Reviu Akuntansi, Manajemen, dan Bisnis (RAMBIS)
ISSN: 2797-958X, Vol 6, No 3, 2026, 1-16 https://doi.org/10.35912/rambis.v6.n3.p1-16.2026

The Effect of Environmental and Bio-Accounting on Food System Resilience with Sustainable Business Moderating Variable

Ade Manggala Hardianto[1], Eka Ananta Sidharta[2], Yuli Novitasari[3*], Liyanita Dewi Kurnia[4], Muhamad Zaky Antovi[5], Rossa Lita[6], Zahra Annisa Putri[7]
Universitas Sains Indonesia, Jawa Barat, Indonesia[1,3,4,5,6,7]
Universitas Negeri Malang, Jawa Timur, Indonesia[2]
ade.manggala@lecturer.sains.ac.id[1], eka.ananta.fe@um.ac.id[2], yuli.novitasari@lecturer.ac.id[3*], liyanitadewi.kurnia@lecturer.sains.ac.id[4], zackyantovi@gmail.com[5], rossalitta2@gmail.com[6], zahrannisa1706@gmail.com[7]

Article History
Received on 06 April 2026
1st Revision on 21 April 2026
2nd Revision on 13 July 2026
3rd Revision on 24 July 2026
Accepted on 27 July 2026

Abstract
Purpose: This study examines how environmental and bio-accounting strengthen livestock governance to enhance food system resilience and sustainable practices.
Research Methodology: This study employs a mixed-methods design combining quantitative analysis and qualitative case studies in Kabupaten Bekasi, Indonesia, a strategic livestock production area facing environmental and governance challenges. Environmental accounting integrates environmental costs and performance indicators into decision-making, while bio-accounting evaluates biological assets based on ecological contributions and impacts.
Results: The findings demonstrate that integrating environmental and bio-accounting improves transparency, accountability, and sustainability-oriented management. These mechanisms enhance resource efficiency, support informed decisions, and strengthen livestock-based food system resilience.
Conclusions: This study confirms that environmental and bio-accounting integration strengthens governance capacity and promotes adaptive management aligned with sustainable principles and long-term value creation.
Limitations: This study focuses on a single regional case, limiting generalizability. Future research should expand regional coverage and apply longitudinal approaches.
Contributions: This study contributes to sustainability accounting literature and provides practical insights for policymakers and managers implementing ESG-oriented livestock governance strategies.

Keywords: *Bio-Accounting, Environmental Accounting, Food System Resilience, Livestock Governance, Sustainable Business Practices*

How to Cite: Hardianto, A. M., Sidharta, E. A., Novitasari, Y., Kurnia, L. D., Antovi, M. Z., Lita, R., & Putri, Z. A. (2026). The Effect of Environmental and Bio-Accounting on Food System Resilience with Sustainable Business Moderating Variable. *Reviu Akuntansi, Manajemen, dan Bisnis*, 6(3), 1-16.

1. Introduction

The growing demand for livestock products has intensified environmental pressures and exposed weaknesses in livestock governance, raising serious concerns regarding long-term sustainability and food system resilience. Global population growth, urbanization, and shifting dietary preferences have increased the consumption of meat, dairy, and other animal-based products, placing substantial strain on natural resources and governance systems (Singh, Jaishree, & Mohamed, 2025; Williams, 2025). This demand has far-reaching implications for environmental systems and the socioeconomic structures that underpin livestock production. As livestock production expands, environmental costs, such as deforestation, greenhouse gas emissions, and water depletion, become increasingly pronounced, threatening biodiversity and undermining the ecosystems on which livestock farming depends (Su, Chang, & Jingjing, 2024; Young, & Melody, 2023). Despite these challenges, livestock governance frameworks continue to prioritize productivity and economic efficiency, while environmental externalities and biological asset dynamics receive limited attention in managerial decision-making. This imbalance weakens the capacity of governance systems to respond to sustainability risks effectively. Environmental degradation, declining soil quality, and inefficient resource use ultimately reduce agricultural productivity and increase long-term operational risk (Ogoudou, Christine, & Ibrahim, 2025). Moreover, a short-term profit orientation often discourages livestock producers from adopting sustainable practices, further compromising the future viability of livestock-based businesses (Osemene, & Johnson, 2024; Du, 2018)

Against this background, this study examines how environmental accounting and bio-accounting can function as governance mechanisms to strengthen livestock governance and support food-system resilience and sustainable business practices. Environmental accounting integrates environmental costs and performance indicators into organizational decision-making, enabling firms to assess ecological consequences alongside financial outcomes (Mook, 2007; Sundarasen, Sheela, & Ahnaf, 2024). Prior studies show that environmental accounting improves accountability, enhances sustainability disclosure, and supports strategic decision-making across sectors (Barroso-Méndez, & Dolores, 2024; Tweedie, 2024; Xia, Liu, & Arman, 2025). Building on this approach, bio-accounting values biological assets in relation to their ecological functions and impacts. Rather than treating livestock solely as economic units, bio-accounting recognises their role within broader ecological systems, including ecosystem regeneration and carbon dynamics (Farfan-Lievano, Angelica, & Eutimio, 2024). This perspective aligns accounting practices with ecological realities and encourages livestock producers to integrate profitability with environmental stewardship, particularly in biologically intensive production systems that are labor-intensive.

To investigate these dynamics, this study adopts a mixed-methods research design that combines quantitative and qualitative case studies. The quantitative component examines the adoption and perceived effectiveness of environmental accounting and bio-accounting practices, drawing insights from environmental management accounting and sustainability-oriented decision-making research (Almasyhari, & Basrowi, 2025; Nair, Sudhashini, & Neeta, 2022; Portillo-Tarragona, Pilar, & Sabina, 2025). Meanwhile, qualitative case studies provide contextual insights into how these accounting practices operate within specific livestock governance settings, addressing institutional gaps and coordination challenges (Eitrem, Anna, & Sven, 2024; Ogoudou et al., 2025)

This study makes a novel contribution by reconceptualizing environmental and bio-accounting as integrated governance instruments, rather than merely technical measurement tools. By positioning accounting within governance structures, this study demonstrates how accounting practices shape strategic decision-making, enhance accountability, and strengthen resilience in livestock-based business systems. This governance-oriented perspective advances social and environmental accounting research by emphasizing the institutional and strategic role of accounting in sustainability transitions (Eitrem et al., 2024; Farfan-Lievano et al., 2024). Furthermore, integrating environmental and bio-accounting into livestock governance improves transparency and strategic sustainability management. Enhanced disclosure and accountability facilitate stakeholder engagement, support efficient resource use, and strengthen the resilience of livestock-based food systems (Barroso-Méndez and Dolores, 2024; Cisneros-Vidales, & Alexander, 2025; Liang, Xinyuan, & Yinkang, 2025).

