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Original Article

Spatio-Temporal Dynamics of Livestock and Poultry Populations in Solapur District, Maharashtra.

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Abstract

This study examines the spatial and temporal dynamics of livestock and poultry populations across eleven talukas in Solapur district, Maharashtra, using data from four livestock censuses (2003 to 2019). The analysis reveals significant heterogeneity in population trends, species composition, and growth trajectories at the sub-district level. Key findings include a dramatic 132.3 per cent increase in cattle population, a 50.4 per cent decline in sheep population, and explosive 158.9 per cent growth in poultry. Taluka-level analysis identifies three distinct clusters: "growth talukas" (Sangola, Madha) showing consistent expansion; "V-shaped recoverees" (Malshiras, Mohol, Pandharpur) demonstrating resilience after initial decline; and "declining talukas" (North Solapur, Akkalkot, and Karmala) facing persistent challenges. The poultry sector exhibits extreme spatial concentration, with Malshiras and Sangola alone accounting for 44.1 per cent of the district's poultry population in 2019. These findings underscore the importance of spatially disaggregated analysis for evidence-based livestock policy formulation and highlight the need for taluka-specific interventions.

Keywords: *Livestock census, spatial analysis, population dynamics, poultry revolution.*

Introduction

The livestock sector occupies a position of paramount importance in India's agricultural economy, contributing significantly to rural livelihoods, nutritional security, and agricultural GDP (Sharma et al., 2017). For millions of small and marginal farmers, livestock serves as a critical asset, providing insurance against crop failure, supplementary income, and employment throughout the year (Birthal et al., 2006). Understanding the dynamics of livestock populations—their size, composition, spatial distribution, and temporal trajectories—is therefore fundamental for evidence-based policy formulation, resource allocation, and the design of sustainable development interventions (Kumar & Mittal, 2011). India's quinquennial livestock censuses, conducted since 1919, provide an unparalleled data source for such analyses (Government of India, 2019). These censuses offer comprehensive, disaggregated counts of various livestock species across states, districts, and increasingly, at sub-district levels. However, much of the existing research has focused on national or state-level aggregates, potentially masking significant heterogeneity at finer spatial scales (Patel & Dalal, 2015). As Singh et al. (2016) demonstrate, regional distribution of livestock populations is influenced by a complex interplay of agro-ecological, socio-economic, and institutional factors that operate at local levels. Maharashtra, one of India's largest and most agriculturally diverse states, presents an interesting case for livestock population analysis. Within Maharashtra, Solapur district occupies a unique agro-ecological position, straddling the transition zone between the wetter Western Maharashtra and the drier Marathwada and Karnataka border regions. The district is characterized by recurrent drought, black cotton soils, and a mixed farming system where livestock, particularly small ruminants, have historically played a crucial role in risk management and livelihood security (Rao & Birthal, 2008). Recent national-level studies have documented significant structural transformations in India's livestock sector, including the shift from draft animals to milk animals, the dramatic expansion of poultry, and the changing composition of small ruminant populations (Birthal et al., 2005; Parappurathu et al., 2018; Sonavale et al., 2020). However, the extent to which these national trends manifest at the micro-regional level, and the spatial heterogeneity therein, remains under-explored.

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As Navyasree et al. (2025) demonstrate in their analysis of Maharashtra, state-level aggregates can conceal substantial inter-district and intra-district variations that have important policy implications.

Objectives

This study addresses this gap by conducting a comprehensive taluka-level analysis of livestock and poultry population dynamics in Solapur district over a 16-year period (2003-2019). The specific objectives are:

- To analyze the spatio-temporal trends in livestock and poultry populations of Solapur district.;
- To compare growth trajectories and instability indices in Solapur district;

Study Area

Solapur district is located in the southeastern part of Maharashtra state, bordering Karnataka to the south and Telangana to the east. The district lies between 17°10' and 18°32' North latitude and 74°42' and 76°15' East longitude, covering an area of 14,845 square kilometers. Administratively, the district is divided into eleven talukas. The district falls within the rainfall shadow zone of the Western Ghats, receiving an average annual rainfall of 500-600 mm, with high inter-annual variability. The climate is semi-arid, with hot summers and mild winters. Black cotton soils dominate the landscape, characterized by high water-holding capacity but poor drainage. Agriculture is the primary livelihood source, with crops including jowar (sorghum), bajra (pearl millet), sugarcane (in irrigated areas), pulses, and oilseeds. Livestock rearing is an integral component of the farming system, with sheep and goat husbandry being particularly important in the drier eastern and southern talukas.

