



Digital Technology Use and Perceived Intergenerational Empowerment in Sustainable Rural Tourism: Evidence from a Youth-Dominated Sample in Mount Muria, Indonesia

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<https://doi.org/10.18280/ijstdp.210827>

ABSTRACT

Received: 24 June 2026

Revised: 16 August 2026

Accepted: 25 August 2026

Available online: 31 August 2026

Keywords:

digital technology use, generational mindset, intergenerational empowerment, rural tourism, sustainable development, work patterns

Digital technology may support sustainable rural tourism when it is embedded in everyday work and learning practices. This cross-sectional study examines associations among generational mindset, work patterns, digital technology use, and perceived intergenerational empowerment in Mount Muria, Indonesia. The sample comprised 300 adults and was strongly youth-dominated (80.0% aged 18–27 years). Partial least squares structural equation modelling used 5,000-sample BCa bootstrapping, blindfolding, PLSpredict, and importance-performance map analysis. Work patterns were strongly associated with technology use ($\beta = 0.557$, $p < 0.001$), while mindset showed a smaller positive association ($\beta = 0.218$, $p < 0.001$). Technology use ($\beta = 0.303$, $p < 0.001$) and work patterns ($\beta = 0.246$, $p < 0.001$) were positively associated with perceived empowerment, whereas the direct mindset association was nonsignificant. Significant specific indirect associations operated through technology use for mindset ($\beta = 0.066$, $p = 0.013$) and work patterns ($\beta = 0.169$, $p < 0.001$). Blindfolding supported predictive relevance, but PLSpredict did not outperform the linear-model (LM) benchmark. Importance-performance map analysis (IPMA) identified work patterns and technology use as the most important improvement priorities.

1. INTRODUCTION

Mount Muria is an ecologically and culturally distinctive rural landscape in Central Java whose volcanic history supports fertile agrarian systems [1] and whose biodiversity remains an important educational and conservation asset [2]. The area also contains major religious and cultural attractions, especially the Sunan Muria pilgrimage landscape, which provides a foundation for wider destination development in Kudus [3-5]. Forest-conservation initiatives further show that tourism development in the Muria area is inseparable from community stewardship and ecological citizenship [6]. These characteristics create an opportunity to connect agrarian livelihoods, cultural heritage, environmental responsibility, and tourism within a place-based rural-development agenda.

That opportunity is not automatically converted into sustainable development. Rural tourism is a territorial process: benefits depend on the spatial distribution of services and infrastructure [7], the extent to which planning protects rural identity and community control [8, 9], and the capacity to prevent protected or culturally sensitive landscapes from being

reduced to commodities [10]. Residents' perceptions of tourism impacts also shape local support [11], while tourism-led spatial restructuring may intensify uneven development when infrastructure and economic gains become concentrated in limited nodes [12, 13]. Conversely, regional tourism clusters can reinforce local production systems when cooperation and innovation are embedded in place-based planning [14]. For Mount Muria, the planning challenge is therefore not simply to increase visitor numbers but to strengthen local capacity to participate in and benefit from tourism-related change.

Digital technologies are increasingly relevant to that challenge. Information and communication technology infrastructure can expand tourism accessibility and service capacity [15], while mobile payment, self-service systems, and digital interfaces have changed how different age groups interact with tourism services [16, 17]. Social media provides additional channels for destination communication across generations [18], and digitalization accelerated sharply during and after the COVID-19 disruption [19]. Rural and agritourism operators also adapted through diversification and changing

service practices [20]. Recent geographic-information and digital-trace studies further demonstrate how technology can connect tourism activity with spatial evidence and planning [21, 22]. Yet digital access alone does not establish whether residents can use technology in ways that strengthen participation, knowledge exchange, and collective capacity.

Technology use is socially conditioned. Generational research reports differences in technology behaviour [23], hospitality-work expectations [24], flexible work arrangements [25, 26], motivation [27], and social meanings attached to work and resources [28]. A growth-oriented mindset can support adaptation [29], while design-oriented thinking encourages iterative problem solving [30]. Entrepreneurial orientation and grit may also influence innovation among younger cohorts [31, 32], and education, internet access, and technology-rich learning environments shape digital capability [33, 34]. Related evidence links generational orientations to climate and tourism behaviour [35] and technology-related product use [36]. These studies suggest that two proximal respondent-level conditions—mindset and work patterns—may be more informative than demographic generation labels when explaining how digital tools are used in a rural-tourism setting.

