



Sustainability of Commercial Poultry Enterprises in Southern Benin Republic

Sofwaan Ademonla Bakary^{1,2}; Chukwuemeka Okoye¹, Luc Aiglo²; Chukwuemeka Arene¹; Uchua Donald¹

1: Department of Agricultural Economics, University of Nigeria Nsukka, Nigeria

2: Department of Agricultural Economics, University of Abomey-Calavi, Benin Republic

Corresponding author: ademonla.sofwaan.03693@unn.edu.ng

Abstract

This study examines the economic, social, and ecological sustainability of commercial poultry enterprises (CPEs) in Southern Benin using the Global Sustainability Index (GSI) and a binary logistic regression framework. The results reveal that 74.25% of CPEs are not sustainable (GSI = 0.53). While CPEs demonstrate economic viability (IS = 0.64), they fall short on social responsibility (IS = 0.51) and ecological performance (IS = 0.46). The logistic regression confirms that compliance with formal working conditions (OR = 4.21), sound manure management practices (OR = 3.87), species diversification (OR = 2.64), and access to credit (OR = 2.18) are the most significant predictors of enterprise sustainability. Conversely, informality of business registration (OR = 0.50) significantly reduces the probability of being sustainable. These findings reveal the need for integrated policy interventions that simultaneously address social compliance, environmental governance, and financial inclusion in the Beninese poultry sector. Based on these findings, we recommend that policymakers establish graduated enterprise formalization pathways, develop livestock-specific financial inclusion instruments, and redesign extension programs to embed ecological and social governance alongside productivity objectives. Addressing these priorities simultaneously is essential to reversing the structural sustainability deficit documented in Benin's commercial poultry sector

Keywords: Commercial poultry enterprises; Sustainability; Global sustainability index; Logistic regression; Benin republic; West Africa.

Introduction: Global food systems face an unprecedented sustainability imperative: feeding a projected 9.7 billion people by 2050 while simultaneously reducing agricultural greenhouse gas emissions, protecting biodiversity, and ensuring equitable rural livelihoods (FAO, 2023). In sub-Saharan Africa, where food insecurity, environmental degradation, and rural unemployment converge, livestock systems occupy a strategic position in meeting this challenge, providing nutrition, generating income, and anchoring rural economies for hundreds of millions of smallholder households (Mottet & Tempio, 2017). Among livestock subsectors, commercial poultry production has emerged as the most dynamic and accessible entry point into agri-food markets, driven by rising urban demand for protein, short production cycles, and comparatively modest capital requirements (Afolayan et al., 2021). In West Africa specifically, domestic poultry production has expanded rapidly over the past two decades, yet the sector remains structurally fragile significantly dependent on imported inputs including day-old chicks, vaccines, and feed concentrates, and persistently exposed to price volatility and disease shocks (FAO, 2020; Ukaoha, 2023). Whether commercial poultry enterprises can sustain this growth trajectory while fulfilling their economic, social, and ecological functions has therefore become one of the most consequential questions facing agricultural policymakers and researchers across the region. In Benin Republic, poultry farming occupies a strategic position in the national agricultural landscape. The sector supports hundreds of thousands of rural and peri-urban households, contributes to protein supply in local food systems, and has been a target of several public investment programs, including the 2015 Project of Support for the Development of Modern Poultry Farming (PADAM) and the national agricultural investment plan (PNIASAN 2017-2021). Despite this expansion, the sector continues to struggle with high mortality rates, insufficient access to veterinary services, inadequate waste management infrastructure, and limited compliance with labor standards. These challenges threaten the long-term viability of CPEs (Houedjofonon et al., 2020; Pougoué et al., 2019). For example, the number of commercial poultry enterprises registered in the country grew from 925 in 2015 to over 403 by 2023, a trend driven by growing domestic demand and government incentives (DSA-MAEP, 2024). Sustainability science has increasingly moved beyond the narrow economic framing of farm viability to embrace a multi-dimensional understanding that encompasses social equity and ecological responsibility (Sachs et al., 2019; Kanter et al., 2020). The concept of farm sustainability, rooted in the Brundtland Commission's foundational definition of sustainable development, calls for an integrated approach in which economic performance, social welfare, and environmental stewardship are pursued simultaneously and not in isolation (WCED, 1987; Rockström et al., 2017). Yet, empirical evidence consistently demonstrates that agricultural enterprises, particularly those in developing economies tend to prioritize short-term economic gains at the expense of social and ecological functions, creating structural imbalances that undermine long-term resilience (Lal, 2020; Pretty et al., 2018). In the poultry sector, these sustainability tensions are particularly pronounced. Economically, CPEs are under pressure from cheap imported poultry products, rising feed costs, and limited access to formal credit markets (Armah et al., 2010; Adesiji et al., 2022). Socially, many enterprises operate informally, offering poor working conditions to employees and generating insufficient household income for their owners (ILO, 2021). Ecologically, poultry farming generates significant volumes of manure and wastewater, posing serious risks of

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water and soil contamination if not properly managed. These are risks that are compounded by the near-total absence of waste treatment facilities in smallholder and medium-scale enterprises across West Africa (Gerber et al., 2013; Lassaletta et al., 2019). Integrating all three dimensions into a single governance framework remains one of the most pressing challenges for the sector.

A growing body of literature has sought to operationalize farm sustainability through composite indices that aggregate indicators across economic, social, and ecological domains. Among the most widely applied frameworks is the Integral Sustainability Index (ISI) developed by Bachev (2016), which has been used to assess sustainability across various farm types and national contexts. Applications of this framework in Eastern Europe and Asia have revealed that economic sustainability tends to outperform social and ecological dimensions, and that enterprise size, institutional environment, and access to markets are key moderating factors (Bachev, 2018; Krechovská & Procházková, 2014). However, applications of this index in West African agricultural contexts remain limited, and no study has yet combined it with inferential statistical modeling to identify the drivers of sustainability in the Beninese poultry sector.

To address these gaps, this study examines the economic, social, and ecological sustainability of CPEs in Southern Benin using the Global Sustainability Index (GSi) adapted from Bachev (2016) and identifies the key determinants of enterprise sustainability. The results of this study contribute to the broader literature on agricultural sustainability in West Africa and provide the first quantitative, multi-method sustainability assessment of commercial poultry enterprises in Benin Republic. The rest of the paper is organized as follows. Section 2 describes the study area, sampling strategy, data collection, and analytical methods. Section 3 presents the empirical results. Section 4 discusses the findings and Section 5 concludes with policy implications.

