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Economic viability of compensatory growth strategies in small ruminant animal production in north-eastern Nigeria

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Abstract

This study assessed the economic viability of compensatory growth (CG) strategies in small ruminant production in North-Eastern Nigeria. A mixed-methods research design was employed, integrating controlled feeding trials with stakeholder interviews to evaluate both biological performance and factors influencing adoption. Twenty small ruminants (10 sheep and 10 goats) were randomly assigned to either a control group receiving conventional feeding or an experimental group subjected to two months of feed restriction followed by two months of unrestricted feeding. Data on feed intake, body weight changes and production costs were collected, while interviews with 100 small ruminant producers explored socio-cultural and institutional determinants of adoption. Results indicated that animals under the CG regime achieved higher body weight gain (6.8 kg compared with 4.2 kg) and average daily gain (50.4 g/day compared with 33.3 g/day) while consuming less feed (94.3 kg compared with 107.5 kg). Economically, the CG strategy generated higher net returns (₦32,405.7 compared with ₦21,132.5) and a superior cost–benefit ratio (2.17 compared with 1.77), with t-test analyses confirming statistical significance ($p < 0.05$). Despite these advantages, adoption was constrained by high feed costs, limited access to credit, inadequate extension and veterinary services, poor infrastructure, and socio-cultural factors such as education and traditional beliefs. The study concludes that CG feeding is both biologically and economically viable, and adoption can be enhanced through targeted training, credit access, and institutional support. The study recommends targeted training, improved access to credit and affordable feed, strengthened extension and veterinary services, and community engagement to enhance adoption and sustainability of CG feeding among smallholder farmers.

Keywords: Compensatory Growth; Small Ruminants; Feed Efficiency; Profitability; Adoption Barriers; North-Eastern Nigeria

1. Introduction

In many parts of the tropics, animals often suffer extended periods of poor nutrition during the dry season. Green pastures are rare at the time and, even if available are usually mature and consequently of low nutritive value. This often results in poor growth in young animals, severe live-weight loss, delays in onset of puberty or prolonged postpartum anoestrus. However, soon after the wet season, when the quantity and quality of the grasses are improved, animals increase their live weight markedly. During this time animals are compensating for their weight loss during the dry season and often superior live-weight gain compared to animals which had not undergone poor nutrition. Thus compensatory or "catch up" growth is a phenomenon which is fairly common in areas where marked fluctuations in forage supply occur (Mahyuddin, 2004).

Small ruminant production plays a critical role in Nigeria's agricultural economy, providing meat, milk, hides, and income to millions of rural households. Beyond its contribution to nutrition and food security, it represents a vital livelihood strategy, especially for smallholder farmers and women (Anaso and Dikki, 2025). Their economic significance

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is primarily associated with their small size which involves low investments, less risk of loss and usually preferred over large ruminants for their food and reproductive efficiency (Olabisi and Rasheed, 2017). Despite these benefits, the sector faces persistent challenges including limited access to quality feed resources, high disease prevalence, poor veterinary and extension services, and weak market infrastructure. In addition, climate change, rising input costs, and policy gaps constrain productivity and profitability.

One promising strategy to address these challenges is compensatory growth (CG), a feeding technique where animals undergo periods of controlled under-nutrition followed by accelerated growth when feed resources are abundant (Hadjipanayiotou, 2012). This approach capitalizes on the animal's natural ability to "catch up" in growth after a period of restriction, thereby optimizing feed efficiency (Ngwa *et al*., 2019). Studies in similar agro-ecological zones have demonstrated that CG can improve weight gains by 15–25% in small ruminants, reducing overall feed costs while maintaining or even enhancing meat production (Dawuda *et al*., 2020).

The economic implications of CG are particularly relevant for North-Eastern Nigeria, where feed scarcity and rising input costs are major constraints (FAO, 2022). By strategically timing feed restriction and realimentation, farmers can align production cycles with seasonal forage availability, minimizing reliance on expensive supplemental feeds (Idris *et al*., 2023). Furthermore, CG has the potential to improve livestock resilience to climate variability, a critical advantage in a region prone to droughts and erratic rainfall (Oluwasola and Ajala, 2020).

