CHARACTERIZATION OF INDIGENOUS CHICKEN PRODUCTION AND RELATED CONSTRAINTS INSIGHTS FROM SMALLHOLDER HOUSEHOLDS IN RURAL KENYA

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IDRC GRANT / SUBVENTION DU CRDI : - GENDER INCLUSIVE VACCINE DISTRIBUTION AND DELIVERY SYSTEMS FOR NEWCASTLE DISEASE AND PESTE DES PETITS RUMINANTS AMONG SMALLHOLDER FARMERS IN KENYA

Scientific African 20 (2023) e01717

Contents lists available at ScienceDirect

Scientific African

journal homepage: www.elsevier.com/locate/sciaf

Characterization of indigenous chicken production and related constraints: Insights from smallholder households in rural Kenya

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ARTICLE INFO

Article history:
Received 24 February 2022
Revised 9 May 2023
Accepted 12 May 2023

Editor: DR B Gyampoh

Keywords:
Biosecurity
Indigenous chicken diseases
Empowerment
Marketing
Indigenous chicken predation

ABSTRACT

Indigenous chickens (IC) contribute significantly to nutrition and socioeconomic wellbeing of rural households. However, despite their potential, production remains low. Attempts to improve IC production among smallholder farmers in Makueni county, Eastern Kenya have achieved little success due to a variety of constraints. This paper explores IC production characteristics and compares the ranks assigned to production and marketing constraints across geographic regions and in male and female-headed households. A descriptive quantitative household survey of 1217 respondents drawn from IC rearing households was conducted and the results integrated with qualitative findings from 22 informants. Results showed an average flock size of 14.9 ± 15.94 IC per household, with female- headed households having relatively fewer chicken than male-headed households. However, relatively more chicken (15.9 ± 18.9) were lost per household during the last disease outbreak compared to the number kept at the time of study. Production system was largely free-range in nature with minimal provision of supplementary feeds. Disease (1.13±0.5), predation (3.16±1.9) and low market prices (3.89±1.9) were three top ranked (Mean Rank±SD) constraints in that order. Lack of capital, high cost of inputs, poor access to extension services and poor access to knowledge ranked significantly higher in female-headed households and in remote areas, while low market price ranked higher in male-headed households. Failure to agree on the selling price was the major constraint to marketing, while rejection of IC due to diseases, inability to agree on selling price and rejection due to size ranked higher in female-headed households compared to male-headed households. Interventions modeled towards improving biosecurity measures to curb diseases, financial empowerment and facilitating access to markets for smallholder farmers should be prioritized.

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https://doi.org/10.1016/j.sciaf.2023.e01717

Introduction

Development of the poultry sub-sector is considered an important pathway to asset creation, poverty reduction and improved household food security in rural areas of developing countries [17]. Chickens are the most prevalent species of domestic fowl worldwide, accounting for about 90% of the total poultry population [16]. The role of small-scale, low-input indigenous chicken production in improving the livelihoods of vulnerable households has been recognized and their importance in national poverty reduction strategies and programs in developing countries is well documented [22]. Indeed, small-scale IC production systems are most common in rural, resource-poor areas that often experience food insecurity [54]. The minimal input requirements and flexible production system under varying ecological zones which permits ownership of IC by anyone, including resource-constrained, children, vulnerable, and disadvantaged populations, contribute to IC popularity [37]. Chicken is also the only livestock that is regarded as being under the independent control of women in many rural settings as most women are able to make independent decisions to sell or slaughter IC without having to engage in formal negotiations with their spouses [15,52]. Also, the IC production system places very little time demands on women [49].

Unfortunately, production of IC by smallholder farmers is fraught with a myriad of constraints. Poultry diseases, predation, high cost of feeds, poor housing structures, inadequate nutrition, lack of extension services, lack of markets and lack of information are just some of the impediments. Most of these constraints transcend regional boundaries but their impact on chicken production vary greatly at regional, local and even household levels owing to strong influence from environmental, economic, socio-cultural, gender and institutional factors. More importantly, gender analysis in chicken production suggests that men and women are impacted differently by these constraints. For women, the constraints are often compounded by patriarchal nature of society and socially constructed gender roles that increases their vulnerability relative to men [48]. Literature further postulates that women frequently have limited access to market information, and production resources like capital, land, and other production inputs which puts them at a disadvantage [8]. Their decision making power over a number of factors of production is also curtailed by cultural norms and unequal power relations within the household [32].

In Kenya, poultry farming is a major livestock subsector with an estimated 31.8 million birds – most (81%) of which are indigenous chickens. The sector contributes to income, food security and nutrition for many households; more so in rural areas and is largely controlled by women [25]. There have been attempts to improve IC production in many rural areas including Makueni county in Kenya through various state and non-state driven initiatives. However, productivity of IC among smallholder farmers in rural Kenya including Makueni County remains low despite the numerous interventions [25,40]. This is partly because the majority of these initiatives frequently overlook constraints that are considered of greater importance by farmers and also fail to consider gender and region specific factors in their intervention programs. A targeted approach to address the constraints that take into consideration gender and region specific differences is thus necessary. This study sought to explore the IC production characteristics among smallholder farmers and compare the ranks assigned to production and marketing constraints across three distinct geographic sub-counties and in male and female-headed households. A clear understanding of gender and area specific differences would aid in the design of targeted interventions that would promote IC production efficiency among rural households.

Methodology

Description of the study site

Makueni county covers an area of 8176.7 Km^2 and is located in South Eastern, Kenya between latitude 1°35′ and 32°00′ S and longitudes 37°10′ and 38°30′ E (Fig. 1). It has an estimated human population of 987,653 and a population density of 120.8 persons per Km^2 [29]. The county lies in the arid and semi-arid zones of Kenya that are prone to prolonged dry spells with temperatures of between 20 and 32 °C. Two rainy seasons are experienced in the county; the long rains which occur between mid-March to April and the short rains between November and December. The upper part of Makueni county is fertile and experiences a higher average annual rainfall of between 800 mm and 1200 mm and is suitable for both crop and dairy farming, while the low lying areas receive reduced rainfall amounts of between 300 mm and 400 mm annually capable of sustaining drought-tolerant crops that double up as important nutrient sources for humans and also critical feed resources for indigenous chickens. Indeed, majority of households in the county engage in mixed subsistence agriculture, which primarily involves raising chickens and small ruminants as well as cultivating drought-tolerant crops for household consumption [41]. The leaf and legume cowpeas (*Vigna unguiculata*), green grams (*Vigna radiata*), pigeon peas (*Cajanus cajan*), and sorghum (*Sorghum bicolor*) were the most common drought-tolerant crops produced in the area [41]. These dry land crops can produce high biomass, even with limited moisture supply, making them strategic feed sources for humans and livestock including IC in relatively arid areas [26,42,46].

Six wards drawn from three administrative sub-counties namely: Kathonzweni and Kitise wards in Makueni sub-county; Makindu and Kikumbulyu wards in Kibwezi west sub-county, and Masongaleni and Mtito Andei wards in Kibwezi east sub-county were the subject of this investigation. Different poultry breeds are kept by smallholder farmers in the three sub-counties among them chickens, ducks, guinea fowl, geese, and turkeys. However, IC remains the most prominent breed. For instance, IC population in the three sub-counties combined was estimated at 842,168, accounting for 93.6% of the poultry population as of 2019 [34]. The wards have different characteristics as briefly described below:

