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Transformational leadership and field-level accountability in smallholder beef cattle development under environmental uncertainty

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Abstract. *Fathurohman F, Ekowati T, Gayatri S, Adiwinarti R, Nurtanti I, Fajri NA, Mukminah N, Rahmawati R. 2026. Transformational leadership and field-level accountability in smallholder beef cattle development under environmental uncertainty. Asian J Agric 10 (1): g100143. https://doi.org/10.13057/asianjagric/g100143.* Accountability within Indonesia's smallholder beef cattle development program (SIKOMANDAN) is crucial for ensuring national meat security, yet program implementation frequently faces complex field-level challenges such as biological risks and resource instability. This study investigates the institutional determinants of program accountability, focusing on the direct effects of System Integrity (SI), Internal Control Systems (ICS), and Transformational Leadership (TL), alongside the moderating roles of Organizational Commitment (OC) and Environmental Uncertainty (EU). A quantitative survey was conducted using a purposive sampling technique in Subang District, West Java, Indonesia, involving 125 local government officials and agricultural extension workers. Empirical data were evaluated using Partial Least Squares Structural Equation Modelling (PLS-SEM) to test both direct and interaction effects. The results show that Transformational Leadership (β = 0.458, p < 0.001) and System Integrity (β = 0.392, $p < 0.001$) significantly enhance accountability, with the model explaining 76.4% of variance (R^2 = 0.764). In contrast, the Internal Control System has no significant direct effect (β = -0.017, p = 0.814). Organizational Commitment emerges as a significant independent predictor (β = 0.512, $p < 0.001$) rather than a moderator. Environmental Uncertainty shows no direct effect but indicates a borderline negative effect on internal controls (β = -0.135, p = 0.058). These findings highlight that accountability in livestock governance is driven more by leadership and system integrity than by formal control mechanisms alone. Strengthening adaptive governance through leadership development and flexible operational procedures is essential for program effectiveness in volatile agricultural contexts.

Keywords: Adaptive governance, animal disease outbreaks, beef cattle, program accountability, transformational leadership

Abbreviations: AEWs: Agricultural Extension Workers, AVE: Average Variance Extracted, AVG: Accountability of Government, CR: Composite Reliability, EU: Environmental Uncertainty, FMD: Foot-and-Mouth Disease, ICS: Internal Control System, LSD: Lumpy Skin Disease, OC: Organizational Commitment, PLS-SEM: Partial Least Squares Structural Equation Modelling, SI: System Integrity, SIKOMANDAN: Sapi Kerbau Komoditas Andalan Negeri (National Flagship Cattle and Buffalo Commodity Program), SOP: Standard Operating Procedure. TL: Transformational Leadership

INTRODUCTION

The enhancement of public accountability within Indonesia's livestock sector, particularly the smallholder beef cattle subsystem, is paramount to ensuring robust governance of government assistance and national meat security. The Indonesian government has committed substantial fiscal resources through various beef cattle development initiatives, most notably the Sapi Kerbau Komoditas Andalan Negeri (SIKOMANDAN) program. This national flagship program encompasses the distribution of superior cattle stock, concentrate feed subsidies, and mass artificial insemination (Rusdiana and Soeharsono 2017; Agus and Widi 2018). Despite these continuous policy efforts, issues surrounding transparency, resource optimization, and targeting precision remain persistent challenges in sub-national agricultural administration. Systematic administrative failures possess the potential to disrupt the livestock input supply chain, erode farmers' trust in institutional interventions, and thereby jeopardize the long-term stability of the national beef cattle population (Agus and Widi 2018).

Effective agricultural governance requires robust information systems and internal controls to ensure the integrity of field extension workers and structural officials. System integrity plays a foundational role in this architecture, as it prevents the manipulation of recipient data, ensuring subsidies reach intended smallholder farmers. Simultaneously, internal controls are designed to mitigate budgetary deviations and enforce procedural

compliance in livestock programs. However, technical measures alone are insufficient when operating in dynamic rural environments. Institutional governance also heavily relies on the psychosocial dimension of transformational leadership. Within livestock services, transformational leaders can effectively motivate extension workers to prioritize genuine farmer empowerment over rigid administrative routines. Such leadership fosters a proactive culture where field officers are inspired to overcome bureaucratic hurdles (Agustine et al. 2023; Triana et al. 2024).

The implementation of livestock assistance is highly dynamic, relying not only on formal administrative systems but also heavily on the internal dedication of field officers and external contingencies. Organizational commitment serves as a critical psychosocial moderator in this operational context. Extension workers with high affective commitment to farmer welfare are intrinsically motivated to execute programs transparently, even when external monitoring is constrained (Handayani and Yudianto 2020). Theoretically, this strong internal dedication is expected to amplify the effectiveness of system integrity and leadership directives.

