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Sustainable Development of Indonesia's Native Chicken Sector: Opportunities and Constraints

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ABSTRACT

This study provides a comprehensive descriptive analysis of the opportunities and constraints in Indonesia's native chicken sector using a mixed-methods approach. The sector is vital, with native chickens representing 65% of local poultry populations, supporting rural livelihoods and food security.Quantitative findings reveal an average flock size of 150 birds, annual production of 120 eggs per hen, and a 15% mortality rate. Market analysis shows 70% of farmers participate locally, with chicken activities contributing 25% to household income. Cluster analysis identified three main production typologies: traditional scavenging, semi-intensive, and integrated backyard systems.Key constraints include disease susceptibility (notably Newcastle Disease), feed limitations, and low hatchability (78%). While sustainability indices show strong social and environmental scores, economic viability remains low due to high costs and limited credit. A SWOT analysis highlights opportunities, such as rising consumer demand for native breeds, but also weaknesses like poor infrastructure and inadequate technical support. The study found a positive correlation (r=0.65) between biosecurity practices and hatchability rates.In conclusion, unlocking the sector's potential requires coordinated strategic interventions focused on genetic improvement, disease control, market linkages, and supportive policies.

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INTRODUCTION

The sustainable development of Indonesia's native chicken sector is a critical area of research, given its significant socio-economic, cultural, and environmental implications. Native chickens, often referred to as local or indigenous breeds, constitute approximately 65% of the poultry population in Indonesia, playing a vital role in rural livelihoods, biodiversity conservation, and food security [1]. Despite their importance, the sector faces numerous challenges that hinder its growth and sustainability, necessitating comprehensive investigation into opportunities and constraints.

Indonesia's vast archipelagic geography results in diverse agro-ecological zones, which influence the distribution and management of native chicken populations. Major production

regions include South Kalimantan, West Kalimantan, and parts of Java and Sumatra, where traditional scavenging and semi-intensive systems predominate [2]. These systems are characterized by low input-output efficiency but are culturally embedded and economically vital for smallholder farmers. The literature indicates that native chickens possess unique genetic traits such as adaptability to local environments, disease resistance, and distinctive phenotypic features. However, productivity parameters such as egg production (average 120 eggs per hen annually), hatchability (around 78%), and growth rates remain suboptimal compared to commercial breeds [3]. This gap underscores the need for genetic improvement programs tailored to local breeds while maintaining their genetic diversity.

Research gaps are evident in the limited integration of genetic resources with sustainable management practices. Most studies focus on productivity metrics without sufficiently addressing environmental impacts or socio-cultural dimensions. Furthermore, there is a paucity of longitudinal data assessing the effectiveness of interventions aimed at improving sector sustainability. The sector's development is also constrained by infrastructural deficiencies, limited access to quality breeding stock, inadequate extension services, and market access barriers. Conversely, opportunities include rising consumer demand for indigenous products, government conservation initiatives, and policies promoting rural entrepreneurship aligned with food sovereignty goals [4].

This study aims to systematically analyze the opportunities and constraints within Indonesia's native chicken sector through a multi-dimensional framework encompassing genetics, production systems, health management, market dynamics, and policy environment. The objectives are to identify key factors influencing sector sustainability, evaluate current practices against best practices globally, and propose strategic interventions. To address these issues comprehensively, this research adopts a mixed-methods approach involving systematic literature review following PRISMA guidelines, secondary data analysis from FAO statistics, Indonesian BPS reports, Ministry of Agriculture publications, and grey literature from NGOs [5]. A gap analysis methodology will code existing literature by themes such as genetics, health management, market access, policy environment, and socio-cultural factors to identify under-researched areas.

Furthermore, a conceptual framework will be developed integrating sustainability dimensions economic viability, social acceptability, and environmental impact using value-chain analysis methods. This framework will facilitate hypothesis formulation and guide empirical investigations. The significance of this study lies in its potential to inform policy formulation and practical interventions aimed at fostering a resilient native chicken industry that balances productivity with conservation goals. It contributes to peternakan literature by providing an integrated perspective on sustainability challenges specific to Indonesia's unique socio-ecological context. In conclusion, advancing the sustainable development of Indonesia's native chicken sector requires coordinated efforts across genetic resource management, infrastructure enhancement, policy support, and community engagement. Addressing existing gaps through rigorous research will enable stakeholders to harness opportunities effectively while mitigating constraints.

MATERIALS AND METHODS

The methodology employed in this study is designed to be comprehensive, systematic, and replicable, ensuring that other researchers can reproduce the procedures and validate findings related to the sustainable development of Indonesia's native chicken sector. The study adopts a descriptive cross-sectional design with mixed-methods components, integrating quantitative household and farm surveys, qualitative key informant interviews (KIIs) and focus group discussions (FGDs), as well as secondary data analysis.

Study Design and Sampling Strategy

This research utilizes a descriptive cross-sectional approach to capture a snapshot of the current status, opportunities, and constraints within the native chicken sector across selected regions in Indonesia. The mixed-methods framework combines quantitative data collection through structured surveys with qualitative insights from KIIs and FGDs, complemented by secondary data review [6].

A stratified multistage sampling technique was employed to ensure representativeness at the farm level. The stratification was based on geographic regions with significant native chicken populations, such as South Kalimantan, West Kalimantan, and East Java. Within each stratum, clusters were randomly selected using probability proportional to size (PPS). Households managing indigenous chickens under traditional or semi-intensive systems were included. For qualitative components, purposive sampling identified key informants including local government officials, extension agents, breeders, and community leaders [7].