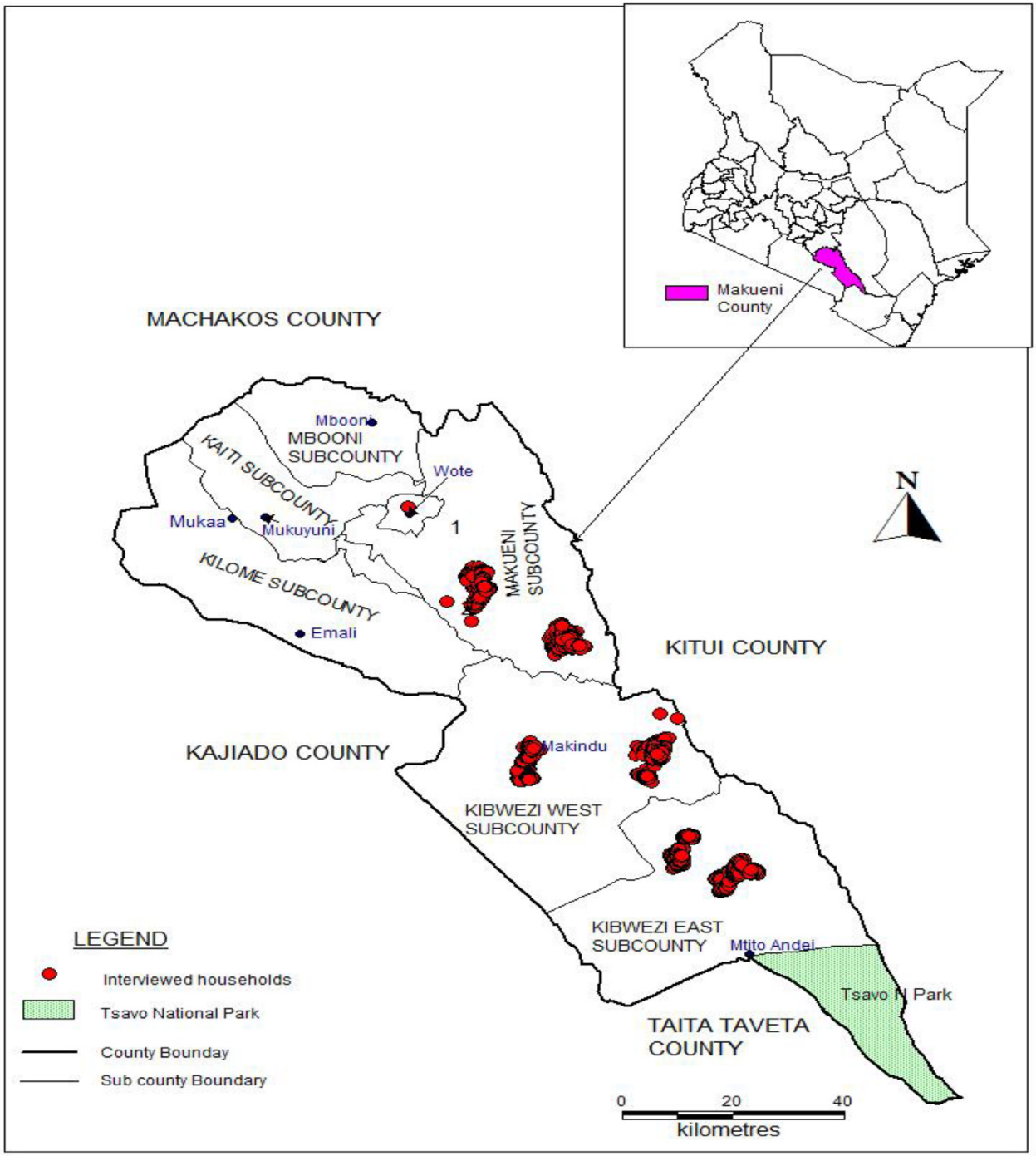

Fig. 1. Clusters of the households surveyed in Makueni County.

Kathonzweni and *Kitise* wards share a common border and are approximately 23 and 55 km away from Makueni County headquarters, respectively. The two wards have well established weekly livestock markets that also handle poultry and poultry products. In the context of this study, Makueni sub-county is considered relatively urban with close proximity and access to large livestock markets, essential veterinary services and the county headquarters.

Makindu and *Kikumbulyu North* wards are approximately 71 km and 113 km from the county headquarters, respectively. The two wards lie along major tarmac roads, *i.e.*: Nairobi - Mombasa highway; classified as an international trunk road and Kibwezi – Kitui road; classified as national trunk road, which makes transportation easier and cheaper. In the context of this

study, Kibwezi west sub-county is thus considered to have fairly good access to amenities but moderate proximity to the county headquarters.

Masongaleni and *Mtito Andei* wards are approximately 127 km and 134 km from the county headquarters, respectively. Both wards are in the remote rural parts of the county and occasionally experience acute food shortage or famine that necessitate food aid from government and development agencies. The road network is poor making transportation difficult and costly. In the context of this study, Kibwezi east sub-county is considered remote, with limited access to amenities and poor access to livestock markets and the county headquarters.

Study design, sample size and sampling procedure

A cross-sectional descriptive study design was adopted for this study in which quantitative and qualitative data collection methods were used. A multi-stage (three-stages) sampling technique was used to select 1217 indigenous chicken keeping households from which the respondents were interviewed. Precisely, three sub-counties (primary sampling units) were first purposively selected from a total of nine, based on the potential role and contribution of IC to the improvement of household livelihood and their proximity to the county headquarters. In each sub-county, two wards (secondary sampling units) were randomly selected from possible seven, six and four wards in Makueni, Kibwezi West and Kibwezi East sub-counties, respectively. Using an estimated population of 100,000 individuals per sub-county as per the 2019 Kenya population and housing census [29], a margin of error of 0.05, and a 95% confidence level, Slovin's formula was applied in calculating the sample size per sub-county as shown below:

$$n = N/\left(1 + Ne^2\right)$$

Where: *n*=number of samples, *N*=population size, *e*=margin of error (error margin), which gave a sample size of at least 400 households per sub-county, translating to at least 1200 households in the three sampled sub-counties

Villages (tertiary sampling units) were then cluster sampled and IC keeping households (ultimate sampling units) randomly selected until the set number was met. Where the sample size was not realized, the adjacent village was included until the allocated sample size for each ward was attained. In each household, a structured questionnaire was administered to the household head or the spouse. Overall, respondents that took part in the study in the three sub-counties were 403, 405 and 409 in Makueni, Kibwezi West and Kibwezi East, respectively.

Of the 1217 respondents interviewed, 964 (79.2%) were female and 253 (20.8%) were male. Most (703) of the 964 female respondents were drawn from male-headed HH and the remaining 261 from female-headed households. Likewise, most (249, 98.4%) of the 253 male respondents were drawn from male-headed households and just 4 (1.6%) from female-headed households.

Qualitative data was collected through in-depth interviews with 22 purposively selected informants deemed to have in-depth knowledge of the subject and sufficiently understanding of their community. The sample size was informed by the data saturation point beyond which no new information was forthcoming and also aligned with the recommended sample size of between 15 and 35 informants - considered sufficient for most studies. For inclusion in the study, an individual had to be above 18, a resident of the study area, a current chicken keeper or from a chicken rearing household, and willing to participate. The informants included both men and women who also served as group leaders, trainer of trainers or role model for other farmers. Majority were women by virtue of being the ones mainly responsible for chicken rearing in most households. These informants were deemed knowledgeable and in a better position to provide in-depth insights into farmers' perspectives, beliefs, behaviors, motivations, and practices related to chicken production and associated constraints. The in-depth interviews provided additional data required to examine the underlying norms, beliefs and practices that influence or reinforce IC production and marketing constraints.

Data collection procedure

The household questionnaire was administered in Kamba, Swahili or English languages and responses captured electronically using the *ArcGIS Survey 123* data collection software. The respondents included household heads or their spouses drawn from indigenous chicken rearing households in the six wards. Besides demographic characteristics, the tool contained questions on chicken production characteristics as well as constraints to chicken production and marketing. The chicken production characteristics covered include: chicken housing, chicken confinement, chicken rearing objectives, feeding, disease control (ND only) and training on chicken husbandry. Respondents were provided with a list of production and marketing constraints and allowed to select multiple options by order of importance. The production constraints were ranked 1–10, *with 1 being most important and 10 least important*, while marketing constraints were ranked 1–5 *with 1 being most important and 5 least important*.

Qualitative data collection was guided by a list of open ended questions with probes being used to gain more insight where necessary. The in-depth interviews were conducted in Swahili, Kamba or English languages and captured in a note book and a tape recorder.

Table 1
Mean number of chicken kept at the time of study.

Sub-county	Pooled (Mean±SD)	Male-headed HH (Mean±SD)	Female-headed HH (Mean±SD)	df	*P-value*
Kibwezi East	13.9 ± 11.5	15.0 ± 12.2	9.4 ± 6.7	421	**.0000**
Kibwezi West	13.2 ± 13.7	13.5 ± 14.2	12.0 ± 11.6	408	.3768
Makueni	17.9 ± 21.1	16.9 ± 15.1	20.2 ± 33.5	375	.2027
All sub-counties combined	14.9 ± 15.9	15.1 ± 13.9	13.8 ± 21.3	1208	.2604

Data analysis

The survey data collected was cleaned and exported into STATA version 13.0 for analysis. The data was analyzed descriptively and the Mean ± Standard Deviation (SD) and percentages generated. The IC production and marketing constraints were ranked individually in the order of importance (frequency) without regard to combination responses. The differences in ranking of production and marketing constraints between male and female-headed households and across sub-counties and wards are explored in this paper.