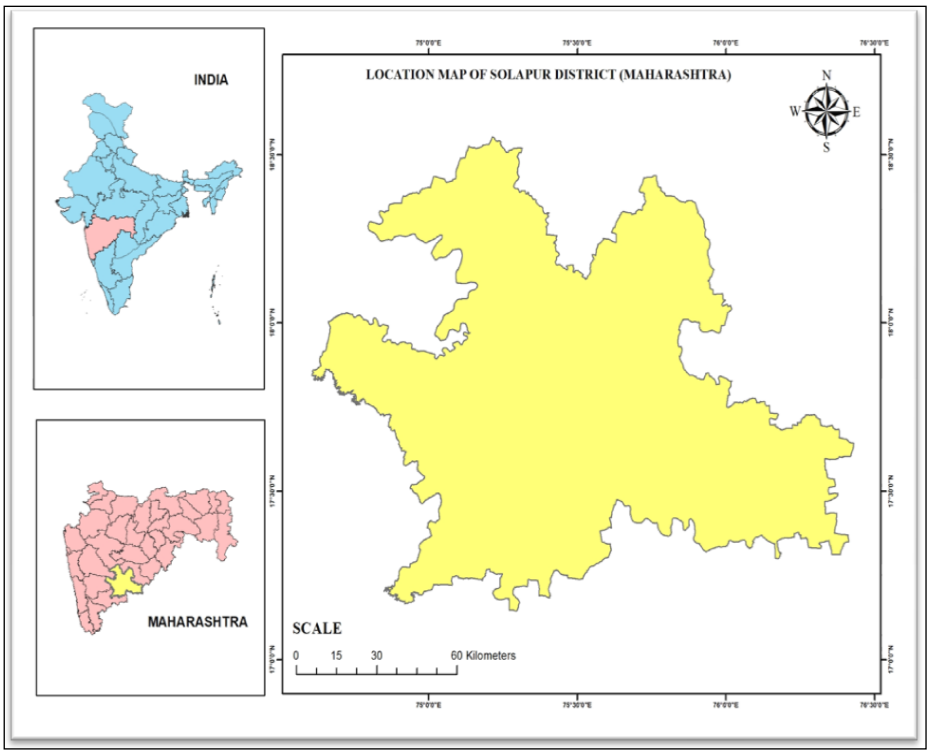

Figure 1: Location Map

4. Materials and Methodology

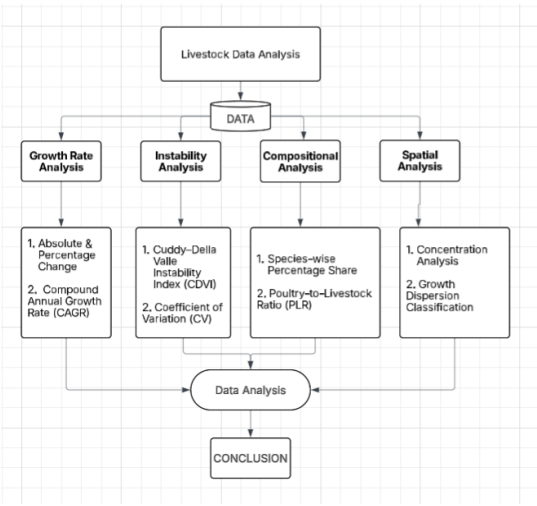

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Figure 2: Methodology Chart

1 Data

Table 1: Livestock Census Data Sources and Coverage.