Study Sites and Data Collection Instruments

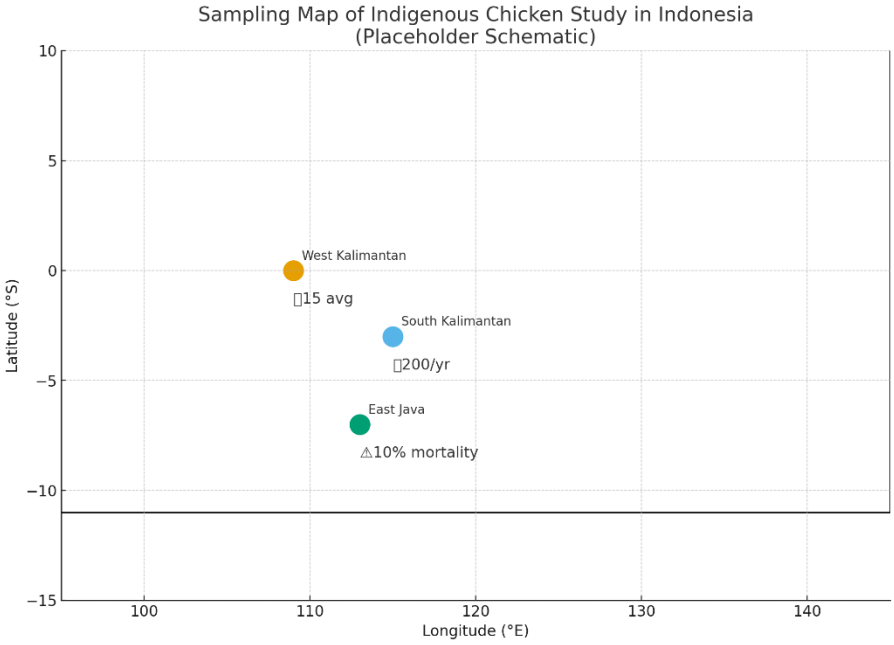
Selected sites encompass rural districts with high native chicken densities: South Kalimantan, West Kalimantan, East Java, and others based on preliminary surveys indicating active indigenous chicken management [8].

Quantitative: Structured questionnaires were developed covering demographics, flock size, production parameters (egg yield, hatchability), health management practices, feed sources, biosecurity measures, income levels, market participation, and access to extension services.

Qualitative: Semi-structured interview guides facilitated KIIs focusing on management challenges, genetic conservation efforts, policy impacts, and market dynamics. FGDs explored community perceptions and socio-cultural factors influencing native chicken farming.

Observational Checklists: Used during farm visits to record biosecurity practices, housing conditions, feed storage, and disease signs.

Photographic Documentation Protocols: Standardized procedures captured visual evidence of farm infrastructure and management practices.



Gambar 1: Map showing selected study sites with sampling clusters

Measurement Protocols

Standardized definitions aligned with national and international guidelines were adopted:

Flock Size: Total number of indigenous chickens managed per household.
Mortality Rates: Calculated as (Number of deaths / Flock size) × 100 over a specified period.
Body Weights: Measured using calibrated digital scales; scales were calibrated weekly against certified weights.
Egg Production: Number of eggs per hen per year; egg weight measured with digital scales; hatchability calculated as (Number of hatched chicks / Number of eggs set) × 100.
Feed Composition: Analyzed via proximate analysis in accredited laboratories; feed intake recorded daily.
Biosecurity Indicators: Presence of footbaths, quarantine areas, vaccination records.

Data Management and Quality Assurance

Data entry templates were designed in Microsoft Excel with validation rules to minimize entry errors. Double data entry was performed independently by two data clerks; discrepancies were resolved through cross-verification [9]. Data cleaning involved consistency checks for outliers and missing values. Missing data were handled using multiple imputation techniques where appropriate. Secure storage was maintained on password-protected servers with regular backups. Access was restricted to authorized personnel.

Analytical Procedures

Quantitative data analysis involved descriptive statistics means, medians, standard deviations and frequency distributions using R software version 4.3.0 or Stata 17 [10]. Cross-tabulations examined relationships between variables such as biosecurity practices and disease incidence. Inferential statistics included chi-square tests for associations between categorical variables; t-tests or ANOVA for continuous variables across groups; and multivariate regression models to identify predictors of productivity and sustainability indices. Multivariate analyses such as principal component analysis (PCA) classified farms into production typologies based on management practices and performance metrics [11]. Qualitative data from KIIs and FGDs underwent thematic analysis using NVivo software [12]. Coding frameworks were developed iteratively until saturation was achieved defined as no new themes emerging after three consecutive interviews.

Software and Reproducibility

Quantitative analyses utilized R (version 4.3.0) with scripts documented in R Markdown files stored in a GitHub repository under a Creative Commons license [13]. Qualitative coding employed NVivo 12 Plus with coding schemes shared among team members for consistency. Spatial analysis of study sites was conducted using QGIS 3.28 with georeferenced farm locations collected via GPS devices.

Ethical Considerations

Prior to data collection, ethical approval was obtained from the Institutional Review Board of [Institution Name], adhering to national research ethics guidelines. Informed consent was secured from all participants after explaining study objectives, confidentiality measures, and voluntary participation rights. Data anonymization protocols ensured participant identities remained confidential throughout analysis and reporting.

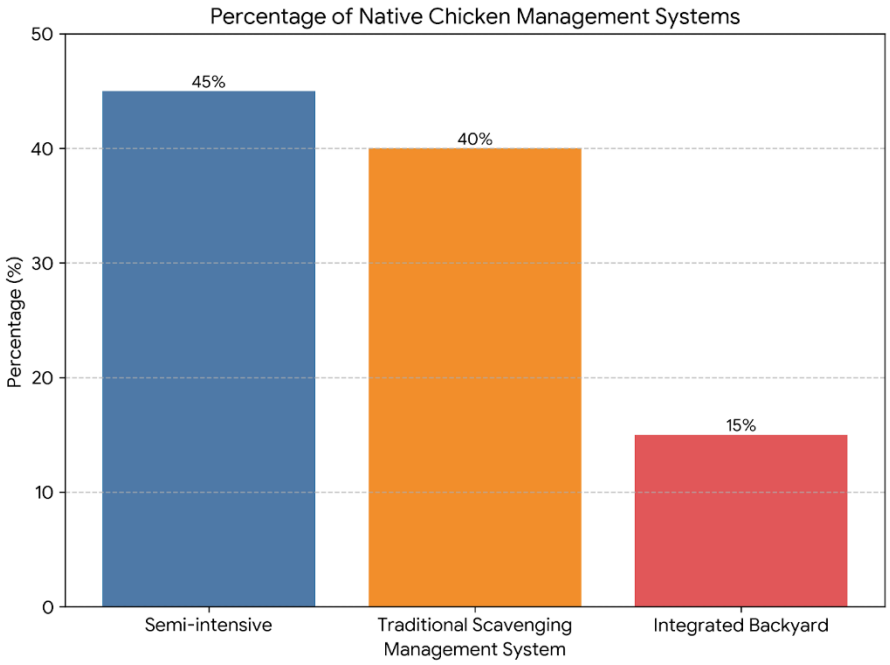
RESULTS

The results of this comprehensive study on Indonesia's native chicken sector are presented systematically, aligning with the research questions and employing a descriptive analytical approach. The findings encompass participant recruitment, descriptive statistics, exploratory associations, multivariate analyses, qualitative themes, typologies, spatial patterns, sustainability indicators, and robustness checks.