To determine differences in means across sub-counties, One-way ANOVA was computed in STATA software (ver. 13.0). The one-way ANOVA model took the form:

$$\mathrm{Yi}_i = \mu + \mathrm{Ai} + \mathrm{gi}$$

Where: Yi is dependent variable, μ is the overall mean, Ai is the fixed effect of zones; i = Makueni, Kibwezi East and Kibwezi West sub-counties; gi is a random error. Further, the Scheffe's post hoc test was computed to explore significant differences between multiple group means. Similarly, an independent *t*-test (two tailed) to compare the means between male-headed and female-headed households and Pearson Chi-square two-sided (χ^2) test to compare two or more categorical data were computed. The level of significance was set at 5% for all analyses.

Audio-recorded qualitative data was transcribed and translated into English. The transcripts were verified by comparing the audio files and scripts. Thematic analysis was carried out in Nvivo (version 12.0 plus) to establish and interpret patterns and relationships from emerging themes. Key quotes, observations and comments from the IDIs are presented verbatim to ensure they were not lost in translation.

Results

Demographic characteristics of household survey respondents

The 1217 respondents (964 females and 253 males) who took part in the study were drawn from 952 (78.2%) male-headed and 265 (21.7%) female-headed households. The average household size was 5.2 ± 2.3 people, with male-headed households having averagely more (5.3 ± 2.29) members than female-headed households (4.8 ± 2.5 people). The mean age of household heads was 53.7 ± 15.5 years, with female household heads being relatively older (62.3 ± 14.0 years) than their male counterparts (51.3 ± 15.1 years). Over half (56.4%) the male household heads and 47.5% of female household heads had primary level of education, while 29.7%, 5.9% and 1.5% of male household heads and 12.3%, 1.9% and 0.0% of female household heads had secondary, college and university level of education, respectively. Relatively more (38.3%) female household heads compared to male household heads (6.5%) did not have any formal education. There were significant differences in education level of the household heads across the three sub-counties (χ^2 = 27.192, p= .001).

Indigenous chicken production characteristics

Indigenous chicken holding averaged 14.9 ± 15.94 per household at the time of study, with significant differences (p = .0000) observed between sub-counties (Table 1). Overall, female-headed households kept averagely fewer chicken (13.8 ± 21.3) than male-headed households (15.1 ± 13.9), though the difference was not statistically significant (p= .2604).

Most of the IC production characteristics varied significantly across male and female-headed households in the various sub-counties (Table 2). Slightly more (76%) male-headed households compared to female-headed households (71.3%) owned a chicken house. The proportion of households that owned a chicken house varied significantly by sub-county (χ^2 = 8.513, p= .014). However, among those who owned a chicken house, only 24.5% (297 households) confined chicken during the day. Of these 297 households, 46.9% did it the whole day and another 46.9% did it during morning hours only. In most (77.8%) households, IC were mostly kept for both home consumption and commercial purposes while a small proportion (2.4%) of households kept IC for commercial purposes only. The proportion of households that sold IC varied significantly by sub-county (χ^2 = 10.1993, p= .006). The reasons for keeping IC were corroborated in the in-depth interviews with informants reporting that IC were mainly kept for subsistence purposes often in modest numbers – less than 30 per household - as illustrated in the excerpt below;

Table 2
Chicken production characteristics.

Variables	Pooled Freq. (%)	Male-headed HH Freq. (%)	Female-headed HH Freq. (%)	χ^2	df	*p value*
Do you have a chicken house?						
Yes	908 (75.0)	721 (76.0)	187 (71.6)	2.05	1	0.15
No	302 (25.0)	228 (24.0)	74 (28.4)			
Do you confine your chicken during the day?						
Yes	294 (24.4)	228 (24.1)	66 (25.4)	0.182	1	0.669
No	912 (75.6)	718 (75.9)	194 (74.6)			
Length of time chicken are confined						
All day	138 (46.9)	109 (47.8)	29 (43.9)	4.418	3	0.211
Morning only	138 (46.9)	102 (44.7)	36 (54.5)			
Afternoon only	10 (3.5)	9 (3.9)	1 (1.5)			
Other	8 (2.7)	8 (3.5)	0 (0.0)			
Reason for keeping chicken						
Home consumption	239 (19.8)	177 (18.7)	62 (23.8)	3.62	2	0.163
Commercial purpose	29 (2.4)	24 (2.5)	5 (1.9)			
Consumption & commercial	940 (77.8)	747 (78.8)	193 (74.2)			
Do you sell your chicken?						
Yes	1032 (87.2)	818 (87.9)	214 (84.6)	1.91	1	0.167
No	152 (12.8)	113 (12.1)	39 (15.4)			
Do you buy feeds for your chicken?						
Yes	459 (38.0)	374 (39.5)	85 (32.7)	3.96	1	**0.047**
No	749 (62.0)	574 (60.5)	175 (67.3)			
Action taken to prevent Newcastle disease in chicken						
Nothing	204 (16.9)	155 (16.4)	49 (18.8)	9.86	3	**0.020**
Vaccinate	167 (13.8)	135 (14.3)	32 (12.3)			
Use herbal remedies	696 (57.6)	534 (56.4)	162 (62.3)			
Others	140 (11.6)	123 (12.9)	17 (6.5)			
Have you ever received training on chicken rearing?						
Yes	288 (23.9)	218 (23.1)	70 (26.8)	1.56	1	0.212
No	917 (76.1)	726 (76.9)	191 (73.2)			

HH = household.

"*I do not keep chicken to sell, I rear indigenous breeds for my own consumption. The other breeds kept for sale (referring to commercial chicken breeds) require a lot of work like building a house, money and time. I do not have money and time to maintain them, I rear local breeds because of minimal labor involved and they are not stressful*" (Female IDI 18).

Less than 40% of the households bought commercial feeds for their IC from the market, while the rest kept the IC on a purely free range system. The proportion of households that bought commercial feeds varied significantly by sub-county ($\chi^2 = 31.363$, p=.0000). To prevent against Newcastle disease, over half (57.6%) the households used herbal remedies, 13.8% used vaccines, while 16.9% did nothing. Slightly more (26.8%) female household heads had received training on chicken rearing than male household heads (23.1%). The proportion of those who received training varied significantly by sub-county in favor of those in urban areas ($\chi^2 = 23.516$, p=.000).

Constraints to indigenous chicken production

Average number of IC lost during the last disease outbreak per household

Households that did not own a chicken house, did not confine IC during the day, and did not buy feeds lost averagely more IC during the last Newcastle disease outbreak than the average number of IC that they were keeping at the time of study (Fig. 2). Only 8.6% of households that did not own a chicken house vaccinated their chicken to prevent ND attack on their chicken. Majority (58.6%) used herbal remedies and 22.0% doing nothing. The number of IC lost during the last ND outbreak averaged 15.9 ± 18.9 per household with female-headed households losing averagely more IC (16.2 ± 18.2) compared to male-headed households (15.7 ± 18.9). The differences in average number of chicken lost across sub-counties were, however, not significantly different.

