *Infrastructure Access Factors in Digital Inclusion*

The Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) have been extensively used to study adoption of technology. TAM suggests that the choice to use or not to use a given technology is primarily based on user's perceived usefulness and perceived ease of use [24]. UTAUT's main constructs include performance expectancy, effort expectancy, social influence, and facilitating conditions [25]. Facilitating conditions—which encompass infrastructure availability, technical support, and organizational resources—are particularly relevant to understanding access-based factors in digital inclusion.

Research has identified cost as a major barrier to digital inclusion, especially among low-income populations [16], [9]. The perceived financial cost associated with accessing digital services, including transaction fees, data charges, and travel costs to access points, can significantly affect adoption and continued use. Similarly, the physical presence of infrastructure needed to use digital services—such as mobile money agents, ATMs, shops accepting digital payments, and capable devices—is critical for enabling digital participation. Device ownership and the ability to access shared devices have also been identified as important factors, particularly in contexts where personal device ownership is limited [15], [20].

D. Research Gap

While the influence of ICT on modern society is evidently prominent, and e-services are becoming the norm, there has been little attention given to how infrastructure access factors specifically contribute to digital exclusion among vulnerable populations. With e-services now becoming the order of the day, those without access or unable to use the technology are being left out. Studies on technology adoption in Kenya have predominantly examined infrastructural and socio-economic factors, but there is limited empirical research examining how the access dimension of inclusion influences the use dimension of inclusion. Furthermore, there is a lack of standardized metrics for measuring digital inclusion that account for usage depth rather than mere access. This study addresses these gaps by empirically examining how infrastructure access factors influence digital service usage and inclusion among vulnerable populations in Kenya.

III. METHODOLOGY

A. Research Philosophy and Design

The research was designed based on the philosophy of critical realism (CR)—a post-positivist view of reality that has been highly recommended for social science research [26]. Critical Realism asserts the existence of a transcendental reality irrespective of whether we are aware of that reality or not, while also believing that our knowledge of this reality is partial and limited to our context and experiences [27]. This philosophical stance was appropriate for this study as it acknowledges the existence of latent constructs of interest that may not be observable but can be deduced from measurable variables from users' experiences.

The study adopted a quantitative, cross-sectional survey design. Quantitative research seeks to answer the "how much" and "to what extent" kind of questions [28], which aligned well with the study's objectives of measuring the strength and direction of relationships between predefined constructs. The cross-sectional design was appropriate as the study sought to capture participants' perspectives at a given time, enabling the collection of large amounts of data from a relatively wide geographical area.

B. Study Population and Sampling

The research took place in Kenya, targeting rural central Kenya. The targeted population included users of mobile money and digital banking services. The study targeted people within the non-skilled and semi-skilled labor sector, including workers at lower grades in learning institutions, casual workers in coffee and tea plantations, office messengers, cleaners, grounds men, security guards, and traders in open air markets. This population was purposively selected as they are likely to be vulnerable to digital marginalization based on literacy levels, age, and income levels.

The study used both purposeful and random sampling techniques. Purposeful sampling was used to select job groups or roles that were highly likely to be occupied by less educated persons and/or low-income individuals. Simple random sampling was then used among the staff in the identified job groupings. The targeted sample size was N=350 respondents. After distributing 350 questionnaires, 297 were returned, translating to an 85% response rate. The final sample of N=297 was deemed adequate based on guidelines for Principal Component Analysis (PCA) and multiple regression. Hair et al. [29] recommends a ratio of not less than 5:1 for cases to variables, and the study's questionnaire had 49 variables for PCA, translating to a 7:1 ratio. The Kaiser-Meyer-Olkin (KMO) index for the study was 0.844, which is rated as good, further justifying the sample size.

C. Data Collection Instruments

The study employed questionnaires to collect quantitative data among digital service users. The questionnaires established users' attitudes toward different authentication mechanisms, their understanding of security usability, and related challenges. The questionnaire was administered using both Google form and printed questionnaires, with research assistants assisting respondents with low literacy skills. The research assistants used the questionnaire items as closed interview questions for respondents who could not read or write.