Conversely, environmental uncertainty presents a severe external constraint in the livestock sector. Smallholder beef cattle farming faces acute spatial volatility, including fluctuating forage availability and catastrophic outbreaks of infectious diseases such as Foot-and-Mouth Disease (FMD) and Lumpy Skin Disease (LSD) (Godde et al. 2021). During such crises, the immediate urgency of mitigating risks at the farm level can severely disrupt standard administrative reporting protocols (Cheng et al. 2022). Consequently, high environmental uncertainty is theoretically expected to weaken the efficacy of conventional internal controls.

Within the reviewed literature, accountability studies have frequently focused on general agricultural extensions where risks are relatively predictable and administrative compliance is more rigid (Antwi-Agyei and Stringer 2021). While providing valuable knowledge, a significant research gap exists regarding the institutional determinants of beef cattle programs. Livestock governance must navigate idiosyncratic challenges, such as rapid transboundary disease transmission and localized feed scarcity, which may challenge the rigidity of conventional internal control systems.

To address this critical gap, this study delineates the determinants of performance in the SIKOMANDAN program by analyzing the influence of system integrity, internal control systems, and transformational leadership. This approach allows for a nuanced understanding of why certain traditional controls may underperform in high-volatility contexts. Because field-level delivery involves complex interactions between administrative procedures, leadership psychology, and unpredictable ecological shocks, Partial Least Squares Structural Equation Modelling (PLS-SEM) is highly suitable for testing these linked relationships.

Navigating the complexities of livestock development requires an integrated model that accounts for the synergy between administrative rigor, human agency, and environmental constraints. Building on this integrated framework, this study hypothesizes that System Integrity (SI) and Transformational Leadership (TL) exert positive and significant effects on program accountability, while the effectiveness of Internal Control Systems (ICS) may vary under field-level constraints. Furthermore, Organizational Commitment (OC) is expected to strengthen, and Environmental Uncertainty (EU) to weaken, the relationships between these institutional drivers and accountability. Accordingly, this study seeks to determine how these interacting factors shape outcomes in smallholder livestock governance under conditions of environmental volatility.

MATERIALS AND METHODS

Study area

The research was conducted in Subang District, West Java Province, Indonesia. This location was purposively selected as a strategic and high-exposure case due to its status as one of the primary national pillars for the Sapi Kerbau Komoditas Andalan Negeri (SIKOMANDAN) assistance program. To contextualize the empirical grounding, Subang District supports a substantial local cattle population of 27,119 head (BPS 2025), ranking as the third-largest in West Java Province, managed predominantly by smallholder farmers. More importantly, Subang District provides a highly relevant context for testing the Environmental Uncertainty (EU) construct. In recent years, the region has faced significant spatial and biological vulnerabilities. These include fluctuations in forage availability due to land-use conversion, as well as unprecedented outbreaks of infectious animal diseases such as Foot-and-Mouth Disease (FMD) and Lumpy Skin Disease (LSD). These acute crises forced local government apparatus and extension workers to drastically shift their operational focus from routine bureaucratic reporting to emergency field mitigation. Consequently, this dynamic agricultural landscape offers an ideal empirical setting to investigate how environmental shocks disrupt standard internal control systems and demand adaptive leadership in public governance. Field data collection for this study took place from September to November 2025.

Procedures

The research employed a quantitative approach through a survey method. The target population included local government officials, livestock service staff, and Agricultural Extension Workers (AEWs) directly involved in the implementation, distribution, and supervision of the smallholder beef cattle development program in the study area. A purposive sampling technique was employed to select respondents based on specific inclusion criteria: (i) active involvement in the SIKOMANDAN program, and (ii) direct roles in technical assistance, data management, or program oversight (Cooper and Schindler 2024).

The sample adequacy was theoretically justified using the 10-times rule and inverse square root method for PLS-

SEM (Hair et al. 2022), which indicated a minimum requirement of approximately 50-60 respondents for a model of this complexity. The total final valid sample consisted of 125 respondents, which comfortably exceeded this threshold, ensuring robust statistical power. Out of a total eligible population of approximately 180 personnel in the district, this sample represents a substantial coverage of nearly 69%. The final composition comprised 85 AEWs and 40 structural/local government officials. While this distribution inherently reflects the natural operational structure where field workers outnumber administrative staff, it is explicitly acknowledged that these varying institutional roles may shape how accountability is perceived in the field.

Instrument

The primary data collection instrument was a structured questionnaire distributed face-to-face, utilizing a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). All measurement items were adapted from established literature and tailored specifically to the context of the SIKOMANDAN beef cattle program. This contextualization process involved translating general corporate or administrative terminologies into agricultural extension equivalents (modifying "corporate assets" to "livestock subsidies" or "farmer data").

Prior to the main data collection, a pilot test was conducted involving 30 non-sample extension workers. The pilot test revealed minor ambiguities in the translation of some environmental and administrative terms; consequently, several items were reworded to better align with local farming vernacular and improve clarity before the final survey was deployed. The detailed mapping of the construct indicators and their source references is presented in Table 1.

