Enhancing UMEGA with Trust in Government and Digital Literacy: A Framework for Assessing the Quality of E-Government Water Monitoring Services in Indonesia

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Abstract. This study develops and validates a sustainable e-government evaluation model in Indonesia by integrating two key constructs—trust in government and digital literacy—into the Unified Model of Electronic Government Adoption (UMEGA). A convergent mixed-methods approach was employed, combining quantitative analysis using Structural Equation Modeling–Partial Least Squares (SEM-PLS) on a nationally stratified survey with semi-structured interviews to capture contextual practices and motivations. The findings reveal that trust in government positively influences the intention to use e-government, while digital literacy not only enhances intention but also actual usage. Perceived usefulness remains a critical determinant of intention, with behavioural intention acting as a mediator toward usage. The application to water quality monitoring services, such as ONLIMO and SPARING, underscores the importance of data transparency and citizens' digital readiness in building public trust. Theoretically, this study extends UMEGA by incorporating contextual dimensions relevant to developing countries. Practically, it provides policy insights for digital literacy programs, data transparency standards, and inclusive, user-oriented service design. The main contribution lies in offering a contextualized, valid, and replicable evaluation framework to strengthen digital governance in Indonesia and other emerging economies.

1 Introduction

Revitalizing digital public services is essential for advancing governance and enhancing institutional viability in Indonesia. The UMEGA framework has been successfully employed

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to analyze e-government uptake across different nations [1]. Nonetheless, Indonesia's unique profile—marked by socio-cultural pluralism, uneven infrastructure, and varying levels of digital literacy—shapes public confidence in state institutions and shapes willingness to engage with online services. Consequently, a robust assessment of e-government diffusion in Indonesia demands a methodology attuned to these contextual realities.

Various initiatives in Indonesia have demonstrated the role of e-government as a support system for real-time data-based public service performance assessment. ONLIMO is a real-time water quality monitoring system developed by the Ministry of Environment and Forestry (KLHK) to measure parameters such as pH, temperature, dissolved oxygen (DO), total dissolved solids (TDS), and turbidity in natural water bodies. The data collected are transmitted directly to a central database, supporting transparency, environmental supervision, and an early warning system. SPARING, on the other hand, is an automatic monitoring system that requires industries to continuously measure wastewater quality, including parameters such as COD, BOD, TSS, pH, and discharge volume. These two systems complement each other, with ONLIMO focusing on environmental water quality while SPARING ensures industrial compliance with environmental standards. The presence of these systems underscores the urgency of an e-government evaluation framework that accounts for trust and digital literacy, as data quality and citizen engagement are significantly influenced by these two dimensions.

Beyond their technological and administrative functions, ONLIMO and SPARING also contribute directly to Indonesia's sustainable inland water governance agenda. Anchored in eco-hydrological principles, both systems embody the adaptive management cycle essential to maintaining the balance between hydrological processes and ecological integrity. Continuous monitoring enables timely responses to pollution and ecosystem stress, ensuring that policy interventions are informed by real-time environmental data. In this regard, these systems operationalize elements of the Sustainable Development Goals—particularly SDG 6 (Clean Water and Sanitation), Targets 6.3 and 6.6—by advancing pollution reduction, improving water quality, and safeguarding aquatic ecosystems. Integrating trust and digital literacy into the UMEGA framework thus enhances not only institutional legitimacy but also the participatory and knowledge-based dimensions of sustainable water governance.

The explanatory power of the UMEGA framework in Indonesia remains constrained by its omission of the constructs of trust and digital literacy. Empirical studies across the nation that detail how these two constructs affect intention and actual capacity among users are similarly thin. This investigation addresses that lacuna by embedding trust in government and digital literacy within the original UMEGA model as it pertains to Indonesia [2]. The central investigative queries examine how trust and digital literacy respectively affect intention and actual use, and whether the latter construct moderates the relationships among the key components of UMEGA. We advance the hypotheses that trust positively influences intent to use and that digital literacy positively affects both intent and observable usage behaviours.

