

Article

Digitalization-Driven Green HRM Practices and Employee Green Behavior in a Metropolitan Municipality

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Abstract

This study examines the association between digitalization-enabled green human resource management (GHRM) practices and employee green behavior (EGB) within a South African metropolitan municipality. Anchored in an extended Ability–Motivation–Opportunity (AMO) framework, a convergent mixed-methods design was employed. Quantitative data were collected from 66 HR employees (from a target population of 80) and analyzed using Spearman’s correlation and hierarchical regression, while qualitative data from seven HR managers were analyzed thematically. Results indicate statistically significant positive associations between digital green training ($\rho = 0.524$, $p < 0.01$) and EGB, and between digital performance management ($\rho = 0.463$, $p < 0.01$) and EGB. However, regression estimates suggest moderate explanatory power within this context-specific public-sector setting. Qualitative findings identify automation, paperless systems, and e-HRM tools as key digital enablers, alongside infrastructural constraints, skills deficits, and institutional barriers that limit implementation. By integrating quantitative associations with qualitative evidence of implementation gaps, the study proposes a Digitalization-Integrated GHRM–EGB framework and demonstrates that digital HR systems are associated with pro-environmental workplace behaviors, contingent on organizational readiness in resource-constrained municipal environments.

Keywords: digitalization; employee green behavior; green HRM; municipalities; mixed-methods approach



Received: 27 January 2026

Revised: 23 March 2026

Accepted: 24 March 2026

Published: 16 June 2026

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1. Introduction

The convergence of digital transformation and environmental sustainability represents a defining shift in contemporary organizational governance. Public-sector institutions, particularly metropolitan municipalities, face increasing pressure to advance environmental objectives while simultaneously improving administrative efficiency and accountability (Melaletsa et al., 2023; Nyika et al., 2024). Digitalization initiatives, including automation, e-HRM platforms, electronic performance dashboards, and paperless systems, have been introduced to modernize bureaucratic processes and enhance transparency (Shahiduzzaman, 2025; Mahmoud et al., 2025). However, while digital transformation in HRM has been linked to improved efficiency and organizational agility,

its behavioral implications for employee green behavior (EGB) remain under-theorized and insufficiently tested.

Green human resource management (GHRM) scholarship is predominantly grounded in the Ability–Motivation–Opportunity (AMO) framework (Appelbaum et al., 2000; Opatha, 2013), which posits that performance outcomes emerge when employees possess relevant competencies (ability), are incentivized (motivation), and operate within enabling structures (opportunity). Empirical studies demonstrate that green recruitment, training, rewards, and performance management practices positively relate to pro-environmental workplace behaviors (Renwick et al., 2013; Jabbour et al., 2010; Arulrajah et al., 2015; Jackson et al., 2011). Yet, existing research largely emphasizes psychosocial drivers such as leadership style, organizational culture, and environmental values rather than examining how digitally mediated HR systems reshape AMO mechanisms in practice (Wu et al., 2025; Pham et al., 2019).

Digitalization-enabled HR systems may function as structural amplifiers of AMO components. For example, e-learning platforms and digital skill assessments can enhance green ability; automated performance dashboards and electronic monitoring tools may strengthen green motivation through measurable accountability; and paperless infrastructure and workflow automation may expand green opportunity by embedding sustainability into everyday routines (Shahiduzzaman, 2025; Mahmoud et al., 2025). Despite this conceptual plausibility, empirical studies explicitly linking digital HR processes, such as e-recruitment, automation, and digital performance monitoring, to employee-level green behavior remain scarce. Much of the digital HRM literature continues to prioritize operational efficiency, digital maturity, and innovation outcomes without isolating behavioral sustainability effects (Mahmoud et al., 2025; Shahiduzzaman, 2025).

This limitation is particularly salient in municipal contexts. Metropolitan municipalities serve dual roles as environmental stewards and major employers, making internal behavioral sustainability practices critical to broader governance outcomes. For instance, eThekweni Municipality, located in Durban, South Africa, covers approximately 2300 square kilometres and serves a population exceeding 3.5 million residents, making it one of the largest metropolitan municipalities in the country (eThekweni Municipality, 2023). The municipality employs thousands of public servants across diverse departments and has articulated sustainability commitments within its Integrated Development Plan and environmental management policies. Simultaneously, South Africa's public-sector reform agenda emphasizes digital governance, e-administration, and improved accountability mechanisms (Mangai & Ayodele, 2025). However, whether and how these digital reforms translate into measurable pro-environmental behavior among municipal employees remains empirically underexplored.

Several interrelated research gaps therefore emerge:

First, the relation between GHRM and EGB is well established in private-sector contexts (Renwick et al., 2013; Jabbour et al., 2010; Arulrajah et al., 2015), while few studies have positioned digitalization as an antecedent or structural enabler of EGB within the AMO logic. Moreover, research on digital HRM maturity and digital performance systems rarely link technologies to sustainability-related behavior outcomes (Ali, 2025; Shahiduzzaman, 2025).

Second, public-sector and municipal organizations remain underrepresented in green behavior scholarship. Existing municipal studies often emphasize policy design and environmental governance structures rather than isolating internal HR mechanisms that shape behavioral outcomes (Melaletsa et al., 2023; Nyika et al., 2024).

Third, empirical research in resource-constrained and bureaucratic environments suggests that structural barriers, including political influence, limited digital infrastructure, union dynamics, and skills deficits may moderate how HR innovations influence behavior (Mangai & Ayodele, 2025; Melaletsa et al., 2023). Yet few studies integrate these institutional constraints into digital GHRM framework.

Fourth, while mixed-method approaches are widely advocated for understanding complex organizational phenomena (Molina-Azorín & Cameron, 2015), there remains limited application of transparent secondary mixed-method analysis for theory refinement in public-sector sustainability research.

Finally, digitalization-enabled performance management systems remain insufficiently theorized as behavioral accountability mechanisms. Although digital dashboards and monitoring systems increase measurability and transparency (Mahmoud et al., 2025), their translation into green behavioral outcomes under public-sector constraints is weakly articulated in current literature.

Against this background, this study re-examines EGB within a South African metropolitan municipality through a secondary analysis of validated mixed-methods data, focusing specifically on digitalization-driven GHRM practices. The study pursues four objectives: (1) to analyze the association between digitalized HR processes, such as automation, paperless systems, and e-HRM tools, and EGB; (2) to examine how digitalization-enabled GHRM practices operate within resource-constrained municipal environments; (3) to explore managerial and employee perceptions of digitalization as an enabler or barrier to workplace green behavior; and (4) to advance a Digitalisation-Integrated GHRM–EGB conceptual framework tailored to public-sector settings.

