

Trend Analysis of Poultry production, population growth and distribution in Ethiopia

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Abstract:

Ethiopia's poultry sector plays a vital role in agricultural development, food security, and rural livelihoods. Despite its importance, there remains limited understanding of the trends in poultry production, population growth, and distribution across the country. Hence, this manuscript presents a comprehensive trend analysis of poultry production, population dynamics, and distribution patterns in Ethiopia from 2004 to 2022. Data from the Central Statistical Agency (CSA) and FAOSTAT were analyzed using non-parametric statistical methods to assess trends in poultry production and population growth. The analysis reveals a consistent upward trend in the poultry population across various regions of Ethiopia except for a slight decrease observed in Addis Ababa during 2004-2007, with indigenous breeds dominating the landscape. Despite challenges such as disease outbreaks and limited commercialization, the poultry sector has experienced significant growth, driven by factors like population increase and shifting dietary preferences. The study also highlights increasing trends in egg and meat production, indicating the sector's potential for further expansion. Recommendations are provided for policymakers, researchers, and industry stakeholders to promote sustainable growth, enhance food security, and improve the livelihoods of poultry farmers in Ethiopia. Overall, the findings underscore the importance of continued investment and innovation in the poultry sector to realize its full potential in contributing to Ethiopia's agricultural development and economic prosperity.

Key words: poultry production, population growth, distribution, trend analysis, mann-kendall test

Introduction

Ethiopia is home to numerous livestock species and is naturally endowed with various agroecological zones and acceptable environmental conditions (Leta and Mesele, 2014)¹. Ethiopia has large poultry population, estimated to be 41.35 million preceded by cattle, 66 million (CSA, 2022)². Poultry production plays a significant role in Ethiopia's agricultural sector, contributing to food security, income generation, and employment opportunities (Fekadu et al., 2023)³. Ethiopia boasts a substantial livestock resource, with poultry being the second most populous category after cattle. However, despite their significance in terms of numbers, there remains limited knowledge about poultry production systems, population growth, egg utilization trends, and development strategies in the country (Urgesa, 2023)⁴. Ethiopia's indigenous poultry production system is an essential component of the country's farming system and it is typified by small flocks, low input, and an unstructured marketing system (Yadesa et al., 2017)⁵. One of the most significant agricultural subsectors for Ethiopia's rural populations is poultry. The population of poultry is almost exclusively made up of native chicken; according to recent estimates, the percentages of native, hybrid,

and exotic fowl are, respectively, 78.04%, 17.58%, and 4.34% (CSA, 2022)². Mekuriaw and Harris-Coble (2021)⁶ also reported recent estimates of which 81.7% of the breeds are native, 10.9% are hybrids, and 7.4% are exotics.

Because of this, poultry is the largest group of livestock species, accounting for over 30% of all animal protein consumed worldwide (Alemneh and Getachew, 2019)⁷. According to Urgesa (2023)⁴, the proportionate share of poultry in the global animal protein production was expected to rise to 40% by 2020, with the developing world experiencing the largest increase.

Ethiopia's poultry industry has expanded significantly in recent years due to a number of factors including population increase, urbanization, and shifting dietary preferences. The country's poultry sector is characterized by a mix of traditional and commercial production systems, with different regions showing varying levels of development and adoption of modern practices (Erdaw and Beyene, 2022)⁸.

Ethiopia, with its large and growing population, presents a unique case study for understanding the dynamics of poultry production, population growth, and distribution. Studying poultry production, productivity and population growth trends is crucial for advancing agricultural development, promoting food security, supporting rural livelihoods, and fostering sustainability within the poultry sector and the broader agricultural landscape (Dixon et al.,2020)⁹. Hence understanding these trends is crucial for policymakers, researchers, and industry stakeholders to develop strategies that promote sustainable growth, improve food security, and enhance the livelihoods of poultry farmers across the country. Therefore, this trend analysis aims to explore the historical patterns and current trends in poultry production, population growth, and distribution across Ethiopia.

