Trends in
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Evaluation and Demonstration of Chicken Cage Production Technology in and around Peri-Urban Areas of Gurage and Siltie Zone, Central Ethiopia Region

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ABSTRACT

Background and Objective: Chicken production is attractive in the context of poverty alleviation and food security. It plays a great role in household income, wealth level, and food and nutritional security, especially for women and youth groups. The objective of this study was to evaluate and demonstrate the chicken cage production technology, to develop alternative chicken extension packages and to determine the economic benefits of technology. **Materials and Methods:** Participant households and the study districts were selected purposively. The study was conducted at Mirab azernet and Gummer districts. The experiment was conducted on 192 commercial layer chicken breeds managed under a cage housing production technology. Participant households receive training on chicken husbandry practices. Data were collected on chicken body weight, mortality of chicken, causes of mortality, age at first egg lay, feed intake, feed conversion ratio, cost of feed and medication, and egg weight at different production periods, annual egg production and farmers' perception on chicken cage production technology and the collected data were using SAS software. **Results:** At the ages of 12, 36, and 44 weeks, of age bovans brown chicken in cage production technology shows significant variation ($p<0.05$) on body weight across two districts. Survival rate of Bovan's brown layer chicken breeds in the cage chicken production technology shows non-significant ($p>0.05$) variation across two locations. The egg production performance of Bovans Brown commercial layer chickens produced in the chicken cage in Mirabe Azernet District was significantly higher ($p<0.05$) than in Gummer District. The participant households and the nearby small-holder households in the study area accepted the chicken cage as a good chicken production technology, especially for urban areas in the study area. **Conclusion:** According to the partial budget analysis, bovans brown commercial layers chicken reared in the chicken cage production technology under urban farmers' management condition with the little addition of little management practices, it was profitable and acceptable. Around urban areas, there is a shortage of land available for chicken house construction, so it is possible that rearing chickens in the chicken cage is a practical solution for urban smallholders to improve income, nutrition, and chicken management efficiency.

KEYWORDS

Chicken cage, commercial layer chicken, urban farmers' chicken management, Gurage and Siltie Zone

ISSN: 2957-9449 (Online)
ISSN: 2957-9430 (Print)
https://doi.org/10.21124/tas.2026.43.53

Received: 07 Feb. 2026
Accepted: 03 Jun. 2026
Published: 30 Jun. 2026

INTRODUCTION

Chicken production is attractive in the context of poverty alleviation and food security. It has a high reproduction rate per unit time, requires very little capital investment and space, and can be maintained even by landless families. Chicken plays a considerable role in household income, wealth level, and food and nutritional security. For women in particular, the small income and savings from the sale of chicken products are crucial because they help them better manage pressing demands and lower their financia[1].

A recent estimation of the chicken population in Ethiopia is approximately 60 mL, 90.8, 4.4, and 4.8% of which are indigenous, exotic and hybrid, respectively, and the national mean annual egg production of Ethiopia was about 369 mL in the year 2020[2].

Chicken has become a more popular source of meat worldwide. Chicken meat makes up around 33% of the world's meat consumption and is predicted to increase by 2 to 3% annually[3]. This is because, in low-income developing countries, chicken is less expensive than other meat sources, whereas in high-income countries, white meat consumption has surged since it is easy to prepare and is a nutritious dietary choice[4].

The non-genetic factors, such as feeding, housing, healthcare, and other management practices, have a much larger influence on production than genetic factors on the chicken production technology[5]. In the developing countries, modern commercial layer chicken breeds can be successfully raised in the cage and floor brooding technology. However, compared to the village chicks, which can cope with temperature changes, they require greater management technology[6].

Approximately 62.2% of the chicken farmers used the floor housing technology for production, while the remaining 37.8% used the cage technology in Addis Ababa[7]. However, this technology is limited in the urban and peri-urban areas, in the study region.

Around urban areas, agriculture is characterized by nearness to the market, limited land, the use of urban resources such as organic wastes and a low amount of wastewater from farmer organizations. Perishable yields from urban agriculture such as vegetables, fresh milk and chicken products and urban agriculture basically accompaniment rural agriculture and increase the efficiency of countrywide food technology[8].

