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Growth rate analysis in production and per capita availability of milk in India and its states

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Abstract
The present study focuses on the estimation of Simple Growth Rate (SGR) and Compound Growth Rate (CGR) for the data on milk production and its per capita availability by fitting linear and exponential functions at all India data for the period of 60 years (1961-62 to 2020-21) and State-wise for the period of 30 years (1991-92 to 2020-21). The highest average milk production (163.76 million tonnes) was found during the last decades Period-VI (2011-12 to 2020-21). The highest average per capita availability of milk (351.20 grams per day) was found during the last decade i.e. Period-VI (2011-12 to 2020-21) which is higher than the recommended level of per capita available. The CGR percent in production of milk in India from 1961-62 to 2020-21 was found to be 4.32%. The highest CGR percent in the production of milk was observed during the same Period-VI (5.90%). The CGR percent of per capita availability of milk in India from 1961-62 to 2020-21 was found to be 2.34%. The highest CGR percent in per capita availability of milk was observed during the Period-VI (4.57%). Thus, the growth rate of milk production and per capita availability of milk has significantly increased during the last 60 years. The highest SGR and CGR in milk production were found to be 6.12 and 6.45%, respectively in Rajasthan, followed by Tripura at 5.59 and 6.29% and Andhra Pradesh at the rate of 5.41 and 6.28% respectively. The lowest SGR and CGR in milk production were found in Manipur at 0.17 and 0.21%, followed by Kerala at 0.78 and 0.81% respectively. All the states of India have shown positive growth rates (both SGR & CGR) in milk production indicating that milk production in India has increased production and an upward trend. Similarly, the highest and most significant positive SGR and CGR in per capita availability of milk were found to be 6.51 and 6.73%, respectively in Andhra Pradesh followed by Telangana at 4.89 and 5.04% and Tripura at the rate of 4.56 and 5.01% respectively. The highest decline in the per capita availability of milk was found in Manipur at the rate of 3.72% of SGR and 0.95% of CGR followed by Assam at the rate of 0.45 and 0.43%. All the states of India have shown positive growth rates (both SGR & CGR) in the per capita availability of milk except Manipur, Assam, and Meghalaya, which have a negative growth rate in the per capita availability of milk.

Keywords: Livestock, cattle, milk production and per capita availability, simple growth rate, compound growth rate

1. Introduction
The livestock sector is one of the fastest-growing agricultural sectors in India. Livestock are domesticated animals raised in agriculture to provide labour forces and commodities like milk, eggs, meat, fur, leather, and wool (Anonymous, 2020) [1]. The livestock and fisheries sectors are critical to the country's socio-economic growth and national economy. About 20.5 million humans depend on livestock for their livelihood. It provides livelihood to two-thirds of rural communities. It also provides work, employment and business to about 8.8% of the population in India. The livestock sector contributes 4.11% of Gross Domestic Product (GDP) and 25.6% of total Agriculture GDP and a Gross Value Added (GVA) of 5.1% both at present day and constant prices for the livestock sector throughout 2019-20. Demand for livestock products is increasing quickly as the growth of population increases in developing countries (Anonymous., 2020) [1].
Livestock cattle farming involves the rearing and husbandry of two types of animals, one type is for food needs such as milk and meat, and another type is for labour purposes such as

ploughing, transportation, etc. Animals that produce milk are called dairy animals. For example, goats, buffalo, cows, etc. Working animals are called draught animals. Diary animals are kept and raised for milk production.

In India, the dairy business has a significant economic influence. The majority of milk produced from buffalo stands first, cow milk places second place and goat milk stands third. India manufactures a wide range of dairy products. Milk and milk products are vital food objects for human beings that give sufficient nutritional dietary supplements specifically to children. There is no doubt that cow's milk is the most widely consumed in India, it is much lighter and less fattening than buffalo milk. Moreover, it is easy to digest, thus, doctors recommend it for little children too. Whole Cow's milk contains about 87% calories (67 kcal) and the remaining 13% protein (3.2gm), fat (4.1), carbohydrate, vitamins, and minerals and Buffalo's milk 117 kcal calories, Protein 43gm, fat 6.5gm, Calcium 210mg, and Iron 0.2mg. In 100 gm of milk, the nutritional value is like this: calories 146 kcal, protein 8 grams, fat 8 grams, calcium 28% of the Recommended Dietary Allowances (RDAs).