Indigenous chicken production constraints

Of the 10 production constraints assessed in the present study, diseases were cited by most (99.6%) respondents, followed by predation (60.9%) (Table 3). Poor access to extension services was least mentioned by just 29.8% of the respondents. When the constraints were ranked (Mean Rank ± SD) by order of importance, diseases (1.13±0.5), predation (3.16±1.9) and low market prices (3.89±1.9) were highest in that order, while poor access to extension services (5.87±2.1), poor access to new knowledge (5.33±2.5) and theft (4.77±2.5) ranked lowest. Other constraints ranked in-between included lack of capital (4.15±1.9), high cost of inputs (4.33±2.2), and lack of markets (4.47±1.9). Consistent with the quantitative findings, in depth interview informants also cited disease outbreaks as a major constraint to indigenous chicken production within

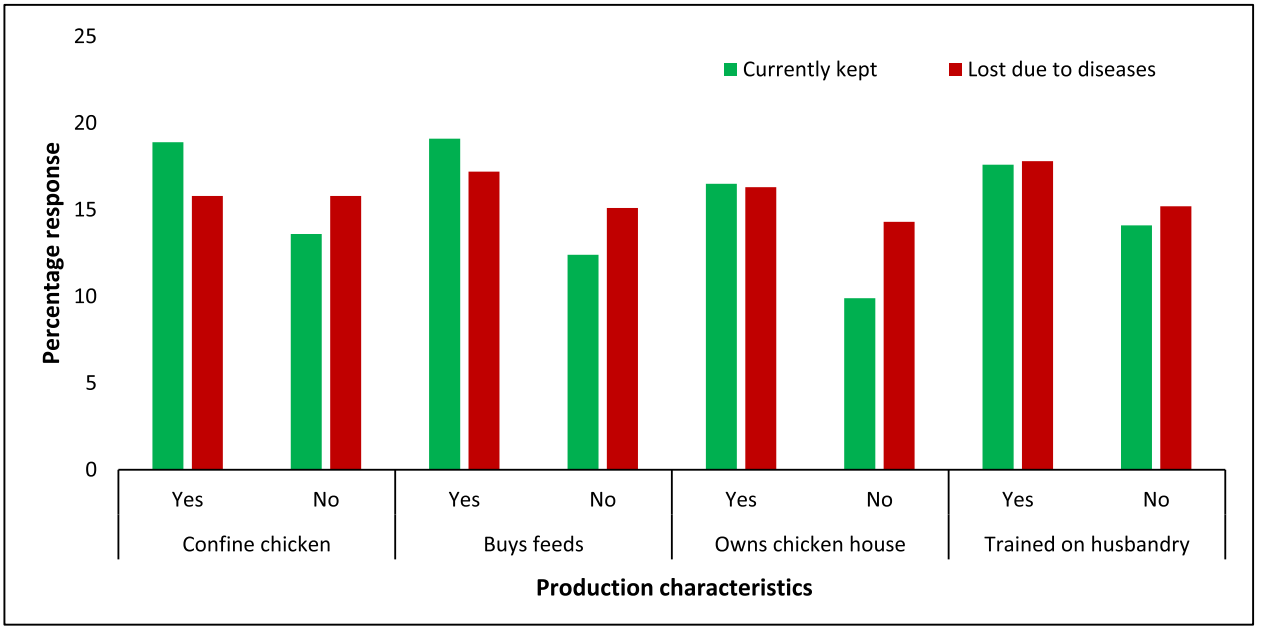

Fig. 2. Indigenous chicken kept currently against those that died due to diseases under different production characteristics.

Table 3
Ranking of production constraints across the sub-counties.

	Kibwezi East (423)		Kibwezi West (410)		Makueni (384)			
Constraints (n = 1217)	Freq.	Mean Rank ± SD	Freq.	Mean Rank ± SD	Freq.	Mean Rank ± SD	*df*	*p-value*
Diseases	421	1.19±0.5	407	1.14±0.6	384	1.06±0.3	2	**.0010**
Predation	253	3.16±1.8	243	3.39±1.9	241	2.93±1.9	2	**.0241**
Low market prices	182	4.0 ± 2.1	199	3.77±1.8	182	3.93±1.9	2	.4999
Lack of capital	176	3.70±1.9	167	4.27±1.9	158	4.521.9±	2	**.0003**
High cost of inputs	163	3.91±2.1	165	4.50±2.3	169	4.57±2.1	2	**.0123**
Lack of markets	160	4.48±2.1	154	4.57±1.9	151	4.35±1.7	2	.6067
Poor access to new info	111	4.43±1.8	161	5.39±2.7	157	5.91±2.6	2	**.0000**
Theft	111	4.91±2.6	148	4.53±2.6	127	4.94±2.4	2	.3127
Poor access to ext. services	110	5.3 ± 2.0	127	6.09±2.1	126	6.14±2.1	2	**.0032**
Others	15	3.0 ± 1.1	18	3.78±2.6	11	5.45±3.8	2	.0691

SD: Standard deviation; df: Degree of freedom;.

the study setting. The adversity of IC diseases resulted from limited knowledge on etiologies, prevention and treatment of the various poultry diseases among farmers. The resulting high IC mortality rates during disease outbreaks was said to demotivate smallholder chicken farmers and this could explain the low IC holding in the area. The devastating effect of disease outbreaks is captured in the excerpt below:

> *"Chicken die very much in April, June and July every year… When they die, people relax and that's why most households don't have chickens. I used to keep 200 chickens and I was left with 70 after the outbreak. Now I have lost hope"* (Female IDI 09).

Comparison by sub-county revealed that diseases (p= .001) and predation (p= .0241), ranked significantly higher in the relatively well developed areas while, lack of capital (p= .0003), high cost of inputs (p= .0123), poor access to new information (p= .0000), and poor access to extension services (p= .0032) were all ranked significantly higher in the far flung remote areas.

Ranking of production constraints in male and female-headed households

More production constraints were ranked significantly higher in female-headed households than male-headed households (Table 4). Precisely, poor access to extension services [t (361) = 2.2801, p = .0232], lack of capital [t (499) = 2.6163, p = .0092], high cost of inputs [t (495) = 2.2909, p = .0224] and poor access to new knowledge and information [t (427) = 2.2578, p = .0245], were all ranked significantly higher in female-headed households compared to male-headed

Table 4
Ranks assigned to production constraints in male and female-headed households.

	Pooled (n = 1217)		Male-headed HH		Female-headed HH			
Constraints	Freq	Mean Rank ±SD	Freq	Mean Rank ±SD	Freq	Mean Rank ±SD	*df*	*P-value*
Diseases	1212	1.13±0.5	947	1.12±0.4	265	1.16±0.6	1210	.2275
Predation	737	3.16±1.9	580	3.18±1.9	157	3.07±1.9	735	.5027
Low market prices	563	3.89±1.9	452	3.79±1.9	111	4.35±2.1	561	**.0058**
Lack of capital	501	4.15±1.9	394	4.27±1.9	107	3.72±1.9	499	**.0092**
High cost of inputs	497	4.33±2.2	398	4.44±2.2	99	3.88±2.0	495	**.0224**
Lack of markets	465	4.47±1.9	381	4.41±1.9	84	4.71±2.0	463	.1986
Poor access to knowledge	429	5.33±2.5	336	5.79±2.5	93	4.82±2.3	427	**.0245**
Theft	386	4.77±2.5	302	4.77±2.5	84	4.80±2.5	384	.9248
Poor access to ext. services	363	5.87±2.1	291	6.00±2.1	72	5.36±2.0	361	**.0232**
Others	44	3.93±2.7	36	3.97±2.8	8	3.75±2.7	42	.8374

SD: Standard deviation.

households. However, low prices were ranked significantly higher in male-headed households compared to female-headed households [t (561) = −2.7685, p = .0058].

Ranking of constraints under different IC production characteristics

Diseases were ranked slightly higher in households that: did not own a chicken house, did not confine IC, bought commercial chicken feeds, had never received training and those that did not sell their IC compared to the opposite, though the differences were not significant.

Predation was ranked significantly higher in households that did not confine poultry during the day (3.06) compared to those that did (3.01), following an independent t-test [t (733) = −2.471, p = .0137]. Likewise, predation ranked significantly higher (3.05) among households that did not buy chicken feeds compared to those that bought (3.34), [t (733) = −2.091, p = .0368]. Predation was also ranked higher among households that did not own chicken house (2.97±1.6), compared to those that owned (3.22±2.0), though the difference was not statistically significant (p=.1262). Theft was ranked higher among households with a chicken house compared to those without. In-depth interview informants corroborated these findings by citing wild animals - particularly birds - as major predators and thieves as some of the challenges faced by farmers in the area.

> *"…You will come and find that your chickens were carried by the eagle or were stolen by the local thieves when you were not around…"* (Female IDI 18).

In addition, theft was ranked significantly higher in households that did not buy feeds (4.49) compared to those that bought (5.19) [t (383) = −2.682, p = .0076] and also among those whose members had received information on IC rearing (4.32) compared to those whose members had not (4.95), [t (382) = 2.185, p = .0295].