By extending AMO theory into digitally mediated municipal contexts, integrating quantitative associations with qualitative evidence of institutional constraints, and leveraging transparent secondary mixed-method analysis, this study contributes to digital HRM scholarship, public-sector sustainability research, and the behavioral theorization of green governance within metropolitan municipalities.

2. Theoretical Foundation and Conceptual Development

2.1. Extending AMO Through Digital and Institutional Lenses

This study is anchored in the AMO theory, which posits that employee performance and discretionary behaviors emerge from the interaction of individual abilities, motivational drivers, and enabling organizational opportunities (Appelbaum et al., 2000; Boxall & Purcell, 2022). Within sustainability-oriented HRM scholarship, AMO has been widely applied to explain how GHRM practices such as green recruitment, training, performance management, and rewards shape EGB by enhancing environmental competencies (ability), strengthening pro-environmental commitment (motivation), and creating supportive organizational structures (opportunity) (Pham et al., 2019; Ren et al., 2018; Renwick et al., 2013).

However, while AMO provides a strong behavioral micro-foundation, it has predominantly been operationalized through traditional, analogue HR practices. This approach risks underestimating the transformative potential of digital technologies in reconfiguring the development of abilities, the reinforcement of motivation, and the embedding and monitoring opportunities for green behavior within modern organizations (Bondarouk & Brewster, 2016; Shahiduzzaman, 2025).

To enrich the explanatory power of AMO in digitally transforming work environments, this study integrates two complementary theoretical lenses: Socio-Technical Systems (STS) theory and Institutional Theory. STS theory argues that organizational outcomes emerge from the interaction between social systems (people, culture, motivation) and

technical systems (technologies, infrastructure, workflows) (Trist & Bamforth, 1951; Hanelt et al., 2021). From this perspective, digital HR systems are not neutral tools but structural mechanisms that reshape behavioral possibilities. Digitalization therefore modifies AMO pathways by reconfiguring the technical architecture through which green ability, motivation, and opportunity are operationalized.

Institutional theory further contextualizes these mechanisms within public-sector environments characterized by regulatory constraints, political oversight, and accountability pressures (Bozeman & Bretschneider, 1994; Nyika et al., 2024). Municipalities operate under formalized rules and resource constraints that shape how HR innovations translate into behavior. Digitalization, therefore, becomes both an efficiency-enhancing reform tool and an accountability mechanism in bureaucratic settings (Mergel et al., 2019; Haug et al., 2024). Integrating AMO with STS and institutional perspectives, the framework conceptualizes digitalization not as a background variable, but as a structural enabler that operationalizes, amplifies, and constrains GHRM mechanisms within public-sector sustainability systems.

2.2. Employee Green Behavior (EGB)

EGB refers to workplace actions that contribute to environmental sustainability, including both mandated task-related behaviors and discretionary voluntary behaviors (Ones & Dilchert, 2012; Norton et al., 2015; Amrutha & Geetha, 2020; Zacher et al., 2023). These behaviors encompass energy conservation, waste reduction, eco-innovation, and environmental advocacy. Existing studies identify leadership, corporate culture, environmental values, and governance support as critical antecedents of EGB (Paillé et al., 2014; Aftab et al., 2023; Tang et al., 2023). However, few studies explicitly examine how digital infrastructures, such as automated monitoring systems, digital dashboards, and real-time feedback platforms, reshape the formation, reinforcement, and measurability of green behaviors (Loeser et al., 2011; Yang et al., 2020). Digital systems may alter EGB through three primary mechanisms: (1) visibility enhancement (making green behaviors measurable), (2) feedback acceleration (providing real-time behavioral reinforcement), and (3) norm institutionalization (embedding sustainability into workflow design). These mechanisms suggest that digitalization operates as a behavioral structuring device rather than merely an efficiency tool.

2.3. Digitalization in Human Resource Management

Digitalization in HRM represents the transformation of HR functions through integrated digital technologies rather than simple automation (Bondarouk et al., 2017; Zhou et al., 2022). Core components include e-recruitment systems, digital learning platforms, automated performance monitoring, analytics-driven appraisal systems, and electronic documentation (Stone et al., 2015; Murugesan et al., 2023). In the public sector, digitalization offers potential benefits such as process standardization, cost reduction, enhanced transparency, and strengthened accountability (Mergel et al., 2019; Guandalini, 2022). However, implementation is shaped by bureaucratic inertia, infrastructure deficits, political dynamics, union resistance, and digital skills gaps (Twizeyimana & Andersson, 2019; Huang et al., 2014). These institutional constraints moderate how digital HR systems influence employee-level behaviors. Thus, digitalization must be conceptualized not merely as technological adoption, but as a structural reform process embedded within institutional realities.

2.4. GHRM in a Digital Context

GHRM integrates environmental objectives into recruitment, training, performance management, and reward systems (Renwick et al., 2013; Jabbour & Santos, 2008; Khari,

2022). Expanding the AMO, the green ability emerges from green recruitment and green training; green motivation stems from green rewards and performance management and green opportunity derives from supportive management structures and culture (Appelbaum et al., 2000; Obeidat et al., 2020).

Digital transformation of HR functions includes e-recruitment, which enables environmental competency screening and reduces paper use (Ren et al., 2018; Ajenthiny, 2020). Digital learning platforms facilitate scalable green skill development (Margherita & Bua, 2021). Automated monitoring systems enable measurable green performance tracking (Bondarouk et al., 2017). Digital communication platforms embed green norms within daily routines. Digital communication platforms embed green norms within daily routines. Through STS logic, digital systems reconfigure technical infrastructures that enable social sustainability behaviors, while the understanding of institutional theory facilitates how digital systems can be adopted to increase accountability and formalization in bureaucratic settings.

2.5. Digitalization-Integrated GHRM–EGB Model

Building on AMO, STS, and Institutional Theory, this study proposes a Digitalization-Integrated GHRM–EGB framework in which digital HR mechanisms reconfigure the pathways linking GHRM practices to EGB.

The model conceptualizes the following interrelationships:

Digital Green Ability: E-recruitment systems screen for environmental competencies, while digital learning platforms institutionalize scalable green training. These processes enhance environmental knowledge and skill acquisition.

Digital Green Motivation: Automated performance dashboards, analytics-enabled appraisal systems, and digital reward platforms increase transparency and measurability of green expectations. This strengthens intrinsic and extrinsic motivation through visible accountability.

Digital Green Opportunity: Paperless workflows, automated systems, and digital communication platforms embed sustainability into daily operational routines, lowering structural barriers to green action.