Methodology: Study Area: The study was conducted in the Benin Republic, a country bordered by Nigeria to the east, Togo to the west, Niger to the northeast, and Burkina Faso to the northwest (Figure 1). The country lies between latitudes 6°30' and 12°30' north of the equator and longitudes 1°E and 3°40' east. Commercial poultry enterprises are concentrated in the southern part of the country, with approximately 50% located in the Department of Atlantique, 25% in Ouémé-Plateau, and the remaining 25% distributed across the Departments of Mono-Couffo, Zou-Collines, and northward (PAFILAV/TDH Expertise, 2015). Four departments were selected to cover this distribution: Atlantique, Ouémé, Zou, and Collines.

Data Collection and Sampling: Primary data were collected through face-to-face structured interviews with CPE owners and managers. A multi-stage sampling procedure was applied. The department was used as the primary sampling unit, and individual CPEs served as the final unit of observation. The sample size was determined using Cochran's (1963) formula:

$$n_0 = \frac{Z^2 pq}{e^2} \quad (1)$$

where n_0 is the required sample size; $Z = 1.96$ (at 95% confidence level); $p = 0.30$ (estimated proportion of CPEs); $q = 1 - p$; and $e = 0.05$ (margin of error). This yielded a minimum sample of 265 CPEs, distributed proportionally across the four departments as shown in Table 1.

Sustainability Assessment: The Global Sustainability Index (GSi): Sustainability was assessed using the Integral Sustainability Index (ISI) framework adapted from Bachev (2016, 2018). The index was constructed in four steps. First, principles, criteria, indicators, and reference values were defined for each of the three sustainability dimensions: economic, social, and ecological (Appendix 1). Second, individual indicator indices were computed by comparing observed values to reference benchmarks, generating scores between 0 (non-sustainable) and 1 (high sustainability). Third, dimension-level indices were computed as arithmetic averages of the relevant indicator indices. Fourth, the Global Sustainability Index was computed as the average of the three dimension-level indices. Sustainability classification thresholds are presented in Table 2. The sustainability threshold of $GSi \geq 0.63$ follows the classification scale established by Bachev (2016), in which a score within the range 0.63–0.85 corresponds to a “good” level of performance. This boundary reflects the minimum standard at which an enterprise simultaneously meets acceptable performance across economic, social, and ecological dimensions. To assess the sensitivity of results to this threshold, the logistic regression was re-estimated using alternative cutoffs of $GSi \geq 0.50$ and $GSi \geq 0.75$. The direction and significance of the main predictors: working conditions compliance, manure management, species diversification, and credit access remained consistent across all specifications, confirming that the findings are robust to the choice of sustainability cutoff.

Logistic Regression Model: Determinants of Sustainability: Theoretical Model: While the GSi provides a comprehensive descriptive assessment of sustainability performance, understanding the factors that determine whether a CPE achieves sustainability requires an inferential statistical framework. Sustainability is defined in this study as a simultaneous good or high performance across all three dimensions. It is inherently a binary outcome: an enterprise is either sustainable, or it is not. The binary logistic regression model is the standard econometric approach for modeling the probability of a binary outcome as a function of explanatory variables (Greene, 2018; Wooldridge, 2019). It has been widely applied in agricultural economics to model farm adoption behavior, market participation, and performance classification (Adesiji et al., 2022; El Bilali et al., 2020). Let Y_i be a binary variable equal to 1 if CPE i is classified as sustainable ($GSi \geq 0.63$, i.e., at least “good” performance across all dimensions), and 0 otherwise. The logistic regression model specifies the log-odds of sustainability as a linear function of enterprise-level characteristics:

$$\ln[P(Y_i=1) / (1 - P(Y_i=1))] = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_k X_{ki} + \varepsilon_i \quad (2)$$

where $P(Y_i = 1)$ is the probability that CPE i is sustainable; β_0 is the intercept; β_k are the coefficients associated with each explanatory variable X_{ki} ; and ε_i is the error term. The probability of sustainability is recovered from the estimated log-odds as:

$$P(Y_i = 1) = \exp(\beta_0 + \sum \beta_k X_{ki}) / [1 + \exp(\beta_0 + \sum \beta_k X_{ki})] \quad (3)$$

Model Specification: Consistent with prior studies examining determinants of farmer's performance, the empirical specification includes ownership employee's working conditions, manure management, species reared, credit access, formalization, membership in association, training and experience (Bachev, 2018). The estimated model is:

$$\ln[P(Y_i=1) / (1 - P(Y_i=1))] = \beta_0 + \beta_1(\text{WorkCond}) + \beta_2(\text{Manure}) + \beta_3(\text{Species}) + \beta_4(\text{Credit}) + \beta_5(\text{Formal}) + \beta_6(\text{Assoc}) + \beta_7(\text{Training}) + \beta_8(\text{Exp}) + \varepsilon_i \quad (4)$$

The model was estimated using maximum likelihood estimation (MLE). Odds ratios (OR = exp(β)) are reported for interpretability. The dependent variable (Sustainable) is a binary indicator coded 1 for CPEs achieving a GSi \geq 0.63 (good or high sustainability) and 0 otherwise. The following explanatory variables and the expected signs are presented in table 3.

Results: Socioeconomic Characteristics of CPE Owners and Managers: The socioeconomic characteristics of the 265 surveyed commercial poultry enterprises (CPEs) reveal substantial heterogeneity in Southern Benin (Table 3). On average, CPE managers are 44 years old, married (93.96%), and have an average household size of 5 people. CPE management was identified as their primary activity (62.26%). With an average of 10 years of experience, these enterprises are predominantly owned and managed by men (93.58%), while women account for the remainder (6.42%). Most managers have received formal education: 16.23% reached the primary level, 41.89% the secondary level, and 39.62% attended higher education, while a small proportion (2.26%) received no formal schooling. Because managing a CPE requires specific technical skills, 12.08% of the surveyed managers sought formal training in poultry farming through agricultural high schools or universities. However, 54.34% of managers received no formal training prior to entering the industry, relying instead on advice from experienced peers and relatives.