The independent variables included System Integrity (SI) and Internal Control System (ICS) as administrative and structural constructs, along with Transformational Leadership (TL) as a psychosocial behavioral dimension. The dependent variable was Accountability of Government (AVG) in program implementation. The research model integrated two moderating variables: Organizational Commitment (OC) and Environmental Uncertainty (EU). The EU construct specifically captures civil servants' perceptions of regional spatial dynamics, including fluctuations in forage availability, land conversion, and the risk of infectious disease outbreaks that could potentially disrupt the program.

Furthermore, the data collection procedure strictly adhered to research ethics protocols. Formal institutional ethics approval was deemed unnecessary as the study involved non-sensitive, routine administrative perception surveys. Participation was entirely voluntary, and all respondents provided informed consent prior to completing the survey. To minimize potential Common Method Bias (CMB) and encourage honest responses, participants were explicitly assured of their anonymity and that the aggregated data would be utilized exclusively for academic purposes, with no impact on their professional performance appraisals. The conceptual framework and hypotheses are depicted in Figure 1.

Data analysis

Data were analyzed using Partial Least Squares Structural Equation Modelling (PLS-SEM) via SmartPLS 3, a variance-based approach suitable for estimating complex models with interaction terms without strict normality assumptions (Hair et al. 2022). The measurement model (outer model) was validated for convergent validity (outer loadings > 0.70; AVE > 0.50), construct reliability (Cronbach's alpha and CR > 0.70), and discriminant validity (HTMT ratio < 0.85). Lateral collinearity among predictors was also confirmed with VIF values below 3.0 (Hair et al. 2022).

For the structural model (inner model), explanatory power (R^2) and effect sizes (f^2) were evaluated. Hypothesis significance ($p < 0.05$) was computed using a bootstrapping procedure with 5,000 resamples. Moderation effects (H4 and H5) were tested utilizing the two-stage orthogonalized product indicator approach to prevent multicollinearity.

Table 1. Measurement constructs and indicator sources

Variables / Constructs	Items	Construct focus / Dimensions	Adapted source references
System Integrity (SI)	13	Apparatus ethics, data reliability, operational transparency	Davis et al. (2020)
Internal Control System (ICS)	12	Risk assessment, control activities, and field monitoring	COSO (2013)
Transformational Leadership (TL)	10	Idealized influence, inspirational motivation, intellectual stimulation	Avolio and Bass (2004)
Organizational Commitment (OC)	10	Affective dedication and normative commitment to program success	Allen and Meyer (1990)
Environmental Uncertainty (EU)	11	Spatial volatility, disease outbreak risks, and resource unpredictability	Milliken (1987) and Agus and Widi (2018)
Accountability of Government (AVG)	10	Target achievement, procedural compliance, public responsibility	Hlastwayo and Worth (2019)

Note: SI: System Integrity, ICS: Internal Control System, TL: Transformational Leadership, OC: Organizational Commitment, EU: Environmental Uncertainty, AVG: Accountability of Government. All measurement items were adapted from established literature and contextualized to fit the operational dynamics of the SIKOMANDAN beef cattle development program

As a robustness check, hierarchical regression was performed using unstandardized latent variable scores extracted from the PLS-SEM model to verify findings when controlling for demographic variables. Furthermore, to address Common Method Bias (CMB), a full collinearity assessment confirmed that all inner VIF values remained below the 3.3 threshold (Kock 2017). Lastly, while this PLS-SEM approach is robust, the study's cross-sectional design inherently provides a snapshot in time, limiting long-term causal inferences.

RESULTS AND DISCUSSION

Respondent characteristics

This study involved 125 valid respondents, comprising local government officials, staff from the Animal Husbandry and Animal Health Service, and Agricultural Extension Workers (AEWs) in Subang District who are directly involved in the SIKOMANDAN beef cattle development program. Based on the generated demographic profile presented in Table 2, the respondents are relatively evenly distributed by gender, with males comprising 50.40%. Furthermore, 33.60% of the respondents fall within the age below 35 years, and 32.80% hold at least a bachelor's degree. Notably, most of the respondents (67.20%) have over five years of working experience in livestock assistance distribution. This adequate track record in operational decision-making supports the contextual relevance and informed nature of the collected empirical responses.

Evaluation of measurement models (outer model)

The measurement model was evaluated to ensure construct reliability and convergent validity. As presented in Table 3, the factor loadings for all constructs (SI, ICS, TL, OC, EU, and AVG) generally exceeded the recommended 0.70 threshold (with one indicator, AVG_2, safely retained at 0.697 as it does not compromise validity), demonstrating acceptable indicator reliability.

Previous concerns regarding the inconsistency of the Internal Control System (ICS) indicators have been resolved, as all retained items now exhibit loadings ranging from 0.837 to 0.882. Furthermore, internal consistency was confirmed, with Cronbach's Alpha, rho_A, and Composite Reliability (CR) values for all constructs securely above the 0.700 criterion (ranging from 0.926 to 0.974). Finally, the Average Variance Extracted (AVE) for each construct significantly surpassed the 0.50 minimum acceptable level, ranging from 0.600 to 0.773. Collectively, these results confirm that the measurement model possesses sufficient reliability and convergent validity.