Lack of capital was ranked significantly higher in households that did not buy feeds [t (499) = −2.7258, p = .0066] and households that mostly confined IC during the day [t (494) = 4.1088, p = .0000] compared to those that bought feeds and those that did not confine IC, respectively. Also, lack of capital, high cost of inputs, low market prices and lack of markets were all ranked higher in households that kept IC for commercial purposes compared to those that kept IC for home consumption or both. Consistent with the survey findings, in-depth informants attributed low production to lack of capital citing the inability to purchase inputs like drugs, vaccines, chicken feeds, production equipment or even construct a proper chicken house, as partly captured in the excerpt below:

> *"…one sack of growers feed is 2500 shillings [$25] and I am beginning to struggle, I do not have money. What am I going to do? I have to stop because I do not have food. My husband asks why I cannot keep many chicken? I tell him that this job is difficult and even the money for buying eggs is not there. …With chicken you must have food. If you do not have food, you cannot say you are keeping chicken"* (Female IDI 12).

Poor access to extension services was of least importance to households that kept IC for commercial purpose compared to those that kept IC for home consumption or both. Likewise, poor access to new knowledge and information on IC production ranked significantly higher in households whose member(s) did not receive training [t (426) = −2.1202, p = .0346], and those that confined IC during the day [t (424) = 2.9363, p = .0035] compared to those that received training and those that did not confine, respectively. Despite not being ranked highly, poor access to extension services and new knowledge were also identified as constraints to IC production in the in-depth interviews, where informants reported that most extension officers or vaccinators in the region were unavailable whenever needed and some were never serious. The few available were said to be quite expensive and often demanded unreasonable compensation and incentives that were beyond the local farmers' capacity. Most of them also prioritized farmers with many animals, as captured in the excerpts below;

Table 5
Ranking of market specific constraints for those who sold chicken.

Constraints	Kibwezi East		Kibwezi West		Makueni		df	*p-value*
	Freq.	Mean±SD	Freq.	Mean±SD	Freq.	Mean±SD		
There are no buyers	77	2.64±1.1	56	2.63±1.2	60	2.25±1.3	2	.1231
There are too many chicken	57	3.26±1.3	47	3.17±1.1	58	2.64±1.2	2	**.0106**
Cant' agree on selling price	177	1.50±0.8	125	1.39±0.8	109	1.71±1.1	2	**.0262**
Birds rejected due to size	83	2.72±1.4	74	2.78±1.4	70	3.33±1.6	2	**.0233**
Birds rejected due to diseases	99	1.81±1.1	67	2.43±1.6	62	3.02±1.7	2	**.0000**

SD=Standard deviation; df= degree of freedom; Freq. = Frequency; Mean Rank±SD = Mean rank ± standard deviation.

"We have one vet officer from the county, and besides being expensive he delays a lot and all your goats/animals may die by the time he makes an appearance and he ignores people, imagine you calling him to check one goat and there is another person calling for multiple, he will go to them and leave you and never show up. Upon following up we were told that the problem is fueling the motorcycle that he says is very expensive for him and that's why we pay him a lot of money" (Male IDI 03).

"I called the veterinary doctor last week and the week ended without me seeing anyone. I called them again and they said they would come and till today they are still coming" (Female IDI 05).

"All these challenges are due to the few extension officers. The veterinary officers do not reach this area. Even once you call him, you have to cater for his transport and after treatment he demands for a pay of Ksh. 1000" (Male IDI 04).

"*I have told you there are vaccinators but they are not serious. Since they do not rear chicken and they have nothing will they bother? They will not bother….. you call them and call them and the week passes and another ends. They will just have assumed and your chicks will be vulnerable*" (Female IDI 16).

Additional constraints identified by IDI informants included harsh environmental conditions like prolonged droughts, dust and acute water shortage often accompanied by inadequate feeds (especially vegetation and human food remnants which are often fed to IC) during such times which result in their slow and poor growth or death. Poor water quality and dust were identified as contributors to frequent disease outbreaks in the region. While lack of knowledge was identified as a challenge to women, the importance of hygiene and provision of clean water in the prevention of diseases were emphasized by the informants:

"Another challenge is that you need to give the chickens clean water. You may go to fetch water which may be contaminated and transmit the disease through the water. So, before you give the chickens that water, you will need to treat the water and you find that a woman may lack that knowledge. The women in this area lack the training" (Female IDI 11).

"Ensuring that the chicken's drinking water is clean and free from contamination. Dogs or other animals should not drink from the same point with chickens because they might have fed on infected chickens and thus spread the disease"- (Male IDI 02).

"*There is need to ensure that the place where chickens sleep and the water they drink is clean…. I can take the water which I give my chickens. Ensure that you have cleaned the utensils properly. Where they feed from has to be cleaned and disinfected. You should also disinfect their house after a week……. Chickens need cleanliness. If you keep chicken without cleanliness you will fail. Chickens are cleanliness"* (Female IDI 01).

Marketing based constraints faced by indigenous chicken farmers

A total of 5 market based constraints were examined out of which failure to agree on the selling price, rejection of IC due to diseases and lack of buyers were ranked as top three generally (Table 5). Ranking of all market specific constraints were significantly different across the sub-counties except the ranking of lack of buyers in the market.

Ranking of marketing based constraints in male and female-headed households

Rejection of chicken due to diseases, rejection of chicken due to size and inability to agree on the selling price were all ranked higher in female-headed households compared to male-headed households, though the differences were not statistically significant (Table 6). Too many chicken in the market were ranked relatively higher (2.94±1.2) in male-headed households than female-headed households (3.38±1.2). In-depth interview informants also identified lack of markets and fluctuating prices as important constraint to IC production in the study setting. The IDI informants reported that price fluctuations were mostly driven by the various seasons of the year and oversupply of IC in the market. For instance, bumper harvests and festive seasons were associated with better market prices, while poor harvests were often accompanied by low market prices since farmers were desperate to get money for food and fund other basic household needs. Part of the conversation is captured in the excerpts below:

Table 6
Ranking of marketing constraints in male and female-headed household.

Constraints	Pooled (n = 1210)		Male-headed (n = 949)		Female-headed (n = 261)		df	*p-value*
	Freq.	Mean±SD	Freq.	Mean±SD	Freq.	Mean±SD		
There are no buyers	193	2.51±1.2	159	2.48±1.2	34	2.65±1.3	191	.4740
There are too many chicken	162	3.01±1.2	136	2.94±1.2	26	3.38±1.2	160	.0844
Cant' agree on selling price	411	1.52±0.9	339	1.53±0.9	72	1.47±0.9	409	.5981
Birds rejected due to size	227	2.93±1.5	183	2.99±1.5	44	2.66±1.5	225	.1767
Birds rejected due to diseases	228	2.32±1.5	195	2.33±1.5	33	2.27±1.5	226	.8321

SD: Standard deviation; df: Degrees of freedom; n: Sample size.

"During the harvest season, livestock like chicken in the market fetch a good price. But when we haven't harvested, so many people take their livestock to the market so as to get money to buy food. At such times, you will find that the chicken and goats are many and that is when the price is low" (Female IDI 15).

"The prices are not always good and they are mostly based on the purpose for the sale, where the farmer is forced to accept the prevailing prices. The prices are not constant, but rather depend on seasons; over the festive seasons the prices are high and when there are disease out breaks, the prices drop to very low levels" (Male IDI 06).

Rejection of birds due to diseases [t (226) = −2.4332, p = .0157] and due to size [t (227) = −2.722, p = .0070] are marketing constraints that were both ranked significantly higher in households that did not have a chicken house compared to those that did. Likewise, rejection of birds due to diseases ranked significantly higher in households that did not buy chicken feeds compared to those that bought [t (226) = −3.3318, p = .0010].

Inability to agree on the selling price was ranked significantly higher among households that bought feeds compared to those that did not [t (409) = 2.7964, p = .0054], while lack of buyers was ranked significantly higher among households that did not sell their IC at the market compared to those that did, [t (191) = −2.8065, p = .0055]. Likewise, those that had never received training ranked failure to agree on selling price [t, (409) = −2.242, p = .0255] and rejection of IC due to size [t (225) = −1.951, p = .0523] significantly higher compared to those that had received training on IC rearing.

Additionally, in-depth informants identified brokerage as an important market based constraint in the study area citing the absence of structured chicken markets as some of the enablers of brokerage. This is emphasized in the interview excerpt below;

"The problem is that you rear chicken but you don't know where to sell. There are no markets. When you look at your chicken you see money but then you do not have anywhere to sell, so you are forced to call brokers who take advantage and buy at very low prices" (Female IDI 09).