Materials and Methods

Data (Information) on annual poultry production, population growth and distribution in Ethiopia for the period of 2004 to 2022 were collected from the Central Statistical Agency (CSA, 2004 -2022)¹⁰ and FAOSTAT (2024)¹¹.

Trend Analysis

The statistical significance of the trend in poultry production and population growth data was assessed using the non-parametric Mann-Kendall and Sen's methods, which are less susceptible to outliers and identify trends in time series without indicating whether they are linear or non-linear (Partal and Kahya, 2006; Yenigun et al., 2008; Hadgu et al., 2013)^{12,13,14}. The trends in Poultry production and population growth dataset were analyzed using the tidyverse, trend and Kendall R packages of R-4.3.3 version. This package has useful functions for data visualization and analysis. The Mann-Kendall trend test and p-value at 95 % Confidence Interval (CI) on Production and population growth data for annual time series from 2004 to 2022 was performed/computed using RStudio and R Programming software. The Mann-Kendall test is a frequently utilized nonparametric test for annual time series data to determine the trend (Chisang et al., 2024; Butler and Vance,2022; Akinbile et al., 2015)^{15,16,17}

The annual trend and its statistical significance were calculated using the trend R package (McLeod,2005; Pohlert,2016)^{18,19}. The Sen's slope function in trend R package was used to calculate the slope of the trend (increase/decrease per year) while the MK test function (Mann-Kendall test) was used to verify if the trend is statistically significant or if it is the result of the variability within the production and population growth (Mangiafico, 2016)²⁰. More information on trend analysis is provided by Akinbile et al. (2015)¹⁷, Butler and Vance (2022) and Mcleod (2005)¹⁶.

The equation (1), (2), (3) and (4) were used to compute the Mann-Kendall's test statistic, the sign function, the variance of S and ZMK (approximates the standard normal distribution) respectively.

The Mann-Kendall's test statistic is given as:

$$S = \sum_{i=1}^{N-1} * \sum_{j=i+1}^N +sgn(x_j - x_i) \quad \text{equation (1)}$$

where S is Mann-Kendall's test statistics; x_i and x_j are the sequential data values of the time series in the years i and j ($j > i$); and N is the length of the time series. A positive S value indicates an increasing trend, and a negative value indicates a decreasing trend in the data series. The sign function is given as:

$$sgn(x_j - x_i) = \begin{cases} +1 & \text{if } (x_j - x_i) > 0 \\ 0 & \text{if } (x_j - x_i) = 0 \\ -1 & \text{if } (x_j - x_i) < 0 \end{cases} \quad \text{Equatio (2)}$$

The variance including the correction term for ties is:

$$Var(S) = \left\{ n(n-1)(2n+5) - \sum_{j=1}^p t_j(t_j-1)(2t_j+5) \right\} / 18 \quad \text{Equation (3)}$$

where p is the number of the tied groups in the data set and t_j is the number of data points in the j th tied group.

For n larger than 10, ZMK approximates the standard normal distribution (Partal and Kahya, 2006; Yenigunet al., 2008)^{12,13} and is computed as follows:

$$\begin{cases} s - \frac{1}{\sqrt{var(s)}} & \text{if } S > 0 \\ 0 & \text{if } S = 0 \\ s + \frac{1}{\sqrt{var(s)}} & \text{if } S < 0 \end{cases} \quad \text{Equation (4)}$$

The presence of a significant trend is evaluated using the Z_{MK} value. The null hypothesis H_0 should be accepted in a two-sided trend test if $Z_{MK} Z_{1-\alpha/2}$ at a given level of significance. The critical value of Z_{MK} in the standard normal table is $Z_{-\alpha/2}$.