Resilient food systems are better equipped to absorb environmental, economic, and climate-related shocks, ensuring continuity in food provision and business operations (Muriithi, Cyrus, & Caroline, 2026; Wang, Jingyi, & Xuebiao, 2026). Overall, this study contributes to the business and accounting literature by bridging the governance, sustainability, and accounting perspectives. It also provides practical insights for policymakers, managers, and industry stakeholders seeking to align livestock governance with sustainability and ESG-oriented strategies. By strengthening governance through environmental accounting and bio-accounting, the livestock sector can move towards more resilient, accountable, and sustainable production systems

2. Literature Review and Hypotheses Development

2.1 Livestock Governance

The livestock sector is a crucial component of global food systems, playing a vital role in food security, livelihood support and economic advancement. A substantial body of literature acknowledges that livestock production significantly contributes to nutritional security and income generation in rural areas worldwide. Nevertheless, recent research increasingly highlights that livestock systems also produce considerable environmental externalities, such as greenhouse gas emissions, deforestation, land degradation, and biodiversity loss (Singh, & Udharwar, 2025; Young, & Melody, 2023). These environmental challenges have heightened concerns regarding the long-term sustainability and resilience of food systems, especially in the context of climate change and resource scarcity (Liang, Xinyuan, & Yinkang, 2025; Musa, 2025). Although the environmental impacts of livestock production are thoroughly documented, much of the current literature is descriptive and sector-specific, often examining emissions or land-use changes in isolation. Governance frameworks that effectively incorporate environmental impacts into organisational and policy decision-making are still remain insufficiently examined, particularly in developing and emerging economies (Ogoudou, Christine, & Ibrahim, 2025; Williams, 2025)

The adoption of environmental and bio-accounting practices can be explained theoretically using institutional theory. Institutional theory posits that organizational behavior is shaped by regulatory pressures, normative expectations, and societal values (Eitrem, Anna, & Sven, 2024). In the livestock sector, increasing regulatory scrutiny, stakeholder activism, and consumer awareness have intensified pressures for transparency and environmental accountability (Osemene, & Johnson, 2024; Saeed, & Ishmael, 2024). Sustainability accounting complements this perspective by emphasizing the integrated reporting of Environmental, Social, And Governance (ESG) performance (Barroso-Méndez & Dolores, 2024). Meta-analytic and meta-synthesis studies indicate that sustainability disclosure is positively associated with corporate reputation and stakeholder trust (Barroso-Méndez and Dolores, 2024; Sundarasen, Sheela, & Ahnaf, 2024). However, critics argue that sustainability accounting often prioritizes disclosure over substantive behavioral change, particularly in sectors characterized by complex ecological interactions, such as livestock production. Recent literature increasingly links environmental and bio-accounting with circular economy principles and food system resilience. Environmental management accounting supports circular eco-innovation by enabling accountability for resource efficiency, waste reduction, and nutrient recycling (Portillo-Tarragona, Pilar, & Sabina, 2025). In livestock systems, practices such as the reuse of manure and valorization of by-products are frequently cited as pathways towards circularity and economic viability. These technological innovations further enhance accounting practices. Digitalization, precision livestock farming, and digital twins improve environmental d32ata collection and system optimization (Mallinger, Kevin, & Warren, 2022; Ogoudou et al., 2025). Recent studies have also indicated that technological and energy transitions contribute to food system resilience, particularly when combined with institutional support and governance capacity (Liang et al., 2025).

2.2 Environmental Accounting

Environmental accounting has emerged as a significant mechanism for integrating environmental considerations into business operations and their strategies. It allows organizations to identify, quantify, and communicate the environmental costs and impacts linked to production activities (Sundarasen, Sheela, & Ahnaf, 2024). In industries related to livestock, environmental accounting has proven beneficial in facilitating more informed managerial decisions by quantifying emissions,

resource use, and environmental inefficiencies (Farfan-Lievano, Angelica, & Eutimio, 2024; Su, Chang, & Jingjing, 2024). Empirical evidence indicates that the adoption of environmental accounting improves both environmental and financial performance. Research in manufacturing and resource-intensive sectors shows that environmental management accounting plays a mediating role in the relationship between environmental innovation and organizational performance (Iqbal, Naveed, & Rai, 2020; Xia, Liu, & Arman, 2025). Likewise, Nair, Sudhashini, and Neeta (2022) report that firms in Malaysia that implement environmental management accounting experience enhanced environmental outcomes and improved financial performance. However, the livestock sector remains underrepresented in empirical studies, limiting the broader applicability of the findings. Despite its potential benefits, environmental accounting faces considerable challenges in its implementation. The lack of standardized frameworks has led to inconsistent reporting practices and reduced comparability among organizations (Tweedie, 2024).

H_1: The adoption of environmental accounting has a positive effect on food system resilience

2.3 Bio-Accounting

Hardianto et al. (2026) stated that bio-accounting extends by incorporating biological and ecological dimensions into accounting systems. Mook (2007) conceptualizes bio-accounting as an approach that recognizes ecological assets, ecosystem services, and biological interdependencies that are typically excluded from conventional accounting frameworks. Farfan-Lievano et al. (2024) further argue that bio-accounting enables a more accurate valuation of environmental assets, thereby strengthening sustainability-oriented decision making. Within livestock systems, bio-accounting facilitates holistic assessments of feed production, land and water use, and the health of ecosystems. Such integration is particularly relevant, given the strong interdependencies between livestock production, biodiversity, and ecosystem services (Young et al. 2023). However, empirical applications of bio-accounting remain limited, with most studies focusing on conceptual development rather than operational implementation. This gap raises questions concerning data availability, measurement reliability, and the institutional capacity to support bio-accounting practices.

H_2: The adoption of bio-accounting has a positive effect on food system resilience

2.4 Business Sustainability

The concept of perceived business sustainability has gained substantial attention in sustainability accounting and governance literature as a key organizational factor that influences how sustainability-related information is interpreted and applied in managerial decision-making. Rather than reflecting objective performance metrics alone, perceived business sustainability represents managers' and stakeholders' assessments of a firm's long-term economic viability, its environmental accountability, and its social legitimacy. These perceptions shape strategic priorities and determine whether sustainability-oriented practices are substantively integrated into organizational operations or treated primarily as symbolic compliance mechanisms.