This research employs a convergent mixed-methods framework to leverage the complementary advantages of quantitative and qualitative methodologies. From the quantitative perspective, a nationally representative survey stratified by province operationalizes the extended UMEGA constructs [3], and SEM-PLS [4] analyses evaluate measurement reliability, structural validity, and pathway coefficients [5]. Concurrently, semi-structured interviews with both service users and managerial representatives investigate perceived barriers, lived experiences, and facilitators of trust. To illuminate contextual variability, a heterogeneity analysis across provincial jurisdictions examines differences in infrastructure, demographic composition, and service delivery cultures. Results from each arm of inquiry are integrated via analytical triangulation at the interpretative level, thereby reinforcing the robustness of the resultant conclusions.

Theoretically, this research builds on the UMEGA framework by integrating two contextual dimensions that are particularly relevant for developing economies. Empirically, it supplies nationwide evidence regarding how trust and digital literacy shape the intention and actual use of e-government services [6]. From a methodological standpoint, the analysis employs a SEM-PLS-oriented approach to create an evaluative framework that includes predictive capacity and assessments of cross-regional heterogeneity. This combination produces more accurate evaluation indicators, assessing not only the technical and functional aspects of the system but also social acceptance, political legitimacy, and the effectiveness of use. Through this approach, the quality of e-government services in water quality monitoring in Indonesia can be evaluated more holistically, with a clear orientation toward sustainable, technology-based environmental governance rooted in eco-hydrological balance and the realization of SDG 6.

2 Literature Review

The UMEGA model builds on the core ideas of the TAM [7] and UTAUT frameworks by combining perceived usefulness, behavioural intention, and actual usage outcomes into a single explanatory model. In developing nations, the rate of new system uptake commonly hinges on two paramount influences: the populace's confidence in governmental bodies and the prevailing standard of digital literacy among citizens. Trust affects how people assess risk, the perceived legitimacy of e-government services, and their overall willingness to interact with public sector platform initiatives. Concurrently, digital literacy equips users with the competencies to discern advantages, negotiate complex digital interfaces, and protect their online identities from potential harm. Consequently, the intentional incorporation of trust and digital literacy into the UMEGA framework is justified to strengthen its predictive validity, especially within the Indonesian sociotechnical context [8].

The 2024 UN survey confirms promising advances in digital government services globally while alerting policymakers to populations that continue to be marginalized. Bridging the digital divide and fostering digital skills in these groups emerge as urgent priorities. Concurrently, a series of studies have demonstrated that citizens' media literacy, their propensity to seek risk information, and their trust in government institutions together forecast an increased likelihood of adopting e-government solutions. This nexus suggests that the perceived legitimacy of institutions and the digital capacities of citizens are mutually reinforcing, rather than independent, factors. In parallel, national media policy reporting indicates that the rapid expansion of digital literacy programs and smarter governance frameworks are, in some locales—including Indonesia—paralleled by measurable gains in the effectiveness of digital services. Collectively, these patterns strengthen the thesis that trust, and literacy are now fundamental drivers of digital governance [9] rather than ancillary outcomes.

Three main gaps emerge from the literature. First, many studies test UMEGA/TAM/UTAUT without modeling trust in government and digital literacy simultaneously, thereby reducing explanatory power in the context of developing countries. Second, there is still a lack of national-scale evidence to test the moderation of digital literacy on the relationship between perceived usefulness/ease of use and intention [10]. Third, researchers infrequently publish examinations of cross-regional heterogeneity and measurement invariance—particularly via approaches such as the MICOM procedure [11]. Variations across regions in infrastructure, demographics, and service culture can appreciably modulate the strength of inter construct relationships, yet these influences are seldom quantified. This study aims to address the identified gaps by utilizing a comprehensive and multidimensional design alongside a clear reporting framework.

Trust in government attenuates citizens' perceptions of uncertainty and risk, thereby strengthening their evaluations of integrity and competence in public sector providers. Operating within the social exchange model, constituents who possess a stable reservoir of institutional trust attribute a higher worth to the benefits delivered and anticipate that future service interactions will be more uniform and reliable. Trust also serves as a "social license" that legitimizes government digital innovation. Therefore, trust is expected to positively correlate with the formation of intentions to use e-government services. H1: Trust in government has a positive effect on the intention to use e-government.