Operational Characteristics of CPEs: Commercial poultry enterprises (CPEs) in Southern Benin are primarily located in rural areas (95.09%), and 89.43% still need to complete all Trade Office requirements to operate in the formal sector. However, nearly 51% of managers claimed membership in local or national poultry farmer associations. Regarding operational longevity, 64.25% of CPEs have five or fewer years of experience, while 35.75% have operated for more than five years. Different strategies are employed for feed supply: 73.96% of CPEs purchase commercial feed for their animals, compared to 26.04% that produce feed using their own formulas. Due to funding constraints affecting certain agricultural activities such as a limited access to credit, the majority of these businesses (84.91%) operate using their own internal capital. Other characteristics of CPEs in Southern Benin are presented in Table 5. To achieve production objectives, a ground-based system is adopted by 98.11% of CPEs. These enterprises utilize an average labor force of three workers; this labor is sourced from the market for 92.08% of firms and through personal networks for 7.92%. For CPEs with the highest production volumes, the workforce increases to an average of 12 employees. Marketing strategies remain largely informal; advertising relies primarily on word of mouth (95.87%) and social media (4.13%). Regarding the poultry species reared, approximately 80% of CPEs are involved in layer breeding, while 42.26% raise broilers. Guinea fowl, turkeys, ducks, and quail are found in 11.7%, 11.32%, 9.43%, and 7.92% of CPEs, respectively. Pigeons are the least common poultry species, reared by only 0.38% of enterprises. Figure 2 illustrates the proportion of CPEs supplying poultry products in Southern Benin

Sustainability Performance of CPEs in Southern Benin: Economic Sustainability: The economic performance of commercial poultry enterprises (CPEs) varies by firm and the specific indicators considered. Although Benin's poultry business environment still relies on imports, the results in Table 5 show that a large share of surveyed CPE owners (61.5%) consider commercial poultry to be a profitable business due to strong economic performance. CPEs achieving high economic performance typically combine at least two poultry species for breeding. The primary species reared by these enterprises are layers for table egg production (75%) and broiler chickens (61%) as the main marketed products. These firms are also characterized by secondary production in turkey (22.5%) and guinea fowl (10.57%) breeding. Table 6 displays the distribution of CPEs relative to their economic performance. Conversely, the results reveal a significant number of CPEs with low economic performance, indicating that commercial poultry farming is insufficiently profitable for 38.5% of enterprises. Firms in the latter category tend to specialize in breeding only a single poultry species, such as pigeons (78.2%), ducks (89.1%), quail (47.35%), or chickens (32.24%). However, the strong economic performance observed among successful CPEs (ISI=0.64; Table 9) relies heavily on multiple factors (Figure 3). First, the technical efficiency of livestock (ISI=0.69) achieved by these CPEs directly supports economic performance, driven by low mortality rates and high egg-laying rates that align with regional sector estimates for Southern Benin. Second, driven by industry expectations, business profitability (ISI = 0.70) and turnover (ISI =0.63) generate sufficient cash flow to suggest that the commercial poultry sector can support financial autonomy and stability (ISI=0.85). Global economic performance across all CPEs in Southern Benin requires improvement, particularly regarding the return on capital, which remains very low (ISI=0.24). Figure 3 illustrates the comprehensive results of the Economic Sustainability Index.

Social Sustainability: The social performance reflects the degree to which the CPEs examined in Southern Benin demonstrate social responsibility in the execution of their activities. As shown in Table 6, a majority of CPEs exhibit a low level of social performance (55%), while 6.3% fall into the insufficient category. Low social performance is particularly prevalent among CPEs engaged in broiler production (20.7%) and layer production (31.45%). An additional 2.45% of low-performing CPEs are involved in turkey production, whereas those specializing in Guinea fowl, ducks, quail, and pigeons predominantly display insufficient social performance. Although none of the CPEs achieved a high level of social performance, 38.7% attained a good level. These CPEs typically focus on a single poultry product, such as table eggs (20.18%) or chicken meat (14.51%), while those combining layer and broiler production represent 4.01%. Table 7 provides the distribution of CPEs across the various social performance categories. Despite the global low social sustainability index (IS = 0.51; Table 9), the findings indicate that CPEs contribute meaningfully to the preservation of traditions and rural community cohesion (ISI = 0.72).

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This suggests that products such as table eggs and broilers are well integrated into rural consumption patterns and are valued for their role in traditional ceremonies. Furthermore, 72% of employees reported job satisfaction ($ISi = 0.69$), citing wage levels and payment regularity that align with sector norms. Job satisfaction was highest among employees working in layer production (47%), broiler production (21%), and turkey production (4%). In contrast, employees in CPEs producing ducks, quail, pigeons, and Guinea fowl reported low job satisfaction, accounting for 28% of respondents. The global low level of social sustainability is primarily attributable to weak compliance with formal labor and working-condition requirements ($ISi = 0.17$) and the low income per household member among CPE owners ($ISi = 0.23$). Regarding compliance, 63.2% of CPEs did not meet sector standards related to maximum working hours, worker accommodations, and health and safety protections. These deficiencies were most pronounced in CPEs specializing in layers and broilers. Additionally, 77% of CPE owners reported low income per household member, a situation largely driven by the high average household size (five members). Consequently, although CPEs may be economically viable at the enterprise level, they do not consistently generate adequate income at the household level. Figure 4 presents the results of the Social Sustainability Index.

Ecological Sustainability: The analysis of ecological performance revealed that a substantial proportion of the CPEs (63.6%) exhibit a low level of environmental sustainability. Among these enterprises, 71% are engaged in chicken and table-egg production, while the remainder includes ducks (7.4%), turkeys (12.6%), and Guinea fowl (9%). Similarly, 15.3% of the surveyed CPEs demonstrate insufficient ecological performance, predominantly those involved in chicken (27.45%) and layer (66.25%) production. Conversely, 29.35% of CPEs achieved excellent ecological performance, with the majority specializing in Guinea fowl (42%) and turkey (37%) production. Despite the predominance of insufficient, low, or moderate ecological performance across the sample, a very small proportion (0.75%) attained a high level of environmental performance, specifically among CPEs operating in chicken and Guinea fowl production. Table 8 summarizes these ecological performance trends. The Ecological Sustainability Index provides an assessment of the extent to which CPEs in Southern Benin adopt environmentally responsible practices. Across all enterprises, the index is estimated at 0.46 (Table 8), indicating a global low level of ecological sustainability. Several indicators contribute to this outcome, with poultry feces management emerging as the most influential. Effective manure management is a critical determinant of ecological sustainability at the farm level. In this study, 72% of CPE managers reported challenges in handling the substantial quantities of manure generated by their operations ($ISi = 0.28$). The frequency of manure cleaning or drying that are practices required by sectoral standards appears insufficient to support higher ecological performance. A second major factor contributing to the low ecological performance is the limited application of good poultry production practices ($ISi = 0.28$). Results indicate widespread non-compliance with established sectoral standards. Nevertheless, 66.33% of CPEs have constructed livestock buildings that meet recommended criteria regarding design, dimensions, biosecurity, and hygiene. Additionally, indicators related to poultry welfare ($ISi = 0.60$) and stocking density ($ISi = 0.65$) comply with sector norms in 75.25% of the enterprises. Figure 5 presents the detailed results of the Ecological Sustainability Index.