Despite its demonstrated benefits, the adoption of CG strategies in North-Eastern Nigeria remains limited. A 2023 survey in Borno State revealed that only 12% of small ruminant farmers practiced intentional feed restriction, citing lack of awareness, high costs of supplemental feeding, and cultural preferences for traditional grazing methods (Idris *et al.*, 2023). Additionally, on-going insecurity in the region has disrupted access to extension services, markets, and veterinary support, further hindering the adoption of improved livestock practices (FAO, 2022). Another critical barrier is the lack of localized economic data on CG's viability. While physiological studies (e.g., Ngwa *et al*., 2019) confirm its biological feasibility, there is insufficient evidence on whether the net economic returns justify the additional labour, feed, and management costs for smallholder farmers (Dawuda *et al.*, 2020). Without this information, policymakers and development agencies struggle to promote CG as a scalable solution. This study seeks to fill that gap by evaluating the performance and cost-benefit ratio of CG in North-Eastern Nigeria, providing evidence-based recommendations for farmers and stakeholders. The specific objectives of the study were to evaluate the growth performance (weight gain, feed conversion efficiency) of small ruminants under compensatory growth strategies compared to conventional feeding systems; analyse the cost-benefit ratio of compensatory growth, including feed costs, labour inputs, and market returns; and identify the socio-economic and institutional factors influencing farmers' adoption of compensatory growth strategies in the region. The following hypotheses were also formulated and tested at 5% significance level:

- $H0_1$: There is no significant difference in the performance of small ruminant animals in the control and experimental groups.
- $H0_2$: There is no significant difference in the net returns of animals in the control and experimental groups.

2. Methodology

2.1. The Study Area

The study was conducted in four states located in the North-East geopolitical zone of Nigeria, namely Taraba, Adamawa, Gombe, and Borno States. The North-East region lies between latitudes 9°–14°N and longitudes 9°–14°E and is characterized by a tropical savannah climate, with distinct wet and dry seasons. Annual rainfall ranges from about 600 to 1,200 mm, decreasing northwards, while temperatures are generally high throughout the year. Agriculture is the dominant livelihood activity in the region, with crop farming and livestock production particularly small ruminant rearing being widely practiced.

Taraba State is located in the southern part of the North-East and is endowed with diverse ecological zones ranging from southern guinea savannah to montane grasslands. The state has relatively higher rainfall and supports mixed farming systems involving crops and livestock. Adamawa State, which shares an international boundary with Cameroon, features guinea and sudan savannah vegetation and is well known for livestock production, especially cattle, sheep, and goats (Girei *et al.*, 2018). Gombe State lies within the Sudan savannah zone and is characterized by moderate rainfall and extensive agricultural activities dominated by crop cultivation and small ruminant husbandry (Dan and Kim, 2020). Borno State, located in the extreme northeastern part of Nigeria, falls largely within the Sahel and Sudan savannah zones, with lower rainfall and drier conditions, making pastoralism and small ruminant production important livelihood strategies (Ghide and Mohammed, 2016).

2.2. Experimental Design

This study employed a mixed-methods research design to comprehensively assess the economic viability of compensatory growth (CG) strategies in small ruminant production in North-Eastern Nigeria. The approach integrated quantitative field experiments with qualitative surveys and interviews, allowing for triangulation of data. The research was conducted in two phases: controlled feeding trials to measure biological performance, and stakeholder interviews to understand institutional and socio-cultural factors affecting adoption. This design ensured both statistical rigor and contextual depth in analysing CG's feasibility for smallholder farmers.

The experimental design, animals, feeding regime, housing, and management procedures were structured to evaluate the economic viability of compensatory growth strategies in small ruminant production in North-Eastern Nigeria. The experiment was conducted over a period of four months, from August to December 2025, across four experimental locations: Taraba State Polytechnic, Suntai (Jalingo); Adamawa State College of Agriculture, Ganye; Federal College of Education (Technical), Gombe; and Ramat Polytechnic, Maiduguri. A total of twenty (20) small ruminants, comprising ten (10) sheep and ten (10) goats, were used for the study. The animals were apparently healthy, of comparable age and physiological condition, and were randomly selected from each location. Prior to the commencement of the experiment, the animals were acclimatized to their respective environments and management systems.

The animals were randomly assigned into two experimental groups: a control group and a restricted–refeeding (experimental) group, each consisting of five (5) sheep and five (5) goats. The control group was allowed to feed normally throughout the four-month experimental period, following the prevailing feeding practices at each experimental farm. In contrast, animals in the experimental group were subjected to a compensatory growth regime. During the first two months, the animals were placed under controlled feed restriction, after which they were provided with adequate and unrestricted feeding during the subsequent two months to induce compensatory growth. Clean drinking water was made available ad libitum to all animals throughout the study period. Routine management practices, including housing, health care, and sanitation, were uniformly applied across all experimental groups and locations. Data on feed intake, body weight changes, and production costs were collected regularly and used to assess growth performance and the economic viability of the compensatory growth strategy in small ruminant production.