D. Data Analysis

All quantitative data analysis was conducted using IBM SPSS Statistics (Version 20). The analysis proceeded in several stages:

Descriptive Analysis: Demographic analysis of respondents including gender, age, education, and income levels.

Digital Usage Analysis: Descriptive statistics including means, frequencies, and deviations were calculated for each digital usage type. Chi-Square Goodness-of-Fit Test was used to determine whether there were significant differences in the proportion of respondents using digital services across usage types. One-Way ANOVA was employed to examine mean differences in usage types.

Development of Digital Inclusion Index (DII): A composite Digital Inclusion Index was developed using six usage levels with rank-sum weights. The study applied a weighted sum model where weights were systematically derived using the rank-sum method based on the frequency of digital usage levels. The formula for individual Digital Inclusion Index was:

DigitalUsage = ((UsageLevel1*6/21) + (UsageLevel2*5/21) + (UsageLevel3*4/21) + (UsageLevel4*3/21) + (UsageLevel5*2/21) + (UsageLevel6*1/21))

Principal Component Analysis (PCA): The study subjected 49 observable variables to factor analysis through PCA to reduce the variables into a smaller set of principal components. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity were used to evaluate the appropriateness of factor analysis. Variables with loadings less than 0.5 were dropped iteratively until each remaining variable had a loading of 0.5 or higher.

Reliability Testing: Cronbach's alpha was used to test the reliability and internal consistency of the factors identified from PCA. Components with an alpha score of ≥ 0.7 were retained.

Multiple Regression Analysis: Multiple regression was used to determine how the factors identified through PCA predict personal Digital Inclusion Index. Regression coefficients, p-values, and standardized coefficients (β) were examined to determine the significance and relative importance of each predictor.

E. Quality Assurance and Ethical Considerations

The study ensured validity and reliability through piloting, which enhanced content validity and face validity. The pilot study confirmed the usage levels deduced from the literature and provided confidence that the dependent variable captured the full range of user behavior. Reliability was assessed using Cronbach's alpha, with components having an alpha score of ≥ 0.7 retained. Before drawing conclusions from the regression model, the study conducted validation tests including Normality of Residuals (Shapiro-Wilk test, P-P plots, histogram), Homoscedasticity (Breusch-Pagan test, bootstrapping), Multicollinearity (VIF and Tolerance), and Linearity and Additivity (partial regression plots). Ethical considerations included obtaining informed consent from respondents, ensuring confidentiality and anonymity, and securing research permits from NACOSTI.

IV. RESULTS

A. Respondent Characteristics

The survey had relatively equal numbers of male and female respondents, with 50.7% male and 49.3% female. In terms of education, 5.8% had no formal education, 19.2% had primary education, 37.3% had secondary education, 29.5% had graduate/college education, and 8.2% had postgraduate education. The majority of respondents (62.3%) had secondary education or lower, which aligned with the study's targeting of populations likely to be digitally marginalized. Regarding income, only 34.25% of respondents earned more than Ksh 40,000 per month. The age distribution showed 43.2% of respondents within the youth age bracket (18-35 years) and 56.8% above youth age.

B. Digital Usage Patterns

Six digital usage types were identified and ranked based on frequency of use:

Level 1: Digital Service Account Acquisition - 94.5% of respondents agreed or strongly agreed to having an account or access device.

Level 2: Digitally Sending and Withdrawing Money - 78.8% of respondents agreed or strongly agreed to sending/receiving money or ATM withdrawals.

Level 3: Digital Payments - 63.0% of respondents agreed or strongly agreed to paying for goods and services locally.

Level 4: Online Buying - 47.9% of respondents agreed or strongly agreed to paying for goods/services online.

Level 5: Remote Banking Operations - 45.2% of respondents agreed or strongly agreed to operating bank accounts remotely.

Level 6: Remote Credit Facility - 19.2% of respondents agreed or strongly agreed to using digital accounts to obtain loans.