Due to inadequate housing especially at night-time; predators account for a substantial number of village chicken mortality in many African countries[9]. One of the barriers to smallholder chicken production technologies in the Amhara Regional State of Ethiopia's at Minjarna Shenkora district is a lack of houses[10].

In most developed and developing urban areas cage chicken rearing is common, even though in the study area this technology is not well known, relatively little research and development has been carried out on the chicken cage as its importance around urban areas in the study region. Chicken are living with human all over the night as a shelter unless otherwise the chicken become attacked by predators due to lack of chicken house or chicken cage in the study area. The households had a high interest of chicken production however there is a lack of enough land to construct chicken house for the production of chicken as a sources of income and consumption of chicken products (eggs and meat), specially the women households and the youths around urban areas, in the study area and currently small households cannot easily buy the chicken products for their children and pregnant women. There for to alleviate these constraints and to boost the interest of the urban households chicken production at large with the small area of land, evaluation and demonstration of chicken cage is crucial to adopt the technology in a large scale in the study area. The objectives were to demonstration of chicken cage production technology; determine the economic gain of the chicken cage production technology and to develop alternative chicken production technology extension packages around the urban areas in the study area.

MATERIALS AND METHODS

Description of the study area and duration: The study was carried out at Mirabe Azernet and Gummer districts from 2021 to 2022. Central Ethiopia Region consists of seven zones and three special districts, including Gurage and Silte zone. Mirabe Azernet and Gummer districts have the most highland agro-ecology. The majorities of smallholder farmers are dispersed and primarily used mixed crop-livestock production technology. In the study area, rain-fed agriculture is predominant. The main cultivated crops were Enset, barley, wheat, faba bean, and field peas and the major produced animals were Cattle, Sheep, Chicken and horses in the study areas. Siltie zone have land coverage of 2700.04 km^2, found in the coordinates of approximately 7°43' to 8°10'N Latitude and 37°86 to 38°53'E Longitude. Mirab Azernet Berbere district is one of the districts in Siltie zone which lies within the Siltie Zone of Central Ethiopia Region. It shares borders at the Southwest: Hadiya Zone, at the Northwest: Gurage Zone and at the East: Misraq Azernet Berbere district. The altitude of Mirab Azernet Berbere is generally ranging from approximately 2400-3280 m above sea level; the average annual rainfall of Mirabe azernet district is greater than 1400 millimeter, and the average annual temperature is 17.50°C[11].

Gummer district Coordinates approximately 8°10 -8°25' N Latitude and 37°40-38°05 E Longitude. Gumer district bordered at North: Ezha district, at the Northwest: Cheha district, at the Southwest: Geta district and at the Southeast: Silte zone. Its administrative center is Arekit town. Gumer district lies between 1,800 to 3,500 m elevations above sea level. Highlands of Gumer is one of the calmer areas of Gurage zone and the mean temperatures ranges from 10 to 20°C[12].

Site selection: This research was conducted at Worabe Agricultural Research Center mandate areas. First, to achieve this activity, gurage and silte zone were selected purposively and from each zone, one district was selected purposively based on potential of chicken production, accessibility of the study area for data collection and after discussion with the zonal livestock and fishery office. Then after discussion from livestock and fishery office coordinators and experts at the district level was held about overall chicken production, suitability of the study areas and chicken rearing technologies, willingness of the urban farmers and chicken production technologys around the study area. Arekit and Lera towns were selected for the experiment at Gummer and Mirabe azernet berbere district, respectively.

Selection of the participant households: A total of 6 urban Women small holder households were selected purposively from the urban areas of Lera and Arekit towns to empower the women households on the basis of their willingness to rear chicken in a cage chicken housing technology, willingness to rear exotic chicken breeds, ability to manage the breeds well and enough time to manage exotic chicken breeds, who can cover the necessary package costs and ability to record the required data were selected.

Chicken keeping is an attractive activity that the women can undertake without having to leave the household, where they will usually be occupied by domestic duties. As such, they do not have to allocate extra time to manage the chicken (daily cleaning of the chicken cage, feeding, watering and other husbandry practices). In this chicken production technology Women were directly involved in chicken production and it perform the work easier for the urban women in the study area.

Training and awareness creation: All participant householders, district level livestock experts (four) and two kebelle development agents (DAs) were received training about chicken cage preparation and handling, chicken management technology in the cage, health care, feeding, watering, data recording and other husbandry practices in the chicken cage production technology.