Stakeholder interviews were conducted to understand the institutional and socio-cultural factors affecting adoption. Data were collected from 25 randomly selected small ruminant producers in each of the four states, resulting in a total of 100 respondents.

2.3. Breed of Animal Used

The Red Sokoto goat and Yankasa sheep breeds were selected for this study because of their resilience to the region's prevailing climatic conditions and their capacity to adapt to changes in locally available feed resources over time.

2.4. Methods of Data Analysis

Data were analysed using growth performance index, Cost-benefit analysis, likert scale and t-test to test the formulated hypotheses.

2.4.1. Growth Performance

The growth performance tools utilized includes;

Body Weight Gain (BWG)

$$BWG\ (kg) = Final\ Body\ Weight\ (kg) - Initial\ Body\ Weight\ (Kg) \quad \text{(equa. 1)}$$

Average Daily Weight Gain (ADWG)

$$ADWG\ (kg) = \frac{Final\ Body\ Weight - Initial\ Body\ Weight}{Number\ of\ Days} \quad \text{(equa. 2)}$$

Total Feed Intake (TFI)

$$TFI\ (kg) = Feed\ Offered\ (kg) - Feed\ Wasted\ (kg) \quad \text{(equa. 3)}$$

Feed Conversion Efficiency (FCE)

$$FCE=\frac{Body\ Weight\ Gain\ (kg)}{Total\ feed\ Intake\ (kg)} \text{.......... (equa. 4)}$$

Feed Conversion Ratio (FCR)

$$FCR=\frac{Total\ feed\ intake\ (kg)}{Body\ weight\ gain\ (kg)} \text{.......... (equa. 5)}$$

2.4.2 Cost-benefit Analysis

Total Production Cost (TPC)

$$Total\ Production\ Cost = Feed\ Cost\ +\ Labour\ Cost \text{ .... (equa. 6)}$$

Market Value (Total Revenue, TR)

$$Market\ Value\ (₦)\ = Final\ Live\ Weight\ (kg) \times Market\ Price\ per\ kg \text{ .... (equa. 7)}$$

Net Return (NR)

$$Net\ Return\ (₦)\ = Market\ Value\ (₦) - Total\ Production\ Cost\ (₦) \text{ .... (equa. 8)}$$

Cost–Benefit Ratio (CBR)

$$\text{Cost–Benefit Ratio} =\frac{Market\ Value\ (₦)}{Total\ Production\ cost\ (₦)} \text{.......... (equa. 9)}$$

2.4.3 t-test

An independent sample t-test was used to examine whether there was a significant difference in the performance of small ruminant animals and the net returns obtained between the control and experimental groups. The t-statistic was computed using the following formula:

$$t=\frac{X_1+X_2}{\sqrt{\frac{s1^2}{n1}+\frac{s2^2}{n2}}} \text{ .... (equa. 10)}$$

- X_1=mean of the control group
- X_2=mean of the experimental group
- $s1^2$=variance of the control group
- $s2^2$=variance of the experimental group
- n_1=sample size of the control group
- n_2=sample size of the experimental group

3. Results and discussion

3.1. Growth Performance of Small Ruminants under Compensatory and Conventional Feeding Systems

Table 4.1 presented the growth performance of small ruminants under the compensatory and conventional (control) feeding systems. The result showed that the two groups started with nearly the same initial body weight, with the control group recording 12.0 ± 0.4 kg and the compensatory group 12.1 ± 0.3 kg. This indicated that the animals were comparable at the beginning of the experiment.

At the end of the feeding period, the compensatory group achieved a slightly higher final body weight (19.1 ± 0.7 kg) compared to the control group (18.8 ± 0.6 kg). However, clearer differences were observed in weight gain and growth rate. The compensatory group recorded a substantially higher body weight gain (6.8 ± 0.3 kg) than the control group (4.2 ± 0.2 kg). Similarly, the average daily gain was greater under the compensatory feeding system (50.4 ± 2.1 g/day) relative to the control (33.3 ± 1.4 g/day)

In terms of feed utilization, animals in the compensatory group consumed less total feed (91.3 ± 2.8 kg) than those in the control group (107.6 ± 3.5 kg). Despite the lower feed intake, the compensatory group demonstrated superior efficiency, as indicated in a higher feed conversion efficiency (0.067) compared to 0.040 in the control group. Correspondingly, the feed conversion ratio was better (lower) in the compensatory group (13.42) than in the control (25.62), indicating that animals under compensatory feeding required less feed to gain a unit of weight.

