

TEMPORAL DYNAMICS AND INSTABILITY PATTERNS IN LIVESTOCK POPULATIONS OF WESTERN INDIA

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ABSTRACT

This study examines livestock population dynamics across three western Indian states—Gujarat, Maharashtra, and Rajasthan—from 1997 to 2019. Using five decadal livestock census periods, we analyzed species-specific data for cattle, buffalo, sheep, and goats. Statistical tools including the Coefficient of Variation (CV%), R-square (R^2), Cuddy Della Valle Instability Index (CDVI), Coppock Instability Index (CII%) and Compound Annual Growth Rate (CAGR%) were applied to assess intertemporal variability and stability trends. The results reveal divergent trends. Gujarat showed relatively stable growth in cattle and buffalo populations with moderate sheep population instability. Maharashtra experienced a notable decline in cattle and buffalo with highly volatile trends in goats. Rajasthan's livestock sector exhibited high volatility, particularly in sheep, while showing robust growth in buffalo and goats. These findings underscore the need for species-specific and state-specific livestock policy frameworks to manage population volatility and ensure sustainability in rural livestock economies.

Key words: Western India, Buffalo, Cattle, Sheep, Goat

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INTRODUCTION

Livestock forms the backbone of India's rural economy, contributing significantly to nutritional security, employment and agricultural resilience. As of the latest estimates, the livestock

sector contributes over 4% to India's GDP and supports nearly 20.5 million people, especially in rainfed and arid regions (Annual report, 2020). However, temporal trends in livestock populations have exhibited marked variations influenced by climatic factors, land use change and socio-economic transformations (Birthal and Taneja, 2006).

Western India, encompassing Gujarat, Maharashtra and Rajasthan, features distinct agro-ecological zones

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where livestock plays a vital adaptive and economic role. Despite being livestock-rich, these states face diverse challenges ranging from overgrazing and fodder scarcity to policy lapses and climate-induced stress. Understanding species-wise population dynamics is crucial to developing regionally tailored livestock policies, particularly in states with a mix of increasing and declining trends(Sharma, 2006).

This study aims to provide a granular, species-specific analysis of livestock population trends over two decades using advanced metrics of instability and growth. Such insights are vital for both academic inquiry and public sector planning.

MATERIALS AND METHODS

This study utilized livestock population data from the Livestock Census conducted by the Ministry of Fisheries, Animal Husbandry and Dairying (GOI), spanning 1997 to 2019. We studied four key species: cattle, buffalo, sheep, and goats across Gujarat, Maharashtra, and Rajasthan.

The following quantitative methods were employed:

1. **Coefficient of Variation (CV%)** – Measures relative variability in livestock population over time.
2. **R-square (R^2)** – Evaluates the degree of linearity in population trends.
3. **Cuddy Della Valle Instability Index (CDVI)** – Adjusts the CV% for trend, offering a refined instability measure (Cuddy and Della Valle, 1978).
4. **Coppock Instability Index (CII%)** – Captures sharp temporal fluctuations (Coppock, 1962).
5. **Compound Annual Growth Rate (CAGR%)** – Indicates smoothed average annual growth rate for different periods.

RESULTS AND DISCUSSION

GUJARAT

Cattle and buffalo populations increased consistently. Cattle rose from 6.2M to 10.5M (Table 1) with a peak CAGR of 5.21% (2003–2007), while buffalo increased from 6.7M to 9.6M, peaking at 4.62% CAGR (2007–2012)(Table 1). Sheep populations declined steadily (CAGR: -3.20%) and showed highest instability (CV%: 49.84; CDVI: 26.84) (Table 1), highlighting the vulnerability of extensive grazing systems. Goats increased marginally (CAGR: 1.27%), but with volatility (CV%: 49.30).

MAHARASHTRA

Livestock patterns here revealed an alarming contraction in cattle and buffalo numbers. Cattle fell from 18M to 13.9M(Table 2), with a CAGR of -1.96%(Table 2) in 1997–2003. Buffalo populations declined slowly but showed remarkable stability (CV%: 4.11; R^2 : 0.69). Goats, contrastingly, surged from 7.2M to 10.6M, showing high early growth (CAGR: 8.04%) but erratic trends thereafter, possibly linked to changes in feed availability and land tenure systems (Ahuja *et al.*, 2003).

The Coppock Index showed severe spikes in cattle (CII: 67.15%)(Table 2).

RAJASTHAN

Rajasthan presented a mix of stability and volatility. While cattle increased from 12.1M to 13.9M, the most significant growth was in buffaloes (9.7M to 13.7M; CAGR: 3.40%). Sheep populations nearly halved i.e.14.5M to 7.9M (Table 3), with -7.16% CAGR (Table 3) during 2003–2007 and CDVI of 10.43 (Table 3). Goats showed robust growth, particularly in the early period, echoing the increased commercialization of goat farming under semi-intensive systems (Singh and Rai, 2006).