Experimental birds' distribution: A total of six chicken cages were constructed and distributed for the selected urban participant households and 192 commercial layer bovans brown pullets were purchased

from Bishoftu chicken rearing private co-operative farm and transported to Mirab azernet and Gummer districts after checking the preparation of participant households to receive chicken and installed the chicken cage at appropriate site, equipment, feed, and other facilities.

Each participant households received 32 commercial layer bovans brown pullets and two month grower ration. Intensive follow-up and data recording were performed after wards by the Worabe Agricultural Research Centre chicken researchers and technical assistant throughout the experimental period.

Feed and feeding management: The growers' ration were purchased by Worabe Agricultural Research Center from Werabe farmers' cooperative Society (Melik), Livestock ration processing Centre and distributed to each participant households based on the number of chickens and daily feed requirement. Drinkers and feeder were cleaned and filled with clean water and chicken feed to encourage the chicken to drink and fed at the time.

For the first week, the grower feed was provided ad libitum. Clean and cool water was given ad libitum, to adapt the chicken cage and the environment, then after two months the participant households prepared chicken rations based on training with the available feed resources at their home in the study area.

Disease prevention and control: The experimental chickens were vaccinated for Marek's, Newcastle disease, Gumboro, and fowl pox diseases at Bishoftu town of private cooperative chicken farm, until the age of 8 weeks. After checking the chicken performance, health and age of chicken we have purchased, transported to the experimental site and distributed to the selected participant households and for a week the chicken were reared around the chicken cage, to adapt the cage, then after a week the chicken were transferred in to the prepared chicken cage.

Every three months, the chickens were periodically vaccinated for Newcastle disease. Strict bio security measures were engaged during the entire experimental periods of chicken production, and treatments for other diseases were provided immediately as the chicken shows the disease symptoms by the veterinary technicians. To prevent bad odors in the chicken cage, the chicken droppings and excrement were collected every day using the corrugated iron sheet at the bottom of the chicken cage and the participant households collected, dry and processed the chicken feces and used as organic fertilizer for their home garden, this practice also surprises the participant households in the study area.

Data collection: The collected data on cage chicken rearing under urban smallholder households were: Body weight of the chicken on monthly basis, mortality of chicken, causes of mortality, age at first egg lay, feed intake, feed conversion ratio, feed cost/feed ingredient and medication cost, egg weight at 5%, at 50% and at pick production period of egg lay, annual egg production performance and perception of the farmers for the cage chicken rearing technology in the study area.

Partial budget analysis: The partial budget analysis was used to identify the economic benefits of the smallholder households with the production of commercial layer chicken breeds in the chicken cage production technology at the study area.

The NET INCOME or change in net income (ΔNI) was calculated as the difference between the changes in total return (ΔTR) and the change in total variable costs (TVC)[13]:

$$\Delta NI = \Delta TR\text{-}TVC$$

Statistical analysis: The collected data were analyzed using the Generalized Linear Model (GLM) procedure of SAS statistical software (version 9.0). The effects of location (Gummer and Mirab Azernet districts) on production and performance parameters were evaluated. Mean comparisons were conducted, and statistical significance was declared at $p<0.05$. Results are presented as means with their corresponding standard error of the mean (SEM)[13].

Ethics statement: The research presented in this manuscript, entitled "Evaluation and demonstration of Chicken cage production technology in and around peri-urban areas of Gurage and Siltie zone, Central Ethiopia Region" has been conducted with adherence to ethical guidelines and regulations as outlined by the Institutional Review Board (IRB) at Southern Agricultural Research Institute (former region), Ethiopia, in accordance with the ethical principles of the declaration.