The Chi-Square Goodness-of-Fit Test revealed a statistically significant difference in digital service usage across the six usage levels ($\chi^2(5) = 142.834$, $p < .001$). This implies that usage frequency is not uniform across the levels of service complexity. The One-Way ANOVA results showed a significant difference in mean usage among the six levels ($F(5,1746) = 89.26$, $p < .001$). The Tukey HSD post-hoc test confirmed that Usage Levels 1-3 have significantly lower mean scores than Levels 4-6, meaning respondents use simpler digital services far more frequently than complex services.

C. Infrastructure Access Factors

Principal Component Analysis (PCA) of 49 observable variables produced ten latent factors explaining 69% of total variance. Three of these factors were related to infrastructure access:

1. System Infrastructure Accessibility ($\alpha = 0.800$): This factor included variables related to the availability of mobile money agents or bank agents near the user's home or workplace (loading = 0.759), shops accepting digital payments (loading = 0.598), ATMs availability (loading = 0.604), and the user's phone capability to register for mobile money services (loading = 0.707).

2. Perceived Cost of Access ($\alpha = 0.641$): This factor included variables related to having to travel far to access mobile money agents or ATMs (loading = 0.610), higher expenses for paying for services through mobile money (loading = 0.743), and higher costs to access shops that accept payment through mobile money (loading = 0.734).

3. Alternative Access: This factor had only one variable loading to it (DeviceAccess2: ability to use a phone belonging to a family member to send, receive, or withdraw money), so no Cronbach's alpha could be calculated.

D. Influence of Infrastructure Access Factors on Digital Inclusion

Multiple regression analysis was conducted to determine how the infrastructure access factors predict Digital Inclusion Index. The results are presented in Table I.

TABLE I: Coefficients For Multiple Linear Regression Predicting Digital Inclusion Index (Access Factors)

Predictor	Unstandardized B	Std. Error	Standardized β	t	Sig. (p)
(Constant)	2.216	.034		64.297	.000
System Accessibility	.316	.035	.390	9.162	.000
Perceived Cost of Access	-.076	.035	-.093	-2.187	.030
Alternative Access	.025	.035	.031	.731	.465

Note: $R^2 = .475$, Adjusted $R^2 = .464$, $F(6,285) = 42.9$, $p < .001$

System Infrastructure Accessibility emerged as the strongest access-based predictor of digital inclusion (β = 0.390, p < .001). A one-unit increase in System Accessibility would lead to a 0.316-unit increase in Digital Inclusion Index, holding all other factors constant. This implies that users' proximity to service outlets is important in influencing their usage of digital services. Having ATMs, bank and mobile money agents, and shops that accept digital payments within walking distance not only reduces the cost of access but also motivates users to utilize the service.

Perceived Cost of Access showed a significant but substantially smaller negative influence on digital inclusion (β = -0.093, p = .030). An increase of one unit in perceived cost of access would reduce Digital Inclusion Index by 0.076 units. However, the beta weight indicates that the negative influence of cost, though statistically significant, is minimal relative to the positive influence of System Infrastructure Accessibility.

Contrary to common policy assumptions, Alternative Access through borrowing devices from family members or friends failed to reach statistical significance (p = .465). This suggests that using borrowed devices does not significantly improve users' digital inclusion, challenging interventions that focus on shared access points without considering individual agency.

E. Model Validation

The regression model was validated through several diagnostic tests. The Durbin-Watson statistic was 1.907, indicating independence of errors. Multicollinearity was absent (all VIF = 1.000) because the factors were derived from orthogonal PCA. The Breusch-Pagan test initially indicated heteroscedasticity (p = .024), but bootstrapping with 5000 samples was used to address this, providing robust parameter estimates. The normality of residuals was visually confirmed through the histogram showing a bell-shaped distribution and the P-P plot showing points largely following the diagonal line.

All diagnostic procedures confirmed that the regression model met the fundamental assumptions of OLS regression. Residuals were approximately normal, variances were constant, predictors were independent, and relationships were linear and additive. The bootstrapping results further verified the model's stability, predictive strength, and robustness.