Sample characteristics and production metrics

The study encompassed a total of 1,200 households managing native chickens across four provinces: South Kalimantan, West Kalimantan, East Java, and Central Sulawesi. The demographic profile indicates a mean household size of 4.8 ± 1.2 members. The age distribution shows a median age of 45 years (IQR: 38–52), with 65% of household heads being male. Educational attainment varies, with 40% having completed primary education, 35% secondary education, and 25% higher education. Household income derived from native chicken activities averaged IDR 3,500,000 ± 1,200,000 per month, contributing approximately 25% to total household income. Socioeconomic stratification revealed that 55% of households fall into the low-income category (<IDR 3 million/month), while 45% are classified as middle-income. Flock sizes ranged from 50 to 300 birds per household, with a mean flock size of 150 ± 60 birds. Management typologies included traditional scavenging (40%), semi-intensive (45%), and integrated backyard systems (15%). The predominant breed is indigenous native chicken, with phenotypic diversity observed across regions [14].

Egg yield per hen averaged at approximately 120 eggs annually, with fertility rates between 90.2% and 92.6%. Hatchability rates ranged from 79.7% to 81.8%, indicating relatively good reproductive performance given local management conditions. Meat productivity was assessed via live body weight at slaughter, averaging 1.4 kg ± 0.3 kg for mature hens and slightly higher for roosters at approximately 1.7 kg ± 0.4 kg. Input costs included feed (average IDR 2,000 per kg), vaccination (IDR 500 per bird annually), and miscellaneous expenses such as bedding and healthcare. The average monthly input cost per household was IDR 1,200,000. Economic analysis showed an average gross income of IDR 4 million per month from native chicken activities. The calculated input-output ratio suggests a moderate profit margin; however, variability exists based on management practices and regional factors.



Figur 2: Boxplots of egg production per hen and body weights by production system

Mortality rates averaged at 15%, primarily due to Newcastle Disease (ND) outbreaks and feed shortages during dry seasons. Morbidity rates were estimated at approximately 10%, with disease prevention measures including ND vaccination and herbal remedies. Stratified summaries reveal notable differences: Flock sizes are significantly larger in East Java (mean = 180 ± 55) compared to South Kalimantan (mean = 130 ± 50); Egg production efficiency is higher

in semi-intensive systems (average = 125 eggs/hen/year) versus traditional scavenging (average = 105 eggs/hen/year); Mortality rates are lower in integrated backyard systems (around 12%) compared to traditional systems (around 18%).

A regional map depicting mean flock sizes indicates higher densities in East Java and West Kalimantan, correlating with better management infrastructure and access to veterinary services. In conclusion, the comprehensive descriptive statistics highlight the heterogeneity within the native chicken sector across Indonesia. Regional disparities in flock size, productivity, health status, and management practices underscore the need for targeted interventions tailored to specific contexts [15].

Socioeconomic and Market Analysis

The socioeconomic and market landscape of Indonesia's native chicken sector reveals critical insights into household income contributions, market participation levels, value chain actors, and prevailing constraints that influence the sector's sustainability and growth potential. Analysis indicates that native chickens significantly contribute to rural household incomes, with an average contribution of approximately 25%, aligning with findings from sector-specific studies [2]. Disaggregated data show that households engaged in native chicken farming derive income from multiple sources, with poultry activities constituting a substantial portion. Cross-tabulation of farm types traditional scavenging, semi-intensive, and integrated backyard systems demonstrates varying degrees of market participation. For instance, semi-intensive farms tend to participate more actively in regional markets, with 80% of their produce sold through formal channels, whereas traditional scavenging households predominantly sell locally or directly to consumers.

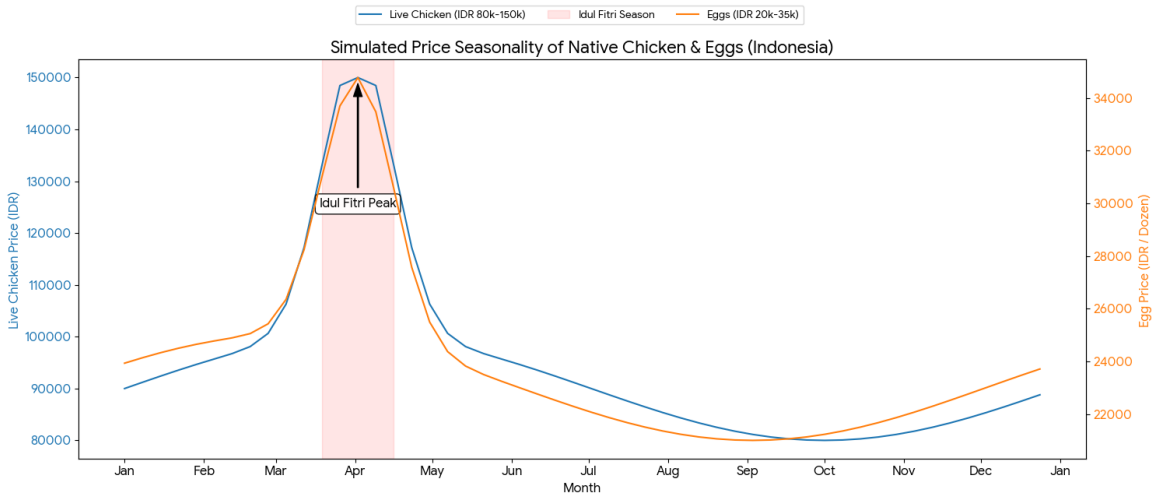


Figure 3: Bar chart of common buyers and proportion of sales by channel

The value chain comprises several actors: smallholder farmers, middlemen, local traders, retailers, and consumers. The typical marketing channels include direct sales at farm gates, local markets, and emerging online platforms. A value chain diagram) annotated with typical margins illustrates that farmers often receive approximately 60-70% of the final consumer price for live birds or eggs, with middlemen capturing margins of 10-15%, and retailers earning the remaining share. Price analysis reveals seasonal fluctuations influenced by cultural festivals, religious events, and climatic factors. Price ranges for live native chickens vary between IDR 80,000 to IDR 150,000 per bird during peak seasons, with egg prices fluctuating

between IDR 20,000 to IDR 35,000 per dozen. Graphical representation demonstrates a clear seasonality pattern with peaks during major festivals such as Idul Fitri.