Discussion

Despite the immense potential, IC production in the present study setting was small scale in nature as most households kept on average 14.9 chicken at the time of study, with female-headed households keeping averagely fewer IC than male-headed households. Consistent with the present findings, Harrison and Alders [23] and Gondwe and Wollny [20] reported flocks of 14.4 and 12.9 chickens per household in Mozambique and Malawi, respectively, while Kondombo et al. [30] reported more than double the flock sizes (33.5 chickens) per household in Burkina Faso. A recent review by Mujyambere et al. [39] established that households kept an average flock size of between 6 and 57.5 chickens across 8 countries, with the lowest observed in Malawi and the highest in Uganda. Likewise, Birhanu et al. [12] explored national-level representative data collected from 3555 indigenous chicken keepers in Nigeria, Ethiopia and Tanzania, and reported an average flock size of 20.3 chickens per household, with an average minimum of 8.0 chickens in Ethiopia and a maximum of 26.5 chickens in Nigeria. From the aforementioned, it is evident that flock size varies widely among farmers, indicative of the various production systems employed and area specific challenges experienced. Khobondo et al. [28] posits that farmer's practices and level of involvement in decision making can affect the productive performance of IC with women being more disadvantaged relative to men. Padhi [47] associated low production to the technologies used, management systems in place, environmental elements at play, and a variety of other production constraints. In the present study, diseases, predators, lack of information and lack of extension services were the major constraints. In addition, access to livestock markets and veterinary facilities also impacted flock size with households in proximity to livestock markets and veterinary services keeping significantly more IC compared to those in far-flung remote areas.

In the present study, disease was ranked highest among all IC production constraints by 99.6% of the respondents. Genderwise, female-headed households lost on average more chicken during the last Newcastle disease outbreak compared to male-headed households. Consistent with our study findings, Birhanu et al. [12] reported that female-headed households were 10.0% more technically inefficient compared to male-headed household due to limited access to resources, information, and other essential services that can help enhance productivity. The significance of disease in IC production in the present study was further exemplified by the large number of IC lost during the last Newcastle disease outbreak. Consistent

with our study findings, Ndathi et al. [43] and Magothe et al. [33], in their studies conducted in Kenya both established that frequent disease outbreaks discouraged farmers from increasing their flocks for fear of huge loses. Similarly, Salo et al. [50], singled out diseases resulting from low biosecurity measures as a major hindrance to IC production in Hadiya Zone Ethiopia. Geographically, disease was ranked significantly higher among households in proximity to active live bird markets in the present study; suggestive of a linkage between the markets and disease epidemiology in the study area. Contact of live chickens from different areas at the market place is known to facilitate the rapid spread and persistence of diseases among IC [21]. Similarly, an earlier study by Ahlers et al. [2] also established that markets serve as a common source of ND infection, sometimes through the random sale of infected birds during outbreaks to salvage those not yet showing clinical signs.

Vaccination which is effective in preventing a number of chicken diseases including ND is rarely practiced by smallholder farmers [44]. In the present study for instance, only 13.8% of the households vaccinated chicken against ND with more (62.3%) female-headed households compared to male-headed households (56.4%) resorting to the use of herbal remedies. Overreliance on herbal remedies was frequently attributed to lack of capital, poor access to extension services, lack of information all of which ranked significantly higher in female-headed households and also among households in the remote areas. Given the high toll of ND on IC, efforts to reduce disease incidence are highly warranted. Henning et al. [24] assessed the impact of vaccination intervention against ND to improve IC production in Myanmar, and reported a relatively high (28.8) benefit: cost ratio (BCR). Aklilu et al. [4] opined that ND control in IC production systems through routine vaccination can enable households to double their incomes and improve their nutrient intake. However, considering the resource limitations and diversified livelihood strategies of IC keeping households, most farmers opt for low cost interventions like use of herbal remedies and antibiotics. The introduction of cost-sharing methodologies using community vaccinators for instance has facilitated increased coverage of vaccinations against ND in indigenous chicken in rural areas [5]. Establishment of a network of community vaccinators who are remunerated by farmers for their services is one way that ND can be controlled in resource constrained rural areas [11]. Indeed, models for the sustainable control of ND under resource-limiting conditions through strategies like training of community vaccinators who work on a fee-for-service basis have proved sustainable in Sub-Saharan Africa since the early 2000s [5,14].

Predation was ranked second after diseases as a constraint to IC production in the present study. Consistent with our findings, Alders and Pym [6] noted that predators were a significant problem in rural areas. Ahlers et al. [2] opined that a sturdy elevated poultry house built using locally available materials can reduce the risk of predation and theft significantly, while Melesse [36] observed that provision of simple nighttime housing structure designed to minimize predator access can protect chicken and chicks against predators and poor weather. Though a large proportion (over 70%) of male and female-headed households in the present study owned a chicken house, just about a quarter confined their IC during the day. This was largely expected since free-range production system is cheaper and more effective for small holder farmers considering that IC have poor conversion efficiency for commercial feed rations. Consistent with our study findings, Akinola and Essien [3] observed that rural poultry production system in Africa was largely free range with little to no input. In the FAO [16] report, it was reported that by-products from local crop processing can partially fulfill the energy and protein requirements of IC by supplementing their scavenging resources. In the present study for instance, drought-tolerant crops such as pigeon peas, green grams, cowpeas are grown and these double up as human food and chicken feeds.

Even though low-input, low-output free-range production system relieves farmers of the need to provide feeds for their flock, it exposes the IC and more so the chicks to predators. Muchadeyi et al. [38] reported attrition rates of up to 60% for chicks which they attributed to predation, while Ndathi et al. [43] identified aerial and terrestrial predators as a significant constraint to chicken production in Kajiado, Kenya. Conroy et al. [13] noted that predation of chicks can cause huge losses and in some instances outnumber those caused by disease. Though chicken coops are important in curbing predators, availability of funds to build the structures and purchase other inputs should be taken into consideration [36]. Indeed, lack of capital and high cost of inputs were considered important constraints to IC production by a majority of respondents in the present study. Precisely, high cost of inputs was ranked fifth generally, but significantly higher in female-headed households compared to male-headed households. In addition, both high cost of inputs and lack of capital were ranked significantly higher in the remote areas compared to relatively developed areas.

There were significant regional differences in access to extension services and information in the present study, with households from far-flung remote areas ranking poor access to extension services and poor access to information on chicken production higher than those in proximity to active market centers. Indeed, most remote areas of developing countries often have limited veterinary and extension services that cannot cover the vast areas effectively, which hinders farmers' access to critical services and information [16]. In their report, the FAO [16] further noted that the sprawling area, insufficient resources and lack of infrastructure in many rural areas of low and middle income countries often contribute greatly to limited veterinary and extension services. In the present study, female-headed households ranked limited access to new knowledge and extension services higher than the male-headed households, further disadvantaging them. Bagnol et al. [9] noted consistent gender disparities in access to and benefits from technologies, extension services, knowledge and other interventions across developing countries. Women often have limited to no benefits from extension services or training in new technologies. According to FAO [18], women farmers received just about 5% of extension agricultural services in 97 countries; with only 15% of the world's extension agents being women; an indication of the existing gender bias in favor of men in the agriculture sector. The significant role of women in chicken husbandry coupled with societal norms, traditions, culture and high illiteracy levels, calls for their greater involvement in poultry development initiatives and trainings [51]. According to

Bagnol [10], a gender sensitive approach at all levels of intervention is necessary to ensure that women benefit from interventions involving chicken-raising activities. Nevertheless, both men and women's needs, priorities and interests should be taken into consideration when designing poultry improvement initiatives.

Markets and improved access to market are vital in enhancing rural incomes in developing countries [45]. According to Alemayehu *et al*. [7], poultry marketing in most developing countries is generally informal and poorly developed. Most farmers are compelled to use intermediaries who purchase chicken at the farm gate at exploitatively low prices [35]. This discourages farmers and the end results is low production [1]. Gausi et al. [19] established that farmers' willingness to increase production was closely linked to availability of efficient markets, while Kena et al. [27] established that lack of organized marketing system, lack of market information, poor access to formal markets and high seasonal price fluctuations were some of the constraints to chicken marketing in Ethiopia. Ouma et al. [45] observed a lower likelihood of female-headed households participating in formal markets as sellers due to lack of market information, lack of time, inability to make decisions and shortage of resources to enable them produce marketable surplus. Latynskiy and Berger [31] opined that improving access to information, infrastructure and organizing farmers into collectives can improve access to organized markets and reduce transaction costs considerably.