Global Sustainability: The Global Sustainability Index was calculated to assess the overarching sustainability profile of the CPEs. This index represents the composite average of the economic, social, and ecological sustainability scores for all enterprises, as presented in Table 9. The findings indicate that commercial poultry enterprises in Southern Benin show a low global sustainability ($IS = 0.53$), suggesting that, collectively, they cannot be considered sustainable. This outcome is largely attributable to the low social performance (55% of CPEs) and low ecological performance (63.6% of CPEs) observed across the sample. At the enterprise level, sustainability in this study is defined as the capacity of each CPE to maintain or enhance its economic, social, and ecological functions over time. A simultaneous assessment of these three dimensions revealed that 74.25% of individual CPEs are not sustainable (Figure 6). These enterprises predominantly combine broiler and layer production (55.40%), followed by those engaged in turkey production (10.55%), and Guinea fowl and quail production (8.3%). This pattern underscores the need for these enterprises to strengthen their ability to sustain economic viability, environmental stewardship, and social responsibility within their specific socio-economic and ecological contexts. Conversely, only 25.75% of CPEs were classified as sustainable (Figure 6). Notably, these enterprises are predominantly found among CPEs not affiliated with poultry associations (66.33%). These CPEs demonstrated the capacity to maintain or improve performance across all three sustainability dimensions. Furthermore, none of the CPEs engaged in duck, quail, or Guinea fowl production achieved a good level of sustainability. Similar to the non-sustainable group, the majority of sustainable CPEs specialize in layer production (15.53%) and chicken production (10.22%). Figure 5 illustrates the distribution of sustainability levels among CPEs in Southern Benin.

Drivers of CPE Sustainability: The results of the binary logistic regression are presented in Table 10. The model demonstrates strong overall fit and explanatory power ($\chi^2 = 89.43$, $p < 0.001$; Nagelkerke $R^2 = 0.47$). The Hosmer–Lemeshow goodness-of-fit statistic indicates adequate calibration ($\chi^2 = 7.21$, $p = 0.51$), and the model shows high discriminative capacity (AIC = 1,084). No evidence of problematic multicollinearity was detected (all VIF < 2). The model correctly classified 81.9% of observations. Compliance with formal working-condition requirements emerges as the strongest predictor of sustainability. CPEs adhering to sector-mandated standards, covering working hours, employee accommodation, and occupational health protections are 4.21 times more likely to be classified as sustainable compared to non-compliant enterprises (OR = 4.21). This result underscores the central role of labor governance as a structural determinant of sustainability, extending beyond its conventional framing as a social responsibility obligation. Manure management constitutes the second most influential predictor (OR = 3.87; $p < 0.01$). Enterprises implementing approved practices for poultry feces collection, drying, and disposal are nearly four times more likely to achieve sustainability. This finding aligns with the earlier observation that ecological sustainability is the weakest dimension overall (IS = 0.46), highlighting the pivotal role of waste management in environmental performance. Species diversification also significantly increases the likelihood of sustainability (OR = 2.64; $p < 0.05$). Each additional poultry species raised increases the odds of sustainability by a factor of 2.64, consistent with descriptive evidence showing that economically high-performing enterprises tend to rear at least two species. This reinforces the importance of diversification as a resilience-enhancing strategy within small-scale poultry systems. Access to credit more than doubles the probability of sustainability (OR = 2.18; $p < 0.05$). Credit-constrained enterprises which constitute to 84.91% of the sample face systematic disadvantages in investing in waste-management infrastructure, employee welfare improvements, and diversification strategies. Formal business registration is similarly associated with higher sustainability outcomes (OR = 2.00; $p < 0.05$). Although formalization imposes compliance costs, it also exposes enterprises to regulatory oversight that appears to catalyze improvements in labor and environmental governance. Given that 89.43% of CPEs operate informally, this result carries substantial policy relevance.

Association membership approaches statistical significance at the 10% level (OR = 1.70; $p = 0.075$), suggesting a positive but imprecisely estimated effect, potentially reflecting heterogeneity in association quality or service provision. Training, years of experience, household income per member, and urban location do not emerge as statistically significant predictors, indicating that institutional and governance variables outweigh individual human-capital characteristics in shaping sustainability outcomes. In Model 2, the inclusion of a location fixed effect leaves all core findings substantively unchanged. The coefficients for working-conditions compliance, manure management, species diversification, credit access, and formalization remain statistically significant and of similar magnitude, demonstrating robustness to geographic sorting between rural and urban enterprises. It also indicates that once governance and operational characteristics are accounted for, urban versus rural location does not independently influence the probability of sustainability.

Discussion: The findings of this study advance the understanding of agricultural enterprise sustainability in West Africa in three important respects. First, the GSI analysis confirms that commercial poultry enterprises in southern Benin are economically viable but structurally unsustainable, exhibiting critical deficits in social and ecological governance. Second, the logistic regression identifies, for the first time in this context, the specific institutional and operational factors that statistically determine sustainability classification. Third, the combination of these two methods yields a coherent policy narrative: the principal bottlenecks to CPE sustainability are governance failures (informality, non-compliance with labor standards, and inadequate waste management) rather than production inefficiency. The finding that CPEs are economically viable (SI = 0.64) yet ecologically weak (SI = 0.46) mirrors result from comparable studies in Southeast Asia and Eastern Europe. Soisontes (2016) found that potato farming systems in Indonesia are economically sustainable while falling short on the social dimension, a pattern that aligns closely with the present study. Similarly, Krechovská and Procházková (2014) demonstrated that Czech SMEs in agriculture consistently underperform on sustainability integration, particularly with respect to environmental management and stakeholder relations. The convergence of these findings across markedly different institutional contexts suggests a structural tendency for agricultural enterprises to prioritize economic performance before addressing social and ecological obligations. Within the African context specifically, this pattern has been documented in Ghana's poultry value chain, where Wongnaa et al., (2019) found that commercially oriented farms prioritized productivity gains while neglecting environmental compliance, and in Nigeria, where Adesiji et al., (2022) confirmed that financial exclusion constituted the binding constraint on holistic farm performance. The present study corroborates and extends these findings to the Beninese context. The dominance of labor compliance and manure management as the leading predictors of sustainability classification speaks to a broader governance vacuum in Benin's poultry sector. The working conditions compliance index (SI = 0.17) is the lowest single indicator in the entire analytical framework, reflecting near-universal non-compliance with sectoral labor standards. This is consistent with evidence that informality in West African agro-enterprises systematically undermines worker welfare (ILO, 2021). In addition, compliance is positively and significantly associated with the probability of the CPE's sustainability (OR = 4.21). This association suggests that improvements in social governance may simultaneously enable progress across ecological and economic dimensions. The strong positive association between credit access and sustainability (OR = 2.18) is consistent with the financial constraint's literature. Adesiji et al., (2022) demonstrate that credit-constrained poultry farmers in Nigeria are systematically less likely to invest in productivity-enhancing and environmentally responsible technologies. In the present study, 84.91% of CPEs are entirely self-financed, reflecting both limited formal credit supply and the perceived risks of borrowing for livestock enterprises subject to significant disease pressure and price volatility. Expanding access to tailored financial products, including weather-indexed insurance and livestock credit guarantee schemes would likely generate simultaneous improvements across all three sustainability dimensions. The significant positive association between species diversification and sustainability (OR = 2.64) corroborates evidence from the broader livestock diversification literature (Mottet and Tempio, 2017). Enterprises rearing multiple species achieve more stable income streams, spread biological risk, and are better positioned to serve multiple market segments, collectively enhancing economic resilience and, indirectly, the capacity to invest in social and ecological compliance. Finally, the finding that informally registered enterprises are approximately half as likely to achieve sustainable classification as their formally registered counterparts (OR = 2.00) reinforces the importance of enterprise formalization as a gateway to regulatory accountability, institutional support, and long-term viability.