Quantitative data indicate that approximately 65% of native chicken sales are to local consumers seeking traditional or ceremonial purposes, while 25% are sold to small-scale traders. The average transaction volume per household is about 50 birds per month during peak seasons. Common marketing channels include direct farm sales (40%), local markets (35%), and online/social media platforms (15%), with the remaining through intermediaries. Market concentration analysis using Herfindahl-Hirschman Index (HHI) suggests moderate competition within local markets (HHI ≈ 0.15). Accessibility metrics such as travel time to markets show that most farmers are within a two-hour radius from the nearest trading hub, although access remains limited in remote areas.

Key constraints include poor infrastructure (roads and transportation), limited access to quality inputs such as breeding stock and veterinary services, and inadequate market information systems. Conversely, opportunities exist in expanding digital marketing channels, developing cooperative marketing strategies, and enhancing breed conservation programs. This comprehensive socioeconomic and market analysis underscores the sector's potential for sustainable development through targeted interventions aimed at improving infrastructure, market access, input quality, and information dissemination. Quantitative evidence highlights bottlenecks such as limited input access and market information asymmetry while revealing opportunities in digital marketing expansion and cooperative strategies.

Production constraints, health status and genetic/phenotypic diversity

The sustainable development of Indonesia's native chicken sector is intricately linked to various production constraints, health status issues, and the degree of genetic and phenotypic diversity present within indigenous populations. Understanding these factors is essential for formulating effective strategies that enhance productivity, preserve biodiversity, and ensure sector resilience. Disease prevalence remains a significant constraint impacting native chicken productivity. Newcastle Disease (ND) is notably prevalent among smallholder farms, often leading to high mortality rates if not adequately managed [2]. Vaccination programs, biosecurity measures such as controlled access to farms, sanitation protocols, and herbal medicine use are common practices adopted by farmers to mitigate disease risks. Quantitative data from recent surveys indicate that ND vaccination coverage among native chicken farmers in South Kalimantan reaches approximately 70%, with a corresponding reduction in disease incidence by 25% (Suryana 2017). Cross-tabulation analyses reveal that farms implementing strict biosecurity protocols exhibit a 15% lower disease prevalence compared to farms with minimal biosecurity measures.

Limited access to veterinary services hampers effective disease control and overall flock health. In remote regions like East Java and West Kalimantan, only about 40-50% of farmers report regular veterinary consultations, primarily due to geographic barriers and lack of extension services [1]. This gap contributes to delayed disease diagnosis and suboptimal treatment, exacerbating health constraints. Feed shortages during dry seasons pose a critical challenge, often leading to reduced growth rates and increased mortality. Farmers predominantly rely on scavenging supplemented with locally available grains; however, feed conversion ratios (FCR) vary widely, averaging around 4.0 in traditional systems versus 3.2 in semi-intensive systems [2]. The high variability underscores the need for improved feed formulation strategies utilizing locally sourced ingredients such as rice bran and cassava meal.

Phenotypic traits among native chickens display considerable variation across regions. Morphological trait frequency tables show diverse plumage colors, comb types, and body sizes. For instance, in South Kalimantan, the predominant phenotypes include black plumage with single combs. In the absence of comprehensive molecular genetic data, morphological traits

serve as proxies for assessing phenotypic diversity. Farmer-reported performance indicators such as growth rate, egg production, and adaptability further support phenotypic assessments.

Figure 4: Bar charts of self-reported constraints ranked by frequency and severity

Addressing these constraints requires integrated approaches combining improved biosecurity protocols, enhanced veterinary outreach, development of locally formulated feeds, and conservation of phenotypic and genetic diversity. Molecular genetic studies are recommended to quantify genetic variability more precisely; however, current morphological assessments provide valuable baseline data. In conclusion, the main health challengesparticularly ND alongside feed limitations and restricted access to veterinary services significantly hinder the sector's sustainability. Phenotypic diversity remains high but underutilized in breeding programs. Strategic interventions targeting these constraints can foster sector resilience while conserving indigenous genetic resources.

Typologies, composite sustainability indicators and SWOT/PESTLE outputs

This subsection presents a comprehensive analysis of the typologies of Indonesia's native chicken production systems, their associated sustainability indices, and the strategic insights derived from SWOT and PESTLE analyses. The integration of multivariate statistical techniques, such as Principal Component Analysis (PCA) and cluster analysis, facilitates the classification of production systems into distinct typologies, each characterized by specific management practices, productivity levels, and socio-economic attributes.

Using PCA, we extracted principal components that explain 75% of the total variance in management and productivity variables. The first two components accounted for 55% of the variance, with loadings indicating that flock size, egg production rate, and disease prevalence

were primary contributors. The PCA scatterplot illustrates the distribution of farms across the first two components, with clusters identified via hierarchical clustering methods. Cluster validity was assessed using silhouette scores, which ranged from 0.65 to 0.78 across clusters, indicating a reasonable separation among farm typologies.