Distribution of chicken flocks geographically

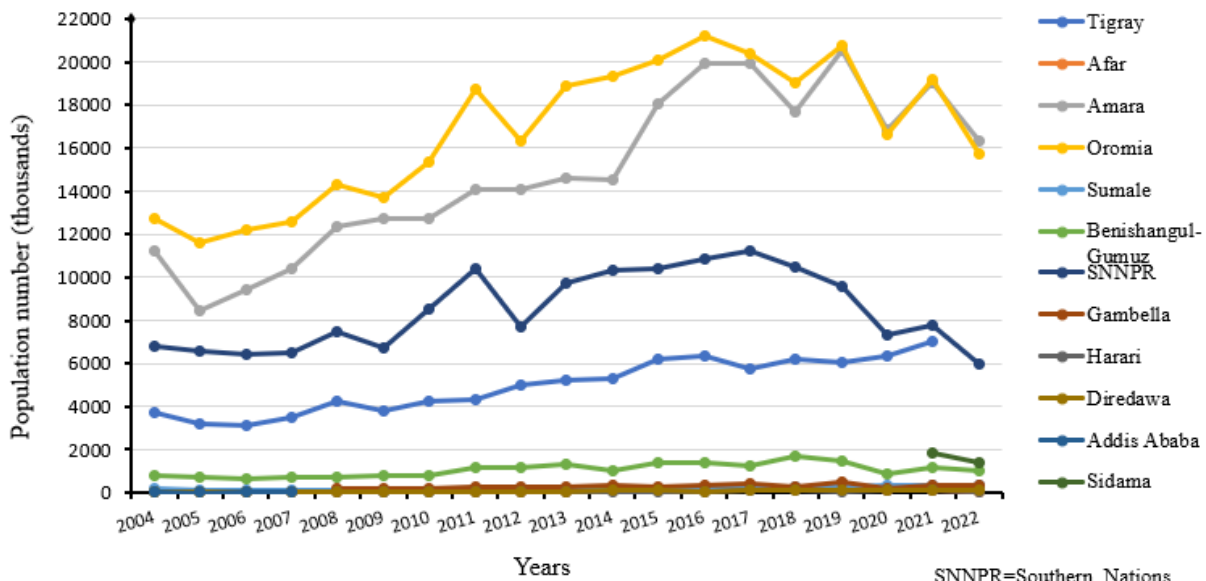
The distribution of Ethiopia's total poultry population by regions from 2004 to 2022 is displayed in Table 1. Ethiopia is home to over 60% of all East African chicken breeds, including hybrid, exotic, and native varieties (Sisay et al., 2018)²¹. According to the CSA (2004-2022)¹⁰ and FAOSTAT (2024)¹¹ data, the Oromia region has the most hens, followed by the Amhara, SNNPR, and Tigray regions. Together, the regions of Oromia (35.9%), Amhara (31.6%), SNNPR (18.1%), and Tigray (10.5%) account for 96.1 percent of the country's chicken population. The regions of Afar, Somalia, Benshangul Gumuz, and Gambela account for the majority of the remaining 3.9 percent.

Over the years, the number of chickens has increased slowly; in 2022, the total population was projected to be 41.35 million (fig 1). One key explanation for the slow expansion in the chicken population could be the high death rate from diseases and predators in the scavenging production systems. One further factor is the restricted growth of commercial poultry production, concerning both the quantity and the number of producers. FAO (2019)²².