RESULTS AND DISCUSSION

Body weight of the commercial layer bovan brown chicken: The mean body weights of the chicken at different growth ages are shown in Table 1. At 8 weeks of age, Bovans brown chicken from Mirab azernet and Gummer district managed under a chicken cage under urban small holder households, the mean body weight was 380 grams per chicken during distribution; at 20 weeks of age, the mean body weight of the chicken was 870.92±2.5 g, and at 48 weeks of age, 1675±23.85 g was recorded. At the age of 12, 36 and 44 weeks of age bovans brown chicken under cage production technology shows significant variation ($p<0.05$) on body weight this might be due to the management variation between the participant households and gaps in data recording time at equal periods of time, which was at early morning before provision of feed. In the study area, Bovans brown chickens were mature enough for egg laying date was after 24 weeks of age as shown in Table 1. The current study was higher than the study by Tadesse *et al.*[14], who reported a final body weight of 1.55 kilogram for Bovans brown chicken under a village production technology in East Lhasa, Ethiopia, and the report of Gebrewahd *et al.*[10], who reported that the final body weight of Bovans brown chicken reared in an intensive technology was 1450.4±38.1 g and that of Bovans brown chicken reared under a backyard scavenging technology was 1242.7±41.3 g at Mekelle, Ethiopia. The current report is higher than the[10] reported; the final body weight and body weight gain of the bovans brown chicken reared under intensive technology were 1450.4±38.1 and 1400.5±37.2 g, respectively, while the respective values for the birds under backyard scavenging technology were 1242.7±41.3 and 1193.1±43.7 g at Mekelle.

Feed efficiency performances of bovans brown chicken reared in chicken cage production in the study area are shown in Table 2. The chickens were reared in a chicken cage from the grower to the finisher (layer period) for approximately 301 days. The initial body weight of bovan brown chicken was 380g/chicken when we distributed the chicken to the participants' households. Daily dry matter intake of the chicken was 76.84, 114.97, and 101.6 g/bird at grower, layer, and at the entire experimental period.

Table 1: Body weight of chicken reared under a cage chicken house at Gummer and M/azerner district

Age of chicken	Mean BWT. of chicken (gm)	SEM	p-value
Initial (8 weeks)	380	-	-
12 weeks	463.17	4.73	0.1408
16 weeks	637.33	5.69	0.5607
20 weeks	870.92	2.50	0.602
24 weeks	1186.7	55.08	0.5549
28 weeks	1398.5	28.81	0.7968
32 weeks	1555.8	17.02	0.5744
36 weeks	1590.5	14.02	0.4055
40 weeks	1639.7	21.54	0.5392
44 weeks	1651.7	20.82	0.3824
48 weeks	1675	23.85	0.75

BWT: Refers to body weight, gm: Fefers to gram and SD: Refers to standard error of mean

Table 2: Performance of Bovans brown chicken reared in a cage chicken rearing technology in the study area

	Growth phases in days		
Parameter	Grower phase (57-147)	Layer phase (148-315)	Entire experiment period (57-315)
DMI (g/day/bird)	76.84	114.97	101.6
IBW (g/bird)	380	870.9	-
FBW (g/bird)	870.9	1675	1675
BW change (g/bird)	490.9	804.1	1295
Egg yield/hen/day (gram)	-	52.1	58.9
ADG (g/day)	5.45	4.81	5.04
FCR (in terms of egg weight)	-	2.21	1.72
FCR (in terms of body weight)	6.39	-	-

DMI: Dry matter intake, IBW: Initial body weight, BW: Body weight, FBW: Final body weight, ADG: Average daily gain and FCR: Feed conversion ratio, Feed conversion efficiency of the experimental chicken was measured by using the following formulas, DMI: The amount of feed offered and refused per cage was recorded daily, and the amount of feed consumed was determined by the difference, BW change (g/bird): The change between the final and initial body weight of the chicken throughout the experimental period and FCR: The feed conversion ratio was calculated as the ratio between the feed consumed and average daily body weight gain during the grower period up to the chicken matured enough or ready to first egg lay (gram of feed/weight gain) and at the layer phase FCR is calculated as the feed consumed divided by the mass of egg yield (gram of feed/weight of egg yield)

Table 3: Mortality percentage of commercial layer Bovans brown chicken in the study area

			Mortality of chicken				
Part.	Location	No. of chicken delivered	At 8 weeks (number)	In (%)	At 12 weeks (number)	In (%)	Overall survival (%)
1	Gummer	32	3	9.37	0	0	90.625
2	Gummer	32	2	6.25	1	3.33	90.625
3	Gummer	32	3	9.37	0	0	87.5
1	M/azernet	32	0	0	0	0	100
2	M/azernet	32	1	3.125	0	0	96.875
3	M/azernet	32	1	3.125	1	3.125	96.875
	Average	32	0.052	5.20	0.01	1.11	93.75