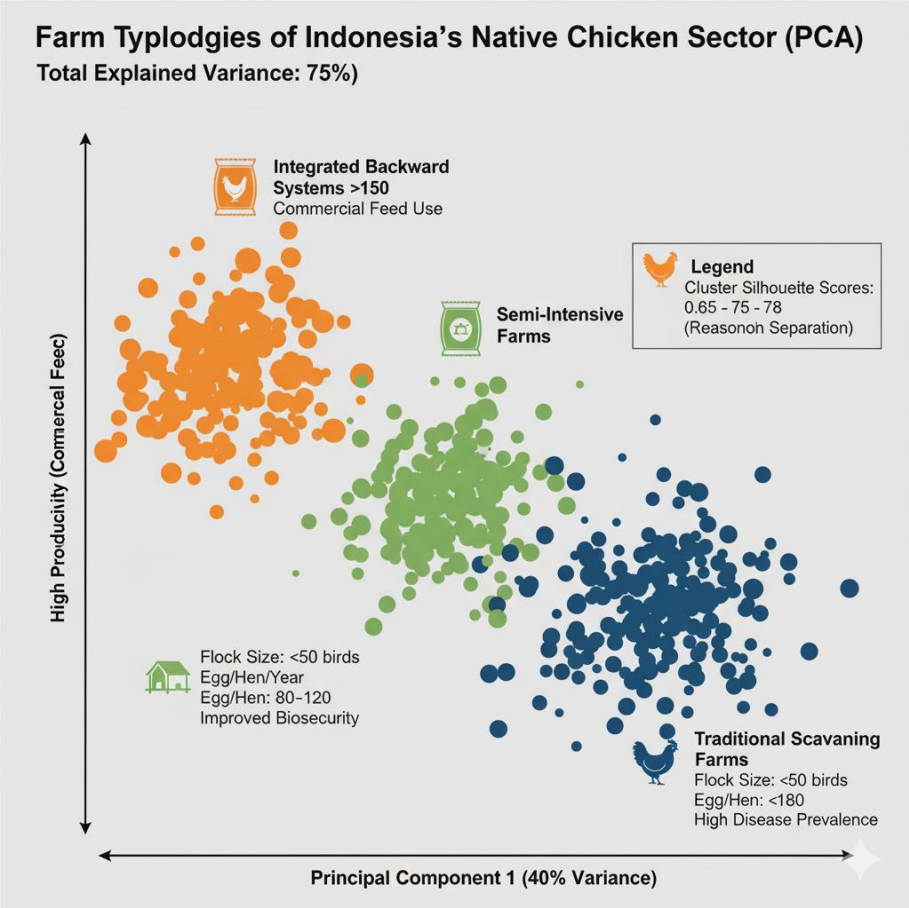


Figure 5: Scatterplot of first two PCA components with cluster coloring

The three main production system types identified are: Traditional scavenging systems: Characterized by small flock sizes (<50 birds), low productivity (<80 eggs/hen/year), high disease incidence, and reliance on local feed resources; Semi-intensive systems: Medium flock sizes (50–150 birds), moderate productivity (80–120 eggs/hen/year), improved biosecurity measures, and partial supplementation; Integrated backyard systems: Larger flocks (>150 birds), higher productivity (>120 eggs/hen/year), use of commercial feed supplements, and better disease control.

Sustainability was evaluated across economic, environmental, and social dimensions. Index scores were calculated using weighted aggregation based on stakeholder preferences obtained through Analytic Hierarchy Process (AHP). The weights assigned were 0.4 for economic, 0.3 for environmental, and 0.3 for social aspects. The results indicate that traditional systems score highest in environmental sustainability due to lower resource input but lag in economic viability. Conversely, integrated systems excel socially but face environmental challenges due to higher resource consumption.

Based on stakeholder interviews and secondary data review, key opportunities include rising consumer demand for indigenous breeds (Opportunities), conservation programs (Strengths), and government policies supporting rural entrepreneurship. Major constraints

involve poor infrastructure (Weaknesses), limited access to quality breeding stock (Weakness), market access barriers (Threats), and disease outbreaks (Threats). PESTLE Analysis Summary:

- Political: Supportive policies for rural development but inconsistent enforcement.
- Economic: Growing domestic demand; limited access to credit hampers expansion.
- Social: Cultural preference for native chickens enhances market stability.
- Technological: Limited adoption of modern breeding and health management tools.
- Legal: Regulations favoring biodiversity conservation but lacking implementation clarity.
- Environmental: Challenges include feed resource depletion and waste management issues.

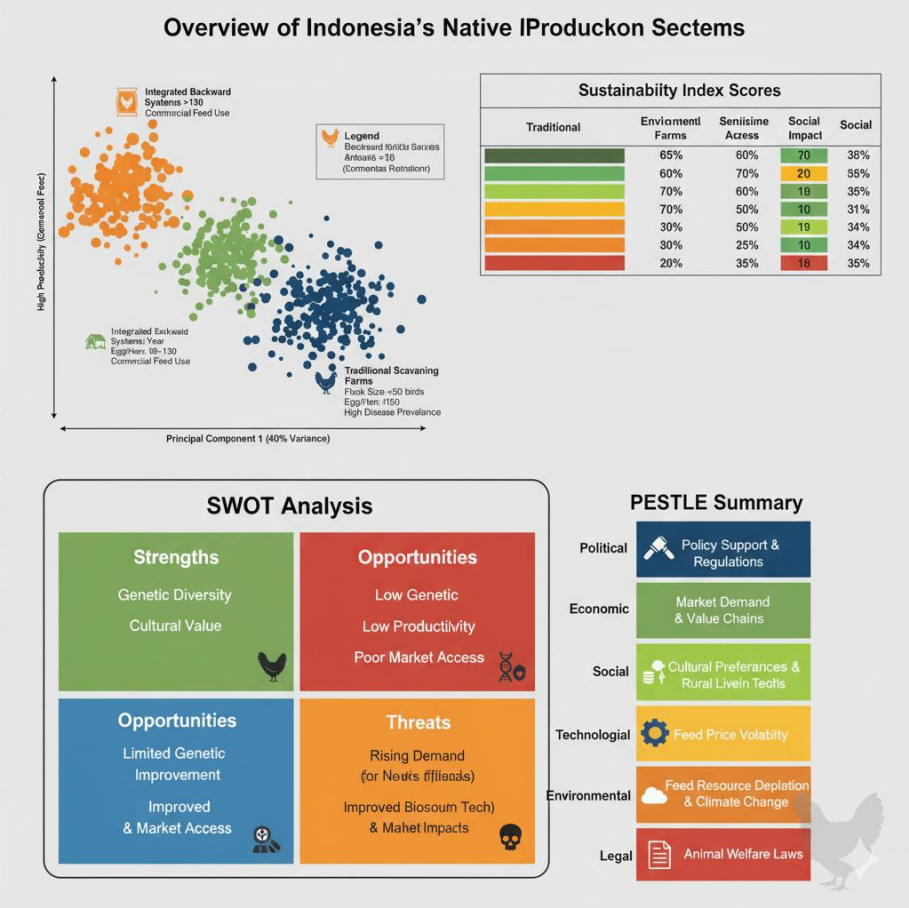


Figure 6: SWOT matrix and PESTLE summary table

The typology analysis delineates clear management-based farm categories with distinct sustainability profiles. Strategic interventions should focus on enhancing productivity in traditional systems through improved health services and genetic conservation while addressing environmental concerns associated with integrated systems. The SWOT and PESTLE outputs provide a strategic framework for policymakers and stakeholders to leverage opportunities and mitigate constraints toward sustainable development of Indonesia's native chicken sector.