CROSS-STATE TRENDS

Buffalo populations emerged as the most stable across all states, aligning with the species' higher economic return, adaptability, and policy support in breeding and fodder schemes. In contrast, sheep

populations were consistently unstable, suggesting systemic neglect and vulnerability to climatic fluctuations (Thornton, 2010). Goats, while growing in number, showed inconsistent trends, requiring better integration into state-level livestock policy frameworks. Felix and Reddy (2023) found the CDVI of 11.97 and 13.91 for Cattle and Buffalo population in the study area during 1997-2009.

CONCLUSIONS

Western India's livestock sectors are on starkly different paths. Gujarat and Rajasthan demonstrated consistent growth in cattle and buffalo, while sheep populations were unstable across the board. Maharashtra's livestock sector saw general contraction except for goats. This necessitates customized, state-specific policies focused on stabilizing small ruminants and integrating climate adaptation, breed improvement, and fodder security for long-term sustainability.

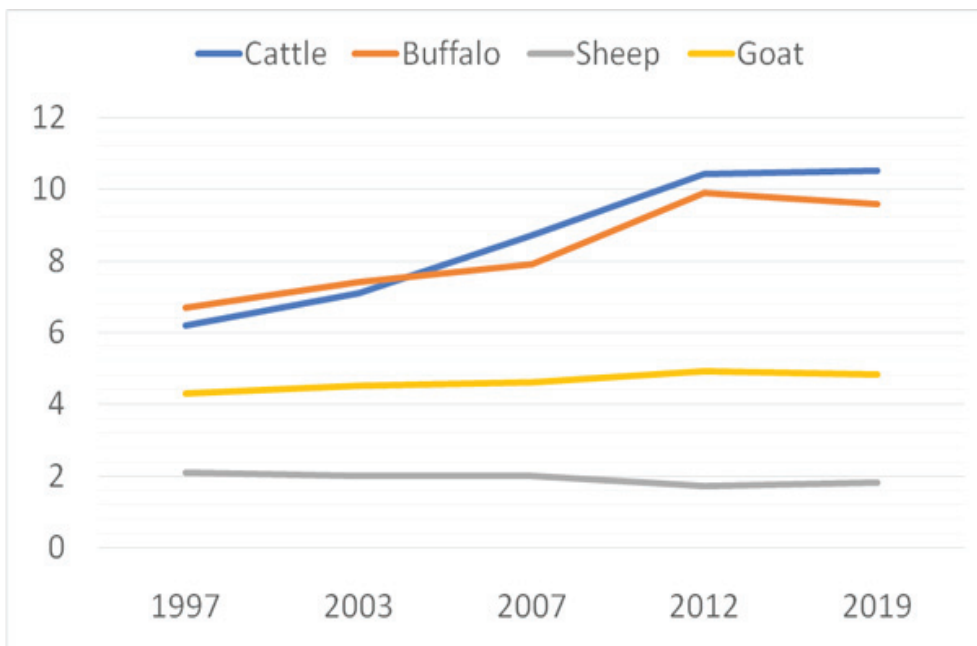


Fig.1. Dynamics of animal population of Gujarat state from 1997-2019 (in millions)

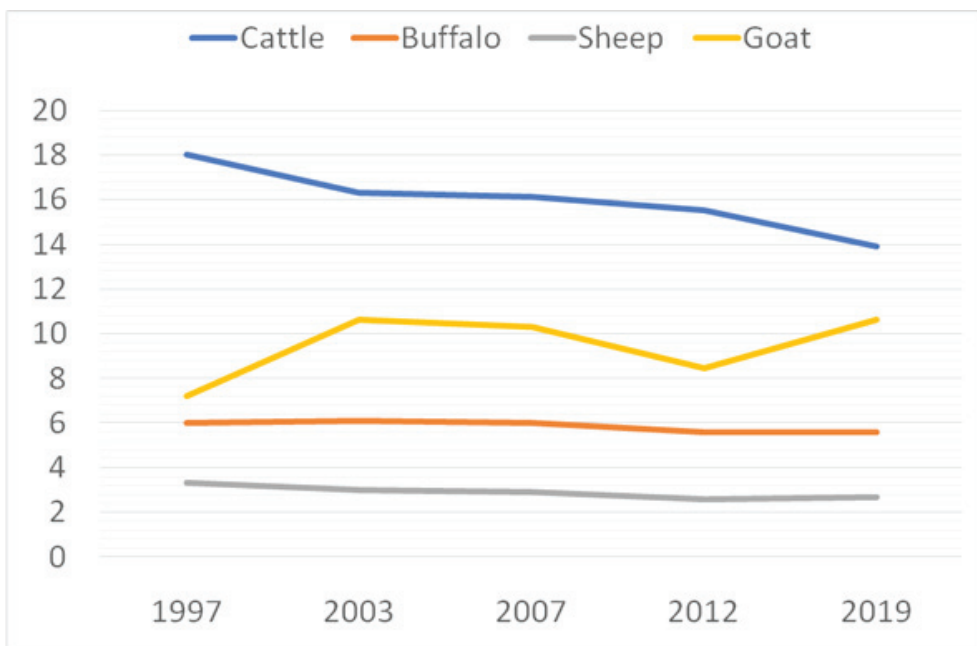


Fig.2. Dynamics of animal population of Maharashtra state from 1997-2019 (in millions)