Census Round	Year	Data Source	Coverage Level
17th Livestock Census	2003	District Animal Husbandry Office, Solapur	Taluka-wise
18th Livestock Census	2007		
19th Livestock Census	2012		
20th Livestock Census	2019		

2 Methodology

The following methodology was used to study livestock dynamics across talukas.

Table 2: Livestock Data Analysis Methodology and Formulas.

Section	Method	Purpose	Formula / Approach
Growth Rate Analysis	Absolute & Percentage Change	Measure magnitude and direction of change (2003–2019)	% Change = ((P2019 − P2003) / P2003) × 100
	Compound Annual Growth Rate (CAGR)	Measure average annual growth	CAGR = [(P2019 / P2003)^(1/16) − 1] × 100
Instability Analysis	Cuddy–Della Valle Instability Index (CDVI)	Measure volatility adjusted for trend	CDVI = CV × √(1 − R²)
	Coefficient of Variation (CV)	Measure dispersion	CV = (SD / Mean) × 100
Compositional Analysis	Species-wise Percentage Share	Identify structural shifts	(Species Population / Total Livestock) × 100
	Poultry-to-Livestock Ratio (PLR)	Measure commercialization	PLR = Poultry Birds / Total Livestock
Spatial Analysis	Concentration Analysis	Measure taluka share in district population	(Taluka Population / District Population) × 100
	Growth Dispersion Classification	Categorize growth trajectories	Based on two periods (2003–2012, 2012–2019)
	Dominance Analysis	Identify leading species in taluka	Highest % share in 2019

Results and Disscussion

1 District-Level Trends: An Overview:

Table 3 reveals a major shift in the district's livestock sector between 2003 and 2019. The most dramatic change is the explosion in poultry, with cocks growing by 457 per cent and total poultry surging to 4.3 million, indicating a move toward commercial production. Cattle and buffaloes also saw strong growth, more than doubling and increasing by 85% respectively, pointing to a focus on dairy. Meanwhile, traditional species collapsed—sheep declined by over 50%, horses and mules by nearly half due to mechanization, and "other livestock" virtually disappeared. Despite these upheavals, total livestock numbers remained almost unchanged, suggesting a fundamental reorganization rather than overall expansion, with farmers shifting from mixed farming toward specialized dairy and poultry operations.

Table 3: District-Level Livestock and Poultry Population (2003-2019)

Species	2003	2007	2012	2019	Absolute Change (2003-2019)	Percentage Change	CAGR (%)
Cows & Bullocks	320,868	432,633	730,461	745,404	424,536	132.3	5.42
Buffaloes	268,335	331,242	449,565	496,454	228,119	85	3.92
Sheep	252,621	212,466	186,059	125,386	-127,235	-50.4	-4.27
Goats	846,154	849,882	706,406	962,504	116,350	13.8	0.81
Horses	6,092	1,444	1,641	3,765	-2,327	-38.2	-2.96
Mules	3,887	2,846	2,273	1,903	-1,984	-51.1	-4.36
Other Livestock	180,641	174,945	14,916	612	-180,029	-99.7	-38.15
Total Livestock	2,246,759	2,183,169	2,091,321	2,333,513	86,754	3.9	0.24
Total Cocks	761,810	1,496,172	1,626,860	4,245,594	3,483,784	457.3	11.21
Total Poultry	1,672,139	1,201,712	2,252,238	4,329,773	2,657,634	158.9	6.11

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2 Temporal Patterns:

The two inter-census periods reveal distinct phases of structural transformation in the district's livestock economy. The 2003-2012 period was characterized by a 6.9 percent decline in total livestock population, driven by sharp contractions in goats (-16.5 %), sheep (-26.3 %), and the near-collapse of other livestock categories. Despite this overall decline, cattle experienced explosive growth of 127.6 % and buffaloes increased by 67.6 %, indicating that the bovine transition toward dairy intensification was already firmly underway while traditional species were being phased out. The 2012-2019 period marked a dramatic reversal, with total livestock rebounding by 11.6 % as the sector consolidated around its new structure. Goats recovered strongly with 36.3 % growth, cattle and buffalo maintained positive albeit slower growth, and the poultry explosion accelerated dramatically with populations nearly doubling in just seven years, while sheep continued their inexorable decline. This two-phase pattern—initial decline during structural adjustment followed by recovery and consolidation—reflects a fundamental reorganization of the district's animal agriculture away from traditional mixed farming toward specialized dairy and commercial poultry operations.