From an institutional theory perspective, organizational responses to innovation in environmental and accounting practices are shaped by normative expectations, shared beliefs, and cognitive frameworks (Eitrem et al. 2024). In the livestock sector, where governance arrangements are often fragmented and regulatory enforcement remains uneven, the effectiveness of environmental and bio-accounting practices depends not only on their formal adoption but also on the perceived importance of sustainability within the organization. When sustainability is regarded as essential for business continuity and competitive advantage, accounting information related to environmental costs and biological assets is more likely to inform both strategic and operational decision-making. However, prior studies have also demonstrated that when sustainability is perceived as a peripheral concern, environmental accounting often becomes a reporting exercise with limited influence on managerial behavior (Du Rietz 2018). This indicates that perceived business sustainability affects the extent to which environmental accounting contributes to sustainable business performance.

H_3: The business sustainability has a positive effect on food system resilience

2.5 Moderating variabel

The literature also links perceived business sustainability to the resilience of food systems. Organizations that view sustainability as a strategic asset tend to adopt adaptive strategies, improve resource efficiency, and strengthen coordination across supply chains, which are key components of resilient food systems (Cisneros-Vidales et al., 2025; Liang et al., 2025). In livestock systems, such perceptions enhance the capacity of environmental and bio-accounting to support resilience by enabling proactive responses to environmental shocks, climate risks and resource constraints (Ogoudou et al., 2025; Young et al., 2023). Conversely, weak sustainability perceptions may hinder the effective translation of accounting information into resilience-enhancing practices, even when accounting systems are formally implemented.

In emerging economies such as Indonesia, perceived business sustainability plays a crucial role because of institutional gaps and governance challenges. Previous studies have shown that in such settings, managerial perceptions and strategic orientations often substitute for strong regulatory pressure in driving sustainability initiatives (Osemene et al. 2024; Saeed et al. 2024). Consequently, perceived business sustainability shapes how environmental and bio-accounting are embedded within livestock governance structures and influences their effectiveness in promoting sustainable business practices and strengthening food system resilience.

H_4: business sustainability moderates Environmental Accounting when unpredictable weather

H_5: business sustainability moderates Bio Accounting when unpredictable weather

3. Research Methodology

3.1 Population And Sample

The target population of this study comprised key stakeholders involved in livestock governance, including livestock farmers, agribusiness managers, policymakers, and representatives of environmental and sustainability-oriented organizations. The empirical context of this study is Bekasi Regency, Indonesia, a strategically important livestock production area characterized by environmental vulnerability and governance challenges. This regional focus is particularly relevant, given previous evidence that livestock governance in developing economies is shaped by institutional deficiencies and coordination constraints (Ogoudou et al., 2025; Williams, 2025). The study includes both rural and peri-urban livestock systems to capture variations in production scale, governance structures, and sustainability practices, as recommended in research on livestock systems and ecological governance (Young et al., 2023). The units of analysis consisted of individual livestock producers, producer cooperatives, and corporate entities engaged in livestock production and processing.

To ensure adequate representation across different operational scales, a stratified sampling technique was employed, covering smallholder farms, medium-sized enterprises, and large agribusiness firms. Respondents were selected based on three parallel criteria, such as active participation in livestock production or governance, involvement in environmental or sustainability initiatives, and demonstrated knowledge of environmental accounting, environmental management accounting, or bio-accounting practices. The targeted sample size of approximately 150 respondents is considered sufficient for conducting multivariate statistical analyses and comparative assessments across stakeholder groups, consistent with prior empirical studies in environmental accounting and sustainability management (Nair, Ahamad, and Jayabalan 2022; Xia et al. 2025).

3.2 Data Collection

This research utilized a mixed-methods approach to data collection to obtain both quantitative and qualitative insights related to livestock governance, environmental accounting, bio-accounting, and food system resilience. The adoption of a mixed-methods design aimed to integrate quantifiable relationships with the contextual dynamics of governance, thereby enriching the analytical framework and enhancing methodological robustness (Eitrem et al., 2024). This integrated approach is

particularly relevant because food system resilience needs to be examined at both the individual-actor and system levels to capture the interactions among governance, environmental integrity, and socioeconomic outcomes (Béné et al., 2023).

Quantitative data were collected using structured questionnaires distributed to stakeholders involved in livestock production and governance. The survey instrument was designed to capture information on the adoption and implementation of environmental accounting, environmental management accounting, and bio-accounting practices. Specifically, the questionnaire addressed environmental cost identification, sustainability reporting, regulatory compliance, and perceived impacts on business performance and food system resilience. The inclusion of bio-accounting indicators was intended to make animals and their welfare more visible within sustainability measurement and organizational accountability (Vinnari & Vinnari, 2022). The survey design was informed by established research in environmental accounting and sustainability management (Nair et al., 2022; Sundarasen et al., 2024).

To complement the quantitative findings, qualitative data were collected through semi-structured interviews with a purposively selected group of respondents with relevant expertise in livestock governance, environmental management, accounting practices, or policy implementation. These interviews explored the motivations for adopting sustainability-oriented accounting practices, perceived implementation challenges, and the role of these practices in promoting sustainable business operations and strengthening food system resilience (Ogoudou et al., 2025). This qualitative component was also consistent with recent livestock sustainability research emphasizing the importance of governance, stakeholder inclusion, environmental performance, and socioeconomic resilience in developing sustainable livestock farming systems (Bilotto et al., 2024). In addition, the use of secondary sources supported analytical validation and aligned with methodological recommendations in sustainability accounting and governance research (Barroso-Méndez et al., 2024; Tweedie, 2024).

3.3 Data Cleaning

Before proceeding with the analysis, the quantitative data underwent systematic data cleaning to ensure accuracy, consistency, and reliability. First, all the survey responses were assessed for completeness. Questionnaires with substantial missing data were excluded from the analysis, while responses with minor missing values were treated using appropriate statistical techniques to minimize potential bias (Nair et al. 2022). Next, the dataset was examined for outliers and inconsistent responses that could bias the results of the multivariate statistical analyses. Extreme values were identified and carefully evaluated, and when necessary, outliers were removed to enhance the robustness of the findings, in accordance with established practices in environmental accounting research (Xia et al. 2025).