%: Refers to percent, Part.: Refers for participant households and No: Refers for number

The final body weight of the chicken at the grower phase was 870.9 g/bird, which was the initial body weight at the layer phase, and the final body weight of the chickens at the layer phase was increased to an average body weight of 1675 g/bird under the chicken cage production technology in the study area under urban smallholder households management technology. Feed conversion efficiency is higher at the layer phases (2.21) than at the age of grower and final ages of the layer chicken as shown above in Table 2. Body weight gain/bird/day of Bovans Brown under cage production technology in the current study is less than the values10 reported that, 7.7+0.23g for the Bovans White chicken breed. The current report is consistent with the study10 reported that, the feed conversion ratio of the bovans brown chicken breed reared under intensive and backyard management technology was 6.71±0.2 and 6.62±0.4, respectively.

Survivability rate of chickens under the chicken cage production technology: Survival rate of commercial layer, bovans brown chicken breeds in the cage chicken production technology up to 12 weeks of chicken age was 93.75%, which shows a good survival rate in the study area. At eight weeks of age, the mortality of chickens on average was (5.2%) under the urban farmers' management condition at Mirab Azernet and Gummer districts, and this mortality percentage was decreased to (1.11%) at 12 weeks of age, as shown in Table 3. In the study area, the most common causes of mortality were mechanical damage, farmers' management problems under cage chicken production technology and transportation stress due to long journeys. At the time of chicken distribution, the season was rainy season. After 12 weeks of age, there was no mortality, and most of the chickens survived in the chicken cage as stated in table 3. The finding was consistent with the result[15], who reported the average survival rate of Bovans brown chicken breed in Dessie town was 94±8.65%, or a 6% mortality rate up to 16 weeks

Table 4: Causes of chicken mortality over locations under chicken cage management technology

Chicken mortality causes under the chicken cage	Chicken mortality in number and mean						
	Gummer		M/azernet				
	In number	Mean	In number	Mean	Grand mean	SEM	p-value
Due to poor management	4	1.333	1	0.333	0.833	0.333	0.101
Disease	2	0.667	0	0	0.333	0.236	0.116
Unknown causes	3	1.000	2	0.667	0.833	0.333	0.643

SEM refers to Standard error of mean

Table 5: Egg at first lay and egg weight of Bovan brown chicken in the chicken cage in the study area

Parameter	Location				
	Gummer	M/azernet	Grand mean	SEM	p-value
Egg at first lay (days)	169.67	174.33	172.00	4.256	0.481
Egg wt. at 5% of egg lay (gm)	44.80	45.93	45.37	0.561	0.226
Egg wt. at 50% of egg lay (gm)	53.00	55.67	54.33	1.027	0.140
Egg wt. at peak production period (gm)	58.67	60.50	59.58	0.986	0.259

Wt: Refers to egg weight, gm: Refers to gram and SEM refers to the standard error of the mean

of age. The current study is also lower than that of the study[10], who reported the mortality of Bovans brown chicken in a backyard scavenging technology who reported mortality of 20.3±2.3%, and the finding is higher than that of findings reported by the same authors in the intensive production technology (3.2±0.1%) at Mekelle town, Ethiopia.

Causes of mortality of chicken under chicken cage management technology at two districts are shown above in (Table 4). Mortality of chicken due to poor management and disease were significantly ($p<0.05$) higher in Gummer district than M/azernet district, this might be due to the management variation between the participant households in the study area. The major causes of mortality under the chicken cage management technology in the study area was mainly poor management practices of the households for their chicken, followed by unknown causes, as shown in Table 4. In any production technology, proper management of chickens can significantly reduce the causes of chicken mortality as well as chicken losses in the study area. The current study is in agreement with that of study[16], who reported, causes of mortality of chicken was at about one-third of the producers reported that sudden mortality occurred frequently due to different diseases in small-scale commercial farms in Maiduguri arid zone. Chick quality; disease, stress and nutrition, and other poor management factors were the major chicken mortality causes.

Egg at first egg lay and egg weight of Bovans brown chicken: Production of bovans brown chicken in the chicken cage production, egg at first lay and egg weight in the peri-urban areas of the Central Ethiopia Regional States of siltie and Gurage zone was reported as shown in Table 5.