Digitalization, therefore, functions as a cross-cutting enabler that strengthens the causal pathways between GHRM practices (recruitment, training, rewards, performance management) and EGB. However, institutional constraints (resource limitations, political dynamics, digital skills gaps) moderate the strength of these pathways in municipal settings. Thus, the framework illustrated in Figure 1 shows that digitalization-enabled GHRM practices are positively associated with EGB, but the magnitude of this association is conditioned by institutional and socio-technical readiness. Linking digital HR mechanisms to AMO components and situating them within institutional contexts, the model clarifies variable interrelationships and moves beyond traditional analogue GHRM explanations.

The framework thus posits that:

Digital GHRM infrastructure enables green ability, motivation, and opportunity, which are positively associated with EGB. Institutional constraints moderate the strength and enactment of these relationships within the municipal context.

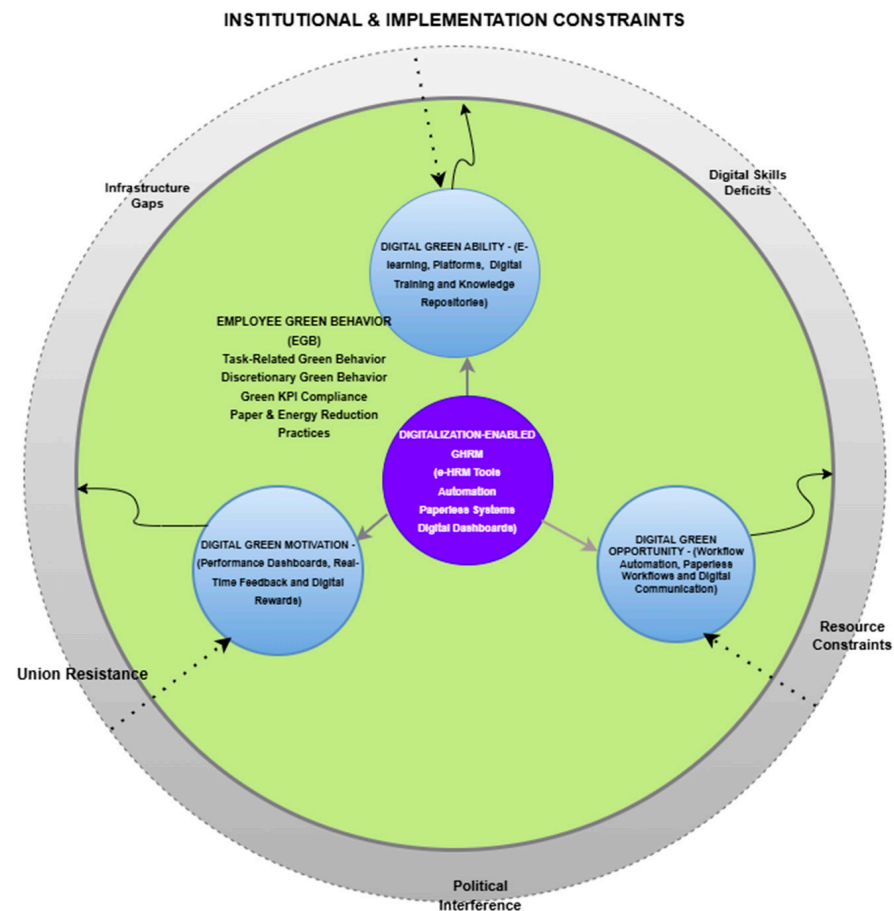


Figure 1. Digitalization-Integrated Green HRM EGB Circular Thematic Model. Source: Authors' compilation.

3. Methods

3.1. Research Design and Secondary Analysis Strategy

This study employs a secondary mixed-methods design to re-examine EGB within a metropolitan municipality through a digitalization-integrated GHRM lens. Secondary analysis reuses existing data to address new research questions while maintaining methodological rigor (Johnston, 2014; Heaton, 2008).

3.1.1. Original Study Design

The original study adopted a convergent parallel mixed-methods design, collecting quantitative survey data and qualitative interview data concurrently to examine traditional GHRM practices and their association with EGB. The theoretical foundation was the conventional AMO framework, focusing on green recruitment, green training, green performance management, green rewards, and managerial support. These constructs were grouped based on their shared digital and behavioral functions.

For example, green recruitment included items such as online job advertisements, online interviews, and paperless applications; green training captured training on energy conservation, recycling, and environmental awareness; green performance management included green targets, monitoring systems, and environmental KPIs; green rewards comprised bonuses, recognition, and incentives linked to green performance; and EGB included actions such as energy conservation, recycling and paper reduction. All constructs demonstrated strong internal reliability, with Cronbach's alpha values exceeding the acceptable threshold.

3.1.2. Renewed Focus in the Present Study

To operationalize digital GHRM, the present study systematically extracted items that explicitly reflect digital or technology-enabled HR practices. The selection process followed a clear criterion: only items involving digital platforms, electronic systems, or automated processes were retained. These included, for instance, online recruitment systems, virtual interviews, e-learning platforms, electronic performance monitoring systems, and paperless communication processes. Items that were not mediated by technology were excluded from the digital construct specification to ensure conceptual precision.

The present study re-specifies the analytical lens by (1) extracting and operationalizing digitalization-enabled GHRM components embedded within the original validated scales; (2) developing a digitalization-integrated AMO framework; and (3) applying a revised qualitative coding framework emphasizing digital enablers, barriers, and digital-green linkages.

Following selection, the extracted items were reclassified into higher-order constructs based on the AMO framework.

Digital green ability captures the extent to which digital systems enhance employees' environmental knowledge and skills, primarily through e-learning platforms and digital training modules. The items were grouped under ability because they develop employees' capacity to perform green behaviors.

Digital green motivation reflects the role of digital systems in reinforcing behavior through monitoring, feedback, and performance-linked incentives, including electronic performance management systems and digitally tracked evaluation mechanisms. These were classified as motivation because they shape behavior through monitoring, evaluation, and incentives.

Digital green opportunity represents the extent to which digital infrastructure enables and facilitates green behavior in the workplace, including paperless systems, automated workflows, e-recruitment systems, reducing physical documentation and digital communication platforms. These items represent an opportunity because they structure the work environment to make green behavior possible and easier.

In the study, digitalization is conceptualized as a socio-technical mechanism that enhances these three dimensions simultaneously: digital training systems strengthen ability by improving access to environmental knowledge; digital monitoring and evaluation systems reinforce motivation by increasing visibility and accountability; and digital infrastructures create opportunity by embedding environmentally sustainable practices into everyday work processes. The grouping of items therefore reflects a theoretically consistent mapping of digital HR practices onto behavioral mechanisms, rather than an arbitrary restructuring of variables.