The data were then reviewed for data entry errors, scale consistency and multicollinearity. Variable coding was checked to ensure that higher scores consistently represented higher levels of environmental accounting adoption, bio-accounting, business performance, and food system resilience. These procedures are consistent with the methodological approaches applied in sustainability accounting and governance studies (Portillo-Tarragona et al. 2025). Finally, reliability and validity tests were conducted to ascertain the adequacy of the measurement instruments before hypothesis testing. Only data that met acceptable reliability and validity thresholds were included in subsequent analyses, thereby ensuring the credibility and rigor of the empirical results (Sundarasen et al. 2024)

3.4 Measurement of Variables

This study operationalizes its core constructs using perceptual measures that are widely applied in sustainability accounting and governance research. All variables were measured using multi-item indicators assessed on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). This approach enables the systematic capture of respondents' perceptions regarding the adoption of accounting practices, business outcomes and food system resilience. Environmental accounting was measured by examining the extent to which livestock organizations identify, measure,

and utilize environmental cost information in managerial and operational decision-making. These indicators reflect practices related to environmental cost identification and allocation, the use of environmental performance indicators, sustainability reporting, and compliance with environmental regulations. This measurement approach is consistent with prior empirical studies demonstrating that environmental accounting enhances transparency, accountability, and sustainability-oriented decision-making in resource-intensive sectors (Nair et al. 2022; Sundarasen et al. 2024)

Bio-accounting is operationalized to capture the degree to which organizations incorporate biological assets, ecological functions and ecosystem-related information into their accounting and governance systems. The measurement focuses on the recognition of biological assets, consideration of land and water use, assessment of biodiversity impacts, and integration of ecological information into strategic and operational decisions. This framework aligns with conceptual and empirical research emphasising the role of bio-accounting in providing a more comprehensive representation of value creation in environmentally intensive sectors, including livestock production ((Farfan-Lievano et al. 2024; Mook 2007; Young et al. 2023)

Perceived business sustainability is measured as a moderating construct that reflects managerial perceptions of sustainability as a strategic business priority. These indicators assess beliefs regarding the importance of sustainability for long-term business viability, competitive advantage, and organizational legitimacy. This perceptual approach is supported by institutional and sustainability accounting literature, which highlights that internal sustainability perceptions strongly influence how accounting information is interpreted and translated into governance practices (Eitrem et al. 2024; Du Rietz, 2018).

Business performance is measured using both financial and non-financial indicators to provide a comprehensive assessment of organizational outcomes. The indicators included perceived profitability, revenue growth, cost efficiency, organizational reputation, stakeholder trust, and market competitiveness. The use of self-reported performance measures is well established in environmental accounting and sustainability management research, particularly in contexts where objective financial data are limited or difficult to access (Barroso-Méndez et al. 2024; Nair et al. 2022).

Food system resilience is operationalized to reflect the capacity of livestock systems to anticipate, absorb, adapt to, and recover from environmental, economic, and governance-related disruptions. The indicators capture the adaptive capacity, production diversity, supply chain robustness, and degree of collaboration among stakeholders within the livestock food system. This operationalisation is grounded in the food system resilience and sustainable livestock governance literature, which conceptualises resilience as a multidimensional outcome shaped by governance quality and sustainability-oriented practices (Liang et al. 2025; Ogoudou et al. 2025; Young et al. 2023)

4. Results and Discussions

Figure 1 presents the outer (measurement) model, which depicts the relationships between each latent construct Bio-Accounting, Accounting Environment, Business Sustainability, Food System Resilience, and the Moderating Effect and its respective observed indicators. The outer loadings shown in this model form the basis for assessing the reliability and validity of the measurement instruments, the results of which are reported in Table 1 and Table 2 below.

4.1 Measurement Model Assessment: A Comprehensive Reliability Analysis

Table 1. Measurement model assessment

Konstruk	Cronbach Alpha	Composite Reliability	Indicator
Bio-Accounting	0.748	0.842	Reliabel
Food System Resilience	0.787	0.843	Reliabel
Accounting Environment	0.740	0.836	Reliabel

Konstruk	Cronbach Alpha	Composite Reliability	Indicator
Business Sustainability	0.706	0.819	Reliabel
Moderating Effect	1.000	1.000	Interaksi (single indicator)

Assessing the reliability of the measurement model is a critical step in validating the constructs being investigated. Reliability analysis ensures that the indicators used to operationalize theoretical concepts demonstrate internal consistency and stability. In this study, reliability was evaluated using Cronbach's Alpha and Composite Reliability (CR). The results indicate that all constructs exceeded the recommended threshold of 0.70, with Cronbach's alpha values ranging from 0.706 to 0.787 and Composite Reliability values ranging from 0.819 to 0.843, as illustrated in the outer model and summarized in Table 1. These findings confirm satisfactory internal consistency and support the robustness of the measurement models.

The Bio-Accounting construct reported a Cronbach alpha of 0.748 and a Composite Reliability of 0.842, indicating good reliability. This result is particularly important given the expanding discourse on environmental and bio-accounting measurements. Recent literature emphasizes the need for consistent and structured indicators capable of capturing ecological assets and extended value creation (Farfan-Lievano et al. 2024; Mook, 2007). As environmental accounting evolves beyond traditional financial metrics toward ecological valuation, the stability of the measurement becomes increasingly essential. Su et al. (2024) further argued that reliable environmental measurement frameworks are necessary for accurately assessing ecological impacts. Therefore, the reliability of the Bio-Accounting construct reflects not only statistical adequacy but also conceptual alignment with contemporary developments in environmental accounting.

The Food System Resilience construct demonstrated strong internal consistency, with a Cronbach alpha of 0.787 and a Composite Reliability of 0.843. This finding is highly relevant to current resilience research, which recognizes food systems as multidimensional structures encompassing adaptability, governance, supplydemand integration, and climate responsiveness. Cisneros-Vidales et al. (2025) and Liang et al. (2025) showed that resilience measurements must account for both systemic stability and adaptive capacity. Reliability values above 0.78 suggest that the selected indicators effectively captured these interconnected dimensions. Consequently, this construct provides a stable empirical basis for examining resilience within complex and uncertain environmental contexts.

The Accounting Environment construct yielded a Cronbach alpha of 0.740 and a Composite Reliability of 0.836, confirming acceptable reliability. From an institutional perspective, environmental accounting practices are shaped by regulatory, normative and governance pressures (Eitrem et al. 2024). Osemene et al. (2024) further demonstrated that corporate governance mechanisms influence the quality of environmental accounting reporting. Therefore, a reliable measurement of the accounting environment is essential, as it reflects the institutional structures that facilitate environmental accountability. The results indicate that this construct is measured consistently and aligns with the institutional theory and environmental management accounting literature.