Empowerment provides the institutional bridge between individual capability and collective action. Community-scale initiatives can support wider transitions when local actors gain greater ability to participate in decisions and control resources [37], while whole-of-society approaches emphasize collaborative governance rather than isolated participation [38]. Intergenerational dialogue can reveal differences in power, knowledge, and experience that conventional tourism planning overlooks [39]. Rural livelihood sustainability similarly depends on local agency and expectations [40], and village-level governance can support Sustainable Development Goal implementation when resources are aligned with local priorities [41]. Agrarian inequalities remain relevant because access to land and productive resources conditions who can benefit from rural transformation [42], while community business models show that institutional arrangements affect whether locally organized transitions generate durable value [43].

The theoretical gap is therefore not whether digitalization matters for tourism, but how work-related and cognitive orientations are associated with digital technology use and perceived intergenerational empowerment within a community setting. Cross-generational place-attachment research shows that generations may relate differently to rural destinations [44, 45], and sustainable rural-development frameworks emphasize multidimensional outcomes [46]. Spatial-planning research also highlights scenario-based and geographic information system (GIS)-supported approaches [47, 48]. These perspectives, however, do not specify whether mindset and work practices are associated with empowerment directly, indirectly through technology use, or both. This distinction matters because a favourable mindset may remain aspirational unless enacted through usable technology, whereas work practices may affect collective capacity both through digital coordination and through non-digital routines of collaboration.

Accordingly, this study evaluates a parsimonious associational model in which generational mindset and work patterns are associated with digital technology use and with perceived intergenerational empowerment, while technology use is also associated with empowerment. The specification

also estimates direct antecedent-to-empowerment paths so that indirect associations through technology use are interpreted alongside the corresponding direct associations. Because the data are cross-sectional and single-source, all paths are interpreted as associations rather than causal mechanisms.

Seven hypotheses are tested. H1 proposes that generational mindset is positively associated with digital technology use. H2 proposes that work patterns are positively associated with digital technology use. H3 proposes that digital technology use is positively associated with perceived intergenerational empowerment. H4 proposes that generational mindset is positively associated with perceived intergenerational empowerment. H5 proposes that work patterns are positively associated with perceived intergenerational empowerment. H6a and H6b propose significant specific indirect associations of mindset and work patterns, respectively, with perceived intergenerational empowerment through digital technology use. The research framework is shown in Figure 1.

The study contributes in three ways. First, it shifts attention from demographic generation categories to respondent-level mindset and work practices as proximal social conditions associated with digital use. Second, it distinguishes direct from technology-linked indirect associations with perceived intergenerational empowerment, allowing the analysis to test whether technology use adds explanatory value beyond the antecedents themselves. Third, it combines structural estimation with blindfolding, out-of-sample prediction, and importance-performance analysis to separate explanatory association from predictive performance and to identify empirically prioritized areas for rural-tourism planning. The analysis does not claim balanced comparisons among Baby Boomers, Generation X, Millennials, and Generation Z because the achieved sample is strongly youth-dominated.

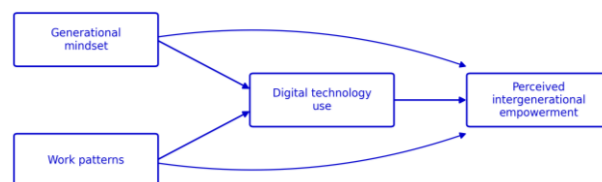


Figure 1. Research framework with direct and technology-linked associations

2. METHODOLOGY

2.1 Research design and sample

This study examined digital technology use and perceived intergenerational empowerment in the Mount Muria rural-tourism context using partial least squares structural equation modelling (PLS-SEM). The analytical sequence combined the PLS algorithm, nonparametric bootstrapping, blindfolding, PLSpredict, and importance-performance map analysis (IPMA). PLS-SEM was selected because the model is prediction-oriented, contains multiple latent constructs, and evaluates both direct and specific indirect associations. The analytical logic follows established applications of PLS-SEM in behavioural and information-systems research [49-53] and the SmartPLS 3 implementation described by Ringle et al. [54].