Egg at first laying date of bovans brown chicken under cage production technology in the study area under urban farmers' management condition at Gummer was significantly ($p<0.05$) earlier than Mirab Azernet district, with the mean egg at first lay date of 172±4.26 days as shown above in Table 5. This variation might be due to the feeding and other management conditions of the participant households in the study area. The late onset of egg lay in the study area might be due to the low management practices of the participant households for their chicken. The mean age at first laying was 138.2 days in the cage chicken housing technology for Bovans brown chicken, according to the report[7], Addis Ababa, Ethiopia, which was earlier than the current study. The current study was consistent with the report[14], age at sexual maturity of 165.5±13.2 days for Bovans brown chicken under a village production technology in East Shewa, Ethiopia. Egg weight of Bovans brown chicken under chicken cage production technology

Table 6: Egg production performance of Bovans brown chicken in chicken cage housing in the study area

Egg production performance of chicken under cage production	Location		Grand mean	SEM	p value
	Gummer	M/azernet			
HDEP at the age of 30 weeks in (%)	20.667	23	21.833	1.5986	0.3603
HDEP at the age of 48 weeks in (%)	53	51.667	52.333	2.0548	0.6702
HDEP at the age of 56 weeks in (%)	76.333	80	78.167	3.325	0.4791
HDEP at the age of 72 weeks in (%)	76.667	78.667	77.667	3.7565	0.7257
Egg yield/hen/year in (number)	221.33	227.33	224.33	3.8442	0.3317

HDEP: Refers for hen day egg production and SEM: Refers to standard error of mean

Table 7: Partial budget analysis of bovine brown chicken rearing under chicken rearing cages

			Variable costs				Returns (incomes)			
Part. HH	Unit	Fixed cost (cage)	Feed	Medication	Chicken purchase	Total var. cost	From the sale of eggs	From the sale of hens	Total income (returns)	Profit/Net income
1	birr	4700	3460	-	2560	6020	3000	18490	21490	15470
2	birr	4700	2760	120	2560	5260	3680	22616	26296	21036
3	birr	4700	2550	150	2560	5260	2780	18600	21380	16120
4	birr	4700	3960	40	2560	6560	5120	19060	24180	17620
5	birr	4700	2160	80	2560	4800	3800	19876	23676	18876
6	birr	4700	2410	45	2560	5015	3630	21824	25454	20439
Av.	birr	4700	2883.3	72.5	2560	5485.8	3668.3	20077.7	23746	18260.2

Part.: Refers to participant farmers, ET: Birr refers to Ethiopian birr and var and cost refers to variable cost

at all production periods under urban small holder households management, were significantly ($p<0.05$) higher at Mirabe Azernet district in the study area. The current finding is consistent to the findings[10] who reported the mean egg weight of bovan brown chicken under an intensive management technology was (57.7±1.1 gram) at Mekelle, Ethiopia, and this study is in line with the report[17], that an egg weight ranging from 56.2 to 58.9 in a medium and light weight bovan brown chicken breed. The sizes of the eggs are predominantly influenced by genetics, but they can also be affected by management techniques related to lighting and feeding. A hen's egg size throughout its life tends to be larger if the hen has a higher body weight when she reaches maturity. Generally, there is a good correlation between egg weight and body weight, but if a flock starts producing eggs earlier, the eggs will typically be smaller, while hens that begin laying eggs later will produce larger eggs. The size of the eggs is significantly influenced by the birds' consumption of energy, total fat, crude protein, methionine, and cysteine in their diet. As noted, by a study[18] adjusting the lighting schedule can impact the rate of maturity; specifically, a reduction in lighting after ten weeks of age can delay maturity and result in larger average egg sizes.

Egg production performance of chicken under cage production technology: The hen day egg production percentage is calculated as the number of eggs collected divided by the number of live hens at that day multiplied by 100 using the formula[19].