The Business Sustainability construct reported a Cronbach alpha of 0.706 and a Composite Reliability of 0.819. Although these values were slightly lower than those of the other constructs, they remained above the acceptable threshold. Sustainability measurement typically integrates heterogeneous dimensions economic, social, and environmental which can result in moderate internal consistency across studies. Barroso-Méndez et al. (2024) and Sundarasen et al. (2024) highlight the complexity of sustainability as a multidimensional construct, often leading to variability in reliability outcomes. Within this context, the reliability values obtained are satisfactory and support the inclusion of Business Sustainability as a stable construct in the model.

The Moderating Effect construct showed a reliability value of 1.000. This outcome was expected because the moderating variable was modeled using a product indicator approach in PLS-SEM. Interaction constructs generated through product indicators typically produce perfect reliability values because of their composite structure. Similar methodological approaches have been reported in studies examining the moderating role of technological innovation in environmental accounting (Saeed et al. 2024; Wang et al. 2026). Thus, the results reflect the statistical characteristics of the modeling technique rather than a measurement anomaly.

Overall, the measurement model demonstrated adequate internal consistency across all constructs. These findings provide empirical justification for proceeding to further validity assessments, including convergent validity (Average Variance Extracted) and discriminant validity testing. Moreover, the reliability results strengthen the theoretical integration of environmental management accounting, institutional theory, and food system resilience in the proposed research framework. The consistency observed in each construct supports both the statistical soundness of the model and the conceptual relevance of the theoretical foundations of this study.

4.2 Discriminant Validity Assessment Using the Fornell–Larcker Criterion

Table 2. Discriminant validity assessment (Fornell–Larcker criterion)

Construct	Bio-Accounting	Food System Resilience	Moderating Effect 1	Moderating Effect 2	Accounting Environment	Business Sustainability
Bio-Accounting	0.757					
Food System Resilience	0.552	0.636				
Moderating Effect 1	-0.460	-0.515	1.000			
Moderating Effect 2	-0.474	-0.556	0.899	1.000		
Accounting Environment	0.419	0.581	-0.465	-0.535	0.740	
Business Sustainability	0.383	0.629	-0.437	-0.518	0.456	0.730

The empirical results, presented in Table 2, indicate that all the constructs satisfy this requirement. Bio-Accounting reports a square root of AVE of 0.757, exceeding its correlations with Food System Resilience (0.552), Accounting Environment (0.419), and Business Sustainability (0.383). This finding confirms that bio-accounting captures a unique conceptual dimension. Theoretically, this aligns with prior research positioning bio-accounting as an extension of environmental accounting that moves beyond conventional disclosure practices toward ecological asset valuation and expanded accountability (Farfan-Lievano et al. 2024; Mook 2007; Su et al. 2024). Contemporary debates suggest that environmental accounting not only measures reality but may also shape institutional perceptions of sustainability performance (Du Rietz 2018; Tweedie 2024). Therefore, the moderate correlations observed reflect conceptual complementarity rather than redundancy.

Food System Resilience also demonstrated satisfactory discriminant validity, with a square root of AVE of 0.636, exceeding its correlations with bio-accounting (0.552) and Business Sustainability (0.629). Although the association with sustainability was relatively strong, it remained below the AVE threshold, confirming construct distinctiveness. This result is theoretically consistent. Resilience emphasizes adaptability, systemic recovery capacity, and shock absorption within food systems (Cisneros-Vidales et al., 2025; Liang et al., 2025; Muriithi et al., 2026), whereas sustainability encompasses broader environmental, social, and economic performance outcomes (Barroso-Méndez et al., 2024; Sundarasen et al., 2024). Studies on livestock governance and environmental transitions further highlight that resilience and sustainability, while interrelated, operate through different institutional and ecological mechanisms (Williams 2015; Young et al. 2023). Thus, the empirical separation between these constructs is justified both statistically and theoretically.

The Accounting Environment construct also satisfies the Fornell–Larcker criterion, as the square root of its AVE exceeds its correlations with other constructs. The positive associations between

Bio-Accounting and Food System Resilience indicate institutional interconnections rather than measurement overlap. Institutional theory explains that environmental accounting practices are shaped by governance structures, regulatory pressures, and normative expectations (Eitrem et al., 2024; Ogoudou et al., 2025; Osemene et al., 2024). Empirical evidence further demonstrates that environmental management accounting adoption is influenced by strategic orientation and organizational context (Chaudhry et al. 2020; Nair et al. 2022). Therefore, the Accounting Environment functions as a contextual driver while remaining conceptually distinct from operational accounting practices and resilience outcomes.

The Moderating Effect construct presents a diagonal value of 1.000, which is expected, given its specification through a product-indicator approach in PLS-SEM. Interaction constructs commonly yield perfect or near-perfect AVE values because of their multiplicative composite structure. The negative correlations observed between the moderating term and several constructs reflect statistical interaction properties rather than conceptual inconsistencies. Similar moderation dynamics have been documented in studies examining technological innovation, bio-accounting, and environmental accounting disclosures (Hardianto et al. 2026; Saeed et al. 2024; Wang et al. 2026). These findings further validate the modeling approach used in this study.

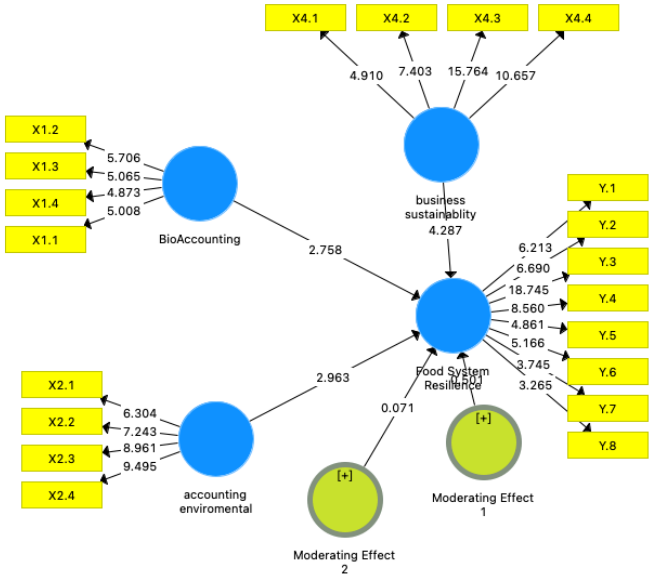

Figure 2. Inner Model

Figure 2 displays the inner (structural) model, which shows the path coefficients (β) linking Bio-Accounting, the Accounting Environment, and Business Sustainability to Food System Resilience, together with the two Moderating Effect paths. This structural model forms the basis for the hypothesis testing results summarized in Table 3 and discussed below. The structural model results provide important insights into the relationships among Bio-Accounting, the Accounting Environment, Business Sustainability, and Food System Resilience. The analysis identified several statistically significant direct effects, whereas the moderating effects were not supported.