Data were collected from May to August 2024 through face-to-face, interviewer-administered surveys in tourism areas

around Mount Muria, Central Java, Indonesia. Eligible respondents were adults aged 18 years or older who lived in, worked in, were familiar with, or had visited the Mount Muria tourism area. Trained enumerators approached potential respondents directly at the study locations, administered the questionnaire in Bahasa Indonesia, and checked each response for completeness at the point of data collection. Recruitment continued until the predetermined target of 300 complete and usable responses was reached, after which the survey was closed. Because the field procedure used a stopping rule based on complete interviews rather than recording all individuals approached, a conventional questionnaire distribution/return rate was not calculated. The final analytical sample therefore comprised 300 complete responses, with no incomplete questionnaires retained. The achieved sample was highly uneven by age and occupation: 80.0% were aged 18–27 years and 76.7% reported student as their primary occupation. This imbalance is treated as a design limitation rather than evidence of representative intergenerational comparison; all generationally relevant constructs are interpreted as respondent-level orientations in a pooled sample. A sensitivity power analysis using the multiple-regression analogue of the most complex endogenous equation (three predictors, $\alpha = 0.05$, power = 0.80) indicated that $n = 300$ was sufficient to detect an effect size of approximately $f^2 = 0.037$, supporting the adequacy of the achieved sample for the estimated model.

The questionnaire included an informed-consent section before the survey items. Respondents were informed that participation was voluntary, responses would be kept confidential and reported only in aggregate for academic purposes, and participation could be discontinued at any time without consequence. The field instrument was developed and administered in Bahasa Indonesia, the respondents' working language. For international reporting, the authors translated the administered items into English for this manuscript and Appendix. Because the survey instrument was originally developed and administered in Indonesian rather than translated from an English source instrument, a prospective translation-back-translation procedure was not used. SmartPLS therefore analysed 300 complete records and required no missing-data algorithm.

2.2 Common-method assessment

Because all constructs were measured from the same respondents in a single survey wave, common-method bias was assessed explicitly. Harman's single-factor test was conducted on the 12 retained indicators; the first unrotated component explained 42.43% of total variance, below the conventional 50% dominance criterion. Full-collinearity VIFs were also calculated from the four latent-variable scores by regressing each construct on the remaining constructs. VIFs were 1.295 for perceived intergenerational empowerment, 1.539 for mindset, 2.085 for technology use, and 2.131 for work patterns. All were below the conservative 3.3 threshold, providing no indication that a single common-method factor dominated the observed associations. These diagnostics reduce, but do not eliminate, the possibility of common-method bias in a cross-sectional self-report design.

2.3 Measures

A structured interviewer-administered questionnaire measured the constructs using a five-point Likert scale ranging

from 1 (strongly disagree) to 5 (strongly agree). Work Patterns comprised three items (Pk1–Pk3) capturing flexible work arrangements, use of digital tools for tourism-related communication and collaboration, and adaptation of work practices when new technologies or methods are introduced. Generational Mindset comprised three items (Pp1–Pp3) measuring willingness to learn and adapt, perceived importance of digital technology for tourism activities, and belief in innovative and sustainable approaches to rural-tourism development. Digital Technology Use comprised three items (Z1–Z3) covering use of digital platforms for tourism information, communication/promotion/transactions, and perceived support of digital technology for community participation. Perceived Intergenerational Empowerment comprised three items (Em1–Em3) measuring cross-generational participation in tourism decisions, intergenerational knowledge and skill sharing, and collaboration across generations in managing tourism resources and activities. The construct captures respondents' perceptions of cross-generational participation and collaboration; it is not a score comparing empowerment levels between age cohorts. The complete administered Indonesian items and their English translations are provided in Table A in the Appendix.

2.4 Model refinement and competing-model assessment

The initial specification included environmental conservation orientation as a two-item antecedent, motivated by literature on environmental education, conservation behaviour, sustainable production, and Indonesian conservation practice [55–61]. In the original measurement model, however, the construct showed weak internal consistency (Cronbach's $\alpha = 0.576$) and highly uneven indicator performance, including one loading close to 0.52. A competing full specification was therefore estimated with direct antecedent-to-empowerment paths. Although environmental conservation orientation showed direct associations with empowerment and technology use, its specific indirect association through technology use was not statistically robust at the 0.05 level, while the measurement weakness remained. Consistent with the requirement that construct quality precede structural interpretation, the final parsimonious specification excluded environmental conservation orientation and retained generational mindset, work patterns, digital technology use, and perceived intergenerational empowerment together with the direct antecedent-to-empowerment paths. All results reported below refer to this final specification. The two environmental-conservation items remain listed in the Appendix for transparency because they were part of the administered instrument but were excluded from the final model after measurement-model reassessment.