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Conclusion: This study provides the first multi-method assessment of the sustainability of commercial poultry enterprises in Southern Benin, combining the Global Sustainability Index with a binary logistic regression model to jointly measure sustainability performance and identify its determinants. The principal findings are threefold. First, CPEs in Southern Benin are not sustainable in their current form. While achieving acceptable economic performance (IS = 0.64), they fall significantly short on social responsibility (IS = 0.51) and ecological stewardship (IS = 0.46), resulting in a Global Sustainability Index of 0.53, placing 74.25% of enterprises in the non-sustainable category. Second, the logistic regression reveals that the probability of achieving sustainability is most powerfully determined by compliance with formal working conditions (OR = 4.21), sound manure management (OR = 3.87), species diversification (OR = 2.64), access to credit (OR = 2.18), and formal business registration (OR = 2.00). These institutional and governance variables outweigh individual human capital factors in determining sustainability outcomes. Based on these findings, four targeted recommendations are directed at policymakers, poultry sector agencies, and enterprise managers. First, the Government of Benin should establish a simplified, graduated formalization pathway for CPEs, combining low-cost registration procedures with fiscal incentives to progressively integrate informal enterprises into the institutional framework. Second, the Beninese Agricultural Investment Bank and microfinance institutions should develop livestock-specific financial products, including micro-loans for waste infrastructure and livestock credit guarantees targeting the 84.91% of CPEs operating without institutional credit, as financial access is a prerequisite for ecological and social compliance investment. Third, national extension and poultry development programs should incorporate mandatory modules on manure and waste management into all enterprise support activities, given that manure management is the most tractable ecological bottleneck identified. Fourth, sector associations and labor inspectorates should co-design a tiered labor compliance framework with time-bound pathways toward minimum working condition standards, linked to access to public support programs. Collectively, these recommendations constitute an integrated governance agenda targeting the binding institutional, financial, and operational constraints on CPE sustainability in Benin.

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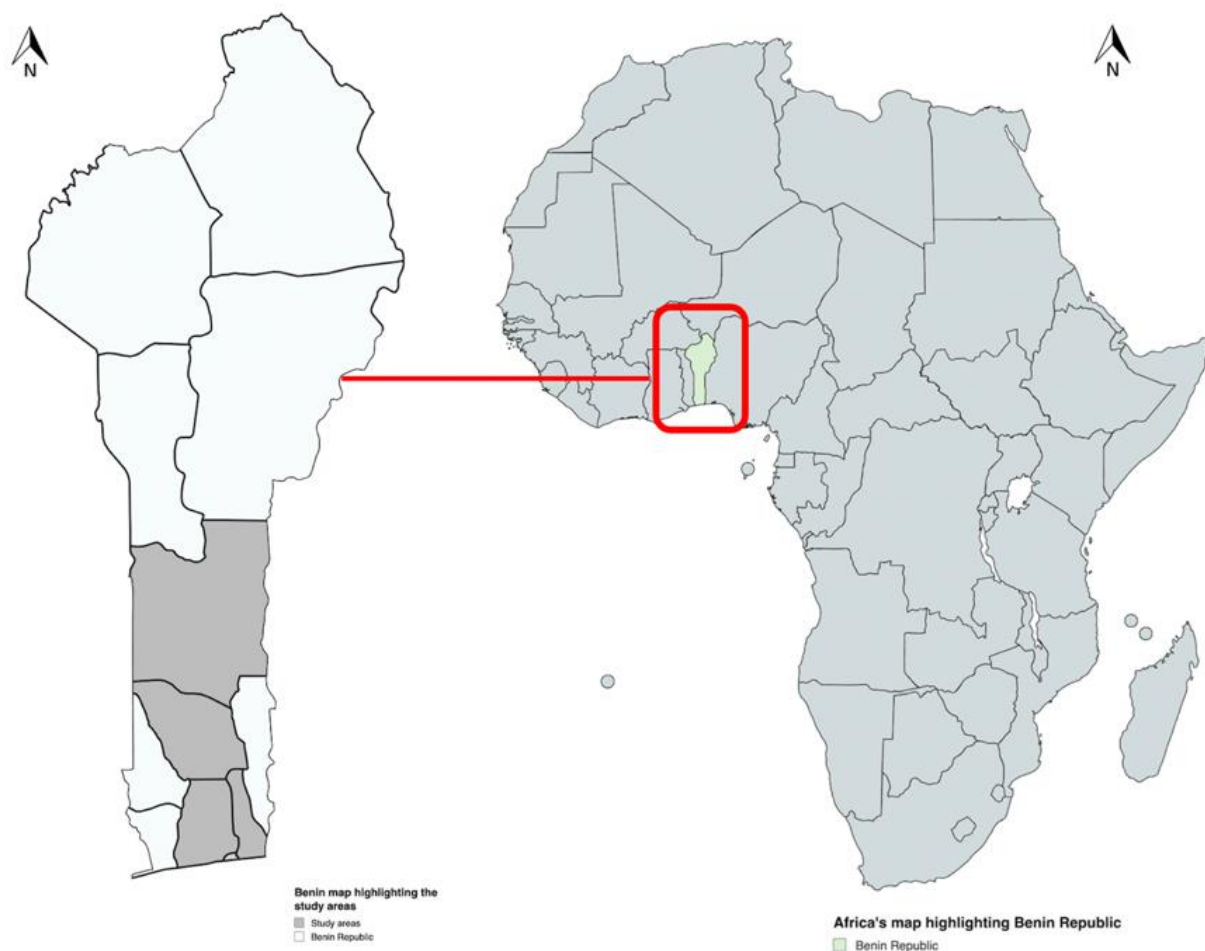