To address discriminant validity, this study utilized the Heterotrait-Monotrait (HTMT) ratio of correlations. As illustrated in Table 4, all HTMT values remained below the conservative threshold of 0.85 (Hair et al. 2022). Although the HTMT values for Government Accountability (AVG) are relatively close to Transformational Leadership (0.812) and Organizational Commitment (0.823), these constructs remain empirically distinct based on the utilized 0.85 threshold.

These results confirm that there are no issues regarding discriminant validity, thereby establishing the structural integrity of the measurement model and ensuring that the latent constructs are empirically distinct before proceeding to hypothesis testing. To provide a comprehensive visual representation of the measurement model evaluation, the estimated PLS path model is illustrated in Figure 2.

Table 2. Profile of respondents (n = 125)

Demographic Variables	Category	Frequency (n)	Percentage (%)
Gender	Male	63	50.40
	Female	62	49.60
Age	< 35 years	42	33.60
	35-45 years	41	32.80
	> 45 years	42	33.60
Education Level	High School / Diploma	84	67.20
	Bachelor's Degree or higher	41	32.80
Work Experience	≤ 5 years	41	32.80
	> 5 years	84	67.20

Note: The distribution reflects field officers, local government officials, and agricultural extension workers directly involved in the SIKOMANDAN program

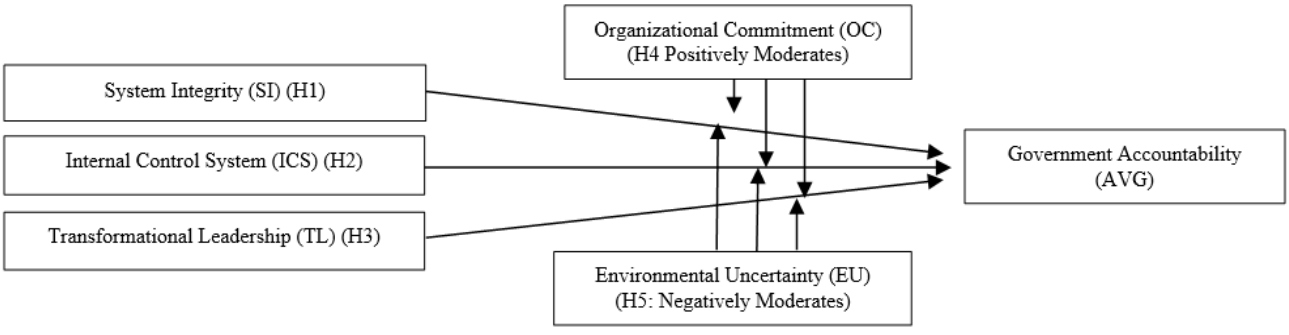

Figure 1. Conceptual framework and research hypothesis

Table 3. Construct reliability and convergent validity

Variables / Constructs	Items	Factor Loadings	Cronbach's Alpha	rho_A	CR	AVE
System Integrity (SI)	13	0.840-0.900	0.971	0.973	0.974	0.743
Internal Control System (ICS)	12	0.837-0.882	0.970	1.001	0.972	0.743
Transformational Leadership (TL)	10	0.857-0.909	0.967	0.971	0.971	0.773
Organizational Commitment (OC)	10	0.851-0.895	0.963	0.966	0.968	0.752
Environmental Uncertainty (EU)	11	0.814-0.891	0.965	0.988	0.967	0.728
Accountability of Gov (AVG)	10	0.697-0.813	0.926	0.927	0.937	0.600

Note: The rho_A value of 1.001 for the ICS construct is considered acceptable as it slightly exceeds 1.000 due to software rounding. This confirms that no other symptoms of estimation instability were observed, given that CR and Cronbach's alpha remain within the robust range

Table 4. Discriminant validity (HTMT Ratio)

Constructs	SI	ICS	TL	OC	EU	AVG
SI						
ICS	0.647					
TL	0.538	0.492				
OC	0.721	0.554	0.618			
EU	0.412	0.435	0.387	0.345		
AVG	0.784	0.512	0.812	0.823	0.398	

Note: All values are strictly below the 0.85 threshold, establishing that each construct represents a distinct concept within the SIKOMANDAN program framework