3 Spatial Pattern:

Between 2003 and 2019 (Table 3), the taluka-wise livestock population in the district showed considerable variation in growth and decline across different regions. Sangola recorded the highest increase, adding 83,763 animals (28.5%), followed by Malshiras with 29,022 (7.3%), and Mohol with 27,625 (14%), indicating strong livestock rearing activities in these areas. Pandharpur, Madha, Mangalwedha, and South Solapur also experienced moderate increases ranging from 4.3% to 8.5%, contributing significantly to the district's total livestock. In contrast, Akkalkot (-31.6%), North Solapur (-27.7%), Karmala (-13.9%), and Barshi (-1.9%) witnessed substantial declines, reflecting local factors such as reduced grazing, urbanization, or shifts in agricultural practices. By 2019, Malshiras (18.2%), Sangola (16.2%), and Pandharpur (12.7%) held the largest shares of the district's livestock population, highlighting their dominance in animal husbandry. Overall, despite declines in some talukas, the total district livestock population increased slightly by 3.9%, from 2,246,759 in 2003 to 2,333,513 in 2019, showing a marginal growth at the district level, driven mainly by high-performing

Talukas.

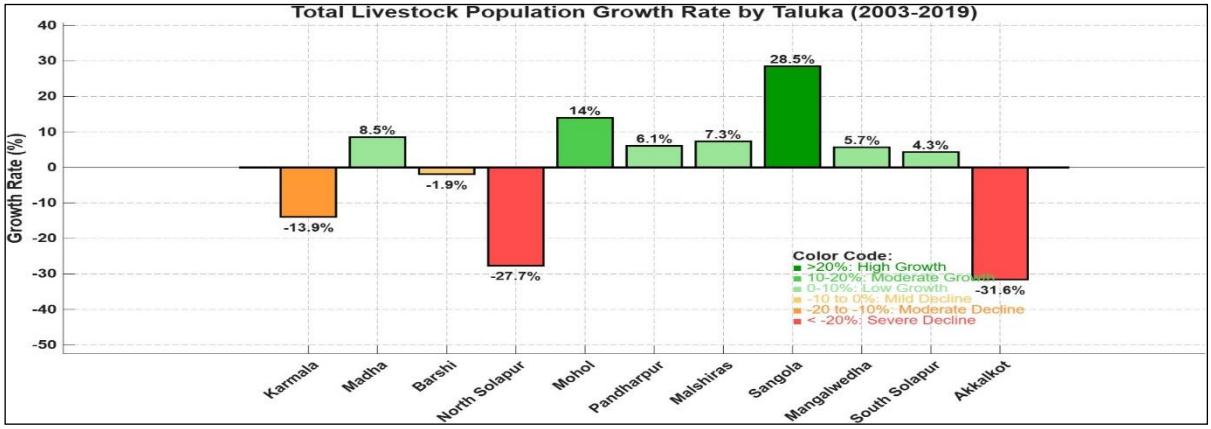

Figure 3: Livestock Population Growth Rate.