The egg production performance of bovans brown commercial layer chicken produced in the chicken cage at Mirabe azernet district was significantly higher ($p<0.05$) than Gummer districts as shown above in Table 6 in the study area. Overall, the egg production performance of bovans brown commercial layer breeds produced in the chicken cage in the study area lay eggs on average of 224.33±3.84 eggs/hen/year under urban households' management conditions. The maximum percentage of hen day egg production was achieved at the age of 56 weeks under cage chicken production technology in the study area as shown in Table 6. This value is greater than that reported by Solomon *et al.*[15], who studied the average annual egg production of bovans brown chickens, was 189.2 eggs/hen/year; reared under a semi-intensive chicken rearing production technology. According to the report of[10], the egg production performance of bovans brown chicken under intensive production conditions was

292.4±17.9 eggs/hen/year, which is higher than the current study, and the author also stated that, under a backyard management technology was 218.2±15.5 eggs/bird/year at Mekelle, Ethiopia. The difference might be due to the management condition of the households at different locations and the type of chicken production technology and management practices at different localities.

Partial budget analysis: The partial budget analysis revealed that the costs of chicken, feed, and medication were variable. However, live chicken sales, spent hen or nonproductive hen sales, egg and existing chicken costs were used as income for farmers, and the chicken cage costs were fixed costs as shown in Table 7. The variable cost and total return partial budget analysis are calculated as follows, based on the current price of each product.

NET INCOME: The change in net income (ΔNI) was calculated as the difference between the changes in total return:

(ΔTR) and the change in total variable costs (TVC)
ΔNI = (ΔTR)-(TVC)
ΔNI =23746-5485.8 Ethiopian Birr
ΔNI =18260.2 Ethiopian Birr

On average, an average net income of 18260.2 Ethiopian birr was incurred for each smallholder household (participant), with in a small cage with the capacity of 32 commercial layer chicken breeds as shown in (Table 7).

Perception of the participant households for the chicken cage production technology: Perception of the participant households for the chicken cage production technology in the study area described as it's acceptable and weak sides of the technology.

The acceptable sides of the chicken cage which was listed by the participant households were; the chicken cage increases hygiene resulting in a much lower incidence of diseases in which the infectious agent is spread through the dropping, ease of management specially during provision of feed, water and egg collection, absence of litter problems, better working conditions, much lower cost of production low feed intake due to no more exercise in the cage, low Adjustment costs involved in adopting the technology, after construction the chicken cage, used for long period of time and it is portable, chicken cage can be constructed by local available materials with in small pieces of land, the technology is not more complex, the collected feces were used as organic fertilizer for home garden vegetation and it is environmentally safe.

The weaknesses of the chicken cage as listed by the participant households, were: lack of exercise for the chicken, lack of dust bathing opportunities for the rearing chicken, and a higher incidence of foot lesions was observed. However, the participant households and the nearby small-holder households in the study area acknowledged the chicken cage as a good chicken production technology, especially for urban areas in the study area.

CONCLUSION

Evaluation and demonstration of chicken cage technology in and around urban areas under small holder household management conditions revealed that is a feasible and productive technology. Bovans brown chickens reared under chicken cage production showed good survival rate (93.75%) was relatively high, indicating the chicken cage reduces mortality when properly used the cage. However, poor management practices were recognized as the major chicken loses followed by disease, and the chicken breed shows

good growth performance, reaching an average final body weight at about 1675 grams at 48 weeks, which is better than some previous studies. Annual egg production of the chicken was also encouraging with an average egg production of 224 eggs /hen/year. Economically, the technology was profitable; the households gained an average net income of 18,260.2 Ethiopian birr per household. In the study areas, there is a shortage of land for chicken house construction; there for, it's possible that using chicken cage production technology is the best opportunity for urban smallholder households to produce chickens for their income and to improve their children's nutrition by feeding them chicken products like meat and eggs. For urban smallholder households and areas with limited land, chicken production using chicken cage technology may be the ideal option.

SIGNIFICANCE STATEMENT

This study addresses the critical challenge of limited land availability for poultry production in urban and peri-urban areas of Gurage and Siltie zones. It demonstrates that chicken cage production technology enables smallholder households to rear a larger number of chickens within a limited space, improving productivity and income. The technology also enhances household nutrition, particularly for women and children, while promoting efficient management practices. The findings provide practical evidence for scaling up cage-based poultry systems in similar resource-constrained settings.

ACKNOWLEDGMENT

The authors of this manuscript would like to acknowledge the Food Technology Resilience Program, Worabe Agricultural Research Center, Mirabe Azernet Berbere and Gummer District livestock experts and the participant smallholder households.

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