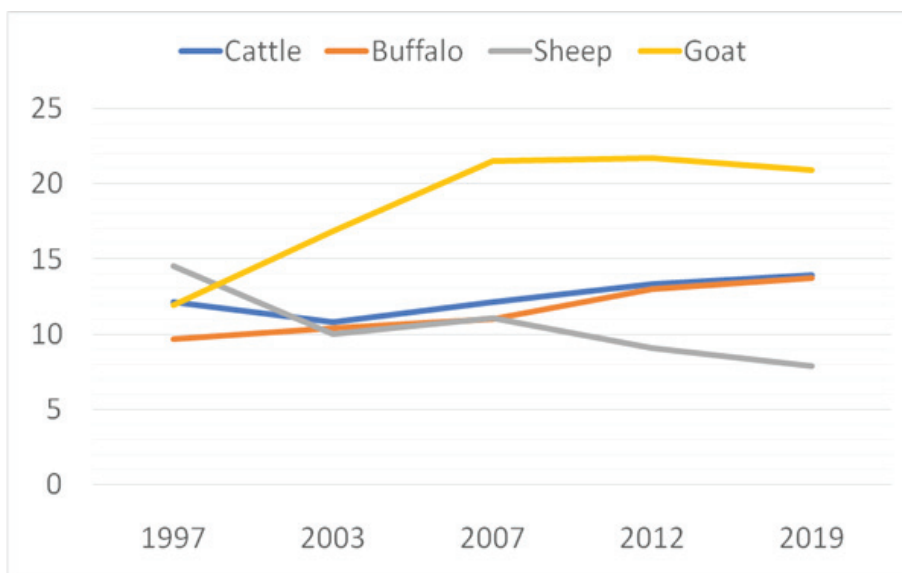


Fig.3. Dynamics of animal population of Rajasthan state from 1997-2019 (in millions)

Table.1. Livestock Dynamics of Gujarat (1997-2019)

State	Gujarat			
Species	Cattle	Buffalo	Sheep	Goat
Population in Millions in 1997	6.2	6.7	2.1	4.3
Population in Millions in 2003	7.1	7.4	2	4.5
Population in Millions in 2007	8.7	7.9	2	4.6
Population in Millions in 2012	10.4	9.9	1.7	4.9
Population in Millions in 2019	10.5	9.6	1.8	4.8
CV	22.47	16.8	49.84	49.3
R Square	0.91	0.85	0.71	0.81
Cuddy Della Valle index(CDVI)	6.74	6.51	26.84	21.49
CII (%)	46.44	43.53	40.14	38.75
CAGR(1997-2003)	2.28%	2.01%	-0.97%	0.91%
CAGR(2003-2007)	5.21%	1.65%	0.00%	0.55%
CAGR(2007-2012)	3.63%	4.62%	-3.20%	1.27%
CAGR(2012-2019)	0.14%	-0.44%	0.82%	-0.29%

Table.2. Livestock Dynamics of Maharashtra (1997-2019)

State	Maharashtra			
Species	Cattle	Buffalo	Sheep	Goat
Population in Millions in 1997	18	6	3.3	7.2
Population in Millions in 2003	16.3	6.1	3	10.6
Population in Millions in 2007	16.1	6	2.9	10.3
Population in Millions in 2012	15.5	5.6	2.6	8.44
Population in Millions in 2019	13.9	5.6	2.7	10.6
CV	9.27	4.11	9.44	16.3
R Square	0.96	0.69	0.81	0.266
Cuddy Della Valle index(CDVI)	1.85	2.29	4.12	13.97
CII (%)	67.15	38.35	40.39	43.73
CAGR(1997-2003)	-1.96%	0.33%	-1.89%	8.04%
CAGR(2003-2007)	-0.31%	-0.41%	-0.84%	-0.72%
CAGR(2007-2012)	-0.76%	-1.37%	-2.16%	-3.90%
CAGR(2012-2019)	-1.54%	0.00%	0.54%	3.31%

Table.3. Livestock Dynamics of Rajasthan (1997-2019)

State	Rajasthan			
Species	Cattle	Buffalo	Sheep	Goat
Population in Millions in 1997	12.1	9.7	14.5	11.9
Population in Millions in 2003	10.8	10.4	10	16.8
Population in Millions in 2007	12.1	11	11.1	21.5
Population in Millions in 2012	13.3	13	9.1	21.67
Population in Millions in 2019	13.9	13.7	7.9	20.84
CV	9.67	14.84	23.92	22.72
R Square	0.62	0.94	0.81	0.68
Cuddy Della Valle index(CDVI)	5.96	3.64	10.43	12.85
CII (%)	40.57	42.63	46.24	47.55
CAGR(1997-2003)	-2.25%	1.40%	-7.16%	7.14%
CAGR(2003-2007)	2.88%	1.41%	2.64%	6.36%
CAGR(2007-2012)	1.91%	3.40%	-3.90%	0.16%
CAGR(2012-2019)	0.63%	0.75%	-2.00%	-0.56%

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