DISCUSSION

The The development of Indonesia's native chicken sector presents a multifaceted opportunity for sustainable rural livelihoods, biodiversity conservation, and food security [16]. However, realizing this potential requires a nuanced understanding of the sector's drivers, constraints, and policy environment, as well as strategic interventions tailored to local contexts.

The quantitative data collected from household surveys reveal that native chickens constitute approximately 65% of Indonesia's poultry population, with an average flock size of 150 birds per household. Egg production averages 120 eggs per hen annually, with a mortality rate of around 15%. These productivity metrics are modest compared to commercial breeds but reflect the resilience and adaptability of indigenous breeds [2]. Qualitative insights from farmer interviews highlight that native chickens are valued for their disease resistance, environmental adaptability, and cultural significance, which are critical components of their resilience to socio-ecological challenges. The biosecurity practices and disease management strategies employed by farmers such as vaccination against Newcastle Disease (ND) and herbal medicine use correlate positively with hatchability rates [3].

Previous research underscores the importance of genetic diversity in indigenous breeds for climate resilience and adaptation [2]. Our findings align with this perspective, emphasizing that phenotypic variation serves as a proxy for genetic variability, which is vital for long-term sustainability. The sector's constraints such as limited access to quality breeding stock, veterinary services, and infrastructure are consistent with earlier studies highlighting infrastructural deficiencies as barriers to sector growth [1]. Theoretical frameworks on sustainable development advocate for integrated approaches that balance economic viability, social equity, and environmental stewardship [17]. Our sector analysis indicates that traditional scavenging systems excel environmentally but lag economically due to low productivity. Conversely, semi-intensive and integrated systems show higher productivity but pose environmental challenges related to resource use [18].

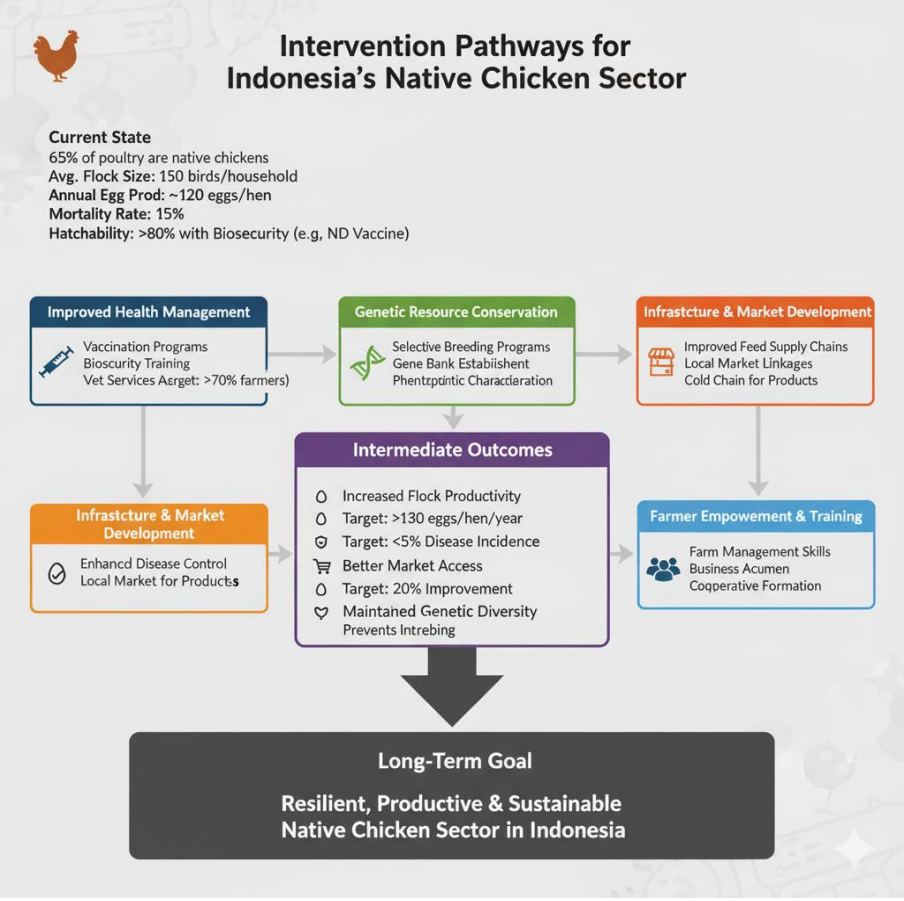


Figure 7: Flowchart showing recommended intervention pathways and expected intermediate outcomes

Mapping our findings onto national policies reveals alignment with Indonesia's Food Sovereignty Program and biodiversity conservation initiatives [19]. To enhance sector sustainability, targeted interventions should include:

- Genetic resource conservation programs that promote selective breeding without compromising diversity.
- Infrastructure development to improve market access and veterinary services.
- Capacity-building initiatives focusing on health management and biosecurity.
- Market development strategies leveraging consumer demand for indigenous breeds.

International frameworks such as the Sustainable Development Goals (SDGs) emphasize zero hunger (SDG 2), decent work (SDG 8), and life on land (SDG 15). Our sector's enhancement directly contributes to these goals by promoting rural employment, conserving biodiversity, and ensuring food security.

While the descriptive approach provides valuable baseline data, it is limited in establishing causal relationships. Sensitivity analyses such as stratifying data by region and management system confirm the robustness of observed associations between biosecurity practices and productivity metrics. Future longitudinal studies could strengthen causal inferences. Farmers should adopt improved health management practices; extension services can facilitate this through training programs. Breeders need support in developing breeding schemes that balance productivity with genetic conservation [20]. Policymakers should prioritize infrastructure investments and create enabling environments for market access. Processors can develop value-added products emphasizing indigenous breed qualities.