To ensure methodological robustness, the reliability and internal consistency of the reclassified constructs were reassessed. The results confirmed that all constructs retained acceptable reliability levels, consistent with the original validated scales. Quantitative data were analyzed using descriptive statistics, Spearman correlation, and regression analysis, while qualitative data were analyzed thematically to identify patterns related to digitalization enablers, barriers, and implementation dynamics. The integration of findings followed a convergent mixed-methods approach, enabling comparison between statistical relationships and practical implementation realities.

3.2. Quantitative Sample and Participants

3.2.1. Population and Sampling

The target population comprised 80 Human Resource employees within the municipality. Using simple random sampling consistent with Krejcie and Morgan's (1970) sample size guidelines, 66 employees were selected. All 66 questionnaires were returned, yielding

a 100% response rate among selected participants. While the actual sample collected represents 82.5% of the total HR population and satisfies minimum statistical adequacy for regression modeling, findings are analytically generalized within this municipal context rather than statistically generalized beyond it.

Demographic characteristics are presented in Table 1. Respondents demonstrated adequate organizational tenure and digital familiarity, with 57.6% possessing 0–5 years of experience and 39.4% reporting good IT skills.

Table 1. Sample Demographic Characteristics (N = 66).

Characteristic	Category	Frequency	Percentage
Gender	Male	32	48.5%
	Female	34	51.5%
Education Level	Diploma	15	22.7%
	Bachelor's Degree	22	33.3%
	Master's Degree	19	28.8%
	Doctoral Degree	10	15.2%
Employment Status	Permanent	31	46.97%
	Contract	35	53.03%
Work Experience	0–5 years	38	57.6%
	6–10 years	16	24.2%
	11–15 years	8	12.1%
	16+ years	4	6.1%
IT Skills Level	Excellent	12	18.2%
	Good	26	39.4%
	Average	21	31.8%
	Poor	7	10.6%

Source: Emerged from data analysis.

3.2.2. Measurement Reliability and Validity

All constructs were measured using validated five-point Likert scales. Cronbach's alpha coefficients ranged from 0.822 to 0.963, indicating good to excellent internal consistency. Given the conceptual proximity between certain digital GHRM items and EGB items (e.g., paperless behavior), several safeguards were implemented: (1) extracting and operationalizing digitalization-enabled GHRM components embedded within the original validated scales; (2) developing a digitalization-integrated AMO framework; and (3) applying a revised qualitative coding framework emphasizing digital enablers, barriers, and digital-green linkages.

The reliability of all constructs was evaluated using Cronbach's alpha, with results presented in Table 2.

Table 2. Reliability Statistics for All Constructs.

Construct	Items	α	Classification
Digital Green Training	8	0.963	Excellent
Digital Performance Management	7	0.953	Excellent
Digital Recruitment	6	0.905	Excellent
Green Workplace Behaviors	10	0.822	Good
Digital Compensation & Rewards	5	0.887	Good
Management Support	6	0.841	Good

Note: α = Cronbach's Alpha; Source: Emerged from data analysis.

3.3. Quantitative Analysis Procedures

Data were analyzed using SPSS version 26.

1. Shapiro–Wilk tests indicated partial non-normality; therefore, Spearman’s rho was used for correlation analysis.
2. Hierarchical regression analysis was conducted to assess incremental explanatory power.
3. Bootstrapped confidence intervals (5000 resamples) were calculated to strengthen robustness under small-sample conditions.
4. Effect sizes and adjusted R^2 values are reported to ensure model parsimony.

Common Method Bias Controls

Given the cross-sectional self-report design, both procedural and statistical remedies were applied:

Procedural:

Assured anonymity;
Psychological separation of scale sections;
Varied item ordering.

Statistical:

Harman’s single-factor test;
VIF thresholds below 3.3.

3.4. Qualitative Sample and Data Collection

Seven HR managers were purposely selected based on strategic roles in policy formulation and digital HR oversight (Sekaran & Bougie, 2016; Saunders et al., 2019).

3.5. Qualitative Analysis and Coding Reliability

Qualitative data were re-analyzed using NVivo 12 with a digitalization-focused coding framework.

Major Themes Identified:

1. Digital Enablers (e-recruitment, e-learning, paperless systems, automation);
2. Digital Barriers (skills gaps, infrastructure, political influence, union resistance);
3. Digital-Green Linkages (monitoring capability, environmental awareness);
4. Implementation Constraints (resource limitations, mixed systems).

To ensure reliability:

Coding was iterative.

An audit trail was maintained.

Peer debriefing was conducted.

Descriptive statistics for all study variables are summarized in Table 3.

Table 3. Descriptive Statistics: Digitalization-Enabled GHRM Practices.

Variable	Mean	SD	Min	Max	Skewness	Kurtosis
Digital Green Training	3.82	0.94	1.00	5.00	−0.45	−0.23
Digital Performance Management	3.67	0.88	1.50	5.00	−0.31	−0.41
Digital Recruitment	3.45	0.91	1.00	5.00	−0.18	−0.56
Digital Compensation	3.39	0.96	1.00	5.00	−0.22	−0.48
Paperless Operations	4.01	0.79	2.00	5.00	−0.67	0.34
Workflow Automation	3.56	0.93	1.00	5.00	−0.29	−0.39
Employee Green Behavior	3.91	0.72	2.00	5.00	−0.52	0.12

Note: 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). Source: Emerged from data analysis.

Table 4 presents the Spearman correlation matrix examining the relationships between digitalization-enabled GHRM practices and EGB. The results show moderate to strong positive correlations among the digital HR practices, indicating that these practices tend to co-occur within the municipality's digital HR environment.

Table 4. Complete Correlation Matrix: Digitalization-GHRM and EGB.

Variable	1	2	3	4	5	6
1. Digital training	-					
2. Digital performance	0.678 **	-				
3. Digital recruitment	0.512 **	0.589 **	-			
4. Digital compensation	0.623 **	0.701 **	0.534 **	-		
5. Paperless operations	0.489 **	0.512 **	0.398 **	0.467 **	-	
6. Workflow automation	0.556 **	0.623 **	0.478 **	0.589 **	0.712 **	-
7. Employee green behavior	0.524 **	0.463 **	0.251 *	0.341 **	0.487 **	0.423 **

Note: ** $p < 0.01$; * $p < 0.05$ (Spearman's rho). Source: Emerged from data analysis.