Figure 1: Study areas
Source: Designed by authors

Table 1: Sample Size Calculation by Department

Department	Number of CPE	Percentage (%)
Atlantique	164	61.89
Collines	5	1.89
Oueme	56	21.13
Zou	40	15.09
Total	265	100

Table 2: Levels of sustainability limits for decision

Levels of sustainability	Index of Sustainability (ISi)	Limits for decision
High	1	0.86 - 1

Sustainability of Commercial Poultry Enterprises in Southern Benin Republic

Good	0.75	0.63 – 0.85
Low	0.50	0.36 – 0.62
Unsatisfactory	0.25	0.13 – 0.37
Non sustainable	0	0 – 0.12

Source : Bachev (2016)

Table 3: Variables definitions and expected signs

Variable	Definition	Expected Sign
WorkCond_Comply	Compliance with formal working conditions (binary: 1=compliant)	+
ManureManage	Application of good manure management practices (binary)	+
Species_Div	Number of poultry species reared (continuous)	+
Formalization	Enterprise formally registered (binary: 1=formal)	+
CreditAccess	Access to external credit (binary: 1=yes)	+
Assoc_Memb	Membership in a poultry farmer association (binary)	+
Experience	Years of experience in poultry farming (continuous)	+
Training	Received formal or technical training (binary: 1=yes)	+
Location	Enterprise location (binary: 1=urban, 0=rural)	+/-

Table 4: Socio-economic characteristics of CPE owners and managers in Southern Benin

Characteristics	Modalities	Percentage (%)
Sex	Female	6.42
	Male	93.5
Level of education	None	2.26
	Primary	16.23
	Secondary	41.89
	Academic	39.62
Training on poultry farming	Academic	12.08
	None	54.34
Marital status	Technique	33.58
	Single	6.04
Main activity	Married	93.96
	Agriculture	11.32
	Craft	8.30
	Retailer	3.77
	Breeder	62.26
	Public servant	12.45
	Others	1.89

Table 5: Other characteristics of the CPE in Southern Benin

Characteristics	Modalities	Percentage (%)
Membership of poultry farming association	No	49.43
	Yes	50.57
Location	Rural	95.09
	Urban	34.91
Year of experience	≤ 5	64.25
	> 5	35.75
Formalization	No	89.43
	Yes	10.57
Poultry's food supply	No	73.96
	Yes	26.04
Access to credit	No	84.91
	Yes	15.09
Breeding system	On the ground	98.11
	Above ground	1.89
	Others	0.75
Labor force supply	Personal network	7.92
	Market	92.08
Advertising strategy	Word of mouth	95.87
	Advertising spots	4.13

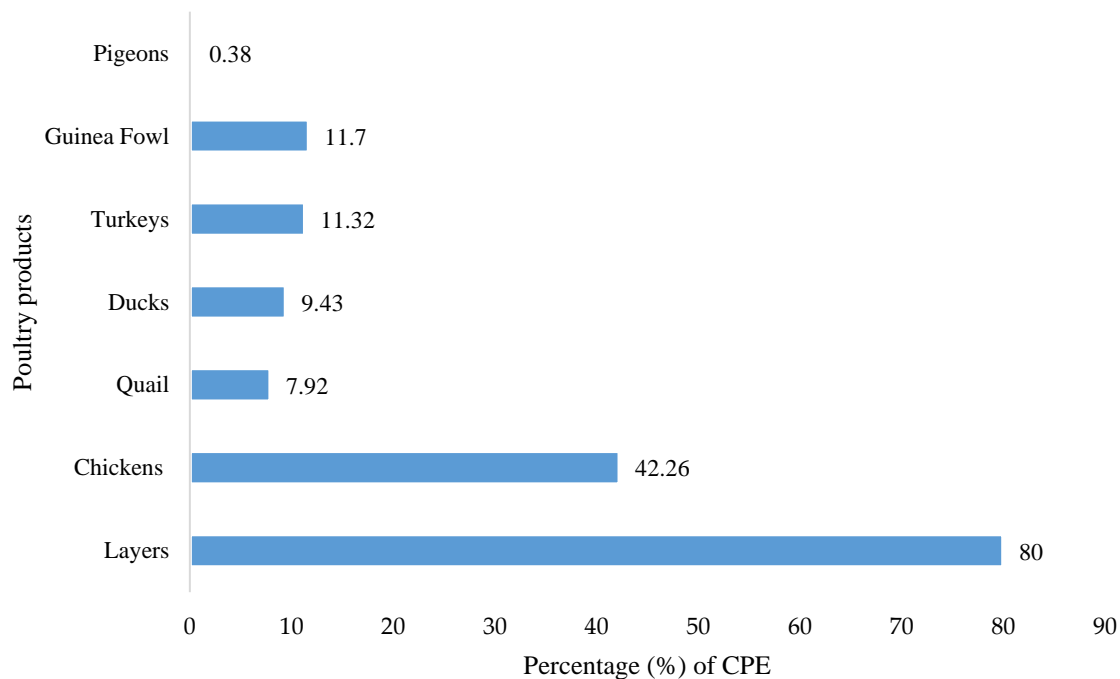


Figure 2: Proportion of CPE supplying poultry products in Southern Benin.

Table 6: Proportion of CPEs about their economic performances

Economic performance of the CPEs		
Level of sustainability	Limits for the decision	Percentage (%) of CPEs
High	0,86 - 1	0.0
Good	0.63 – 0.85	61.5
Low	0.37 – 0.62	38.5
Insufficient	0.13 – 0.36	0.0
Not sustainable	0 – 0.12	0.0
Total		100