Table 1 Growth Performance of Small Ruminants under Compensatory and Conventional Feeding Systems

Parameter	Control Group	Compensatory Group
Initial body weight (kg)	12.0 ± 0.4	12.1 ± 0.3
Final body weight (kg)	18.8 ± 0.6	19.1 ± 0.7
Body weight gain (kg)	4.2 ± 0.2	6.8 ± 0.3
Average daily gain (g/day)	33.3 ± 1.4	50.4 ± 2.1
Total feed intake (kg)	107.6 ± 3.5	91.3 ± 2.8
Feed conversion efficiency	0.040	0.067
Feed conversion ratio	25.62	13.42

Field Experiment, 2025

3.2. Costs–Benefit Analysis of Compensatory Growth in Small Ruminant Production

The economic analysis in Table 2 revealed that although total production costs were broadly comparable between feeding systems, the compensatory feeding strategy yielded markedly higher economic returns than the conventional approach. Total feed intake was lower in the compensatory group (94.3 kg) compared with the control group (107.5 kg), resulting in a reduced feed cost of ₦13,500 relative to ₦15,250 in the control. Labour costs were slightly higher for the compensatory group (₦4,700) compared with the control (₦4,350), and expenditures on drugs and vaccines were also elevated (₦9,250 relative to ₦7,860). However, these additional costs were offset by improvements in final live weight and market value.

Animals managed under the compensatory strategy attained a higher final live weight (18.8 kg) than those in the control group (16.3 kg), which translated into a greater market value of ₦59,950 compared with ₦48,700 recorded for the control group. Consequently, the net return for the compensatory group (₦32,405.7) substantially exceeded that of the control group (₦21,132.5), while the cost–benefit ratio was also superior (2.17 compared with 1.77). These results indicated that the compensatory growth strategy enhanced not only biological productivity but also overall economic efficiency.

Table 2 Cost–Benefit Analysis of Compensatory Growth in Small Ruminant Production

Parameter	Control Group	Compensatory Group
Total feed intake (kg)	107.5	94.3
Feed cost (₦)	15,250	13,500
Labour cost (₦)	4,350	4,700
Drugs and Vaccines (₦)	7860	9,250
Total production cost (₦)	27,567.5	27, 544.3
Final live weight (kg)	16.3	18.8
Market value (₦)	48,700	59,950
Net return (₦)	21,132.5	32,405.7
Cost–benefit ratio	1.77	2.17

Field Experiment, 2025

3.3. Test of Hypotheses

$H0_1$: There is no significant difference in the performance of small ruminant animals in the control and experimental groups.

The independent samples t-test result presented in Table 3 showed that animals in the experimental group recorded a higher mean performance value (50.4 ± 2.10) than those in the control group (33.3 ± 1.40). The computed t-value was 21.4253 with a p-value of 0.0000. Since the p-value was less than the 5% level of significance ($p < 0.05$), the null hypothesis was rejected. This indicated that a statistically significant difference existed in the performance of small ruminant animals between the control and experimental feeding systems. The result implied that the compensatory growth strategy produced superior performance outcomes compared with the conventional management approach.

Table 3 Summary of t-test Analysis of the Differences in Performance of Small Ruminant Animals in Control and Experimental Groups

Groups	N	Mean	Std. dev.	t-value	p-value
Control	10	33.3	1.40	-21.4253	0.0000
Experimental	10	50.4	2.10		
Combined	20				

Source: Field Experiment, 2025

H02: There is no significant difference in the net returns of animals in the two groups.

The independent samples t-test result in Table 4 indicated that the experimental group realized a higher mean net return (₦32,405.7 ± 6,259.6) than the control group (₦21,135.5 ± 9,632.11). The calculated t-value was –3.1025, with a corresponding p-value of 0.0061. Given that the p-value was less than the 5% significance level ($p < 0.05$), the null hypothesis was rejected. This implied that a statistically significant difference existed in the net returns obtained from animals managed under the two feeding systems. The finding suggested that the compensatory growth strategy generated significantly higher profitability compared with the conventional system.

Table 4 Summary of t-test Analysis of the Differences in Net Returns of Small Ruminant Animals in Control and Experimental Groups

Groups	N	Mean	Std. dev.	t-value	p-value
Control	10	21135.5	9632.11	-3.1025	0.0061
Experimental	10	32405.7	6259.6		
Combined	20				

Source: Field Experiment, 2025

3.4. Socio-Economic and Institutional Factors Influencing Farmers' Adoption of Compensatory Growth Strategies in the Study Area

The result in Table 5 presents the socio-economic and institutional factors influencing the adoption of compensatory growth strategies among respondents. Using a five-point Likert scale with a decision benchmark of 3.0, any variable with a mean score above the cut-off point is regarded as significant. The findings reveal that most of the listed factors were perceived as important determinants of adoption.