2.5 Partial least squares structural equation modelling evaluation

The measurement model was assessed using outer loadings, Cronbach's α , ρ_A , composite reliability (CR), average variance extracted (AVE), the Fornell-Larcker criterion, the heterotrait-monotrait ratio (HTMT), and variance inflation factors (VIF). The structural model was assessed using standardized path coefficients, R^2 , adjusted R^2 , f^2 , model-fit diagnostics, and bootstrapped confidence intervals. The PLS

algorithm standardized the data (mean 0, variance 1), used path weighting, an initial weight of 1.0, a maximum of 500 iterations, and a stop criterion of 10^{-7} . Statistical significance was assessed with 5,000 bootstrap samples, a two-tailed test, a 0.05 significance level, and bias-corrected and accelerated (BCa) confidence intervals. Exact p values are reported. Blindfolding used an omission distance of 7.

2.6 Predictive assessment and importance-performance analysis

Out-of-sample prediction was assessed using PLSpredict with 10 folds and 10 repetitions. Q^2_{predict} values were examined together with root mean squared error (RMSE) and mean absolute error (MAE), and PLS prediction errors were compared with a linear-model (LM) benchmark [50]. IPMA was conducted with perceived intergenerational empowerment as the target construct. Standardized total effects represent construct importance, whereas rescaled latent-variable scores represent performance on a 0–100 scale. This combination is used to identify relatively important but underperforming areas for practical intervention.

3. RESULTS AND DISCUSSION

3.1 Sample profile

Table 1 summarizes the demographic profile. All respondents were adults aged 18 years or older. The sample was dominated by respondents aged 18–27 years (80.0%), with 6.7% aged 28–44 years, 12.0% aged 45–59 years, and 1.3% older than 59 years. Most respondents reported 10–12 years of education (87.3%), and students represented 76.7% of the sample. Figure 2 displays age, education, and occupation distributions so that the imbalance is visually explicit. The pooled estimates therefore primarily represent a digitally exposed, youth-oriented population and must not be interpreted as balanced cross-generational comparisons.

Table 1. Demographic profile of respondents

Indicator	Frequency	Percentage (%)
Age: 18–27	240	80.0
Age: 28–44	20	6.7
Age: 45–59	36	12.0
Age: >59	4	1.3
Education: 6–9 y	8	2.7
Education: 10–12 y	262	87.3
Education: 13–16 y	24	8.0
Education: >16 y	6	2.0
Occupation: Farmer	28	9.3
Occupation: Civil servant	8	2.7
Occupation: Trader	6	2.0
Occupation: Student	230	76.7
Occupation: Other	28	9.3

3.2 Measurement model and final specification

The final four-construct measurement model showed acceptable reliability and convergent validity (Table 2). Perceived intergenerational empowerment had $\alpha = 0.8512$, CR = 0.9098, and AVE = 0.7707; technology use had $\alpha = 0.8511$, CR = 0.9098, and AVE = 0.7708. Reporting four decimals clarifies that these highly similar values are not identical. Mindset showed $\alpha = 0.7357$, CR = 0.8448, and AVE = 0.6464.

Work patterns had $\alpha = 0.6979$, marginally below 0.70, but CR = 0.8262 and AVE = 0.6143 were acceptable. Outer loadings ranged from 0.712 to 0.904, with all retained indicators exceeding 0.70.