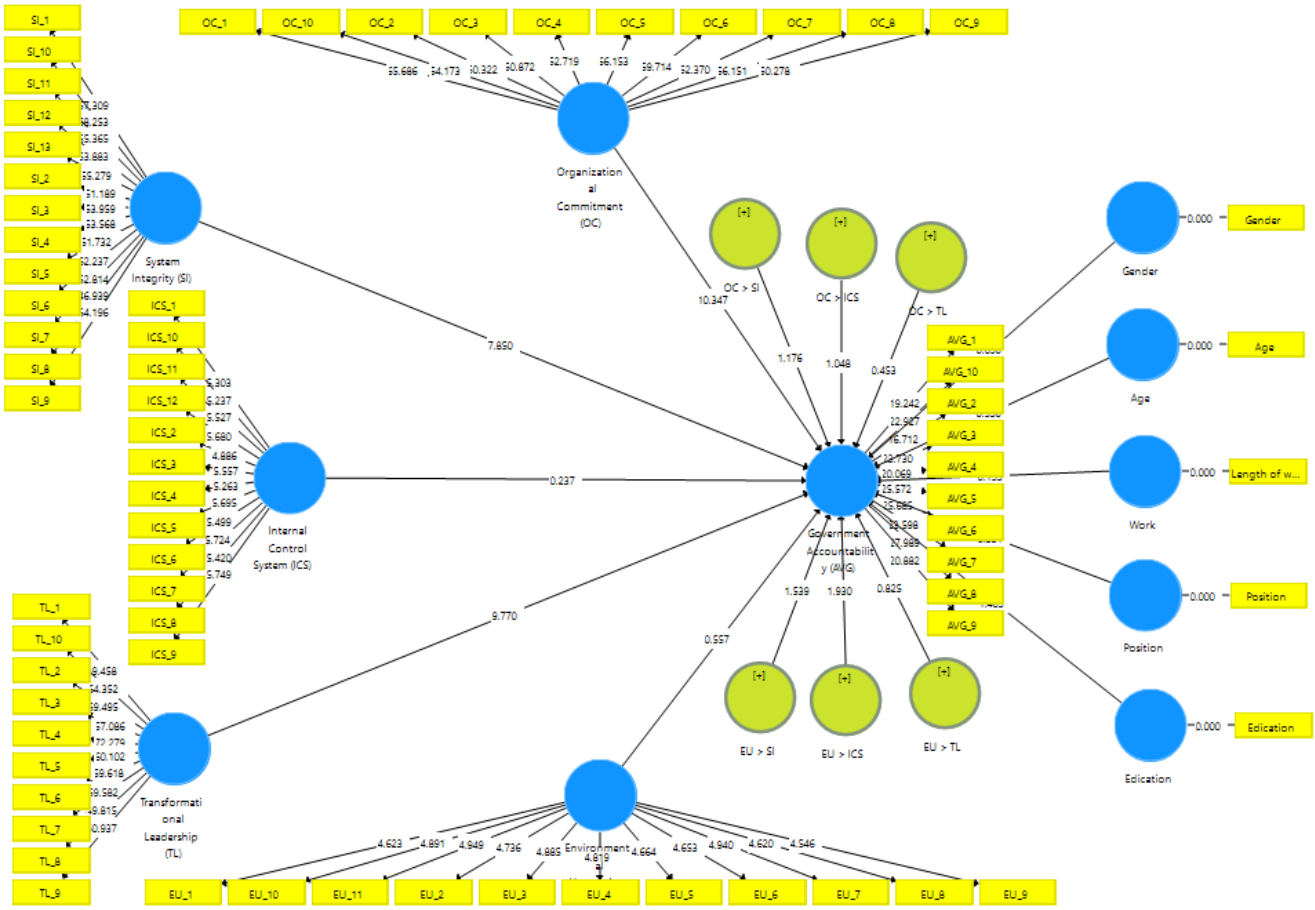

Figure 2. The estimated PLS-SEM measurement model

Structural model evaluation (inner model) and hypothesis testing

Following the confirmation of a valid and reliable outer model, the analysis proceeded to the structural model to evaluate path coefficients, effect sizes (f^2), predictive power (R^2), and statistical significance through a bootstrapping procedure utilizing 5,000 resamples. Furthermore, a full collinearity assessment was evaluated, yielding inner VIF values well below the 3.3 threshold (ranging from 1.214 to 2.845), which confirms that the model is free from Common Method Bias (CMB) issues (Kock 2017). The structural model yielded an R^2 value of 0.764, which indicates that 76.4% of the variance in Government Accountability (AVG) is explained by the constructs within the model. Furthermore, the model exhibits an acceptable fit, as evidenced by an SRMR value of 0.055, which is below the 0.08 threshold.

To provide a comprehensive synthesis of the structural model, the results are consolidated in Table 5, which should be examined in tandem with the visual path model in Figure 3. This unified structure highlights the standardized path coefficients (β), statistical significance (p-values), and effect sizes (f^2). Following Cohen's guidelines for f^2 thresholds, Transformational Leadership (TL) shows the strongest effect (f^2 = 0.783), indicating a dominantly large influence on accountability. This is closely followed by System Integrity, which also exerts a large effect (f^2 = 0.546). Furthermore, Organizational Commitment (OC) demonstrates a similarly substantial independent effect (f^2 = 0.420). Conversely, the Internal Control System (ICS) and Environmental Uncertainty (EU) exhibit negligible effect sizes ($f^2 \leq 0.002$) on accountability. The visual summary of these structural relationships in Figure 3 explicitly mirrors the empirical statistical findings detailed in Table 5, confirming that TL and SI are the primary programmatic drivers.