Year	Tigray	Afar	Amara	Oromia	Sumale	Benishangul-Gumuz	SNNPR	Gambella	Harari	Diredawa	Addis Ababa	Sidama	Total (CSA, 2004-2022) ¹⁰	Total (FAOST AT, 2024) ¹¹
2004	3725	49	11244	12761	173	785	6780	NA	32	44	62	NA	35656	35656
2005	3180	38	8442	11637	155	732	6586	NA	31	45	21	NA	30869	32222
2006	3131	49	9401	12227	92	636	6391	NA	33	49	22	NA	32032	34199
2007	3474	44	10368	12604	107	743	6517	NA	32	48	22	NA	33958	39508
2008	4262	54	12365	14330	113	708	7466	174	36	56	NA	NA	39564	38049
2009	3830	27	12756	13673	77	774	6707	202	33	48	NA	NA	38128	42053
2010	4266	29	12740	15337	56	821	8504	210	39	51	NA	NA	42053	49287
2011	4309	67	14048	18762	106	1149	10408	303	53	81	NA	NA	49287	44893
2012	5003	58	14117	16345	113	1141	7691	302	43	80	NA	NA	44893	50377
2013	5243	43	14611	18850	159	1306	9732	299	51	84	NA	NA	50377	51350
2014	5288	124	14525	19314	196	1042	10354	344	72	92	NA	NA	51351	56867
2015	6190	132	18031	20076	163	1375	10434	307	71	87	NA	NA	56867	60506
2016	6330	106	19959	21201	177	1363	10851	358	74	85	NA	NA	60505	59495
2017	5736	198	19962	20408	161	1250	11249	386	94	103	NA	NA	59547	56056
2018	6191	216	17705	19014	250	1672	10491	302	98	118	NA	NA	56057	59420
2019	6032	185	20502	20767	250	1480	9542	490	77	93	NA	NA	59420	48956
2020	6318	93	16827	16669	354	885	7347	229	105	130	NA	NA	48956	56993
2021	7001	92	19061	19160	319	1156	7814	315	130	122	NA	1825	56993	41351
2022	NA	63	16335	15714	384	1016	5974	315	85	99	NA	1366	41351	41960

NA = Not Available

Table 1. Distribution of total Poultry Population by Region in Ethiopia (in thousands)



Source: CSA (2004 - 2022)¹⁰ and FAOSTAT (2024)¹¹

SNNPR=Southern, Nations, Nationalities and People region

Figure 1: Distribution and Trends of Poultry Population in Ethiopia

Distribution Trend Analysis

The Mann-Kendall Trend Statistics is a non-parametric test used to detect trends in time series data. It's particularly useful when the data doesn't meet the assumptions of normality required by parametric tests (Agbo et al., 2023)²³. Hence, the Mann-Kendall Trend Statistics analysis reveals a consistent increasing trend in the poultry population across various regions in Ethiopia from 2004 to 2022, except for a slight decrease observed in Addis Ababa during 2004-2007 (Table 2). Tigray exhibits a significant increasing trend (P-value = < 0.0001) in poultry population over the specified period, as indicated by the high ZMK value and with a very steep Sen's slope of 223,213.7 (positive Sen's slope). Similar to

Tigray, Afar region also shows a significant increasing trend (P-value = 0.0063) with a positive Sen's slope indicating a considerable increase in poultry population. Amhara, Oromia, Somali, Benishangul-Gumuz, SNNPR, Gambella, Harari and Diredawa regions exhibit statistically significant increasing trends (P-values < 0.05) with positive Sen's slopes, indicating substantial growth in poultry population over the period considered. Addis Ababa (2004-2007) region is the only one showing a decreasing trend (P-value = 0.734) during the specified period with the negative Sen's slope value of -7096, though not statistically significant. The overall poultry population in Ethiopia, as reported by CSA (2004 - 2022)¹⁰, shows a highly significant increasing trend (P-value = 0.00034) with a very large Sen's slope of 1,664,052, indicating a substantial overall

increase in the poultry population over the years. The total poultry population reported by FAOSTAT for 2024 also shows a significant increasing trend (P-value = 0.0051) with a positive Sen's slope, although slightly lower than the CSA data.

With the exception of a minor decline in Addis Ababa between 2004 and 2007, the Mann-Kendall Trend Statistics analysis concludes that there is a continuous upward trend in the number of chickens in Ethiopia's different regions from 2004 to 2022. The findings show how the Ethiopian poultry sector has expanded and become more significant over the given time frame.