Digital literacy encompasses a set of cognitive, technical [7], and safety skills that enable citizens to effectively find, evaluate, and use digital services. Individuals with higher literacy experience lower learning burdens, stronger self-efficacy, and lower risk of error. This increases the tendency to form intentions and maintain actual usage. In contexts with skill and access gaps, digital literacy serves as a key enabler of service inclusion. H2: Digital literacy has a positive effect on intentions and actual usage of e-government.

Within the TAM and UTAUT frameworks [12], perceived usefulness embodies the conviction that a system will enhance task efficacy and overall utility. Citizens who see that e-government platforms streamline procedures, reduce waiting times, or provide better results are more likely to intend to adopt them. Empirical evidence corroborates this association across varied service sectors, and the correlation is particularly robust for activities that formerly necessitated in-person attendance. In Indonesia, tailoring service design to pragmatic realities and local contexts is expected to enhance users' perception of usefulness and, in turn, strengthen their intention to engage. H3: The advanced in this research asserts that perceived usefulness significantly and positively influences the intention to adopt e-government services.

The model positions Trust in Government [10] (→ Intention), Digital Literacy [13] (→ Intention & Use), and Perceived Usefulness (→ Intention) as the main pathways in accordance with H1–H3. The Intention variable is viewed as a proximal mediator toward Use, while other UMEGA constructs (e.g., perceived ease of use, facilitating conditions, perceived risk) can be treated as control variables reported in the Methods section without explicit hypotheses. This approach maintains the focus on the novelty of trust and digital literacy while preserving alignment with established adoption model traditions.

Water quality information is a crucial aspect of environmental governance that can be optimized through e-government services to enhance transparency, accountability, and public participation. Integrating water quality data into digital systems and open government data enables citizens to monitor environmental conditions, strengthen public trust, and promote environmental literacy [14]. The use of IoT technologies in e-government services further allows real-time water quality monitoring, supporting early detection of pollution and the sustainability of environmental governance.

Assessing the quality of e-Government services in water quality monitoring applications, such as ONLIMO and SPARING, is important because the quality of the system, information, and services influences the perception of usefulness and ease of use, which are determinants of public adoption. Accurate, timely, and transparent information fosters trust in the government and strengthens the legitimacy of environmental policies. Digital literacy acts as a moderating factor that enhances the public's ability to understand and utilize data, thereby strengthening the relationship between service quality and trust in the government. Thus, the integration of service quality, public trust, and digital literacy makes e-Government assessment a crucial foundation for realizing transparent and participatory environmental governance.

3 Methodology

An assessment of the reflective measurement model was performed across all constructs in this study, including Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Condition, Perceived Risk, Trust in Government, Digital Literacy, Attitude, and Behavioural Intention. The evaluation of reliability and validity followed established SEM-PLS procedures.

Indicator loadings were expected to exceed 0.70, while items with values between 0.40 and 0.70 were retained only if the construct's composite reliability (CR ≥ 0.70) and average variance extracted (AVE ≥ 0.50) remained within acceptable limits. Discriminant validity was confirmed through the Heterotrait–Monotrait (HTMT) ratio (<0.90) and cross-loading analysis, ensuring that each indicator aligned most strongly with its intended construct. The Fornell–Larcker criterion was used as an additional confirmation of discriminant validity.

Prior to the main survey, a pilot study and expert review were conducted to verify conceptual coverage and wording clarity. Indicators were removed only when their exclusion improved both CR and AVE without compromising conceptual completeness. Split-sample stability tests were applied in place of MICOM to examine consistency across random subsamples, accepting CR and AVE differences of ≤0.10 as evidence of stability. Missing data, which accounted for less than 5% of responses, were treated using pairwise deletion at the indicator level.