Because of a wide variety of initiatives underneath-taken through the authorities in improving the productivity of milk over the period, milk production in the country has extended from 17.0 to 198.4 million tonnes from 1950-51 to 2019-20 which accounts for more than 1000% increase in milk production and yields to per capita availability of 406 gram per day per person (Anonymous, 2021) [2] which is more than the minimum quantity recommended (300 grams per day per person) by the Indian Council of Medical Research (ICMR).

India is the world's largest milk producer with 23% of overall production which is followed by the United States of America, China, Pakistan and Brazil. Uttar Pradesh is the highest milk-producing state in India, contributing around 18% to the total milk production, followed by Rajasthan (11%), Andhra Pradesh (10%), Gujarat (8%) and Punjab (7%). Punjab and Haryana are the having the highest per capita availability of milk in India (Anonymous, 2021a) [3].

Growth rates are widely used in agriculture because they have important policy implications (Prajneshu and Chandran, 2005) [4]. Growth rate analysis plays a pivotal role in informing strategic decision-making, driving financial performance, and enhancing competitive advantage in today's dynamic business environment. It empowers businesses to adapt to changing market conditions, capitalize on growth opportunities, and achieve long-term sustainability and success. The estimation growth rate is essential for making informed decisions, planning for the future, allocating resources efficiently, evaluating performance, managing risks, and advancing knowledge in various disciplines (Jain, 2018) [5]. It provides valuable insights that drive decision-making processes and facilitate progress and development in both the public and private sectors. Therefore, keeping the above facts in view the present study was conducted to analyse the simple and compound growth rates in milk production and per capita availability of milk for the data at all India and state levels. By leveraging growth rate analysis, farmers, policymakers, and stakeholders can make informed decisions that drive economic growth, alleviate poverty, and ensure food security for present and future generations.

2. Materials and Methodology

In the present study, the secondary data is confined to the milk production (million tonnes), and per capita availability of milk (gram/day)) for all India data for the period of 60 years (1961-62 to 2020-21) and State-wise for the period of 30 years (1991-92 to 2020-21) were collected from the Directorate of Economics and Statistics, Govt. of India and www.indiastat.com_website. Further, the same was used to estimate the Simple Growth Rate (SGR) and Compound Growth Rate (CGR) by fitting the following functions:

2.1 Simple Growth Rate (SGR)

The SGR was computed by fitting a simple linear model given by:

$$Y_t = a + bt + e_t$$

Where,

'Y_t' is the milk production and per capita availability at the time t

't' is the time in years, the independent variable

'a' is an intercept

'b' is the linear regression coefficient and

'e_t' is an error term

Then the SGR percentage rate is now calculated as follows (Sananse and Maidapwad, 2009) [6]:

Simple Annual Growth Rate in Percentage (SAGR%)

$$= \frac{\hat{b}}{\bar{Y}} \times 100$$

2.2 Compound Growth Rate (CGR)

Compound Growth Rates (CGR) were computed by fitting the exponential model (Prajneshu and Chandran, 2005) given by:

$$Y_t = ab^t e_t.$$

The above equation can be transformed into linear form using logarithmic as follows:

$$lnY_t = \ln(a) + t * \ln(b) + \ln(e_t)$$

Where,

'Y_t' is the milk production and per capita availability at the time t

't' is the time in years, the independent variable

'a' is an intercept/ average production

'b' is the exponential regression coefficient and

'e_t' is an error term

The Compound Growth Rate in Percentage (CGR %) can be expressed as

CGR percent = [Antilog ($\widehat{lnb}$) -1)] x 100.