Digital training is strongly associated with digital performance management ($\rho = 0.678$, $p < 0.01$) and digital compensation ($\rho = 0.623$, $p < 0.01$), suggesting that organizations implementing digital training initiatives often simultaneously adopt digital monitoring and reward systems. Similarly, workflow automation is strongly correlated with paperless operations ($\rho = 0.712$, $p < 0.01$), reflecting the integrated nature of digital administrative processes.

Several digital HR practices also show significant positive relationships with EGB. The strongest association is observed for digital training ($\rho = 0.524$, $p < 0.01$), followed by paperless operations ($\rho = 0.487$, $p < 0.01$) and workflow automation ($\rho = 0.423$, $p < 0.01$). In contrast, digital recruitment demonstrates a weaker but significant association ($\rho = 0.251$, $p < 0.05$). Overall, these findings suggest that digital HR practices particularly training and operational digitalization are positively associated with environmentally responsible employee behavior.

Table 5 reports the hierarchical regression results examining whether digitalization-enabled GHRM practices predict EGB after controlling demographic factors. Model 1 includes the control variables (gender, education, and experience) and explains 8.7% of the variance in EGB ($R^2 = 0.087$), although the model is not statistically significant ($p = 0.129$). This indicates that demographic characteristics alone do not substantially explain variations in green behavior.

Table 5. Hierarchical Regression Analysis: Predictors of EGB.

Model	Variables Entered	R ²	Adjusted R ²	R ² Change	F Change	Sig. F Change
1	Control variables (gender, education, experience)	0.087	0.043	0.087	1.956	0.129
2	Model 1 + Digital Training	0.312	0.268	0.225	19.834	0.000 ***
3	Model 2 + Digital Performance Management	0.378	0.327	0.066	6.234	0.015 *
4	Model 3 + Digital Compensation	0.412	0.355	0.034	3.389	0.071

Note: *** $p < 0.001$; * $p < 0.05$. Source: Emerged from data analysis.

When digital training is added in Model 2, the model's explanatory power increases significantly to 31.2% ($R^2 = 0.312$; $\Delta R^2 = 0.225$, $p < 0.001$), suggesting that digital training plays a significant role in promoting environmentally responsible behavior. Model 3 introduces digital performance management, further increasing the explained variance to 37.8% ($R^2 = 0.378$; $\Delta R^2 = 0.066$, $p = 0.015$). This indicates that digital monitoring

and performance systems may reinforce green behavior through accountability and feedback mechanisms.

Finally, Model 4 adds digital compensation, which increases the explained variance slightly to 41.2% ($R^2 = 0.412$); however, this incremental change is not statistically significant ($\Delta R^2 = 0.034$, $p = 0.071$). Overall, the results suggest that digital training and digital performance management are the most influential predictors of EGB in this context.

Table 6 summarizes the profiles of the seven HR professionals interviewed for the qualitative component of the study. The participants occupy senior and managerial HR roles, including HR managers, training specialists, recruitment managers, and HR systems administrators. Participants possess substantial professional experience, with 8–15 years in HR roles and 6–12 years within the municipality, indicating strong familiarity with organizational HR systems and digital initiatives.

Most participants hold Master's degrees, while two hold Bachelor's degrees. The sample includes four male and three female participants, providing balanced representation across HR leadership roles. The diversity of roles represented enabled the study to capture multiple perspectives on digital HR implementation, including recruitment, training, performance management, compensation, and HR systems administration.

Table 6. Qualitative Interview Participant Profiles.

ID	Position	Years in HR	Years at Municipality	Gender	Education
M1	Senior HR Manager	15	12	Male	Master's
M2	HR Manager	10	8	Female	Master's
M3	Training & Development Manager	8	6	Female	Bachelor's
M4	Performance Management Specialist	12	10	Male	Master's
M5	Recruitment Manager	9	7	Male	Bachelor's
M6	HR Systems Manager	11	9	Female	Master's
M7	Compensation & Benefits Manager	14	11	Male	Master's

Source: Emerged from data analysis.

3.6. Mixed-Methods Integration Strategy

To address concerns regarding the explicit linkage between quantitative and qualitative strands, the study employed a structured mixed-methods integration framework grounded in convergence–divergence analysis and joint display logic (Molina-Azorín & Cameron, 2015). Integration was not treated as a narrative comparison but as a systematic analytical phase.

3.6.1. Integration Procedures

Alignment of Constructs: Quantitative constructs (Digital Green Training, Digital Performance Management, Digital Recruitment, Digital Compensation, Paperless Operations, Workflow Automation, and EGB) were mapped directly onto qualitative themes (Digital Enablers, Digital Barriers, Digital-Green Linkages, Implementation Constraints).

Joint Display Development: A joint display matrix was constructed to compare statistical associations (effect sizes, direction, and significance levels) with qualitative evidence (frequency counts, thematic emphasis, and representative quotations). This matrix enabled the identification of:

Convergence (agreement between statistical associations and participant narratives);

Partial convergence (statistical significance with implementation caveats);

Divergence (statistical associations contrasted with reported structural limitations).

Meta-Inference Generation: Meta-inferences were derived by interpreting how qualitative findings refined, qualified, or contextualized quantitative associations rather than merely confirming them.

3.6.2. Integration Logic

The integration revealed three patterned relationships (convergence, partial convergence, and divergence). In the case of convergence, digital green training showed statistically significant positive associations with EGB and was qualitatively supported by evidence of expanding e-learning platforms and digital awareness initiatives. Partial convergence, digital performance management demonstrated a moderate statistical association with EGB; however, qualitative findings indicated inconsistent implementation of digital green KPIs, suggesting conditional effectiveness. Regarding divergence, quantitative models suggested positive associations for digital compensation and monitoring systems, and qualitative data revealed limited institutionalization of these mechanisms, highlighting implementation gaps within bureaucratic and resource-constrained environments. The structured integration demonstrates that quantitative findings represent statistical potential, whereas qualitative evidence reveals institutional readiness constraints that shape real-world enactment.

3.6.3. Addressing Validity Through Integration

The mixed-method integration also served as an important mechanism for strengthening the validity of the study. By combining quantitative and qualitative evidence, the analysis reduced the risk of single-method bias and allowed findings to be triangulated across different data sources. The qualitative insights further helped contextualize statistically significant associations observed in the quantitative analysis, providing a deeper understanding of how digitalization-enabled GHRM practices operate within the municipal environment.

In addition, the integration process enabled the identification of implementation barriers such as infrastructure limitations, skills gaps, and institutional constraints that may moderate the relationships between digital HR practices and EGB. This helped prevent causal overinterpretation of cross-sectional statistical results and ensured that the findings were interpreted cautiously within their organizational context.