S/N	Region	Z _{MK}	MK statistics	P-value	Sen's slope	Trend
1	Tigray (2004-2021)	4.848	129	<0.0001	223213.7	Increase
2	Afar	2.729	79	0.0063	4755.8	Increase
3	Amhara	4.338	125	<0.0001	617031.6	Increase
4	Oromia	3.499	101	0.00047	482069.0	Increase
5	Somali	3.436	102	0.00041	13505.5	Increase
6	Benishangul-Gumuz	3.009	87	0.0026	42798.4	Increase
7	SNNPR	1.889	55	0.059	157827.0	Increase
8	Gambella (2008-2022)	2.474	51	0.013	10833.5	Increase
9	Harari	5.108	147	<0.0001	4511.0	Increase
10	Diredawa	4.890	141	<0.0001	4664.8	Increase
11	Addis Ababa (2004-2007)	-0.340	-2	0.734	-7096.0	Decrease
Total (CSA, 2004-2022) ¹⁰		3.569	103	0.00034	1664052.0	Increase
Total (FAOSTAT, 2024) ¹¹		2.799	81	0.0051	1346250.0	Increase

Table 2. Mann-Kendall Trend Statistics for Poultry Population by Region in Ethiopia for 2004-2022

Trends in Eggs and Meat Production

Table 3 presents the number of eggs produced per breed of chicken (CSA, 2004–2022)¹⁰, the overall number of eggs produced (FAOSTAT, 2024)¹¹, and the total amount of meat produced (FAOSTAT, 2024)¹¹ during the period of 2004–2022. Egg production (measured in thousands) for native chicken breeds began in 2005 at approximately 97458 thousand eggs, reached a peak of 123,624 thousand eggs in 2021, and then declined to 105,204 thousand eggs in 2022. Even though, data is missing for some years exotic breeds produce eggs started from 5,992 thousand eggs in 2009, peaked at 407,012 thousand eggs in 2022. Exotic Breeds started from 792 thousand eggs in 2008, peaked at 34,606 thousand eggs in 2021, then slightly decreased to 17,822 thousand eggs in 2022. Overall, Egg production in Ethiopia has shown a consistent upward trend over the years, with occasional fluctuations. The total number of eggs produced has increased substantially from 2004 to 2022. While there is a general upward trend, there are fluctuations in egg production from year to year. These fluctuations could be attributed to various factors such as changes in market demand, disease outbreaks affecting poultry, changes in government policies, and variations in weather conditions affecting poultry farming. From 2004 to 2009, egg production showed relatively steady growth, with some fluctuations. The growth during this period might be attributed to increased investment in poultry farming, improved farming practices, and rising demand for eggs. The period from 2010 onwards witnessed a significant increase in egg production. The growth rate appears to accelerate during this period, with the total number of eggs produced more than doubling between 2010 and 2022. This rapid growth could be influenced by several factors, including increased investment in the poultry sector, improved infrastructure, technological advancements in poultry farming, and rising demand for eggs due to population growth

and changing dietary habits. Notably, there is a substantial spike in egg production from 2020 to 2022. The total number of eggs produced more than doubled between 2019 and 2020, and then again between 2020 and 2022. This sharp increase could be due to several factors, including increased government support for the poultry sector, expansion of commercial poultry farms, adoption of advanced farming techniques, and a surge in demand for eggs driven by population growth, urbanization, and changes in dietary preferences. The increasing trend in egg production indicates a growing poultry industry in Ethiopia. This has several implications, including economic benefits such as job creation, income generation for farmers, and contribution to food security. However, it also brings challenges such as ensuring sustainable production practices, addressing environmental concerns associated with poultry farming, and maintaining quality standards to meet consumer demands (CSA, 2004-2022)¹⁰.

According to the FAOSTAT (2024)¹¹ total meat production from all chicken breeds shows fluctuation over the years, with a peak of 73,000 tons in 2015 and total eggs have been increasing steadily over the years, reaching a peak of 1146670 thousand tons in 2022.

Indigenous breeds consistently contribute to egg production, with a notable increase over the years. Hybrid breeds have shown a significant increase in egg production, becoming a major contributor by 2022. Exotic breeds also contribute to egg production, although their numbers are comparatively lower than the other breeds. Total egg production has been steadily increasing over the years. Meat production shows fluctuations but generally maintains a significant level. These trends indicate a growing demand for both eggs and meat, with various breeds contributing to meeting this demand.