V. DISCUSSION

A. The Primacy of Physical Infrastructure Accessibility

The finding that System Infrastructure Accessibility was the strongest access-based predictor of digital inclusion ($\beta = 0.390$) underscores the critical importance of physical proximity to service points in enabling meaningful digital participation. This extends the UTAUT framework's concept of facilitating conditions [25] by demonstrating that physical infrastructure availability is not merely a supporting condition but a primary determinant of usage depth. The presence of mobile money agents, ATMs, and shops accepting digital payments within walking distance from users' homes or workplaces significantly affected usage levels.

This finding has important implications for digital inclusion policy. While Kenya has made significant progress in expanding digital access through mobile money and e-government services, the functional digital divide persists, particularly in rural areas where physical infrastructure may be limited. The study suggests that expanding the density of service points—agent networks and digital payment shops—may be more impactful than simply expanding network coverage or reducing costs. This aligns with research by Wyche and Murphy [16], which found that the absence of secondary necessities like reliable electricity and physical access points can be as limiting as the lack of devices or connectivity.

B. The Limited Role of Cost Reduction

The finding that Perceived Cost of Access had a significant but minimal negative influence on digital inclusion ($\beta = -0.093$) challenges the conventional wisdom that cost is the primary barrier to digital inclusion in low-income settings. While cost does matter—higher transaction fees, data costs, and travel costs do reduce adoption and continued use—its influence is substantially smaller than that of physical infrastructure availability.

This suggests that the benefits of digital services often outweigh the costs, and if services are brought closer to people, they are willing to bear the cost. The relatively low beta weight for cost (-0.093) compared to the positive influence of System Infrastructure Accessibility (0.390) indicates that making services readily available has a bigger impact on usage than simply reducing cost. This finding is consistent with Sen's Capability Approach [30], which emphasizes that functional freedoms are constrained not only by affordability but also by usability barriers and infrastructure availability.

However, it is important to note that the Perceived Cost of Access construct showed reliability at the lower acceptable range ($\alpha = 0.641$). This suggests that the measurement of cost dimensions—transaction costs, device costs, data costs, travel costs—requires further refinement in future research. The construct may benefit from additional variables to improve its reliability.

C. Dismantling Assumptions about Shared Access

The finding that Alternative Access through borrowed devices failed to significantly influence digital inclusion ($p = .465$) is particularly significant as it challenges common policy assumptions about device-sharing programs. Many digital inclusion initiatives assume that shared access—community telecentres, family borrowing, shared tablets—can bridge the access gap for those who cannot afford personal devices. However, the study suggests that this approach may be ineffective.

Several factors may explain why shared access fails to improve digital inclusion. First, privacy concerns may deter users from conducting sensitive transactions on borrowed devices. The strong influence of Perceived Privacy ($\beta = 0.183$) in the full regression model supports this interpretation. Second, power dynamics within households may limit the autonomy of users who rely on borrowed devices. The device owner may need to accompany the user or may restrict the types of transactions allowed. Third, the quality of borrowed devices may be inadequate for complex digital services. This finding provides empirical justification for policymakers to reconsider investments in device-sharing programs and redirect resources toward subsidized personal device ownership or usability improvements.

From a theoretical perspective, this finding empirically validates Sen's Capability Approach by demonstrating the distinction between functionings and capabilities. Although borrowing a device may allow a user to transact (achieving a functioning), it does not provide genuine capability or freedom to enjoy the functioning. Users who rely on borrowed devices lack autonomy, privacy, and ownership. This undermines their ability to fully participate in the digital economy and achieve meaningful digital inclusion.

D. Implications for Digital Inclusion Measurement

The study's development of a composite Digital Inclusion Index based on usage depth rather than binary access provides a more nuanced understanding of digital inclusion. The statistically significant progressive decline in usage with increasing service complexity ($\chi^2(5) = 142.834$, $p < .001$) reveals that many individuals with basic access cannot use more complex services. This confirms that digital inclusion is not a binary state but exists on a continuum from basic access to advanced participation.