Failure to agree on the price was also among the top ranked marketing constraints in the present study. Interestingly, households from areas in proximity to livestock markets ranked "too many chicken in the market" significantly higher compared to those from remote areas. This was likely caused by the large number of chicken sellers who are frequently drawn to the weekly livestock markets, where the supply is typically greater than the demand, leading to low prices. Gausi et al. [19] cited low prices, higher supply and long distance to reliable markets as major constraints to IC marketing in rural Malawi. In the present study, pricing was associated with a number of factors among them supply and demand that is often driven by seasons. In Ethiopia, factors like plumage color, sex, comb type, feather covers and general quality of chicken also informed the price of chicken at the market [53]. Consistent with earlier studies, both rejection of birds due to size and due to diseases ranked higher in female-headed households compared to male-headed households in the present study. In addition, rejection of birds because of diseases and due to their small size ranked much higher in households located in the remote parts of the study area.

Conclusion and recommendations

This study has demonstrated that indigenous chicken production in the study area is still quite low (15 chicken per household), with most households raising them for subsistence. The majority of production characteristics were significantly different in male and female headed households. Even though diseases were listed as the biggest production constraint, the majority of households relied on herbal remedies or did nothing to protect IC against Newcastle disease, which could help explain the high IC mortalities reported annually. Predation, low market pricing, a lack of capital, high input costs, a lack of markets, inadequate access to extension services, and poor information access are some of the additional constraints mentioned. It is clear from the study that the production and marketing constraints cited vary depending on the gender of the household head and the location of the household in relation to its' proximity to peri-urban centers and related services.

To overcome some of these barriers, site-specific local management techniques targeting constraints regarded as being of greatest importance to men and women need to be evaluated for sustainability, cost effectiveness and the greater involvement of women. Additionally, strategic initiatives in capacity building for indigenous chicken production, especially disease management, which emerged as the study's most outstanding challenge, might be used to increase IC production efficiency. This can be actualized by forming collectives such as agricultural groups and cooperatives through which IC farmers can access training, information and extension services as well as linkages to reliable markets for their IC, thus encourage production.

Funding source

This project (Grant No. 109063) was funded by The Livestock Vaccine Innovation Fund which is supported by the Bill & Melinda Gates Foundation (BMGF), Global Affairs Canada (GAC), and Canada's International Development Research centre.

Declaration of Competing Interest

The authors declare that they have no known competing interests.

CRediT authorship contribution statement

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References

[1] G.K. Abebe, J. Bijman, A. Royer, Are middlemen facilitators or barriers to improve smallholders' welfare in rural economies? Empirical evidence from Ethiopia, J. Rural Stud. 43 (2016) 203–213, doi:10.1016/j.jrurstud.2015.12.004.
[2] C. Ahlers, R.G. Alders, B. Bagnol, A.B. Cambaza, M. Harun, R. Mgomezulu, et al., Improving Village Chicken Production: A Manual for Field Workers and Trainers, 139, Australian Centre for International Agricultural Research (ACIAR), Canberra, Australia, 2009, p. 194.
[3] L.A.F. Akinola, A. Essien, Relevance of rural poultry production in developing countries with special reference to Africa, World's Poult. Sci. J. 67 (4) (2011) 697–705.
[4] H. Aklilu, C.J. Almekinders, A.J. Van der Zijpp, Village poultry consumption and marketing in relation to gender, religious festivals and market access, Trop. Anim. Health Prod. 39 (2007) 165–168.
[5] R.G. Alders, B. Bagnol, M.P. Young, Technically sound and sustainable Newcastle disease control in village chickens: lessons learnt over fifteen years, World Poult. Sci. J. 66 (2010) 433–440, doi:10.1017/S0043933910000516.
[6] R.G. Alders, R.A.E. Pym, Village poultry: still important to millions, eight thousand years after domestication, World Poult. Sci. J. 65 (2009) 181–190, doi:10.1017/S0043933909000117.
[7] A. Alemayehu, T. Yilma, Z. Shibeshi, T. Workneh, Village chicken production systems in selected areas of Benishangul-Gumuz, Western Ethiopia, Asian J. Poult. Sci 9 (3) (2015) 123–132.
[8] D.A. Ankrah, C.Y. Freeman, A. Afful, Gendered access to productive resources – evidence from small holder farmers in Awutu Senya West District of Ghana, Sci. Afr. 10 (2020) 1–12, doi:10.1016/j.sciaf.2020.e00604.
[9] B. Bagnol, Gender issues in small-scale family poultry production: experiences with Newcastle Disease and Highly Pathogenic Avian Influenza control, Worlds Poult. Sci. J. 65 (2009) 231–240.
[10] Bagnol, B. (2012). Advocate gender issues: a sustainable way to control Newcastle Disease in village chickens. INFPD Good Practices of Family Poultry Production Note No 03.
[11] B. Bagnol, R.G. Alders, R. Costa, C. Lauchande, J. Monteiro, H. Msami, R. Mgomezulu, A. Zandamela, M. Young, Contributing factors for successful vaccination campaigns against Newcastle disease, Livest. Res. Rural Dev. 25 (2013) *Article #95.* Retrieved March 2, 2023, from http://www.lrrd.org/lrrd25/6/bagn25095.htm .
[12] M.Y. Birhanu, T. Alemayehu, J.E. Bruno, F.G. Kebede, E.B. Sonaiya, E.H. Goromela, et al., Technical efficiency of traditional village chicken production in Africa: entry points for sustainable transformation and improved livelihood, Sustainability 13 (2021) 8539, doi:10.3390/su13158539.
[13] C. Conroy, N. Sparks, D. Chandrasekaran, A. Sharma, D. Shindey, L.R. Singh, A. Natarajan, K. Anitha, The significance of predation as a constraint in scavenging poultry systems: some findings from India, Livest. Res. Rural Dev. 17 (6) (2005) 70 http://www.lrrd.org/lrrd17/6/conr17070.htm.
[14] S.E. Dumas, L. Lungu, N. Mulambya, W. Daka, E. McDonald, E. Steubing, A.J. Travis, Sustainable smallholder poultry interventions to promote food security and social, agricultural, and ecological resilience in the Luangwa Valley, Zambia, Food Secur. 8 (2016) 507–520, doi:10.1007/s12571-016-0579-5.
[15] S.E. Dumas, A. Maranga, P. Mbullo, S. Collins, P. Wekesa, M. Onono, S.L. Young, Men are in front at eating time, but not when it comes to rearing the chicken": unpacking the gendered benefits and costs of livestock ownership in Kenya, Food Nutr. Bull. 133 (11) (2017), doi:10.1177/0379572117737428.
[16] FAO (2014). Family poultry development - Issues, opportunities and constraints. Animal production and health working paper no. 12. Rome, Italy.
[17] FAO, (2012). Small livestock, big impact. Retrieved on 27/4/2021 from ⟨13:italic ⟩www.ilriclippings.wordpress.com⟨/13:italic⟩
[18] FAO. (2016). The female face of farming. Available at: http://www.fao.org/gender/resources/infographics/the-female-face-of-farming/en/. Accessed: May 21, 2021.
[19] J.C.K. Gausi, A.C.L. Safalaoh, J.W. Banda, D.H. Ng'ong'ola, Characterization of the smallholder poultry marketing systems in rural Malawi: a case study of Malingunde Extension Planning Area, Livest. Res. Rural Dev. 16 (12) (2004) http://www.lrrd.org/lrrd16/12/gaus16097.htm. G.
[20] T.N. Gondwe, C.B.A. Wollny, Local chicken production system in Malawi: household, flock structure, dynamics, management and health, Trop. Anim. Health Prod. 39 (2007) 103–113.
[21] B. Haile, T. Fentie, The role of live chicken markets as a source of replication and dissemination of newcastle disease virus in Chickens, Northwest Ethiopia, Poult. Sci. 100 (4) (2020) 101075 doi.org/10.1016/j.psj.2020.08.025.
[22] Hailemichael, A., Gebremedhin, B., Gizaw, S. and Tegegne, A. (2016). Analysis of village poultry value chain in Ethiopia: implications for action research and development. LIVES Working Paper 10. ILRI: Nairobi, Kenya.
[23] J.L. Harrison, R.G. Alders, An assessment of chicken husbandry including Newcastle disease control in rural areas of Chibuto, Mozambique, Trop. Anim. Health Prod. (2009), doi:10.1007/s11250-009-9480-y.
[24] J. Henning, J. Morton, R. Pym, T. Hla, K. Sunn, J. Meers, Economic analysis of interventions to improve village chicken production in Myanmar, Prev. Vet. Med. 110 (2013) 525–540, doi:10.1016/j.prevetmed. 2013.01.005.
[25] C.N. Kamau, L.W. Kabuage, E.K. Bett, Impact of improved indigenous chicken breeds on productivity. The case of smallholder farmers in Makueni and Kakamega counties, Kenya, Cogent Food Agric. 4 (1) (2018) 1477231.
[26] O.B. Kashongwe, B.O. Bebe, J.W. Matofari, C.G. Huelsebusch, Effects of feeding practices on milk yield and composition in periurban and rural smallholder dairy cow and pastoral camel herds in Kenya, Trop. Anim. Health Prod. 49 (2017) 909–914, doi:10.1007/s11250-017-1270-3.
[27] Y. Kena, D. Legesse, Y. Alemu, Poultry Marketing: Structure, Spatial Variations and Determinants of Prices in Eastern Shewa Zone, Ethiopia, Ethiopian Agricultural Research Organization, Debrezeit Research Center, 2002.
[28] J.O. Khobondo, T.K. Muasya, S. Miyumo, T.O. Okeno, C.B. Wasike, R. Mwakubambanya, et al., Genetic and nutrition development of indigenous chicken in Africa, Livest. Res. Rural Dev. 27 (7) (2015) 122.
[29] KNBSThe 2019 Kenya Population and Housing Census Volume IV: Distribution of Population by Socio-Economic Characteristic, Kenya National Bureau of Statistics, 2019 ISBN: 978-9966-102-11-9.
[30] S.R. Kondombo, A.J. Nianogo, R.P. Kwakkel, H.M.Y. Udo, M. Slingerland, Comparative analyses of village chicken production in two farming systems in Burkina Faso, Trop. Anim. Health Prod. 35 (2003) 563–574.
[31] E. Latynskiy, T. Berger, Networks of rural producer organizations in Uganda: what can be done to make them work better? World Dev. 78 (2016) 572–586, doi:10.1016/j.worlddev.2015.10.014.
[32] T.N. Macharia, S. Ochola, M.K. Mutua, E.W. Kimani, Association between household food security and infant feeding practices in urban informal settlements in Nairobi, Kenya, Dev. Orig. Health Dis. 9 (1) (2018) 20–29, doi:10.1017/S2040174417001064.
[33] T.M. Magothe, T.O. Okeno, W.B. Muhuyi, A.K. Kahi, Indigenous chicken production in Kenya: current status, Worlds Poult. Sci. J. 68 (2012) 119–132, doi:10.1017/S0043933912000128.
[34] Makueni County GovernmentCounty Statistical Abstract, Makueni County. KNBS, 2020.
[35] C. Mapiye, M. Mwale, J.F. Mupangwa, M. Chimonyo, R. Foti, M.J. Mutenje, A research review of village chicken production constraints and opportunities in Zimbabwe, Asian-Australas. J. Anim. Sci. 21 (11) (2008) 1680–1688.
[36] A. Melesse, Significance of scavenging chicken production in the rural community of Africa for enhanced food security, World's Poult. Sci. J. 70 (3) (2014) 593–606, doi:10.1017/s0043933914000646.
[37] M. Milkias, M. Molla, S. Tilahun, Productive and reproductive performance of indigenous chickens in Gena Bossa District of Dawro Zone, Ethiopia, Int. J. Livest. Prod. 10 (1) (2019) 24–32.
[38] F.C. Muchadeyi, S. Sibanda, N.T. Kusina, J.F. Kusina, S. Makuza, Village chicken flock dynamics and the contribution of chickens to household livelihoods in a smallholder farming are in Zimbabwe, Trop. Anim. Health Prod. 37 (4) (2005) 333–334.
[39] V. Mujyambere, K. Adomako, S.O. Olympio, M. Ntawubizi, L. Nyinawamwiza, J. Mahoro, A. Conroy, Local chickens in East African region: their production and potential, Poult. Sci. 101 (2022) 101547, doi:10.1016/j.psj.2021.101547.