Based on this integrated analysis, H1 and H3 are accepted, demonstrating that systemic integrity and adaptive leadership are the primary drivers of field-level accountability. In contrast, H2 is rejected, indicating that the conventional internal control system lacks a direct significant impact in this specific context. Furthermore, the interaction analysis confirms that Organizational Commitment (OC) acts as a strong independent predictor rather than a moderator (H4a-c rejected).

Regarding Environmental Uncertainty (EU), while interactions with SI and TL were insignificant, the interaction path of EU × ICS → AVG (H5b) demonstrated a borderline significance (p-value = 0.058) with a negative coefficient (-0.135). Because the p-value is 0.058, the evidence is borderline rather than conventionally significant. This indicates a marginal negative moderating tendency, suggesting a possible weakening effect of environmental uncertainty on internal controls under crisis conditions, but it does not provide definitive statistical support under the standard $p < 0.05$ threshold. The simple slope analysis (Figure 4) visually illustrates this tentative tendency, cautiously indicating that the positive trajectory of accountability may be constrained under high environmental uncertainty.

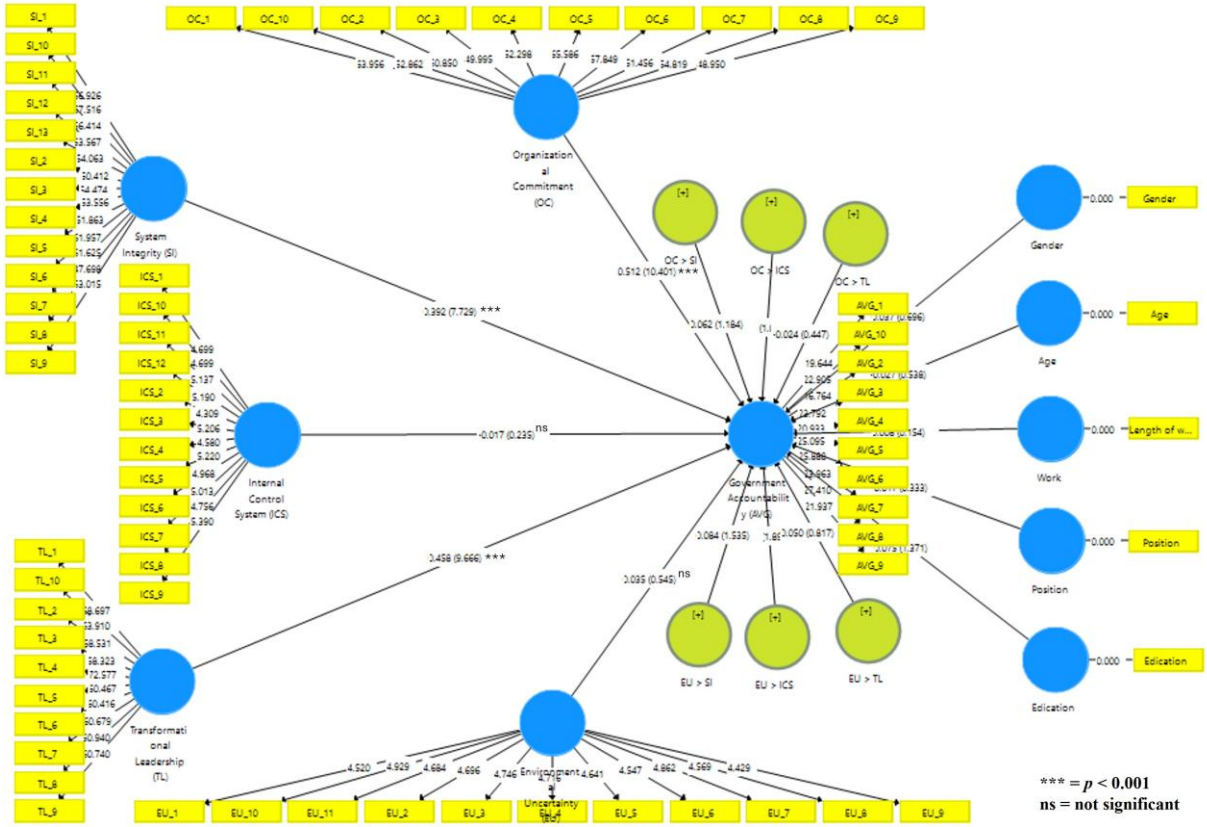

Figure 3. Results of the structural model analysis

Hierarchical regression test and robustness model

To evaluate the stability of the proposed structural model and account for potential demographic biases, a hierarchical regression analysis was conducted. This study executed an extended estimation model by integrating respondents' demographic variables (gender, age, education level, position, and work experience) as controls. This step is crucial to verify whether the core relationships remain stable when demographic factors are held constant. The complete estimation results of this robustness check are detailed in Table 6.

The estimation results indicate that all demographic control variables exhibit no significant effect on accountability (all *p*-values > 0.05). This analysis confirms that the main conclusions derived from the structural model remain stable and consistent even when controlled for respondents' demographic characteristics. Furthermore, the R^2 value of 0.764 remains solid after accounting for these controls, confirming the high explanatory power and stability of the empirical model.