Table 3. Path coefficients and hypothesis testing

Hypothesis	Path Relationship	β (Original Sample)	t-value	p-value	Result
H_1	Bio-Accounting → Food System Resilience	0.250	2.679	0.008	Supported

Hypothesis	Path Relationship	β (Original Sample)	t-value	p-value	Result
H_2	Accounting Environment → Food System Resilience	0.252	2.529	0.012	Supported
H_3	Business Sustainability → Food System Resilience	0.361	4.544	0.000	Supported
H_4	Moderating Effect 1 → Food System Resilience	-0.045	0.517	0.606	Not Supported
H_5	Moderating Effect 2 → Food System Resilience	-0.006	0.077	0.939	Not Supported

Bio-accounting has a positive and significant effect on Food System Resilience ($\beta = 0.250$; $t = 2.679$; $p = 0.008$). This finding confirms that enhanced bio-accounting practices strengthen the systemic resilience of food systems. This result aligns with Farfan-Lievano et al. (2024), who conceptualized bio-accounting as extending environmental accounting beyond disclosure towards ecological asset valuation and measurable environmental performance. Mook (2007) highlights the expanded value-added dimension of social and environmental accounting for capturing broader ecological contributions. Empirical evidence from Su et al. (2024) further demonstrates that advanced environmental accounting measurements improve resource allocation efficiency and ecological outcomes. From a resilience perspective, structured environmental measurements enhance the adaptive capacity and responsiveness to shocks within food systems (Cisneros-Vidales et al., 2025; Liang et al., 2025). Therefore, bio-accounting operates not only as a reporting mechanism but also as a strategic instrument that enables resilience.

The Accounting Environment also had a positive and significant effect on Food System Resilience ($\beta = 0.252$; $t = 2.529$; $p = 0.012$). This finding underscores the importance of institutional, regulatory, and governance contexts in shaping the resilience outcomes. Institutional theory explains that environmental accounting practices are embedded in regulatory frameworks and normative pressures (Eitrem et al., 2024). Corporate governance structures and environmental reporting systems reinforce accountability mechanisms that indirectly strengthen adaptive capacity (Osemene et al., 2024). In addition, the adoption of environmental management accounting is influenced by the organizational context and strategic orientation (Iqbal et al., 2020; Nair et al., 2022). Studies on food and livestock systems further demonstrate that governance coordination and institutional design are central to resilience-building processes (Ogoudou et al., 2025; Young et al., 2023). These findings confirm that resilience is institutionally conditioned, rather than purely operational.

Business Sustainability exerts the strongest positive effect on Food System Resilience ($\beta = 0.361$; $t = 4.544$; $p = 0.000$). This indicates that organizations with stronger sustainability performance are better positioned to maintain stability and adaptability in food systems. This result is consistent with meta-analytic evidence showing that sustainability disclosure enhances reputational strength and long-term organizational performance (Barroso-Méndez et al. 2024). The integration of environmental accounting with sustainability practices has been shown to improve ESG performance and carbon management outcomes (Sundarasen et al., 2024; Xia et al. 2025).

However, the moderating effects were not statistically significant. Moderating Effect 1 → Food System Resilience ($\beta = -0.045$; $p = 0.606$) and Moderating Effect 2 → Food System Resilience ($\beta = -0.006$; $p = 0.939$) were not significant. These results suggest that the interaction terms neither strengthen nor weaken the primary relationships meaningfully. Although previous studies have documented the significant moderating roles of technological innovation and bio-accounting in environmental accounting contexts (Hardianto et al. 2026; Saeed et al. 2024; Wang et al., 2026), The findings indicate that resilience in this model is primarily driven by direct structural and institutional effects rather than contingent interaction mechanisms.

4.3 Discussion

Bio-accounting plays a significant role in strengthening food systems' resilience amid growing pressures from climate change, population growth, and resource scarcity. Food system resilience refers to the ability of food systems to anticipate, absorb, adapt to, and recover from shocks while maintaining food security and sustainability (Cisneros-Vidales et al., 2025). By integrating biological and environmental data into accounting systems, bio-accounting moves beyond traditional financial reporting and incorporates the measurement of natural capital, ecosystem services, and biodiversity (Farfan-Lievano et al. 2024; Mook 2007). This integration enables organizations to better understand the long-term ecological consequences of their operational decisions, thereby supporting more sustainable and resilient food production systems. Bio-accounting supports regulatory compliance and strategic decision making. Increasing global sustainability regulations require organizations to disclose their environmental impacts and adopt greener production practices (Osemene et al. 2024; Williams 2025). By embedding ecological data into corporate strategies, firms are better prepared to respond to regulatory and external uncertainties. Institutional pressures further encourage the adoption of advanced environmental accounting practices, thereby strengthening organizational legitimacy and resilience (Eitrem et al. 2024).

Food system resilience has become increasingly important in addressing the challenges of climate change, economic instability, and global health crises. Resilience refers to the ability of food systems to withstand shocks while maintaining essential functions, such as production, distribution, and consumption (Cisneros-Vidales et al., 2025). In this context, the accounting environment plays a crucial role in strengthening resilience by promoting transparency, accountability and sustainability. A robust accounting framework enables stakeholders to assess risks, allocate resources efficiently, and make informed decisions that support long-term food security. The accounting environment encompasses financial reporting standards, environmental accounting practices, and governance mechanisms that shape organizational behavior. Integrating environmental accounting into corporate decision-making not only improves sustainability performance but also enhances social responsibility (Almasyhari et al., 2025). In the food sector, where environmental impacts are substantial, sustainability disclosure strengthens corporate reputation and stakeholder trust (Barroso-Méndez et al. 2024). These elements are essential for resilience because transparency and credibility enhance market stability and reinforce consumer trust.

Environmental accounting, as a central component of the accounting environment, enhances food system resilience by identifying and quantifying environmental costs and risks. Environmental management accounting practices enhance resource efficiency, reduce waste, and generate cost savings (Iqbal Chaudhry et al., 2020). Tools such as life cycle assessment enable food producers to evaluate the environmental impacts across the value chain and adopt more sustainable production methods. Investing in renewable energy and sustainable technologies fosters long-term stability by reducing environmental vulnerability and strengthening adaptive capacity (Wang et al., 2026). Strategic decision-making is more effective when environmental considerations are embedded in accounting systems. Firms that align their financial objectives with environmental responsibility are better positioned to respond to climate uncertainty and market volatility.