[40] Mutua, B.M. (2018). Challenges facing indigenous chicken production and adoption levels of biosecurity measures in selected areas of Makueni county, Kenya. M.Sc diss., South Eastern Kenya University.
[41] C.W. Muui, R.M. Muasya, D.T. Kirubi, Baseline survey on factors affecting sorghum production and use in eastern Kenya, Afr. Jo. Food Agric. Nutr. Dev. 13 (1) (2013) 7339–7353 https://www.ajol.info/index.php/ajfand/article/view/85324/75258.
[42] M. Mwangi, S.M. Karanja, P.N. Karogo, A.M. Kibe, Effects of intercrop population density and row orientation on growth and yields of sorghum-cowpea cropping systems in semiarid Rongai, Kenya, J. Agric. Sci. 6 (5) (2017) 36–43, doi:10.5539/jas.v6n5p34.
[43] A.J.N. Ndathi, E.N. Muthiani, E.C. Kirwa, P.F.K. Kibet, H.K. Cheruiyot, Constraints and Opportunities in Indigenous Chicken Production and Marketing in Mashuru and Loitoktok Divisions of Kajiado district, KARI Headquarters, P.O. Box 57811, Nairobi, Kenya, 2012.
[44] S.W. Njue, J.L. Kasiiti, S.G. Gacheru, in: Assessing the Economic Impact of Commercial Poultry Feeds Supplementation and Vaccination Against Newcastle Disease in Local Chicken in Kenya, IAEA-TECDOC-1489, Viena, 2006, pp. 116–124. www.pub.iaea.org.mtcd/publications/pdf/te-1489-web-pdf.
[45] E. Ouma, J. Jagwe, G. Aiko, S. Abele, Determinants of smallholder farmers' participation in banana markets in Central Africa: the role of transaction costs, Agric. Econ. 41 (2) (2010) 111–122, doi:10.1111/j.1574-0862.2009.00429.x.
[46] M.O. Oyier, J.O. Owuoche, M.E. Oyoo, E. Cheruiyot, B. Mulianga, J. Rono, Effect of harvesting stage on sweet sorghum (Sorghum bicolor L.) genotypes in western Kenya, Sci. World J. 2017 (2017) 8249532, doi:10.1155/2017/8249532.
[47] M.K. Padhi, Importance of indigenous breeds of chicken for rural economy and their improvements for higher production performance, Scientifica 16 (2016) Art. ID 2604685. Available at, doi:10.1155/2016/2604685.
[48] A.K. Panda, Family poultry production for poverty alleviation and gender equity in India, Empowering Farmwomen Through Livestock and Poultry Intervention, ICAR-Central Institute for Women in Agriculture, Bhubaneswar, India, 2016 108.
[49] A.R. Quisumbing, L.R. Brown, H.S. Feldstein, L. Haddad, C. Peña, Women: the key to food security, Food Nutr. Bull. 17 (1) (1996) 1–2, doi:10.1177/156482659601700116.
[50] S. Salo, G. Tadesse, D. Hilemeskel, Village chicken production system and constraints in Lemo District, Hadiya Zone, Ethiopia, J. Poult. Fish. Wildl. Sci. (2016), doi:10.4172/2375-446X.1000158.
[51] T. Tabler, M.L. Khaitsa, J. Wells, Smallholder Farmer Constraints to Village Chicken Production, Mississippi State University Extension Service, 2019 Publ. No. 3315.
[52] O. Thieme, F. Sonaiya, A. Rota, F. Guèye, F. Dolberg, R. Alders, Defining family poultry production systems and their contribution to livelihoods, in: Decision tools For Family Poultry Development, FAO Animal Production and Health Guidelines No. 16, Rome, Italy, 2014, pp. 3–8.
[53] M. Tilahun, M. Mitiku, W. Ayalew, Agroecology is affecting village chicken producers' breeding objective in Ethiopia, Scientifica 2022 (2022) 1–12 Article ID 9492912, doi:10.1155/2022/9492912.
[54] J.T. Wong, J. de Bruyn, B. Bagnol, H. Grieve, M. Li, R. Pym, et al., Small-scale poultry in resource-poor settings: a review, Glob. Food Secur. 15 (2017) 43–52, doi:10.1016/j.gfs.2017.04.003.