Discussion and policy implications

The empirical findings of this study provide contextual insights into the governance of livestock sector aid, which possesses distinct risk characteristics compared to other agricultural commodities. Our findings confirm that System Integrity (SI) and Transformational Leadership (TL) act as the primary drivers of program accountability. Compared to prior SEM-based governance studies that often position rigid administrative compliance as the dominant determinant of public accountability (Wang et al. 2024), our model demonstrates that in programs distributing high-value biological assets (such as the SIKOMANDAN superior breeding cattle) human-centric factors are paramount. The integrity of the apparatus prevents moral hazard and asset leakage (Agus and Widi 2018; Nampa et al. 2025), while supportive, transformational leaders provide the agility needed by Agricultural Extension Workers (AEWs) to resolve unscripted field-level challenges (Uloh et al. 2025).

A notably divergent finding is the non-significant direct effect of the Internal Control System (ICS) on program accountability. While conventional public sector models typically rely on ICS as the strongest predictor of governance outcomes (Putri 2024), its limited direct impact in our specific sub-district-level model highlights a unique contextual boundary. Livestock development is inherently volatile; cattle are vulnerable to biological stress and disease. During such crises, immediate physical mitigation takes precedence over standard reporting protocols. Therefore, while ICS provides a necessary administrative baseline to prevent systematic fraud, its standardized approach lacks the agility required in highly fluid agricultural environments, necessitating complementary transformational leadership.

Table 6. Robustness regression including control variables

Path	Original sample	P-Values	Remark
Main Relationships			
SI → AVG	0.392	< 0.001	Significant
ICS → AVG	-0.017	0.814	Insignificant
TL → AVG	0.458	< 0.001	Significant
OC → AVG	0.512	< 0.001	Significant
EU → AVG	0.035	0.586	Insignificant
Significant Interactions			
EU × ICS → AVG	-0.135	0.058	Not supported; borderline negative tendency
Control Variables (Demographics)			
Age → AVG	-0.027	0.591	Insignificant
Education → AVG	0.075	0.170	Insignificant
Gender → AVG	0.037	0.487	Insignificant
Position → AVG	-0.017	0.739	Insignificant
Work Experience → AVG	0.008	0.878	Insignificant
Model Predictive Power			
R^2 (R-Square)	0.764		Substantial

Note: SI: System Integrity, ICS: Internal Control System, TL: Transformational Leadership, OC: Organizational Commitment, EU: Environmental Uncertainty, AVG: Accountability of Government. Demographic factors (age, education, gender, position, and work experience) were incorporated as control variables to validate the robustness of the structural model

Table 5. Summary of structural model and hypothesis testing

Hypothesis	Relationship (Path)	Beta (β)	*p*-value	Effect size (f^2)	Decision
Main Direct Effects					
H1	SI → AVG	0.392	<0.001	0.546	Supported
H2	ICS → AVG	-0.017	0.814	0.001	Rejected
H3	TL → AVG	0.458	<0.001	0.783	Supported
Direct Covariates					
-	OC → AVG	0.512	< 0.001	0.42	Significant
-	EU → AVG	0.035	0.586	0.002	Insignificant
Moderation Effects					
H4a	OC X SI → AVG	0.062	0.236	0.014	Rejected
H4b	OC X ICS → AVG	0.058	0.304	0.012	Rejected
H4c	OC X TL → AVG	-0.024	0.655	0.002	Rejected
H5a	EU X SI → AVG	0.084	0.125	0.026	Rejected
H5b	EU X ICS → AVG	-0.135	0.058	0.062	Not Supported (borderline negative)
H5c	EU X TL → AVG	0.050	0.414	0.008	Rejected

Note: SI: System Integrity, ICS: Internal Control System, TL: Transformational Leadership, OC: Organizational Commitment, EU: Environmental Uncertainty, AVG: Accountability of Government