The study population comprised Indonesian residents aged 17 years and above who had accessed at least one e-government service in the preceding 12 months. Stratified sampling by province, with proportional adjustment for urban and rural representation, was used to achieve national representativeness. The target sample size was 800 respondents (minimum 400), sufficient to ensure statistical power (0.80) for detecting small to medium effects and to enable comparative subgroup analyses. Data were collected primarily through an online survey equipped with anti-duplication features (cookie/device fingerprinting), supplemented by tablet-based offline surveys at selected public service locations to mitigate coverage bias. Post-stratification weighting was applied to correct demographic imbalances.

In summary, all measurement indicators met established reliability and validity thresholds (loadings >0.70, CR >0.70, AVE >0.50), while HTMT values below 0.90 confirmed discriminant validity. These results demonstrate strong measurement consistency and construct integrity across all reflective variables.

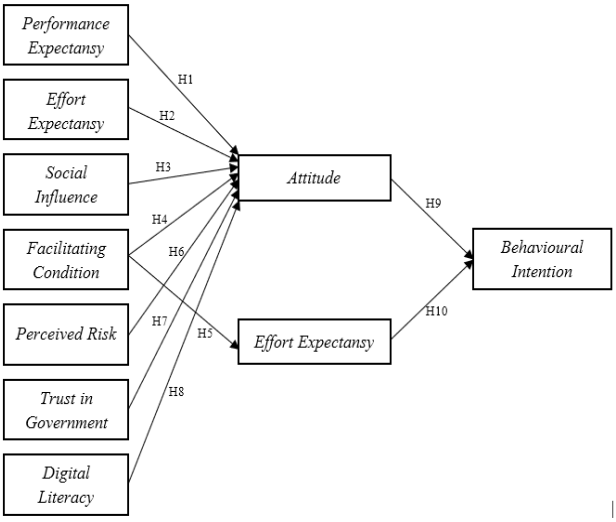

Fig. 1 Framework for the relationship between variables

Figure 1 presents the conceptual framework, positioning seven antecedents—Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Condition, Perceived Risk, Trust in Government, and Digital Literacy—as predictors of Attitude toward e-government services. Attitude, in turn, drives Behavioural Intention, mediating the influence of these factors, while Effort Expectancy also exerts a direct effect on intention. Trust in Government, and Digital Literacy—as determinants of Attitude toward e-government services (by hypotheses H1–H8). The expected influence is positive for all antecedents except Perceived Risk, which is predicted to be negative toward attitude. Furthermore, Attitude drives Behavioural Intention (H9), thus acting as a proximal mediator that channels the influence of these factors to adoption intention. Specifically, Effort Expectancy also has a direct path to Behavioral Intention (H10) to capture the effect of convenience that is immediately translated into intention, in addition to its influence through Attitude. Thus, the model tests both direct and indirect effects, while highlighting the role of Trust in Government and Digital Literacy as key drivers of usage intention.

Table 1. Rule of Thumb Outer Model

Criteria	Parameter	Threshold
Convergent Validity	*Loading Factor*	> 0,70
	Average Variance Extracted	> 0,50
Discriminant Validity	*Cross Loading*	> 0,70
	HTMT	< 0,90
Reliability	*Cronbach Alpha*	> 0,70
	Composite Reliability	> 0,70

4 Results

The survey produced a representative sample of users of Indonesia's water quality monitoring applications, including ONLIMO and SPARING. Duplicate and straight line responses were removed prior to analysis. The dataset reflects demographic diversity across provinces in terms of age, gender, education, income, and ICT experience.

Validity and reliability testing in SmartPLS confirmed that all reflective constructs met accepted measurement standards. Convergent validity was achieved with Average Variance Extracted (AVE) values around 0.50, indicating that indicators clustered coherently around their latent constructs. Discriminant validity assessed using the Heterotrait–Monotrait ratio (HTMT < 0.90), showed that all constructs were sufficiently distinct. Reliability results were strong, with Cronbach's alpha and composite reliability (CR) consistently above 0.70, confirming internal consistency.

Overall, these results demonstrate that the measurement model is statistically robust and suitable for structural analysis. In practical terms, respondents consistently interpreted items related to trust, digital literacy, and perceived usefulness, reinforcing the conceptual soundness of these constructs across Indonesia's varied digital environments.