Year	Eggs Production per chicken breeds in numbers in 1000s			Total eggs production in number in 1000s (CSA, 2004 – 2022) ¹⁰	Total eggs production in number in 1000s (FAOSTAT, 2024) ¹¹	Meat total (t) (FAOSTAT, 2024) ¹¹
	Indigenous	Hybrids	Exotic			
2004	NA	NA	NA	63523	915000	47
2005	97458	NA	5326	102784	835000	43
2006	57495	7395	2569	67460	890000	45
2007	61204	7949	12506	81660	905000	46
2008	68241	6251	792	75284	875000	49
2009	71748	5992	1348	79089	885000	50
2010	78066	NA	NA	78066	877500	59
2011	89725	7771	805	98301	900000	54
2012	78895	14845	936	94676	909000	60
2013	85491	6218	1424	93133	932000	62
2014	89560	9578	1703	100841	967000	69
2015	93801	7605	5164	106571	1208000	73
2016	95767	8097	10772	114636	1187000	72
2017	92692	12137	22126	126956	1196000	67
2018	85919	16138	34708	136764	1138609	71
2019	82243	30594	38636	151473	1182610	58
2020	110569	176443	29809	316821	1112745	68
2021	123624	210564	34606	368794	1144655	49
2022	105204	407012	17822	530038	1146670	49

NA = Not available

Table 3: Trends in eggs and meat production per chicken breeds from CSA and FAOSTAT

Trend Analysis of Eggs and Meat

The Mann-Kendall Trend Statistics provides insights into the trends in meat and egg production across different chicken breeds and the total production in Ethiopia from 2004 to 2022 (Table 4). The indigenous breed shows a significant increasing trend (p-value = 0.0011) in egg production, supported by a high ZMK (3.26) and the Sen’s slope is 2950215, suggesting a substantial increase in egg production over time. Hybrids also exhibit a significant increasing trend (p = 0.00027 in egg production, with a higher ZMK (3.65) and Sen’s slope is 2258041, indicating a considerable increase in egg production over the years. The exotic breed shows a significant increasing trend (P-value = 0.0045) in egg production, although with a slightly lower ZMK (2.84) value compared to hybrids and the Sen’s slope is 1778507, suggesting a notable increase in egg production over time. The total poultry production, including meat and eggs from all chicken breeds according to the Central Statistical Agency (CSA, 2004-2022)¹⁰, exhibits a significant increasing trend, with a high ZMK (4.83) value and a very

low P value = 0.0001 with the Sen’s slope is 6462604, reflecting a substantial increase in total egg production over the analyzed period.

Both meat and egg production from all chicken breeds show significant positive trends. The total meat production from all chicken breeds, according to FAOSTAT in 2024, shows a significant increasing trend (p = 0.0063), although with a lower ZMK (2.73) value compared to the total production reported by CSA with Sen’s slope of 1,585, showing a considerable increase in total egg production over the analyzed period. The total egg production from all chicken breeds, according to FAOSTAT in 2024, exhibits a significant increasing trend (p=<0.0001), supported by a high ZMK (4.45) value and a very low P-value and Sen’s slope of 1,000 indicating considerable increase in egg production over the years.

Generally, from 2004 to 2022, Ethiopian chicken breeds' egg and meat output increased consistently and significantly, according to the Mann-Kendall trend analysis. This suggests that the nation's chicken industry is expanding favorably and may eventually advance.