Business sustainability has become a central framework for organizations seeking long-term viability in an era marked by climate change, resource scarcity and economic volatility. Within food systems, sustainability is particularly critical because these systems directly influence food resilience, environmental quality, and socioeconomic stability. Global projections indicate that food production must increase substantially to meet the demands of a growing population, thereby intensifying the pressure on natural resources.

5. Conclusions

5.1 Conclusion

This study demonstrates that environmental and bio-accounting function not only as technical measurement tools but also as governance instruments that strengthen food system resilience within livestock systems. The empirical findings confirm that bio-accounting positively influences food

system resilience, indicating that integrating biological asset valuation and ecological information into accounting systems enhances adaptive capacity, resource efficiency, and long-term sustainability. Likewise, the accounting environment representing institutional, regulatory, and governance structures significantly contributes to resilience outcomes, highlighting that resilience is shaped not only by operational practices but also by broader institutional arrangements. Business sustainability emerged as the strongest predictor of food system resilience, suggesting that organizations with a strategic sustainability orientation are better equipped to anticipate, absorb, and respond to environmental and economic shocks. However, perceived business sustainability did not moderate the relationship between accounting practices and resilience. This indicates that, in the context studied, resilience is primarily driven by direct structural and governance factors rather than interaction effects. This study advances the sustainability accounting literature by integrating institutional theory, environmental accounting, and food system resilience within a unified governance framework. It offers practical implications for policymakers and livestock managers by demonstrating that embedding ecological and biological valuation into accounting systems enhances transparency, accountability, and strategic resilience in livestock-based food systems

5.2 Research Limitations

This study focused on a single regional case in Kabupaten Bekasi, Indonesia, which may limit the generalizability of the findings to livestock governance contexts with different institutional, regulatory, or ecological characteristics. In addition, the cross-sectional nature of the data restricts the ability to capture how the adoption of environmental and bio-accounting practices, as well as their effects on food system resilience, may evolve over time. Future research should expand coverage across multiple regions or countries to enable comparative analysis and enhance the robustness of the findings, and should apply longitudinal approaches to examine the long-term impacts of environmental and bio-accounting adoption on business sustainability and food system resilience.

5.3 Suggestions and Directions for Future Research

Future research should expand the geographical scope beyond Kabupaten Bekasi to improve the generalizability of the findings across different livestock production systems and institutional contexts. Comparative studies across regions or countries would provide deeper insights into how environmental and bio-accounting practices operate under diverse governance structures. Further studies should incorporate longitudinal research designs to examine the long-term impact of environmental and bio-accounting implementation on food system resilience and sustainable business performance. Future research should explore the moderating role of sustainable business practices more comprehensively by integrating ESG indicators and digital sustainability reporting frameworks. Finally, future research is recommended to develop quantitative measurement models for bio-accounting implementation in livestock sectors, particularly those linking biological asset valuation with environmental performance and governance effectiveness, to strengthen empirical validation within sustainability accounting literature

Acknowledgement

The author would like to express sincere appreciation to all parties who supported the completion of this study. Special gratitude is extended to the Rector of Universitas Sains Indonesia for the institutional support and encouragement that contributed to the successful implementation of this study. We also appreciate the cooperation, data access, and valuable practical insights provided by the stakeholders in the livestock sector in Kabupaten Bekasi during the research process.

Author Contributions

AMH contributed to the conceptualization and design of the study, led the formal analysis, and was primarily responsible for drafting and supervising the overall manuscript as the corresponding author. EAS contributed to the development of the research methodology, validated the analytical approach, and assisted in reviewing and editing the manuscript. YN was responsible for data curation and investigation, and contributed to reviewing and editing the manuscript. LDK assisted with data curation, investigation, and the provision of research resources. MZA contributed to the formal analysis, statistical processing, and visualization of the results. RL contributed to the investigation

process, provision of resources, and reviewing and editing of the manuscript. ZAP contributed to the investigation, coordinated project administration, and participated in reviewing and editing the manuscript. All authors have read and approved the final version of the manuscript.

References

Almasyhari, A. K., Rachmadani, W. S., Sari, Y. P., & Basrowi. (2025). Strategic decision-making: Linking corporate choices, social responsibility, and environmental accounting in waste management. *Social Sciences and Humanities Open, 11*. https://doi.org/10.1016/j.ssaho.2025.101404

Barroso-Méndez, M. J., Pajuelo-Moreno, M. L., & Gallardo-Vázquez, D. (2024). A meta-analytic review of the sustainability disclosure and reputation relationship: Aggregating findings in the field of social and environmental accounting. *Sustainability Accounting, Management and Policy Journal*, *15*(5), 1210-1254. https://doi.org/10.1108/SAMPJ-04-2022-0168

Bilotto, F., Harrison, M. T., Vibart, R., Mackay, A., Christie-Whitehead, K. M., Ferreira, C. S. S., Cottrell, R. S., Forster, D., & Chang, J. (2024). Towards resilient, inclusive, sustainable livestock farming systems. *Trends in Food Science & Technology, 152, Article 104668*. https://doi.org/10.1016/j.tifs.2024.104668

Béné, C., Frankenberger, T. R., Nelson, S., Constas, M. A., Collins, G., Langworthy, M., & Fox, K. (2023). Food system resilience measurement: Principles, framework and caveats. *Food Security*, *15*(6), 1437-1458. https://doi.org/10.1007/s12571-023-01407-y

Cisneros-Vidales, A. A., Palacio-Aponte, Á. G., Algara-Siller, M., & Fekete, A. (2025). Measuring food system resilience in the Peruvian regions of Amazonas and San Martín. *Measurement: Food, 20*. https://doi.org/10.1016/j.meafoo.2025.100257

Du Rietz, S. (2018). Information vs knowledge: Corporate accountability in environmental, social, and governance issues. *Accounting, Auditing and Accountability Journal*, *31*(2), 586-607. https://doi.org/10.1108/AAAJ-01-2013-1198

Eitrem, A., Meidell, A., & Modell, S. (2024). The use of institutional theory in social and environmental accounting research: A critical review. *Accounting and Business Research*, *54*(7), 775-810. https://doi.org/10.1080/00014788.2024.2328934

Farfan-Lievano, A., Ceballos, O. I., & Mejia Soto, E. (2024). Bioaccounting measurement of environmental assets: Beyond environmental accounting. *Meditari Accountancy Research*, *32*(6), 2001-2033. https://doi.org/10.1108/MEDAR-09-2022-1796

Hardianto, A. M., Novitasari, Y., Widyaningsih, W., & Amanah, M. S. (2026). The effect of life cycle assessment on performance sustainability: The moderating roles of bioaccounting and smart environmental. *The Indonesian Accounting Review*, *15*(2), 171-190. https://doi.org/10.14414/tiar.v15i2.5485

Iqbal Chaudhry, N., Asad, H., Amir Ch, M., & Hussian, R. I. (2020). Environmental innovation and financial performance: Mediating role of environmental management accounting and firm's environmental strategy. *Pakistan Journal of Commerce and Social Sciences*, *4*(3), 715-737.