5 Discussion

The results show that trust in government and digital literacy are pivotal in shaping citizens' intentions to adopt and use e-government services, supporting hypotheses H1 and H2. Digital literacy not only increases intention but also strengthens actual usage, underscoring its dual role as both an enabling skill

and a behavioural driver. Perceived usefulness continues to be a central determinant of intention, while the pathway from intention to use remains stable, confirming its mediating function within the UMEGA framework.

Trust enhances adoption by legitimizing government digital platforms and lowering perceived risk, particularly where transparency and public data accuracy are critical. Digital literacy, in turn, reduces cognitive effort and improves users' capacity to interpret environmental data such as pH, turbidity, or chemical oxygen demand. Together, these constructs bridge the technical and social dimensions of e-government, translating digital systems into trusted governance instruments.

In the context of inland water governance, platforms such as ONLIMO and SPARING demonstrate how e-government can operationalize transparency and accountability. By providing real-time access to environmental quality data, these systems contribute directly to Sustainable Development Goal (SDG) 6 on clean water and sanitation. When citizens understand and trust these digital reports, water monitoring evolves from top-down oversight into participatory co-management.

The study therefore reframes e-government diffusion as not only a technological matter but a sustainability governance issue. Effective implementation requires simultaneous attention to system reliability, citizen capability, and institutional credibility. Policy priorities should include:

1. Targeted digital literacy and environmental data education programs;
2. Clear data transparency and accountability standards;
3. Simple, purpose-driven service design; and
4. Adaptive strategies reflecting provincial infrastructure and socio-cultural conditions.

Performance indicators such as service completion time, data accuracy, and user retention can track both governance quality and environmental effectiveness.

Methodologically, this study extends the UMEGA framework by embedding trust and digital literacy—two variables critical in developing contexts—without diminishing the explanatory power of traditional constructs such as perceived usefulness. Empirically, it provides national-level evidence that social and cognitive dimensions are not peripheral but core to sustainable digital governance.

Limitations include the reliance on self-reported data and the cross-sectional design, which restrict causal inference. Future studies should link survey findings to actual usage logs, employ longitudinal or quasi-experimental designs, and test cross-sector generalizability. Moderator effects based on regional development, infrastructure quality, or demographic profiles also warrant deeper exploration to refine policy targeting.

6 Conclusion

This study shows that e-government adoption in Indonesia cannot be adequately explained by generic technology acceptance models without accounting for contextual realities such as institutional variation, infrastructure inequality, and digital capability gaps. By integrating trust in government and digital literacy into the UMEGA framework, the findings reveal that these dimensions are not merely complementary factors but foundational to building sustainable digital service ecosystems. Strengthening trust lowers perceived risk and enhances legitimacy, while improving literacy increases readiness, comprehension, and actual use of public digital platforms.

The use of a mixed-methods approach—combining PLS-SEM with interpretative phenomenological analysis (IPA)—provides both statistical and contextual validation. Results confirm that trust significantly drives behavioural intention, digital literacy promotes both intention and usage, and perceived usefulness remains central to technology adoption. Together, these relationships outline a comprehensive model for understanding citizen engagement in digital governance.

In practical terms, the study underscores how water quality monitoring applications such as ONLIMO and SPARING illustrate the intersection of digital governance and environmental sustainability. By providing transparent, real-time data on indicators like pH, turbidity, and COD, these systems allow citizens and local authorities to co-monitor water

resources. This transparency not only improves environmental accountability but also strengthens institutional credibility and citizen participation—key principles of sustainable water governance under SDG 6.

The primary contribution of this research lies in expanding the UMEGA model through the simultaneous inclusion of trust and literacy, verified through both in-sample and out-of-sample predictive tests. Beyond theoretical enrichment, the study offers a policy-oriented toolkit emphasizing scalable digital literacy initiatives, auditable transparency mechanisms, and citizen-centered service design. These interventions collectively advance both digital inclusion and environmental stewardship.

Future research should adopt longitudinal and quasi-experimental designs, linking survey insights with actual usage logs to assess behavioural persistence over time. Extending this framework to other service domains and developing-country contexts will deepen the understanding of how trust, literacy, and sustainability jointly shape the long-term success of digital public services.

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