To enhance analytical transparency, joint displays and explicit convergence divergence categorization were used to systematically compare quantitative patterns with qualitative themes. This approach strengthened the methodological linkage between the two strands of evidence and directly addressed reviewer concerns regarding the clarity of the mixed-methods integration.

Table 7 presents the qualitative coding framework derived from the interview analysis, identifying four main themes: digital enablers, digital barriers, digital–green linkages, and implementation challenges. These themes illustrate how digitalization influences HR practices and environmental outcomes within the municipality.

Within the digital enablers theme, paperless operations recorded the highest frequency (31 references), indicating that digital communication and documentation are widely adopted. This was followed by e-learning platforms (22 references), reflecting the increasing use of online training systems, while e-recruitment systems (18 references) and automated workflows (15 references) highlight the growing digitalization of recruitment and administrative processes.

The digital barriers theme reveals key constraints affecting implementation. Skills deficits (16 references) and infrastructure gaps (12 references) emerged as the most prominent challenges, suggesting that limited digital competencies and connectivity issues

continue to affect system adoption. Participants also noted institutional constraints such as political interference (9 references) and union resistance (7 references). The digital green linkages theme indicates that participants associate digital systems with environmental benefits. Sub-themes such as environmental awareness (14 references), cost efficiency (13 references), and monitoring capabilities (11 references) suggest that digital tools support both sustainability awareness and monitoring of environmental performance.

Table 7. Qualitative Coding Framework: Digitalization Themes.

Main Theme	Sub-Themes	Code Frequency	Representative Quotes
Digital Enablers	E-recruitment systems	18	"We now use LinkedIn and video interviews"
	E-learning platforms	22	"Training is moving online, more accessible"
	Paperless operations	31	"Most communications are digital now."
	Automated workflows	15	"Attendance and leave are automated."
Digital Barriers	Infrastructure gaps	12	"Connectivity issues affect implementation."
	Skills deficits	16	"Many staff lack online skills."
	Political interference	9	"Political appointments bypass digital systems."
	Union resistance	7	"Unions fear job losses from automation."
Digital-Green Linkages	Environmental awareness	14	"Digital reduces paper, saves trees."
	Monitoring capabilities	11	"We can track green KPIs digitally."
	Cost efficiency	13	"Digital saves money and the environment."
Implementation Challenges	Mixed systems	10	"We run manual and digital in parallel."
	Change management	8	"Staff resist new digital processes."
	Resource constraints	11	"Limited budget for full digitalization".

Source: Emerged from data analysis.

Finally, the implementation challenges theme highlights practical constraints during digital transformation. Mixed systems (10 references) indicate the continued coexistence of manual and digital processes, while resource constraints (11 references) and change management issues (8 references) reflect organizational and financial limitations affecting full digital integration. Overall, the findings suggest that while digital technologies support operational efficiency and environmental initiatives, their effectiveness depends on adequate infrastructure, digital skills, and institutional support.

3.7. Ethical Considerations

The original study received ethical clearance (HSSREC/00000377/2019). Secondary analysis used anonymized data only, with no additional data collection. All procedures adhered to confidentiality and responsible research standards.

4. Results

The results are presented in three parts: (i) quantitative findings on the relationships between digitalization-enabled GHRM practices and EGB; (ii) qualitative themes explaining how HR managers experience and interpret digitalization as an enabler or barrier for green workplace behaviors; and (iii) mixed-methods showing areas of convergence and divergence across both strands. For clarity, descriptive statistics and psychometric properties of the measures are presented first (Tables 2 and 3), followed by bivariate associations (Table 4) and multivariate prediction (Table 5). The qualitative themes and illustrative quotations are summarized in Table 7, while the thematic map is illustrated in Figure 1. The integration matrix is presented in Table 8.

Table 8. Mixed-Methods Integration: Convergence and Divergence Analysis.

Research Question	Quantitative Finding	Qualitative Finding	Integration Status	Interpretation
Does digital training influence EGB?	Strong positive correlation ($r = 0.524$, $p < 0.05$)	E-learning adoption confirmed; managers' reports increased accessibility	Convergence	Digital training is an effective enabler of EGB
Does digital performance management influence EGB?	Moderate positive correlation ($r = 0.463$, $p < 0.05$)	Automated KPI tracking is emerging; mixed implementation	Partial Convergence	Potential exists, but implementation is incomplete
Are digital Systems fully implemented?	Positive relationships assume functionality	Significant barriers: skills gaps, infrastructure, resistance	Divergence	Statistical potential implementation reality
Is digital infrastructure adequate?	Correlations assume digital readiness	Infrastructure limitations and connectivity issues were reported	Divergence	Readiness gap threatens effectiveness
Do employees have digital skills	Analysis assumes competency	10.6% poor IT skills; training needs identified	Divergence	Skills development is required before the full benefits are realized

Source: Authors' compilation.

4.1. Quantitative Findings: Digitalization-Enabled GHRM and EGB

The internal consistency of all constructs was adequate to excellent. As shown in Table 2, the digitalization-enabled GHRM dimensions demonstrated strong reliability: Digital Green Training ($\alpha = 0.963$), Digital Performance Management ($\alpha = 0.953$), Digital Recruitment ($\alpha = 0.905$), and Digital Compensation & Rewards ($\alpha = 0.887$). Green Workplace Behaviors ($\alpha = 0.822$) and Management Support ($\alpha = 0.841$) also achieved good reliability. These results support the suitability of the measures for subsequent inferential analyses.

Descriptive statistics indicated generally favorable perceptions of digitalization-enabled GHRM practices and EGB (Table 3). Among the digitalization indicators, Paperless Operations recorded the highest mean ($M = 4.01$, $SD = 0.79$), followed by Digital Green Training ($M = 3.82$, $SD = 0.94$) and Digital Performance Management ($M = 3.67$, $SD = 0.88$). EGB also recorded a relatively high mean ($M = 3.91$, $SD = 0.72$). The skewness and kurtosis values reported in Table 3 suggested modest negative skew across most constructs, consistent with responses clustering toward agreement on the 5-point scale.

Spearman's correlation analysis revealed statistically significant associations between digitalization-enabled GHRM practices and EGB (Table 4).

Digital Green Training showed the strongest association with EGB ($r = 0.524$, $p < 0.05$), followed by Paperless Operations ($r = 0.487$, $p < 0.01$), Digital Performance Management ($r = 0.463$, $p < 0.05$), and Workflow Automation ($r = 0.423$, $p < 0.01$). Digital Compensation was positively associated with EGB ($r = 0.341$, $p < 0.01$), while Digital Recruitment showed a weaker but statistically significant relationship ($r = 0.251$, $p < 0.05$).