Liang, X., Dou, Y., Ohuru, R., de By, R., Jin, X., Feng, S., Meng, F., & Zhou, Y. (2025). Local food system resilience in China integrating supply and demand. *Global Food Security, 44*. https://doi.org/10.1016/j.gfs.2025.100830

Mallinger, K., & Purcell, W. (2022). Systemic design requirements for sustainable digital twins in precision livestock farming. *ResearchGate, 718–725*. Retrieved from https://www.researchgate.net/publication/365034970

Mook, Laurie Ingrid. (2007). Social and Environmental Accounting: The Expanded Value Added Statement.

Muriithi, C., Kiria Chege, C., Ouedraogo, I., & Mwongera, C. (2026). The role of product diversification in enhancing market vendor adaptability and food-system resilience in Senegal, West Africa. *Sustainable Futures, 11*. https://doi.org/10.1016/j.sftr.2025.101593

Musa, I., O. Emmanuel Olanipekun, and E. Magaji. (2025). Evaluating the Impact of Climate Finance on Food System Resilience. *Vol. 2*.

Nair, S., Ahamad, S., & Jayabalan, N. (2022). The adoption of environmental management accounting: A study on manufacturing firms in Malaysia. *International Journal of Business and Management*, *2*(6), 10-17. https://doi.org/10.26666/rmp.ijbm.2022.2.2

Ogoudou, C., Adéchian, S. A., Egah, J., Baco, M. N., Seidou, A. A., Sanni Worogo, H. S., & Alkoiret, I. T. (2025). Governing digital innovation in livestock systems: Institutional gaps and coordination challenges in Benin. *Pastoralism, 15*. https://doi.org/10.3389/past.2025.15108

Osemene, O. F., Adinnu, P., Fagbemi, T. O., & Olowookere, J. K. (2024). Corporate governance and environmental accounting reporting in selected quoted African companies. *Global Business Review*, *25*(4), 1096-1119. https://doi.org/10.1177/09721509211010989

Portillo-Tarragona, P., Kuba-Khoury, V., Aranda-Usón, A., & Scarpellini, S. (2025). Environmental management accounting and accountability for circular eco-innovation projects. *Sustainability (Switzerland)*, *17*(6). https://doi.org/10.3390/su17062392

Saeed, U. F., Kamil, R., & Wiredu, I. (2024). The moderating role of technological innovation on ownership structure, financing decisions and environmental accounting disclosure. *Cogent Business and Management*, *11*(1). https://doi.org/10.1080/23311975.2024.2396543

Singh, J., Moustafa, S. A., Mondal, S., Waheed, F., Meier, I. B., Narayan, V. A., Rizig, M., & Salama, M. (2025). Digital adaptation of odor identification test: Current knowledge, gaps, and initial insights from a DAC global cohort. *Journal of Alzheimer's Disease Reports, 9*. https://doi.org/10.1177/25424823251362132

Singh, N. K., Chandrakar, P., Mahanthesh, M. T., Taye, T., Singh, I. P., Singh, V. P., Bara, S., & Vithalrao, U. S. (2025). Environmental impact and mitigation approaches in livestock production systems: A review. *Archives of Current Research International*, *25*(8), 351-364. https://doi.org/10.9734/acri/2025/v25i81423

Su, C., Geng, Y., Liu, G., Borrion, A., & Liang, J. (2024). Emergy-based environmental accounting of China's nickel production. *Ecological Indicators, 161*. https://doi.org/10.1016/j.ecolind.2024.112006

Sundarasen, S., Rajagopalan, U., & Alsmady, A. A. (2024). Environmental accounting and sustainability: A meta-synthesis. *Sustainability (Switzerland)*, *16*(21).

Tweedie, J. (2024). Environmental accounting: In communicating reality, do we construct reality? Critical Perspectives on Accounting, 100. https://doi.org/10.1016/j.cpa.2024.102764

Vinnari, E., & Vinnari, M. V. (2022). Making the invisibles visible: Including animals in sustainability (and) accounting. *Critical Perspectives on Accounting, 82, Article 102324*. https://doi.org/10.1016/j.cpa.2021.102324

Wang, J., Zhang, S., Zhu, H., Dai, X., & Zhang, X. (2026). How does renewable energy transition promote food system resilience in China: The moderating role of artificial intelligence. *Journal of Agriculture and Food Research, 26*. https://doi.org/10.1016/j.jafr.2026.102637

Wang, J., Zhang, S., Zhu, H., Dai, X., & Zhang, X. (2026). How does renewable energy transition promote food system resilience in China: The moderating role of artificial intelligence. *Journal of Agriculture and Food Research, 26*. https://doi.org/10.1016/j.jafr.2026.102637

Williams, R. (2025). Looking to livestock: Gauging the evolution of the EU's agri-climate law and policy. *Transnational Environmental Law*, *14*(1), 69-93. https://doi.org/10.1017/S2047102524000256

Xia, L., Fatema, N., Rahman, M. M., & Hossain, A. (2025). Nexus of environmental management accounting, and carbon emission management on environmental, social, and governance performance: Evidence from symmetrical and asymmetrical approach. *Humanities and Social Sciences Communications*, *12*(1). https://doi.org/10.1057/s41599-025-05465-9

Young, K. R., Alata, E., Chimner, R. A., Boone, R. B., Bowser, G., Bourgeau-Chavez, L., Fuentealba, B., Gilbert, J., Ñaupari, J. A., Polk, M. H., Resh, S. C., Turin, C., & Zarria-Samanamud, M. (2023). Ecological change and livestock governance in a Peruvian national park. *Land*, *12*(11). https://doi.org/10.3390/land12112051