S/N	Breeds	Production parameter	ZMK	Mk-statistics	P-value	Alpha	Sen’s Slope	Trend
1	Indigenous	Eggs	3.258	87	0.0011	0.05	2950215	Increase
2	Hybrids	Eggs	3.647	82	0.00027	0.05	2258041	Increase
3	Exotic	Eggs	2.842	70	0.0045	0.05	1778507	Increase
4	Total (CSA, 2004-2022) ¹⁰		4.828	139	<0.0001	0.05	6462604	Increase
5	Total Meat and Eggs from all Chicken (FAOSTAT, 2024) ¹¹							
6	From all Chicken	Meat of chicken (tons)	2.729	79	0.0063	0.05	1585	Increase
7		Egg (tons)	4.446	128	<0.0001	0.05	1000	Increase

Table 4. Mann-Kendall Trend Statistics of Poultry Production (Meat and eggs) by chicken breeds type and total in Ethiopia for 2004-2022

Conclusion and Recommendations

Conclusion

Based on the comprehensive trend analysis of poultry production, population growth, and distribution in Ethiopia from 2004 to 2022, several conclusions can be made:

- The analysis reveals a consistent increasing trend in the poultry population across various regions of Ethiopia during the specified period. Except for a minor decrease observed in Addis Ababa between 2004 and 2007, all other regions showed significant increasing trends. Tigray, Afar, Amhara, Oromia, Somali, Benishangul-Gumuz, SNNPR, Gambella, Harari, and Diredawa regions all showed statistically significant increasing trends in poultry population.
- The distribution of Ethiopia's total poultry population by region indicates that Oromia, Amhara, SNNPR, and Tigray regions account for the majority (96.1%) of the country's chicken population. However, over the years, there has been a gradual increase in the poultry population across all regions.
- Egg production in Ethiopia has shown a consistent upward trend over the years, with occasional fluctuations. Indigenous, hybrid, and exotic breeds all contribute to egg production, with significant increasing trends observed in each category. Meat production also shows fluctuations but generally maintains a significant level, indicating a growing demand for both eggs and meat.
- The total poultry production, including meat and eggs from all chicken breeds, displays a significant increasing trend over the analyzed period indicating favorable expansion and advancement in Ethiopia's chicken industry.
- The increasing trends in poultry population, egg, and meat production have significant implications for Ethiopia's agricultural sector, food security, income generation, and employment opportunities. The growth in these areas suggests positive development in the poultry industry and its contribution to the overall economy.
- Overall, the trend analysis provides valuable insights into the dynamics of poultry production, population growth, and distribution in Ethiopia, highlighting the importance of continued monitoring and strategic interventions to ensure sustainable growth and development in the poultry sector.

Recommendations

Based on the comprehensive analysis of poultry production, population growth, and distribution trends in Ethiopia, several recommendations can be made:

- Policymakers should prioritize the development and implementation of policies aimed at supporting the sustainable growth of the poultry sector. These policies should focus on promoting modern and efficient production systems, improving infrastructure, enhancing access to veterinary services, and facilitating market access for poultry farmers.
- There is a need for further research and development efforts to better understand the dynamics of poultry production, population growth, and distribution in Ethiopia. This includes

studying the factors influencing productivity, exploring the potential of genetic improvement programs, and identifying strategies to address challenges such as disease management and feed availability.

- Efforts should be made to strengthen the capacity of poultry farmers through training programs, extension services, and knowledge sharing initiatives. This will help improve farming practices, enhance productivity, and promote sustainable growth within the sector.
- Given the significant impact of diseases on poultry production, there is a need to prioritize disease control measures and biosecurity practices. This includes vaccination programs, surveillance systems, and awareness campaigns aimed at reducing the prevalence of diseases and minimizing their economic impact on poultry farmers.
- While traditional production systems remain predominant, efforts should be made to promote the adoption of commercial poultry production practices. This includes providing incentives for investment in commercial farms, supporting the establishment of hatcheries and feed mills, and facilitating access to inputs and technology.
- Collaboration between government agencies, research institutions, industry stakeholders, and international organizations is essential for addressing the multifaceted challenges facing the poultry sector. By working together, these stakeholders can leverage their expertise and resources to develop effective solutions and promote the sustainable growth of the sector.

Conflict of interest

The authors declare that they have no conflict of interest.

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