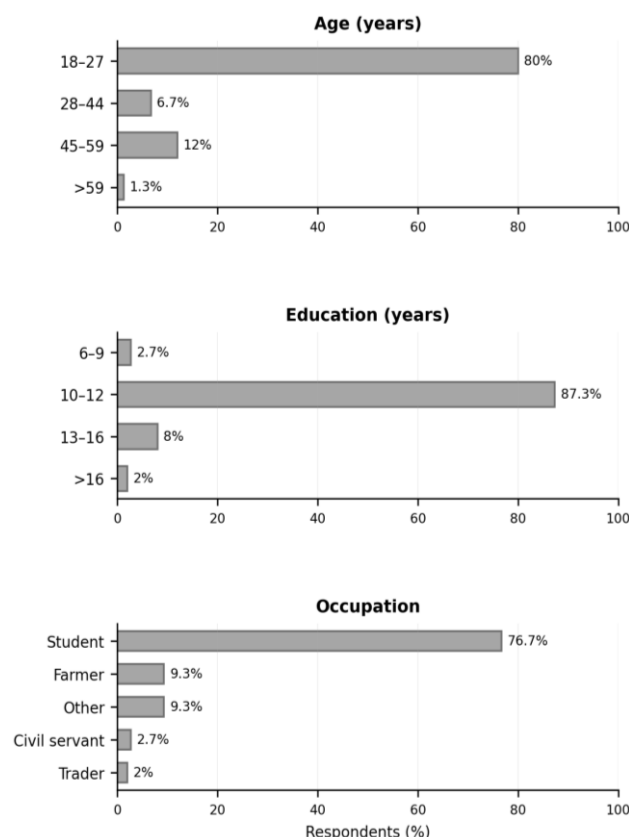


Figure 2. Age, education, and occupation distribution of respondents

Discriminant validity was satisfactory. All HTMT values were below 0.90, with the highest value between technology use and work patterns (0.831). Outer VIF values ranged from 1.278 to 2.681, and inner VIF values ranged from 1.443 to 2.052, indicating no critical collinearity. Model-fit indices were moderate (SRMR = 0.0965; NFI = 0.6906), so interpretation emphasizes the prediction-oriented and associational logic of PLS-SEM rather than global fit alone. Excluding the weak environmental-conservation construct improved measurement coherence and provided the principal methodological justification for selecting the four-construct specification as the final model.

Table 2. Reliability and convergent validity

Construct	α	CR	AVE
Perceived intergenerational empowerment	0.8512	0.9098	0.7707
Generational mindset	0.7357	0.8448	0.6464
Work patterns	0.6979	0.8262	0.6143
Technology use	0.8511	0.9098	0.7708

Note: CR = composite reliability; AVE = average variance extracted.

3.3 Structural model, direct associations, and indirect associations

Table 3 presents the 5,000-sample bootstrapped results. Mindset was positively associated with technology use ($\beta = 0.218$, $T = 3.955$, $p < 0.001$), supporting H1. Work patterns

showed the strongest association with technology use ($\beta = 0.557$, $T = 10.495$, $p < 0.001$), supporting H2. Technology use was positively associated with perceived intergenerational empowerment ($\beta = 0.303$, $T = 4.128$, $p < 0.001$), supporting H3. The direct mindset–empowerment association was small and nonsignificant ($\beta = -0.046$, $T = 0.678$, $p = 0.498$), so H4 was not supported. In contrast, work patterns were positively associated with empowerment ($\beta = 0.246$, $T = 3.653$, $p < 0.001$), supporting H5. The model explained 49.1% of technology-use variance ($R^2 = 0.491$; adjusted $R^2 = 0.488$) and 22.8% of empowerment variance ($R^2 = 0.228$; adjusted $R^2 = 0.220$).

Both specific indirect associations were significant after the direct paths were included. The mindset $\rightarrow$ technology use $\rightarrow$ empowerment association was $\beta = 0.066$ ($T = 2.487$, $p = 0.013$; BCa 95% CI = 0.025–0.128), supporting H6a. The work patterns $\rightarrow$ technology use $\rightarrow$ empowerment association was larger at $\beta = 0.169$ ($T = 4.068$, $p < 0.001$; BCa 95% CI = 0.089–0.254), supporting H6b. These findings should not be labelled causal mediation because temporal ordering cannot be established from the cross-sectional design. Instead, they show that technology use accounts for a statistically significant portion of the association between each antecedent and perceived empowerment while the corresponding direct association is simultaneously estimated.

Table 3. Direct and indirect effects

Path	β	T	p
Mindset $\rightarrow$ technology use	0.218	3.955	<0.001
Work patterns $\rightarrow$ technology use	0.557	10.495	<0.001
Technology use $\rightarrow$ perceived empowerment	0.303	4.128	<0.001
Mindset $\rightarrow$ perceived empowerment	-0.046	0.678	0.498
Work patterns $\rightarrow$ perceived empowerment	0.246	3.653	<0.001
Mindset $\rightarrow$ technology use $\rightarrow$ perceived empowerment	0.066	2.487	0.013
Work patterns $\rightarrow$ technology use $\rightarrow$ perceived empowerment	0.169	4.068	<0.001

Notes: Two-tailed BCa bootstrap with 5,000 samples; exact p values are reported.

The structural pattern identifies work practices—not demographic generation labels—as the strongest proximal correlate of digital technology use. The work-pattern coefficient ($\beta = 0.557$) is more than twice the mindset coefficient, and its $f^2 = 0.422$ indicates a large contribution to explained technology-use variance. This is consistent with evidence that flexible and alternative work arrangements reshape technology use [25, 26], that hospitality workers increasingly expect digitally enabled flexibility [24], and that remote collaboration accelerated technology appropriation [19, 62]. For rural tourism, digital adoption therefore appears closely tied to routines of coordination, task execution, flexibility, and livelihood organization rather than to favourable attitudes alone.