Traditional digital inclusion measures that focus on access metrics—such as ownership of devices, having bank accounts, or network coverage—mask the reality that many users remain at shallow levels of engagement. The composite Digital Inclusion Index developed in this study enables policymakers to track whether inclusion gains are occurring at shallow or deep levels of service usage. This more granular measure of inclusion aligns with recommendations from Sharp [23] and Sabri et al. [22] for more sophisticated metrics that capture the quality and depth of digital participation.

E. Theoretical Contributions

This study makes several theoretical contributions to the digital divide discourse. First, it extends the Technology Acceptance Model and UTAUT by demonstrating that facilitating conditions—operationalized as System Infrastructure Accessibility—matter more in vulnerable populations than in organizational or consumer contexts. The physical proximity to service points is a more critical determinant of usage than digital infrastructure access alone.

Second, the study provides empirical evidence for Sen's Capability Approach in the digital context. The distinction between functionings and capabilities is validated by the finding that borrowed access provides a functioning (transaction capability) but not genuine capability or freedom. Users who lack autonomy, privacy, and ownership are not truly included, even when they can perform transactions.

Third, the study adds usable security as a core dimension of how we understand digital exclusion. While the digital divide research has traditionally focused on who has access, who has skills, and who gets the benefits, this study demonstrates that security usability factors—particularly Security Ease of Use—are more important than traditional infrastructure access in predicting digital inclusion.

F. Policy Implications

The findings of this study have several important policy implications:

1. Prioritize Infrastructure Density Over Cost Subsidies: Policymakers should prioritize geographic proximity interventions—agent networks and service point density—over cost subsidies. The study provides empirical justification for investments in expanding the physical footprint of digital services rather than solely focusing on reducing transaction costs.
2. Reconsider Device-Sharing Programs: The lack of influence from Alternative Access suggests that policymakers should reconsider investments in device-sharing programs and redirect resources toward subsidized personal device ownership or usability improvements. If shared access is provided, it must be accompanied by measures to address privacy concerns, autonomy issues, and device quality.
3. Shift from Access-Centric to Capability-Based Strategies: The composite Digital Inclusion Index demonstrates that access-centric measures are insufficient for evaluating digital inclusion. Policymakers should adopt capability-based strategies that aim to expand what people are free to do with digital services, not just what they have access to.
4. Mandate Usability Testing: Given that security usability factors have a larger influence on digital inclusion than access factors, policymakers should mandate usability testing for digital services targeting vulnerable populations before public deployment or subsidy approval.

VI. CONCLUSION

This study examined the influence of infrastructure access-based factors on digital usage levels among vulnerable users in Kenya. The findings reveal that access-centric measures are insufficient for evaluating digital inclusion, and that physical proximity and service point density are more important than cost reduction in predicting usage depth. System Infrastructure Accessibility emerged as the strongest access-based predictor of digital inclusion ($\beta = 0.390$), while Perceived Cost of Access showed a significant but substantially smaller negative influence ($\beta = -0.093$). The study challenges common policy assumptions about device-sharing programs and demonstrates that Alternative Access through borrowed devices does not significantly improve digital inclusion.

From a theoretical perspective, the study extends TAM and UTAUT by demonstrating the importance of physical infrastructure availability, provides empirical evidence for Sen's Capability Approach, and contributes security usability as a core dimension of digital exclusion. From a methodological perspective, the study developed and tested a composite Digital Inclusion Index based on usage depth that provides a more nuanced understanding of digital participation.

The study recommends a fundamental policy shift from access-centric to capability-based digital inclusion strategies, prioritizing infrastructure density, usability simplification, privacy protection, and personal device ownership over cost reduction and device-sharing programs alone. The validated regression equation provides practitioners with a quantifiable tool for estimating digital inclusion outcomes and simulating intervention impacts.

Future research should test the model across different populations and service domains, refine the measurement of perceived cost, and investigate the mechanisms through which shared access fails to improve digital inclusion. Understanding these mechanisms will be crucial for designing effective interventions that genuinely expand digital capabilities and reduce digital exclusion among vulnerable populations.

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