4 Species-Specific Spatial Patterns:

Table 4 provides a taluka-wise breakdown of cattle and buffalo population changes from 2003 to 2019, revealing stark spatial inequalities in the distribution of bovine growth across the district. The data shows that the impressive district-wide increase of 424,536 cows and bullocks was overwhelmingly concentrated in just three talukas, with Malshiras, Mohol, and Madha together accounting for an extraordinary 60.4 percent of the total growth, indicating that dairy intensification is a highly localized phenomenon likely centered in areas with better market access, irrigation infrastructure, or cooperative networks. Malshiras emerged as the undisputed leader, adding an enormous 112,361 cattle with a growth rate of 326.4 percent and a remarkable CAGR of 9.54 percent, now holding the largest district share at 19.7 percent, while Mohol followed closely with 83,515 additional cattle and the highest percentage growth in the district at 353.3 percent. In stark contrast, Akkalkot and North Solapur were the only talukas to record negative growth in cattle populations, losing 6,473 and 3,004 animals respectively, with negative CAGRs indicating sustained contraction, while Barshi and South Solapur showed only minimal growth well below the district average. The buffalo dynamics follow a similar spatial pattern, with Pandharpur adding the most buffaloes at 38,578 to claim the largest district share of 16.9 percent, closely followed by Malshiras and Sangola, while Akkalkot again stands out as the sole negative performer with a slight decline in its buffalo population. This spatial analysis reveals a fascinating intra-district contrast between North Solapur's sharp decline and South Solapur's modest growth, possibly due to urbanization pressures from Solapur city, while the Akkalkot anomaly of negative growth in both cattle and buffalo makes it a significant outlier requiring further investigation.

Table 4: Taluka-wise Cattle Population (Cows-Bullocks and Buffalo)

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Taluka	Cows and Bufellows				Buffalo			
	Absolute Change	% Change	CAGR (%)	Share in District (2019)	Absolute Change	% Change	CAGR (%)	Share in District (2019)
Karmala	34,349	113.8	4.86	8.7	13,031	85.9	3.96	5.7
Madha	60,793	262.4	8.38	11.3	21,861	126.6	5.25	7.9
Barshi	14,428	41.3	2.19	6.6	16,985	86.7	3.99	7.4
North Solapur	-3,004	-18.1	-1.24	1.8	2,864	18.7	1.08	3.7
Mohol	83,515	353.3	9.9	14.4	21,150	91.9	4.16	8.9
Pandharpur	48,282	111.8	4.8	12.3	38,578	84.7	3.92	16.9
Malshiras	112,361	326.4	9.54	19.7	40,637	114.2	4.87	15.4
Sangola	51,097	170.3	6.39	10.9	37,488	128.3	5.3	13.4
Mangalwedha	28,612	138	5.56	6.6	22,062	107.9	4.69	8.6
South Solapur	1,576	6.3	0.38	3.6	14,200	65.7	3.22	7.2
Akkalkot	-6,473	-17.1	-1.16	4.2	-737	-2.9	-0.18	5
Total	**424,536**	**132.3**	**5.42**	**100**	**228,119**	**85**	**3.92**	**100**

5 Small Ruminants:

Between 2003 and 2019 (Table 5), small ruminant populations in the district showed sharply contrasting trends, with sheep collapsing while goats expanded modestly. The sheep population declined by 50.4 percent district-wide, falling from 252,621 to 125,386, with every taluka recording losses and the steepest declines in Mohol (-75.7%), Akkalkot (-73.7%), and Madha (-68.9%), indicating a widespread retreat from sheep rearing due to lower profitability and shrinking grazing lands. Despite this collapse, Malshiras and Sangola retained 66.8 percent of the district's remaining sheep, suggesting increasing concentration. In contrast, goats increased by 13.8 percent overall, from 846,154 to 962,504, but this growth was highly polarized, with Sangola (83.8%), Malshiras (34.2%), and Mangalwedha (25.9%) driving the increase while six talukas including Karmala and Akkalkot recorded declines. By 2019, Sangola, Malshiras, and Mangalwedha accounted for nearly half the district's goats. The weak correlation between sheep losses and goat gains, particularly in Malshiras and Sangola where huge sheep declines coincided with huge goat increases, suggests farmers are actively substituting sheep with goats rather than abandoning small ruminants entirely, responding to market dynamics where goat meat commands premium prices while sheep products have become less remunerative.