Collectively, these bivariate results indicate that digitalization-driven HR practices are positively associated with EGB, with training and operational digitalization (paperless systems) emerging as the strongest correlates.

To assess incremental prediction beyond background factors, hierarchical regression analysis was conducted with EGB as the dependent variable (Table 5).

The model, including control variables (gender, education, and experience) was not statistically significant (Model 1: $R^2 = 0.087$; Sig. F Change = 0.129). When Digital Training was introduced (Model 2), explanatory power improved substantially ($R^2 = 0.312$; $\Delta R^2 = 0.225$; Sig. F Change = 0.000), indicating that digital green training accounted for a meaningful proportion of variance in EGB beyond the controls.

The addition of Digital Performance Management in Model 3 produced a further statistically significant improvement ($R^2 = 0.378$; $\Delta R^2 = 0.066$; Sig. F Change = 0.015). The inclusion of Digital Compensation in Model 4 increased overall explanatory power ($R^2 = 0.412$), although the incremental change was marginal at conventional thresholds ($\Delta R^2 = 0.034$; Sig. F Change = 0.071).

Overall, the regression results reinforce the primacy of digital training and digital performance management as key quantitative predictors of EGB within the dataset (Table 5).

4.2. Qualitative Findings: Digitalization Themes and Implementation Realities

The qualitative findings deepened the statistical patterns by showing how managers interpret digitalization as both an operational enabler of green workplace practices and a site of organizational constraint. Four overarching qualitative categories emerged from the re-analysis: digital enablers, digital barriers, digital green linkages, and implementation challenges. These themes, sub-themes, code frequencies, and representative quotations are summarized in Table 7, while the overall thematic architecture is depicted in Figure 1.

With respect to digital enablers, participants emphasised the expanding presence of e-recruitment systems, e-learning platforms, paperless operations, and automated workflows. Paperless operations featured most prominently in the qualitative dataset (Table 7), with managers highlighting shifts toward digital communication and reduced printing. This operational shift was frequently described as inherently “green” due to reduced paper consumption, aligning with the high quantitative mean for paperless operations (Table 3). E-learning was also repeatedly identified as a practical mechanism for widening access to environmental training, supporting the strong quantitative relationship between digital training and EGB (Table 4) and the substantial variance explained in the regression model when training was introduced (Table 5).

However, participants also identified persistent digital barriers that complicate implementation and limit system-wide impact. As shown in Table 7, managers cited infrastructure and connectivity constraints, uneven digital skills among staff, political interference, and union resistance as recurring obstacles. These constraints were further compounded by the continued operation of mixed manual digital systems, which participants described as reducing efficiency and weakening standardization. In addition, several accounts suggested that institutional pressures can disrupt intended digital processes, particularly where formal digital procedures coexist with informal or politically influenced workarounds.

Participants also made explicit digital green linkages, describing digitalization not only as an efficiency-enhancing intervention but as a mechanism enabling environmental awareness, monitoring capabilities, and cost efficiencies (Table 7). Managers reported that digital tools can improve the visibility of “green” expectations and facilitate tracking of environmental key performance indicators, which conceptually aligns with the digitalization-enabled motivation pathway and the emerging quantitative role of digital performance management (Tables 4 and 5). Nonetheless, the qualitative findings consistently signaled that realizing these benefits depends on readiness conditions—particularly infrastructure adequacy and staff digital capability, rather than on technological availability alone (Figure 2).

Figure 2 shows the digitally integrated GHRM–EGB circular thematic model, illustrating structural drivers, digitally mediated AMO mechanisms, EGB, and multi-level outcomes.



Figure 2. Digitalization-integrated GHRM-EGB circular thematic Map. Source: Authors' compilation.

4.3. Mixed-Methods Integration: Convergence, Divergence, and Meta-Inferences

Mixed-methods integration assessed whether quantitative “statistical potential” aligned with qualitative “implementation realities.” The integration matrix (Table 8) shows both convergence and divergence across research questions. Convergence was most evident for digital training, where quantitative results demonstrated a strong positive relationship with EGB (Table 4) and qualitative findings confirmed the growing use of e-learning and digitally mediated training access (Table 7), producing convergence in the interpretation that digital training functions as a practical pathway for strengthening green ability and facilitating green behavior (Table 8).

Partial convergence was observed for digital performance management. Quantitatively, digital performance management correlated positively with EGB (Table 4) and improved model fit when introduced into the regression sequence (Table 5). Qualitatively, participants acknowledged emerging monitoring capacity and digital KPI tracking, but emphasized uneven implementation and incomplete system integration (Table 7), producing partial convergence (Table 8).

Divergence was most pronounced regarding full implementation and organizational readiness. While the quantitative associations presume functional and stable digital systems, qualitative findings underscore substantial constraints, skills deficits, infrastructure limitations, resistance dynamics, and mixed-system operation that weaken implementation consistency (Table 7). This produced divergence between measured relationships and contextual feasibility, captured in Table 8 as a readiness gap: statistical relationships indicate potential benefits, but practical realisation is conditional on addressing infrastructural, capability, and change-management constraints. Taken together, the integrated results indicate that digitalization-enabled GHRM practices are positively associated with EGB, while qualitative evidence clarifies that implementation barriers can moderate the extent to which this potential is translated into routine, organization-wide green behavior outcomes (Table 8; Figure 2).

5. Discussion

5.1. Interpretation of Findings

This study examined the association between digitalization-enabled GHRM practices and EGB within a South African metropolitan municipality. The findings indicate that digital green training and digital performance management are positively associated with reported EGB. However, these associations demonstrate moderate explanatory power and should be interpreted as context-bound relationships rather than evidence of causal influence.

The integration of quantitative and qualitative findings suggests that digital HR systems may function as behavioral structuring mechanisms by enhancing visibility, measurability, and reinforcement of green expectations. At the same time, qualitative evidence reveals implementation inconsistencies, infrastructural limitations, and institutional constraints that condition the strength and stability of these associations. Thus, digitalization appears to create enabling conditions for green behavior, but its effectiveness depends on organizational readiness and administrative capacity.

The practical significance of these findings lies in demonstrating that digital HR systems are not merely administrative efficiency tools; they may also shape sustainability-related workplace behaviors when aligned with structured GHRM practices. For municipalities facing resource constraints, digitalization may offer scalable mechanisms for embedding environmental accountability into routine HR processes. However, the findings also caution that digital transformation alone is insufficient. Without complementary investment in skills, infrastructure, and institutional alignment, digital systems may generate symbolic compliance rather than sustained behavioral change.