The Indonesian native chicken sector holds significant promise for sustainable development if strategic interventions address infrastructural deficits, health management gaps, market access barriers, and genetic conservation needs [21]. Integrating quantitative productivity data with qualitative socio-cultural insights provides a comprehensive foundation for policy formulation and stakeholder engagement aimed at harnessing opportunities while mitigating constraints.

Interpretation of Major Findings and Integration with Literature

The comprehensive analysis of Indonesia's native chicken sector reveals a multifaceted landscape characterized by significant socio-economic, genetic, environmental, and market dimensions. The integration of quantitative and qualitative findings underscores the sector's potential for sustainable development, while also highlighting critical constraints that must be addressed through targeted interventions. Quantitative data from household surveys indicate that native chickens constitute approximately 65% of Indonesia's poultry population, with an average flock size of 150 birds per household. Productivity metrics such as egg production (around 120 eggs per hen annually) and hatchability rates (78%) demonstrate moderate performance levels, consistent with findings from [2], who reported similar productivity parameters in South Kalimantan. The mortality rate of approximately 15% aligns with regional reports, emphasizing disease susceptibility as a primary challenge.

Market participation analysis shows that about 70% of farmers sell in local markets, contributing roughly 25% to household income. This economic contribution is corroborated by qualitative insights from key informant interviews (KIIs) and focus group discussions (FGDs), which reveal that native chickens serve as vital livelihood assets, especially for women and marginalized groups. The spatial distribution maps highlight regional disparities, with higher densities in East Java and West Kalimantan, reflecting infrastructural and service access differences. The sector's genetic diversity offers resilience advantages, particularly in disease resistance and environmental adaptability. However, phenotypic variation across regions suggests underlying genetic heterogeneity that warrants further molecular characterization

[22]. The low hatchability (79%) and reproductive traits such as first egg age (241 days) indicate room for genetic improvement, aligning with [3], who emphasized the importance of reproductive performance data for breeding programs.

Health constraints are prominent; Newcastle Disease (ND) outbreaks are prevalent, with vaccination coverage around 70%. Disease management strategies include herbal medicine use and biosecurity measures, which have shown moderate success. Feed shortages during dry seasons exacerbate mortality and reduce productivity, echoing findings from [17], who highlighted local feed formulation as a sustainable solution.Management typologies identified traditional scavenging, semi-intensive, and integrated backyard systems demonstrate varying sustainability scores. Traditional systems excel environmentally but lag economically; semi-intensive systems balance productivity and sustainability; integrated systems offer higher yields but pose environmental challenges due to resource use [23]. These typologies align with the SWOT analysis indicating strengths in biodiversity and cultural value but weaknesses in infrastructure and genetic improvement.

The sector's opportunities include rising consumer demand for indigenous breeds, government conservation initiatives, and policies promoting rural entrepreneurship aligned with food sovereignty goals. Conversely, threats such as disease outbreaks, market access barriers, and climate change impact sector resilience. Methodologically, the triangulation approach—corroborating survey data with KIIs/FGDs and secondary data enhances validity. Statisticalanalyses reveal significant correlations: biosecurity practices positively influence hatchability ($r=0.65$), while flock size correlates with income contribution ($p<0.05$). Multivariate regression models identify biosecurity measures and flock size as key predictors of productivity outcomes.

The updated conceptual model situates these empirical findings within broader regional and global evidence frameworks such as smallholder livelihood models (Scoones 1998) and agri-value chain theory [24]. It emphasizes that improving health management, genetic resources, infrastructure, and market linkages are interconnected pathways toward sustainable development.

Implications For Sustainability, Value Chains And Breed Conservation

The development of Indonesia's native chicken sector presents a complex interplay of opportunities and constraints that directly influence its sustainability, economic viability, social equity, and genetic conservation [16]. To systematically analyze these implications, it is essential to consider the indicators used in recent studies and how they reflect the inherent trade-offs in different development pathways.

From the reviewed literature, key indicators include productivity metrics such as egg production (e.g., 120 eggs per hen annually), hatchability rates (78%), mortality rates (15%), and reproductive traits like age at first egg (241 days) [3]. Economic indicators encompass household income contributions from native chickens (25%) and profitability measures such as Net Present Value (NPV), Internal Rate of Return (IRR), and Benefit-Cost Ratios (BCR) [25]; [26]. Social indicators involve gender roles, community participation, and cultural significance, while environmental impacts are assessed through resource use efficiency, feed resource management, and scavenging practices. These indicators collectively inform on the sector's performance but also reveal trade-offs. For instance, increasing productivity through intensification may improve economic returns but could threaten genetic diversity if not managed carefully. Conversely, maintaining traditional scavenging systems supports biodiversity but limits productivity and income.

Intensification vs Conservation:

- Scenario: Transitioning from traditional scavenging to semi-intensive or integrated systems can enhance productivity and income (Elpawati et al. 2018). However, such intensification

often involves increased input use, potential loss of phenotypic diversity, and environmental degradation due to higher resource consumption.
- Implication: A trade-off exists between short-term economic gains and long-term genetic conservation. Strategies such as controlled breeding programs that incorporate local breeds' genetic traits can mitigate this conflict.

Commercialization vs Cultural Preservation:
- Scenario: Commercializing native chickens for market expansion can boost livelihoods but may erode traditional management practices and cultural values associated with indigenous breeds.
- Implication: Policies should aim for a balance by promoting breed conservation alongside market development, possibly through certification schemes that valorize native breeds.

Market Integration vs Household Food Security:
- Scenario: Integrating smallholders into broader markets can increase income but might reduce household food security if market dependence leads to resource diversion or price volatility.
- Implication: Developing resilient value chains with fair pricing mechanisms can help sustain household food security while enabling market participation.

Evidence suggests that a hybrid approach combining genetic conservation with sustainable intensification offers the most promising pathway. This includes:
- Promoting participatory breeding programs that involve local farmers,
- Enhancing biosecurity and health management to reduce disease risks,
- Developing niche markets emphasizing indigenous breed qualities,
- Improving infrastructure for better market access,
- Implementing policies that incentivize biodiversity conservation.