Table 5: Taluka-wise Small Ruminants Population (Sheep and Goat)

Taluka	Sheep				Goat			
	Absolute Change	% Change	CAGR (%)	Share in District (2019)	Absolute Change	% Change	CAGR (%)	Share in District (2019)
Karmala	-5,997	-49.4	4.8	4.9	-13,363	-20.1	7.9	5.5
Madha	-5,808	-68.9	3.3	2.1	8,436	10.7	9.4	9.1
Barshi	-525	-11.4	1.8	3.2	-4,441	-8	6.6	5.3
North Solapur	-1,450	-43.3	1.3	1.5	-10,326	-31.5	3.9	2.3
Mohol	-13,275	-75.7	6.9	3.4	-9,296	-11.8	9.3	7.3
Pandharpur	-8,296	-66	5	3.4	7,977	7.4	12.7	12
Malshiras	-42,711	-56.6	29.9	26.2	42,677	34.2	14.7	17.4
Sangola	-22,199	-30.4	29	40.6	81,601	83.8	11.5	18.6
Mangalwedha	-16,736	-57.8	11.5	9.7	21,068	25.9	9.6	10.6
South Solapur	-1,647	-34.6	1.9	2.5	6,642	13.6	5.8	5.8
Akkalkot	-8,591	-73.7	4.6	2.5	-14,625	-20	8.6	6.1
Total	**-127,235**	**-50.4**	**100**	**100**	**116,350**	**13.8**	**100**	**100**

6 Poultry Revolution: Spatial Concentration and Explosive Growth:

Between 2003 and 2019 (Table 6), the district's poultry population exhibited remarkable growth, though with significant variation across talukas. Overall, the population more than doubled from 1,672,139 to 4,329,773, reflecting a 158.9% increase and highlighting the rapid expansion of commercial poultry farming. Malshiras led the district with the largest increase of 777,665 birds (245.3%), followed by Sangola (556,578; 218.1%), Mohol (256,596; 217.1%), and Madha (254,982; 179.1%), collectively forming the major hubs of poultry production. Pandharpur and Mangalwedha also experienced significant growth (132.8% and 129.1%, respectively), while Karmala, Barshi, and South Solapur showed moderate increases ranging from 90.1% to 122.4%. In contrast, North Solapur (-30.8%) and Akkalkot (-17.4%) recorded declines, indicating localized challenges in poultry rearing. By 2019, Malshiras (25.3%), Sangola (18.8%), Pandharpur (11.4%), and Mangalwedha (11.5%) accounted for the largest shares of the district's poultry population, underscoring their dominance in this sector. The data highlights the shift toward intensive and commercially oriented poultry farming, which has become a key contributor to the district's livestock economy.

Table 6: Taluka-wise Poultry Population - 2003 and 2019

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Taluka	Absolute Change (2003-19)	% Change	Share % (2019)
Karmala	115,970	90.1	5.7
Madha	254,982	179.1	9.2
Barshi	115,810	122.4	4.9
North Solapur	-23,708	-30.8	1.2
Mohol	256,596	217.1	8.7
Pandharpur	282,732	132.8	11.4
Malshiras	777,665	245.3	25.3
Sangola	556,578	218.1	18.8
Mangalwedha	281,002	129.1	11.5
South Solapur	49,606	93.5	2.4
Akkalkot	-9,599	-17.4	1.1
Total	**2,657,634**	**158.9**	**100**

7 Compositional Shifts: Changing Livestock Portfolios:

The changing composition of livestock populations reveals how different talukas have repositioned their animal husbandry sectors. Between 2003 and 2019 (Table 7), the species composition of district-level livestock (excluding poultry) underwent significant changes, reflecting a shift toward high-value and commercially viable animals. Cows and bullocks showed the largest increase in share, rising from 14.3% to 31.9% (+17.6%), followed by buffaloes, which grew from 11.9% to 21.3% (+9.4%), and highlighting the growing importance of dairy and draught animals. Goats also increased moderately from 37.7% to 41.3% (+3.6%), indicating their continued role as adaptable and profitable small ruminants. In contrast, sheep declined sharply from 11.2% to 5.4% (-5.8%), while horses, mules, and other livestock virtually disappeared, collectively losing 8.2% of the total share, reflecting mechanization and reduced reliance on minor livestock. Overall, the composition trends indicate a strategic shift toward cattle, buffaloes, and goats, which dominate the district's livestock economy, while less productive or traditional species have diminished significantly.