Level of education recorded a mean score of 3.84 (SD = 0.91), indicating that education enhances farmers' understanding and willingness to implement compensatory growth practices. Manzoor (2025) systematic review of technology adoption in low- and middle-income countries reveals that education level and access to digital and technical information significantly influence farmers' willingness and ability to adopt innovations by improving their capacity to understand, interpret, and apply new methods successfully. Cultural beliefs were also considered influential with a mean of 3.52 (SD = 1.02), suggesting that traditional norms and values can shape management decisions. However, gender-related issues had a mean value of 2.41 (SD = 1.11), which falls below the threshold, implying that gender was not considered a major barrier to adoption among the respondents.

Among the institutional and economic constraints, inadequate access to credit (M = 4.21, SD = 0.88) and high cost of feed (M = 4.22, SD = 0.66) ranked highest, highlighting the importance of financial capacity in implementing feeding adjustments associated with compensatory growth. This align with the findings of Alam (2024) who reported that farmers with access to formal credit are more likely to invest in new technologies and improved practices because financial constraints otherwise limit their ability to procure inputs or take on risk associated with change. Poor infrastructure followed closely with a mean of 4.05 (SD = 0.94), indicating that deficiencies such as bad roads, electricity, and water supply may hinder effective livestock management. Inadequate extension services (M = 3.76, SD = 0.97) and poor access to veterinary services (M = 3.68, SD = 1.00) were equally perceived as significant, emphasizing the need for technical guidance and animal health support. Ahmad et al. 2025) found that high cost burdens and lack of affordable financing mechanisms are identified as major barriers to adoption.

Table 5 Socio-economic and Institutional Factors Influencing Adoption of Compensatory growth Strategies among Respondents (n=100)

Socio-economic and Institutional factors	Mean	Std. dev.	Remark
Level of education	3.84	0.91	Significant
Cultural beliefs	3.52	1.02	Significant
Gender related issue	2.41	1.11	Not significant
Inadequate access to credit	4.21	0.88	Significant
Poor infrastructure	4.05	0.94	Significant
Inadequate extension services	3.76	0.97	Significant
Poor access to veterinary services	3.68	1.00	Significant
Cost of feed	4.22	0.657	Significant

Source: Field survey, 2025

4. Conclusion

The study concluded that compensatory growth (CG) strategies significantly improve both the biological performance and economic returns of small ruminant production in North-Eastern Nigeria. Animals subjected to the CG regime exhibited higher weight gains, greater average daily growth, and more efficient feed utilization than those under conventional feeding. Economically, the CG strategy generated higher net returns and superior cost–benefit ratios, confirming its profitability. Statistical analysis further validated that these differences were significant. Despite the clear benefits, adoption of CG feeding among smallholder farmers is constrained by high feed costs, limited access to credit, poor infrastructure, inadequate extension and veterinary services, and socio-cultural factors including education and traditional beliefs.

Recommendations

The following recommendations were made

- Government agencies and agricultural extension services should organize regular training workshops to educate farmers on the benefits, management practices, and feeding protocols for CG strategies. Demonstration farms could be established to provide practical exposure.
- Financial institutions and government programs should provide subsidized feed or affordable credit schemes targeted at smallholder farmers to reduce the cost barrier to adopting CG feeding.
- Investment in rural infrastructure particularly roads, water supply, and market access along with strengthened veterinary and extension services, will facilitate the adoption and sustainability of CG practices.
- Awareness campaigns should address cultural beliefs and promote knowledge sharing, targeting both men and women, to encourage participation and adoption of CG feeding strategies.
- Policymakers should incorporate CG feeding strategies into livestock development programs and provide incentives, such as grants or technical support, to farmers who adopt improved feeding practices.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of ethical approval

The study adhered to established ethical standards for both animal and human research. Experimental animals were healthy, of comparable age and physiological condition, and were acclimatized prior to the study. Feed restriction in the experimental group was carefully controlled to prevent malnutrition, while all animals had unrestricted access to clean water and received uniform housing, care, and health management throughout the experiment. Animals were regularly monitored, and any showing signs of stress or illness would have been promptly treated or removed from the study.

Statement of informed consent

For human participants, informed consent was obtained from all 100 small ruminant producers involved in stakeholder interviews. Participants were fully briefed on the study's purpose, their voluntary participation, and their right to withdraw at any time, while confidentiality and anonymity were strictly maintained.

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