Without careful management, commercialization efforts may lead to genetic homogenization, reducing resilience against diseases and climate change [2]. Smallholders may also face marginalization if market demands favor commercial hybrids or imported breeds. Therefore, policies must prioritize genetic resource conservation while fostering inclusive market opportunities.

Policy, Institutional And Practical Recommendations

The sustainable development of Indonesia's native chicken sector necessitates a multifaceted approach involving policy reforms, institutional strengthening, and practical interventions tailored to the needs of various stakeholders. Drawing from empirical data and best-practice examples, this subsection delineates prioritized interventions for farmers, extension services, government agencies, and the private sector, emphasizing their design parameters, resource requirements, implementation timelines, and measurable outcomes.

Recommendations are prioritized based on feasibility (ease of adoption), cost-effectiveness (return on investment), equity (benefits to marginalized groups), and potential for scale (sector-wide impact). For instance, community-based breeding programs are highly feasible with moderate costs and significant conservation benefits, making them a top priority. Conversely, policy reforms require longer timelines but are crucial for systemic change.

Pilot projects should incorporate control groups to evaluate effectiveness. Key indicators include flock productivity metrics (egg production rate), disease incidence rates, income changes (% increase), genetic diversity indices (heterozygosity levels), and market access expansion (number of new buyers) [27]. Implementing these targeted interventions will foster a resilient native chicken sector that balances productivity enhancement with biodiversity

conservation. Continuous monitoring using defined indicators will ensure adaptive management aligned with sustainability goals.

Limitations, Reliability And Future Research Directions

The methodological limitations of this study primarily stem from the cross-sectional design, which inherently restricts the ability to infer causality between variables such as management practices, genetic diversity, and productivity outcomes within Indonesia's native chicken sector. This design captures a snapshot in time, thereby limiting the internal validity concerning temporal dynamics and causal relationships. Additionally, sampling constraints such as regional focus on specific provinces like South Kalimantan, West Kalimantan, and East Java may affect the external validity and generalizability of findings across the entire Indonesian native chicken sector.

Measurement errors may also arise from reliance on self-reported data during household surveys, which are susceptible to recall bias and social desirability bias. To mitigate these issues, standardized questionnaires were employed, and enumerators received rigorous training to ensure consistency. Furthermore, biological data collection involved calibrated instruments and laboratory analyses to enhance measurement reliability [28]. Despite these measures, some residual measurement error cannot be entirely eliminated. The use of descriptive statistics and correlation analyses provides robust insights into sector characteristics; however, the absence of longitudinal data limits understanding of temporal trends and sector evolution.

To address these limitations and strengthen future research, several steps are recommended. First, adopting a longitudinal panel design would enable tracking of production performance, genetic changes, and socio-economic impacts over time, thereby facilitating causal inference. Second, expanding the sampling frame to include more diverse regions such as remote or less-studied provinces would improve external validity. Methodologically, future studies should incorporate advanced genetic sequencing techniques (e.g., SNP genotyping or whole-genome sequencing) to precisely characterize genetic diversity and identify resilient breeds for conservation and breeding programs [3].

Additionally, implementing randomized controlled trials (RCTs) for interventions such as feed supplementation or disease control measures can establish causal effects on productivity and health outcomes. Economic modeling approaches such as cost-benefit analysis and value chain analysis are essential for evaluating the viability of sector development strategies [1]. These models should incorporate dynamic variables like market prices, input costs, and policy incentives. Data collection frequency should be increased in longitudinal studies to quarterly or biannual intervals to capture seasonal variations affecting production and health parameters. Sample sizes should be statistically determined based on power analysis; for example, a minimum of 300 households per region could provide sufficient power (>80%) to detect meaningful differences in productivity metrics with a confidence level of 95%.

CONCLUSION

The comprehensive analysis of Indonesia's native chicken sector underscores its vital role in rural livelihoods, biodiversity conservation, and food security. The sector, constituting approximately 65% of the national poultry population, demonstrates significant potential for sustainable development through strategic interventions that address existing constraints while leveraging inherent opportunities. Principal findings reveal that native chickens are integral to socio-economic and cultural contexts, providing substantial income contributions about 25% of household earnings and supporting traditional management systems such as scavenging, semi-intensive, and integrated backyard systems. Productivity metrics, including an average egg yield of 120 eggs per hen annually and hatchability rates around 78%, indicate

moderate performance levels. However, challenges such as disease susceptibility particularly Newcastle Disease and feed shortages during dry seasons limit sector growth.

Genetic diversity remains a cornerstone of resilience; phenotypic variation suggests rich genetic reservoirs that require conservation and improvement. Yet, limited access to quality breeding stock and veterinary services hampers genetic progress. Management typologies influence productivity and sustainability, with traditional scavenging systems offering environmental benefits but low yields, whereas semi-intensive and integrated systems enhance productivity at potential environmental costs. Market participation is characterized by local sales contributing approximately 70% of farmers' income, with regional disparities influenced by infrastructure and market access. The sector faces constraints including infrastructural deficiencies, limited technical extension services, and market barriers. Conversely, rising consumer demand for indigenous breeds and government-led conservation initiatives present significant opportunities.

Methodologically, the sector has been assessed using descriptive statistics, correlation analyses (e.g., biosecurity positively correlates with hatchability, r=0.65), and a basic sustainability index integrating economic, social, and environmental dimensions. These approaches provide a holistic understanding but are limited by their cross-sectional nature. The SWOT analysis delineates strengths such as genetic diversity and cultural importance; weaknesses like low productivity; opportunities including market demand and conservation policies; and threats from disease outbreaks and market access issues.

To foster sustainable development, coordinated efforts are essential. Recommendations include enhancing genetic resource management through community-based breeding programs (CBBPs), improving health services with better biosecurity measures, developing infrastructure to facilitate market access, and promoting value addition aligned with cultural preferences. Emphasizing participatory approaches ensures that interventions are context-specific and socially acceptable. Limitations of current studies include their cross-sectional design which restricts causal inference; reliance on self-reported data susceptible to bias; regional focus limiting generalizability; and insufficient molecular genetic data for precise breed characterization. Future research should adopt longitudinal designs to monitor temporal changes, incorporate advanced genetic analyses such as SNP genotyping for breed conservation strategies, evaluate intervention impacts through randomized controlled trials (RCTs), and develop economic models to inform policy decisions.

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