Table 7: Species Composition of Livestock (Excluding Poultry) - District Level

Species	2003 (%)	2019 (%)	Change (%)
Cows & Bullocks	14.3	31.9	17.6
Buffaloes	11.9	21.3	9.4
Sheep	11.2	5.4	-5.8
Goats	37.7	41.3	3.6
Horses	0.3	0.2	-0.1
Mules	0.2	0.1	-0.1
Other Livestock	8	0.03	-8
Total	**100**	**100**	-

8 Instability Analysis:

Table 8: Instability Index (CDVI) for Major Species by Taluka

Taluka	Cattle	Buffalo	Sheep	Goats	Poultry	Overall Livestock
Karmala	34.2	21.8	28.4	18.3	32.1	12.4
Madha	41.7	28.3	52.1	8.9	38.4	6.8
Barshi	18.9	24.1	11.2	12.4	36.7	2.1
North Solapur	12.4	11.8	31.6	26.5	29.8	18.3
Mohol	48.2	26.7	61.3	12.8	52.1	14.6
Pandharpur	31.5	23.4	58.9	6.7	41.2	7.9
Malshiras	52.6	29.1	34.2	15.3	48.6	8.2
Sangola	38.9	27.6	24.8	28.4	43.8	12.5
Mangalwedha	36.7	26.3	41.2	14.7	45.2	9.6
South Solapur	12.1	19.7	28.9	16.8	81.3	11.3
Akkalkot	15.8	8.9	52.4	16.2	38.9	24.7
Average	**31.2**	**22.5**	**38.6**	**16**	**44.4**	**11.7**

Table 8 shows, the Instability Index (CDVI) for major livestock and poultry species highlights the variability and temporal fluctuations in taluka-level populations. Among the species, poultry exhibited the highest instability, with an average CDVI of 44.4, reflecting rapid growth, commercialization, and market-driven fluctuations across talukas. Sheep populations were also highly unstable (38.6), particularly in Madha (52.1), Mohol (61.3), Pandharpur (58.9), and Akkalkot (52.4), indicating sharp declines or variable management practices over time. Cattle showed moderate instability (31.2) with the highest variability in Malshiras (52.6), Mohol (48.2), and Madha (41.7), consistent

with the substantial growth in dairy-focused areas. Buffaloes and goats were relatively more stable, with average CDVIs of 22.5 and 16, respectively, though some talukas like Sangola and Malshiras exhibited moderate fluctuations. Overall livestock (excluding poultry) showed low variability (11.7), suggesting that despite species-specific fluctuations, the district's total livestock numbers remained comparatively stable. Talukas such as Malshiras, Mohol, and Sangola consistently recorded higher instability across multiple species, reflecting dynamic livestock management, commercialization trends, and ecological or socio-economic influences.

Conclusion

This study analysed livestock and poultry population dynamics in Solapur district, Maharashtra, at the taluka level over 2003–2019 using data from three quinquennial livestock censuses. Growth rate measures, including absolute change, percentage change, and CAGR, were applied across eleven talukas and seven species categories to capture magnitude and direction of change. The findings reveal a district livestock sector undergoing profound transformation, characterized by species-specific shifts, extreme spatial heterogeneity, and structural reorganization. Cattle and buffalo experienced substantial growth, forming a nascent dairy belt, while sheep declined sharply and goats remained resilient. Poultry exhibited explosive growth, leading to a district-wide poultry-to-livestock ratio increase from 0.74 to 1.86, with Malshiras and Mangalwedha emerging as poultry-dominated talukas. Talukas displayed diverse trajectories: consistent growers, V-shaped recoverees, continuous decliners, growth reversers, and late recoverees, reflecting heterogeneous patterns hidden by aggregate district data. Spatial concentration was evident in species distribution, with poultry and cattle clusters indicating specialization, while goats were ubiquitous. Overall, compositional shifts and species substitution, rather than absolute expansion, define the evolving livestock economy of Solapur district.

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Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper

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