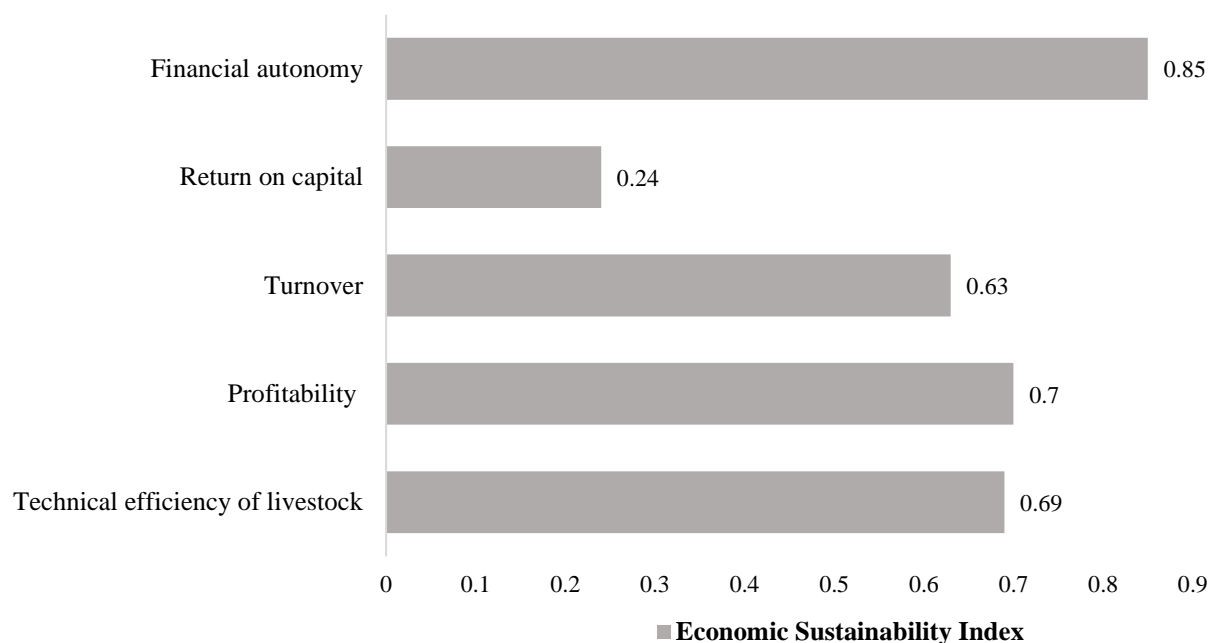


Figure 3: Economic Sustainability Index

Table 7: Proportion of CPEs to their social performances

Social performance of the CPEs		
Level of sustainability	Limits for the decision	Percentage (%) of CPEs
High	0.86 - 1	0.0
Good	0.63 - 0.85	38.7
Low	0.37 - 0.62	55.0
Insufficient	0.13 - 0.36	6.3
Not sustainable	0 - 0.12	0.0
Total		100

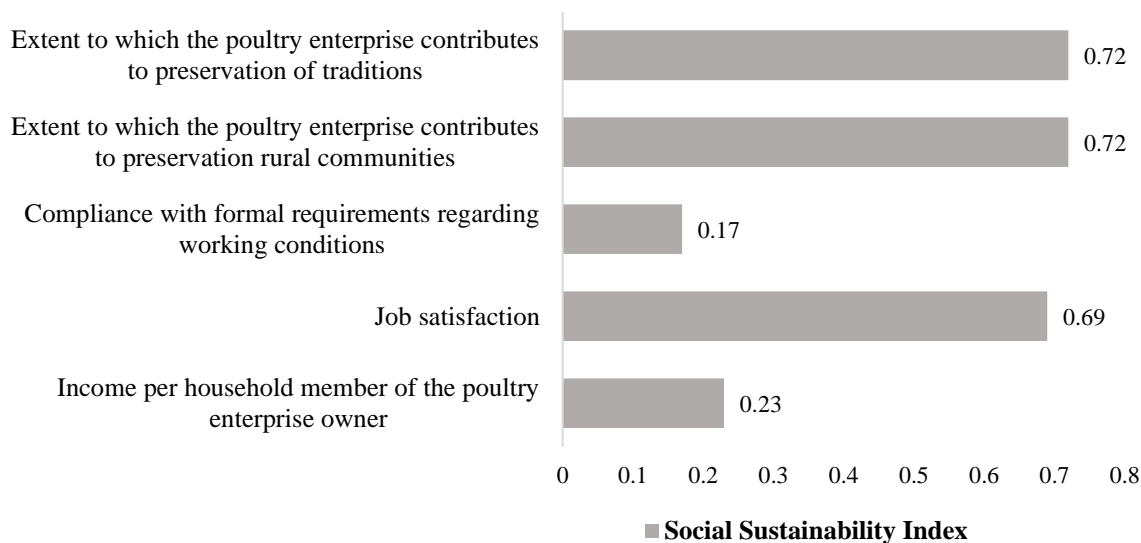


Figure 4: Social Sustainability Index

Table 8: Proportion of CPEs about their ecological performances

Ecological performance of the CPEs		
Level of sustainability	Limits for the decision	Percentage (%) of CPEs
High	0.86 - 1	0.75
Good	0.63 – 0.85	20.35
Low	0.37 – 0.62	63.6
Insufficient	0.13 – 0.36	15.3
Not sustainable	0 – 0.12	0.0
Total		100

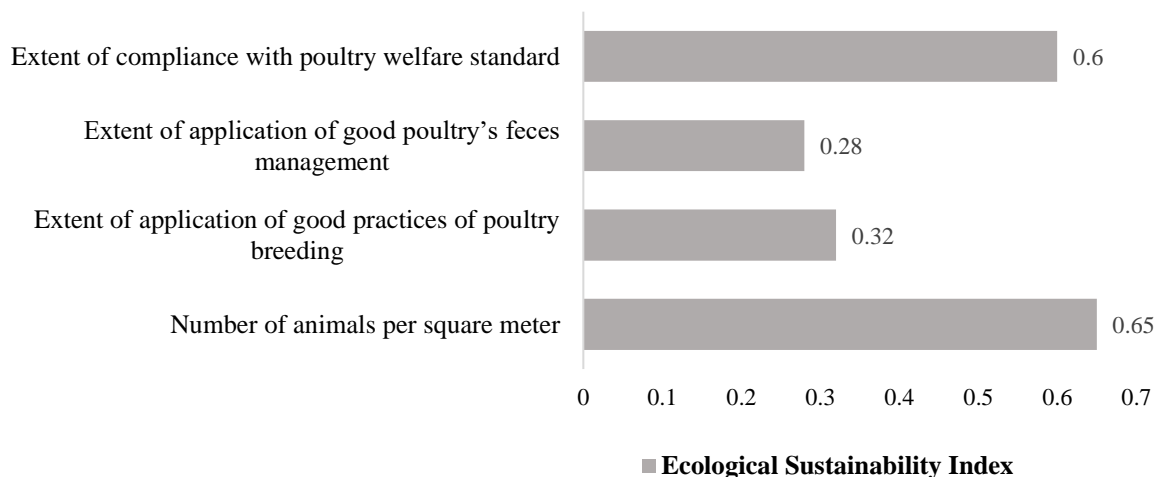


Figure 5: Ecological Sustainability Index

Table 9: Global Sustainability Index of CPEs in Southern Benin

Indicators	Indices
Economic Sustainability Index	0.64
Social Sustainability Index	0.51
Ecological Sustainability Index	0.46
Global Sustainability Index	0.53