5.2. Theoretical Implications

This study advances theory in three ways. First, it extends the AMO framework by integrating digitalization as a structural enabler of green ability, green motivation, and green opportunity (Appelbaum et al., 2000; Boxall & Purcell, 2022; Renwick et al., 2013). While AMO has been widely applied in GHRM research, it has rarely incorporated digital HR infrastructures as core explanatory mechanisms. By conceptualizing digital systems as socio-technical amplifiers of AMO pathways, the study enriches behavioral HR theory in digitally transforming work environments.

Second, drawing on socio-technical systems logic, the study demonstrates that sustainability behaviors emerge from the interaction between technical infrastructures (digital dashboards, e-learning systems, paperless workflows) and social systems (motivation, norms, managerial reinforcement). This moves beyond leadership-centric explanations of EGB and situates digitalization within the behavioral architecture of organizations.

Third, the findings highlight the moderating role of institutional constraints in public-sector contexts. Institutional theory suggests that bureaucratic rules, accountability pressures, and political dynamics shape organizational practice (Bozeman & Bretschneider, 1994). Qualitative evidence indicates that such constraints influence how digital GHRM mechanisms are enacted. Thus, digitalization-enabled GHRM should be understood as context-contingent rather than universally transferable.

Importantly, the study refrains from asserting that digitalization causes EGB. Rather, it demonstrates statistically significant associations that are theoretically interpretable within an extended AMO socio-technical institutional framework.

5.3. Practical and Policy Implications

For municipal leaders and HR practitioners, the findings suggest that digital HR investments may yield sustainability-related behavioral benefits when integrated systematically into recruitment, training, and performance management systems.

Specifically, digital green training platforms may support scalable environmental skill development. Digital performance dashboards may enhance accountability for green KPIs. Paperless and automated workflows may normalize environmentally responsible routines. However, effective implementation requires attention to digital literacy, infrastructure stability, and stakeholder alignment, including unions and political actors. Policymakers should therefore view digitalization not solely as an e-governance reform but as a behavioral governance mechanism that requires complementary change-management strategies.

5.4. Context-Specific Limitations

Several limitations constrain the generalization of the findings. First, a cross-sectional design prevents conclusions regarding temporal ordering or causal direction. It is plausible that environmentally oriented employees perceive digital HR systems more favorably, rather than digital systems shaping behavior.

Second, the study is confined to a single metropolitan municipality with specific digital maturity levels, institutional structures, and resource conditions. Digital transformation outcomes in public administration are widely recognized as context-dependent (Mergel, 2021; Gil-Garcia et al., 2016). Therefore, the findings are analytically transferable to similar municipalities but not statistically generalizable across all public-sector organizations.

Third, the reliance on secondary mixed-methods data constrained construct specification to variables available in the original dataset (Johnston, 2014; Heaton, 2008). Fourth, self-reported measures introduce the possibility of social desirability bias, particularly in sustainability domains where normative expectations are strong (Kim et al., 2017; Zacher et al., 2023). Fifth, the study did not incorporate objective environmental performance indicators (e.g., energy use reduction, paper audits, environmental compliance metrics). Consequently, the findings pertain to perceived behavioral engagement rather than demonstrable environmental impact.

5.5. Directions for Future Research

Future research should employ longitudinal and panel designs to clarify the temporal dynamics of digitalization-enabled GHRM mechanisms (Mergel, 2021; Gil-Garcia et al., 2016). Comparative multi-municipality studies would help identify boundary conditions across varying levels of digital maturity and institutional constraint (Weerakkody et al., 2017; Begany & Gil-Garcia, 2024).

Experimental and intervention-based designs (e.g., digital KPI rollouts, structured e-learning interventions) could test specific digital pathways through which green ability and motivation are strengthened (Assoratgoon & Kantabutra, 2023; Yadegaridehkordi et al., 2023). Finally, future work should integrate behavioral measures with objective environmental and cost-effectiveness metrics to evaluate whether digital HR systems contribute to measurable sustainability performance gains (Kim et al., 2017; Zacher et al., 2023).

6. Conclusions

The purpose of this study was to re-examine EGB within a metropolitan municipality by analysing the role of digitalization-enabled GHRM practices through a secondary mixed-methods design. By integrating quantitative associations with qualitative implementation insights, the study provides a cautious yet theoretically informed assessment of how digital HR infrastructures relate to pro-environmental workplace behavior in a public-sector context.

The findings indicate that digital green training and digital performance management systems are positively associated with reported EGB. However, these relationships demonstrate moderate explanatory power and are shaped by institutional, infrastructural,

and socio-technical conditions. Digitalization, therefore, should not be interpreted as a direct causal driver of sustainability outcomes, but rather as an enabling mechanism that may strengthen the AMO pathways when organizational readiness and administrative capacity are present.

The study contributes to theory by extending AMO through socio-technical and institutional perspectives, positioning digital HR systems as structural amplifiers of green ability, motivation, and opportunity within bureaucratic environments. Methodologically, it demonstrates how transparent secondary mixed-methods analysis can refine theory while acknowledging measurement constraints. Substantively, it highlights that digital transformation in municipalities holds behavioral potential, but its effectiveness depends on alignment between technology, skills, governance processes, and change-management capacity.

Importantly, the conclusions are context-bound to a single metropolitan municipality and should be interpreted as analytically transferable to similar public-sector settings rather than statistically generalized across all organizations. Future research incorporating longitudinal designs, comparative municipal contexts, and objective environmental performance indicators will be essential to determine whether digitalization-enabled GHRM mechanisms translate into measurable sustainability outcomes.

Overall, this study advances a digitally integrated, context-sensitive framework for understanding sustainability-oriented HR systems in the public sector. It underscores that digital transformation, when embedded within coherent GHRM architectures and supported by institutional readiness, may contribute to environmental governance goals, but only as part of a broader socio-technical reform process rather than as a standalone technological solution.

Author Contributions: Conceptualization, T.H.A. and E.E.; methodology, T.H.A.; software, T.H.A.; validation, T.H.A.; formal analysis, T.H.A.; investigation, T.H.A.; resources, T.H.A.; data curation, T.H.A.; writing original draft preparation, T.H.A.; writing review and editing, T.H.A., V.N.M., E.E., S.O.A.; visualization, T.H.A.; supervision, E.E., V.N.M.; project administration, T.H.A., V.N.M., E.E., S.O.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted and approved by the Humanities and Social Sciences Research Ethics Committee of the University of KwaZulu-Natal (Ethical clearance: HSSREC/00000377/2019 and date 21 October 2019).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the original study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy and ethical restrictions.

Acknowledgments: The authors acknowledge eThekweni Municipality for granting access to conduct the original research.

Conflicts of Interest: The authors declare no conflicts of interest.

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