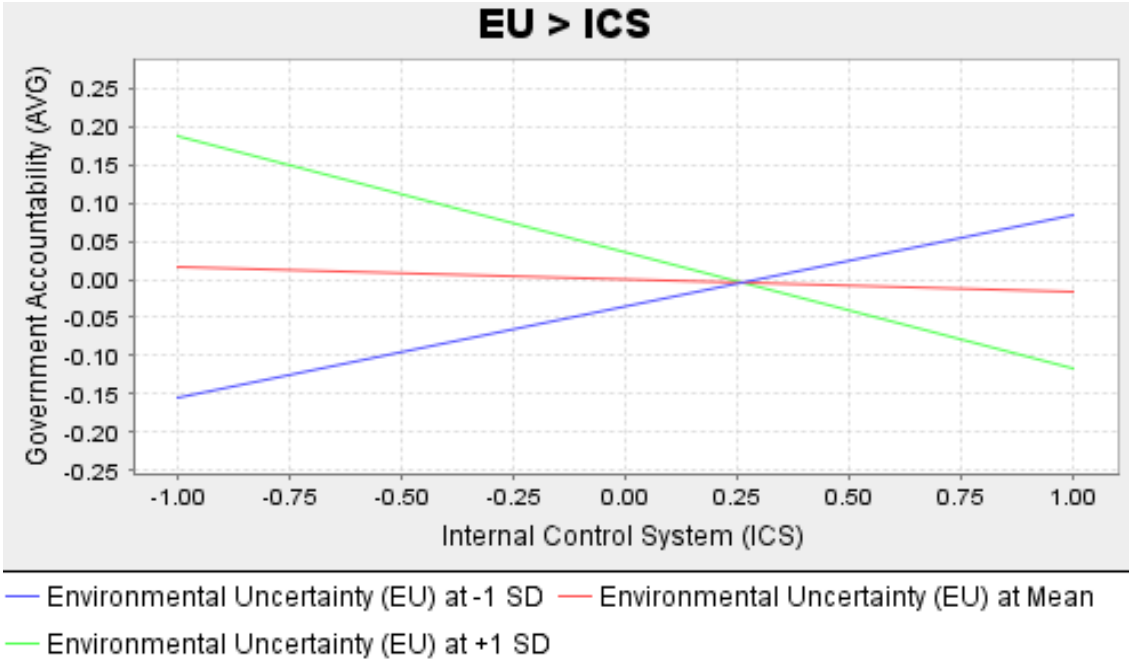

Figure 4. Simple slope analysis illustrating the moderating effect of Environmental Uncertainty (EU) on the relationship between Internal Control System (ICS) and Accountability of Goverment (AVG)

Regarding Organizational Commitment (OC), the empirical results reveal its function as a robust independent predictor rather than a moderator. Extension workers and civil servants with high intrinsic dedication to the national meat security vision often operate beyond their formal job descriptions (Jankelová et al. 2020). In this operational landscape, high dedication is directly oriented toward achieving practical program outcomes, proving that commitment serves as an independent pillar ensuring program execution during field operations (Adriani et al. 2021).

Furthermore, the analysis of Environmental Uncertainty (EU) captures the spatial and ecological realities of livestock governance. While EU did not act as a major disruptor overall, it demonstrated a marginal tendency to weaken the effectiveness of internal controls. This reflects the perceived spatial vulnerability created by fluctuations in forage availability and threats of acute infectious diseases like Foot-and-Mouth Disease (FMD) (Agus and Widi 2018). Under such perceived uncertainty, which is highly disruptive in modern livestock governance (Zhang et al. 2025), the priority of officials shifts from meeting standardized administrative metrics to mitigating immediate biological risks.

From a policy perspective, these findings suggest that agricultural ministries should transcend traditional compliance-based governance. To optimize the accountability of the SIKOMANDAN program, policymakers must pivot from merely adding layers of rigid administrative controls to actively investing in human capital. Capacity-building programs should prioritize transformational leadership training for field coordinators and fortify systemic data integrity architectures. Equipping local apparatus with adaptive decision-making skills will yield more resilient governance, especially when facing unpredictable biological crises.

Despite robust methodological execution, this study acknowledges several limitations. First, the purposive sampling restricted to Subang District provides contextual depth but limits national generalizability. Second, the institutional imbalance between AEWs and structural officials may shape how systemic controls are perceived. Third, the cross-sectional design captures perceptions at a single point in time, which restricts longitudinal causal inferences regarding fluid environmental uncertainties. Finally, self-reported surveys carry inherent risks of common method variance. Future research should incorporate multi-source data, triangulating perceptual responses with objective performance metrics from the Ministry of Agriculture, and deploy longitudinal designs across multiple provinces.

In conclusion, this study demonstrates that Transformational Leadership (β = 0.458, p < 0.001) and System Integrity (β = 0.392, p < 0.001) are the primary drivers of accountability in the SIKOMANDAN program, with the model explaining a substantial 76.4% of variance (R^2 = 0.764). In contrast, the Internal Control System shows no significant direct effect (β = -0.017, p = 0.814), indicating that formal control mechanisms alone may be insufficient in dynamic livestock governance contexts. Organizational Commitment emerges as a strong independent predictor (β = 0.512, p < 0.001), while Environmental Uncertainty does not directly affect accountability but exhibits a borderline negative moderating tendency on internal controls (β = -0.135, p = 0.058).

These findings highlight the importance of adaptive governance, where leadership capacity and system integrity

play a more decisive role than rigid procedural compliance. Policymakers may also consider adapting standard operating procedures to incorporate flexible protocols that remain responsive during localized ecological disruptions and infectious disease outbreaks, alongside continued investment leadership development among extension workers. Despite these contributions, this study is limited by its cross-sectional design, reliance on self-reported perceptions, and geographically restricted sample in Subang District. Therefore, future research should employ longitudinal methods, incorporate multi-source data, and expand to a multi-regional scale to validate and refine these adaptive governance models across diverse agro-ecological zones.

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