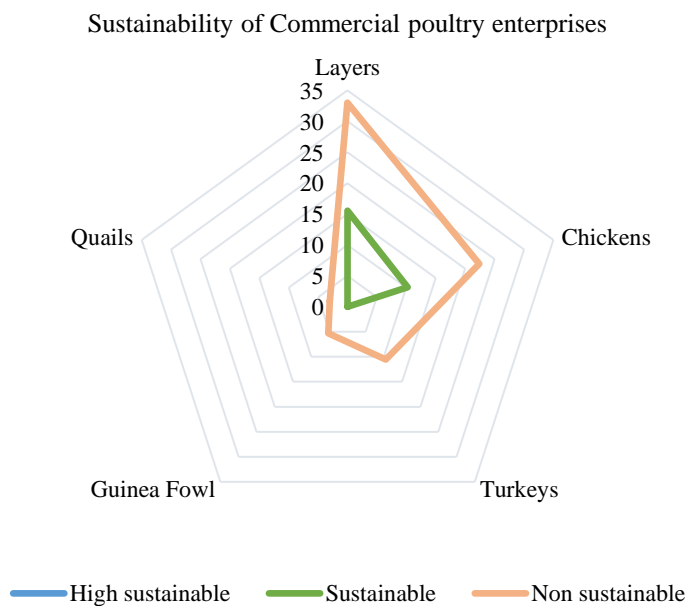


Figure 6: Global Sustainability of commercial poultry enterprises

Table 10: Logistic Regression Results : Determinants of CPE Sustainability

Variable	Model 1		Model 2	
	Estimate S.E	Odds Ratio (95% CI)	Estimate S.E	Odds Ratio (95% CI)
WorkCond_Comply	1.437*** (0.412)	4.21 (1.88-9.44)	1.389*** (0.421)	4.01 (1.76-9.14)
ManureManage	1.353*** (0.399)	3.87 (1.77-8.47)	1.312*** (0.408)	3.71 (1.67-8.24)
Species_Div	0.971** (0.387)	2.64 (1.24-5.63)	0.948** (0.393)	2.58 (1.20-5.56)
CreditAccess	0.779** (0.341)	2.18 (1.12-4.25)	0.741* (0.349)	2.10 (1.06-4.16)
Formalization	0.693** (0.319)	2.00 (1.07-3.74)	0.661** (0.327)	1.94 (1.02-3.68)
Assoc_Memb	0.531* (0.298)	1.70 (0.95-3.05)	0.514* (0.303)	1.67 (0.92-3.03)
Training	0.441 (0.287)	1.55 (0.88-2.73)	0.428 (0.291)	1.53 (0.87-2.71)
Experience	0.038 (0.031)	1.04 (0.98-1.10)	0.036 (0.032)	1.04 (0.97-1.10)
Constant	-3.241 (0.731)	-	0.347 (0.463)	-
Observations		264		264
Nagelkerke R ² (χ^2)		0.47*		0.49
Hosmer-Lemeshow		7.21		7.43
AIC		1,084		1,072
Fixed Effects		No		Yes
Likelihood Ratio			0.041*	

*** p < 0.001; ** p < 0.01; * p < 0.05

S.E. : Robust Standard Error

Appendix

Appendix 1: Principles, criteria, indicators, and reference values for assessing the sustainability of commercial poultry enterprises in Benin.

Principles	Criteria	Indicators	Reference values
	Economic dimension		
High economic Efficiency	Economic efficiency of resource utilization	Livestock productivity	Reasonable for the owner
	Economic efficiency of activity	Profitability	Reasonable for the owner
Good financial stability		Turnover	Reasonable for the owner
		Return on own capital	Reasonable for the owner
		Overall liquidity	Reasonable for the owner

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	Financial capability	Financial autonomy	Reasonable for the owner
Social dimension			
Good social efficiency for Farmer and farmer households	Farmers welfare	Income per household member of the poultry enterprise owner	Reasonable for the owner
	Working conditions	Compliance with formal requirements for working conditions	Reasonable for the owner Standards for working conditions in the sector
Acceptable social efficiency for not farmers	Preservation of rural communities	Extent to which the poultry enterprise contributes to Preservation rural communities	Global contribution
	Preservation of traditions	Extent to which the poultry enterprise contributes to Preservation of traditions	Global contribution
Ecological dimension			
Protection of agricultural lands		Number of animals per surface	within limits of acceptable number for each poultry species
	Breeding technique	Extent of application of good practices of poultry breeding	Same with the approved rules in the sector
Animal welfare	Feces management	Extent of application of good poultry's feces management	Same with the approved rules in the sector
	Norms for animal welfare	Extent of compliance with poultry welfare standard	Standard for animal breeding

Source: Author, adapted from Bachev (2016)

Appendix 2: Levels of sustainability with the ranges of reference values

Indicators	References Values (RV)	Levels of sustainability				Non sustainable
		High	Good	Low	Insufficient	
Livestock productivity	Same with the average for the sector	> rv	=rv	< rv	<< rv	<<< rv
Profitability	Same with the average for the sector	> rv	= rv	< rv	<< rv	<<< rv
Turnover	Reasonable for the owner	> rv	= rv	< rv	<< rv	<<< rv
Return on own capital	Mean in the sector	> rv	= rv	< rv	<< rv	<<< rv
Overall liquidity	Mean in the sector	> rv	= rv	< rv	<< rv	<<< rv
Financial autonomy	Mean in the sector	> rv	= rv	< rv	<< rv	<<< rv
Income per household member of the poultry enterprise owner	Same with other sectors in the region	> rv	= rv	< rv	<< rv	<<< rv
Job Satisfaction	Reasonable for the farmer	> rv	= rv	< rv	<< rv	<<< rv
Compliance with formal requirements for working conditions	Standards for working conditions in the sector	> rv	= rv	< rv	<< rv	<<< rv
Contribution to preservation rural communities	Global contribution	> rv	= rv	< rv	<< rv	<<< rv
Contribution to	Global contribution	> rv	= rv	< rv	<< rv	<<< rv

preservation of traditions						
Number of animals per surface	Within limits of acceptable number	= rv	> rv <	>>rv <<	>>> rv <<<	>>>> rv <<<<
Application of good practices of poultry breeding	Approved methods	= rv	> rv <	>> rv <<	>>> rv <<<	>>>> rv <<<<
Application of good poultry's feces management	Approved manure storage methods	= rv	> rv <	>> rv <<	>>> rv <<<	>>>> rv <<<<
Compliance with poultry welfare standard	Standards approved for animal breeding	> rv	= rv	< rv	<< rv	<<< rv

*rv: Reference Value

Source: Author, adapted from Bachev (2016)