The results also refine a simple ‘digital native’ interpretation. Cohort differences in mobile-payment use [16], self-service technology [17], climate-related tourism behaviour [35], and technology-related product use [36] demonstrate that generation can correlate with digital behaviour. In the present youth-dominated sample, however, the more defensible interpretation concerns respondent-level orientations: work patterns and mindset are associated with

technology use regardless of whether the respondent belongs to a specific demographic cohort. This shifts planning attention away from generational stereotypes and toward the design of work and learning environments in which digital tools solve concrete coordination, marketing, payment, information, and enterprise problems.

The contrast between the direct and indirect mindset results is especially informative. Mindset was associated with technology use, and its specific indirect association with empowerment through technology use was significant, yet its direct association with empowerment was not. This pattern suggests that an adaptive or innovation-oriented mindset is not, by itself, strongly associated with perceived cross-generational participation and collaboration in this sample. Its relevance appears to be expressed mainly when such orientation is accompanied by actual technology use. This interpretation remains associational, but it provides a more precise theoretical contribution than a generic claim that a positive mindset directly empowers communities.

Work patterns display a different configuration. They were directly associated with empowerment and also indirectly associated through technology use. The total standardized association of work patterns with empowerment was 0.415, whereas the total association of mindset was only 0.020 because its negative nonsignificant direct coefficient offset the positive indirect association. Work practices may therefore relate to perceived empowerment through both digital and non-digital channels, including coordination, role flexibility, information sharing, and joint task execution. Technology use adds a significant associated route, but it is not the only route through which work practices correspond with empowerment.

Technology use itself was positively associated with perceived intergenerational empowerment ($\beta = 0.303$; $f^2 = 0.061$). Its coefficient is estimated simultaneously with the direct work-pattern and mindset paths, reducing the risk of attributing all antecedent-related association to technology use. This specification is therefore comparatively conservative and theoretically more defensible: technology use is treated as one enabling correlate within a broader empowerment system rather than as a sufficient mechanism or causal lever.

The explanatory pattern remains bounded. The final model explains approximately half of technology-use variance but less than one-quarter of empowerment variance. Perceived empowerment is therefore likely to depend on additional factors not represented here, including institutional authority, trust, access to productive resources, social networks, leadership, and governance. The moderate global fit reinforces the need for restraint. The findings identify statistically supported associations that can guide further inquiry, not a deterministic account of sustainable rural transformation.

3.4 Predictive relevance, importance-performance map analysis, and planning implications

Blindfolding supported predictive relevance for both endogenous constructs. Cross-validated redundancy was $Q^2 = 0.373$ for technology use and $Q^2 = 0.173$ for perceived intergenerational empowerment, both above zero. PLSpredict likewise produced positive latent-variable Q^2_{predict} values of 0.480 for technology use and 0.167 for empowerment. At the indicator level, all six endogenous indicators had positive Q^2_{predict} values. However, the LM benchmark produced lower RMSE than PLS for all six indicators. The model therefore shows predictive relevance relative to a naïve

benchmark but no out-of-sample predictive superiority over the linear model. This distinction is important: the structural estimates are useful for explanation and prioritization, but the model should not be presented as a high-accuracy forecasting tool.

With the direct work-pattern association with empowerment included, Table 4 summarizes the IPMA priorities and places work patterns first in the practical ranking. For perceived intergenerational empowerment, work patterns had the highest standardized importance (0.415) with performance of 33.17, followed by technology use (importance = 0.303; performance = 28.93). Mindset had the highest performance (47.67) but almost no net importance (0.020) because its positive indirect association was offset by a small negative nonsignificant direct association. The resulting priority structure therefore places work-practice design first and task-linked technology use second, rather than treating technology alone as the dominant intervention target.

For Mount Muria, the first planning implication is to organize digital capability around actual tourism and livelihood routines. Training in digital marketing, booking and payment, visitor information, local-product promotion, mapping, and community communication is more likely to be useful when embedded in how residents already coordinate work. Programs should therefore combine technology training with collaborative task design, role sharing, and practical opportunities to apply digital tools to real destination and enterprise problems.

The second implication concerns intergenerational capability exchange. Younger participants may contribute familiarity with digital interfaces, while older residents may contribute agricultural knowledge, cultural interpretation, religious heritage, and conservation experience. Such arrangements align community empowerment with collaborative governance [37-39]. Because the present sample is youth-dominated, this recommendation should be understood as a planning proposition consistent with the construct definition rather than direct evidence that older and younger cohorts differ in measured empowerment.

Table 4. Importance-performance map analysis (IPMA) priorities for perceived intergenerational empowerment

Construct	Importance	Performance	Planning Interpretation
Work patterns	0.415	33.17	Highest priority: collaborative work-routine design
Technology use	0.303	28.93	Second priority: task-linked digital capability
Mindset	0.020	47.67	Maintain adaptive learning; lower marginal priority

Participatory rural-tourism planning depends on locally grounded governance and community control [63], while evidence from an Indonesian tourism village highlights the role of livelihood assets and social capital in community well-being [64]. Recent digital-tourism planning research links technology interventions to inclusive and environmentally oriented regional development [65], and smart-tourism evidence shows that technology readiness can strengthen the

relationship between sustainability perceptions and pro-environmental behaviour [66]. The present study complements this literature by showing that work practices have the strongest total association with perceived empowerment, while technology use remains an important, but not exclusive, associated route.

Taken together, the final model changes the planning narrative from technology provision to capability-in-use. Sustainable rural tourism in Mount Muria should not treat digitalization as an end-state or measure success only through visitor growth. The results instead support interventions that connect digital tools with collaborative work routines, local enterprise, knowledge exchange, and participatory governance. Because the evidence is cross-sectional, these priorities should be implemented and evaluated experimentally or longitudinally rather than assumed to produce causal empowerment effects.

3.5 Contribution and limitations

The study offers three contributions. First, it identifies a coherent four-construct specification and explicitly estimates direct antecedent-to-empowerment paths. Second, it distinguishes two associational patterns: mindset is related to empowerment primarily through its positive association with technology use, whereas work patterns show both a direct and a technology-linked indirect association. Third, it integrates explanatory PLS-SEM estimates with common-method diagnostics, blindfolding, PLSpredict, and IPMA, making clear that statistical association, predictive relevance, and intervention priority are distinct claims. Conceptually, the central contribution is therefore not that technology ‘causes’ empowerment, but that usable technology and work practices occupy different positions within the observed network of associations.

The planning contribution follows from the IPMA. Work patterns have the highest total importance for perceived empowerment, while technology use combines the second-highest importance with the lowest performance among the three predictors. Practical programs should therefore integrate digital capability with work-routine redesign rather than prioritize technology provision in isolation. Mindset performs relatively well but contributes little net importance once direct and indirect associations are considered simultaneously, suggesting lower marginal priority for attitude-oriented interventions alone.

Several limitations remain. First, the sample is strongly youth-dominated and cannot support balanced cohort comparisons; all findings concern pooled respondent-level perceptions. Second, the cross-sectional single-source design does not establish temporal or causal ordering, even though common-method diagnostics did not indicate a dominant common factor. Third, the final model explains 22.8% of empowerment variance and does not outperform the LM benchmark in PLSpredict, indicating substantial omitted determinants and limited forecasting advantage. Fourth, the environmental-conservation construct was removed because its two-item measurement was unreliable; future studies should develop and validate a broader conservation scale rather than infer that conservation is unimportant. Future research should use balanced age cohorts, longitudinal or quasi-experimental designs, stronger multi-source measurement, and external validation across other rural-tourism destinations.

4. CONCLUSIONS

Digital technology use is positively associated with perceived intergenerational empowerment in Mount Muria's rural-tourism context, but the model shows that work practices are the stronger overall correlate. Work patterns are strongly associated with technology use ($\beta = 0.557$, $p < 0.001$) and directly associated with empowerment ($\beta = 0.246$, $p < 0.001$), while technology use is also positively associated with empowerment ($\beta = 0.303$, $p < 0.001$). Mindset is positively associated with technology use ($\beta = 0.218$, $p < 0.001$) but has no significant direct association with empowerment. Significant specific indirect associations through technology use are observed for both mindset ($\beta = 0.066$, $p = 0.013$) and work patterns ($\beta = 0.169$, $p < 0.001$).

The findings therefore support an associational account of digital rural transformation rather than a causal pathway model. Blindfolding indicates predictive relevance, but PLSpredict does not outperform the linear benchmark. IPMA identifies work patterns as the highest-importance predictor of perceived empowerment, followed by technology use, while mindset has relatively high performance but minimal net importance. For planning, the most defensible implication is to connect digital tools to collaborative work routines, tourism tasks, local enterprise, and intergenerational knowledge exchange. Future studies should validate these relationships with more balanced cohorts, stronger multi-item sustainability measures, and longitudinal or experimental designs.

ACKNOWLEDGMENT

The authors gratefully acknowledge funding from the Directorate of Research, Technology, and Community Service (DRTPM), Ministry of Education and Culture, Indonesia (Contract No. 73.12.6/UN37/PPK.10/2024), and the valuable contributions of all study participants.

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NOMENCLATURE

AVE	average variance extracted
IPMA	importance-performance map analysis
PLS-SEM	partial least squares structural equation modelling
Q ²	Stone-Geisser cross-validated predictive relevance

APPENDIX

Table A. Administered Indonesian instrument and English translation

Code	Bahasa Indonesia (Administered)	English Translation (Reporting)
Pk1	Apakah Anda bersedia menggunakan pola kerja yang fleksibel dalam mendukung kegiatan pariwisata di desa?	Are you willing to use flexible work patterns to support tourism activities in the village?
Pk2	Apakah Anda menggunakan teknologi digital untuk berkomunikasi dan bekerja sama dalam kegiatan pariwisata?	Do you use digital technology to communicate and collaborate in tourism activities?
Pk3	Apakah Anda mampu menyesuaikan cara kerja ketika terdapat teknologi atau metode baru yang diterapkan dalam kegiatan pariwisata?	Are you able to adjust your way of working when new technologies or methods are introduced in tourism activities?
Pp1	Apakah Anda bersedia mempelajari hal-hal baru dan menyesuaikan diri dengan perubahan dalam kegiatan pariwisata?	Are you willing to learn new things and adapt to changes in tourism activities?
Pp2	Menurut Anda, apakah teknologi digital penting untuk mendukung kegiatan pariwisata di desa?	In your opinion, is digital technology important for supporting tourism activities in the village?
Pp3	Apakah Anda percaya bahwa pendekatan yang inovatif dan berkelanjutan penting untuk mengembangkan pariwisata perdesaan?	Do you believe that innovative and sustainable approaches are important for developing rural tourism?
PI1	Apakah Anda mendukung kebijakan dan berbagai inisiatif untuk menjaga kelestarian lingkungan dalam pengembangan pariwisata desa?	Do you support policies and initiatives to preserve the environment in rural tourism development?
PI3	Apakah Anda berpartisipasi secara aktif dalam kegiatan yang mendukung keberlanjutan dan kelestarian lingkungan di sekitar destinasi wisata?	Do you actively participate in activities that support sustainability and environmental conservation around tourism destinations?
Z1	Apakah Anda menggunakan platform digital untuk memperoleh dan menyebarkan informasi mengenai kegiatan atau destinasi pariwisata?	Do you use digital platforms to obtain and disseminate information about tourism activities or destinations?
Z2	Apakah Anda menggunakan teknologi digital untuk komunikasi, promosi, dan/atau transaksi dalam kegiatan pariwisata?	Do you use digital technology for communication, promotion, and/or transactions in tourism activities?
Z3	Menurut Anda, apakah penggunaan teknologi digital mendukung keterlibatan masyarakat dalam kegiatan pariwisata desa?	In your opinion, does the use of digital technology support community involvement in rural tourism activities?
Em1	Apakah generasi yang berbeda memiliki kesempatan untuk berpartisipasi dalam pengambilan keputusan terkait kegiatan pariwisata desa?	Do different generations have opportunities to participate in decision making related to rural tourism activities?
Em2	Apakah generasi yang berbeda saling berbagi pengetahuan dan keterampilan untuk mendukung pengembangan pariwisata desa?	Do different generations share knowledge and skills to support rural tourism development?
Em3	Apakah generasi yang berbeda bekerja sama dalam mengelola sumber daya dan kegiatan pariwisata desa?	Do different generations work together in managing rural tourism resources and activities?

Note: Scale for all items: 1 = Sangat Tidak Setuju / Strongly Disagree; 2 = Tidak Setuju / Disagree; 3 = Kurang Setuju / Somewhat Disagree; 4 = Setuju / Agree; 5 = Sangat Setuju / Strongly Agree. The English wording below was prepared for publication reporting; the field instrument was administered in Bahasa Indonesia. PI1 and PI3 constituted the Environmental Conservation Orientation construct in the originally administered questionnaire. They are reported here for transparency but were excluded from the final model following measurement-model reassessment.