3. Results and Discussion

To know the summary of the milk production and per capita availability of milk in India, as well as different states of India, the descriptive statistics such as mean, Standard Deviation (SD), Coefficient of Variation (CV), kurtosis and skewness, were computed for the 60 years of data on milk production and per capita availability of milk and presented in Table 1. The average milk production during the study period (1961-62 to 2020-21) was observed at 70.60 million tonnes

with SD 51.74 million tonnes and CV (%) was 74.11%, which indicated a huge variation in the production of milk from 1961-62 to 2020-21. The same pattern was observed in the case of per capita availability of milk, the average value was 197.38 grams per day & SD was 86.58 with CV (%) being 43.87%. The data on the production of milk and per capita availability of milk seems to be platykurtic and positively skewed which are demonstrated by the coefficient of kurtosis and coefficient of skewness respectively for milk production (0.24 and 1.05) and per capita availability of milk (0.13 and 0.97) presented in Table 1.

Table 1: Descriptive statistics for milk production and per capita availability of milk for all India data from 1961-62 to 2020-21

Measures	Milk	
	Production (Million tonnes)	Per Capita Availability (gram/day)
Mean	70.60	197.38
Median	54.80	177.00
Standard Deviation (SD)	51.74	86.58
Coefficient of Variation (CV %)	74.11	43.87
Kurtosis	0.24	0.13
Skewness	1.05	0.97

To know the temporal (decade) variation in milk production and per capita availability of milk, all India data (over the 60 years data from 1961-62 to 2020-21) is divided into six different periods namely Period-I (1961-62 to 1970-71), Period-II (1971-72 to 1980-81), Period-III (1981-82 to 1990-91), Period-IV (1991-92 to 2000-01), Period-V (2001-02 to 2010-11), and Period-VI (2011-12 to 2020-21) then CV (%) values are computed and compared the mean value over different time-period using one-way ANOVA.

The period-wise average milk production and per capita availability of milk and CV (%) are computed for all India's milk production and per capita availability of milk data and the results are presented in Table 2. The result from Table 2 revealed that there is a significant difference in average production and per capita availability of milk over different periods under consideration at a 5% level of significance. The average milk production during the study period (from 1961-62 to 2020-21) was found to be 70.60 million tonnes with a CV (%) of 73.29%. Further, the highest average milk production (163.76 million tonnes) was found during the last decades Period-VI (2011-12 to 2020-21) followed by Period-V (2001-02 to 2010-11) and the lowest average milk production (20.29 million tonnes) was found during Period-I (1961-62 to 1970-71) which is statistically on far with Period-II (1971-72 to 1980-81) milk production of 26.59 million tonnes. However, the highest CV (17.50%) in milk production was observed during Period-VI with an average milk production of 163.76 million tonnes and the lowest CV (4.02%) was observed during Period-I with an average milk production of 20.29 million tonnes. The computed mean and CV are plotted in Fig. 1 and 2 for better visualization.

The average per capita availability of milk during the study period (from 1961-62 to 2020-21) was found to be 197.38 grams per day which is below the recommended level with CV (%) of 43.87%. Further, the highest average per capita availability of milk (351.20 grams per day) was found during the last decade i.e. Period-VI (2011-12 to 2020-21) which is higher than the recommended level of per capita available and the lowest average per capita availability of milk (112.60 gram per day) was found during Period-I which is statistically on far with Period-II (1971-72 to 1980-81) per capita availability of milk of 117.60 gram per day. However, the highest CV (13.64%) in per capita availability of milk was observed during Period-VI with a mean per capita availability of milk of 351.20 grams per day and the lowest CV (5.63%) was observed during Period-II with mean per capita availability of milk of 117.60 grams per day. The computed mean and CV are plotted in Fig. 3 and 4 for better visualization. & 117.60 grams per day)

Table 2: Period-wise comparison of milk production and per capita availability in India

	Milk			
	Production (Million tonnes)		Per Capita Availability (gram/day)	
	Mean	CV (%)	Mean	CV (%)
Period-I	20.29^{e}	4.02	112.60^{e}	6.30
Period-II	26.54^{e}	12.40	117.60^{e}	5.63
Period-III	44.09^{d}	14.71	157.40^{d}	8.41
Period-IV	67.98^{c}	12.64	197.90^{c}	6.86
Period-V	100.92^{b}	13.19	247.60^{b}	8.77
Period-VI	163.76^{a}	17.50	351.20^{a}	13.64
Overall Period	70.60	73.29	197.38	43.87
F-value	157.59*		154.113*	
CD	12.28		20.77	

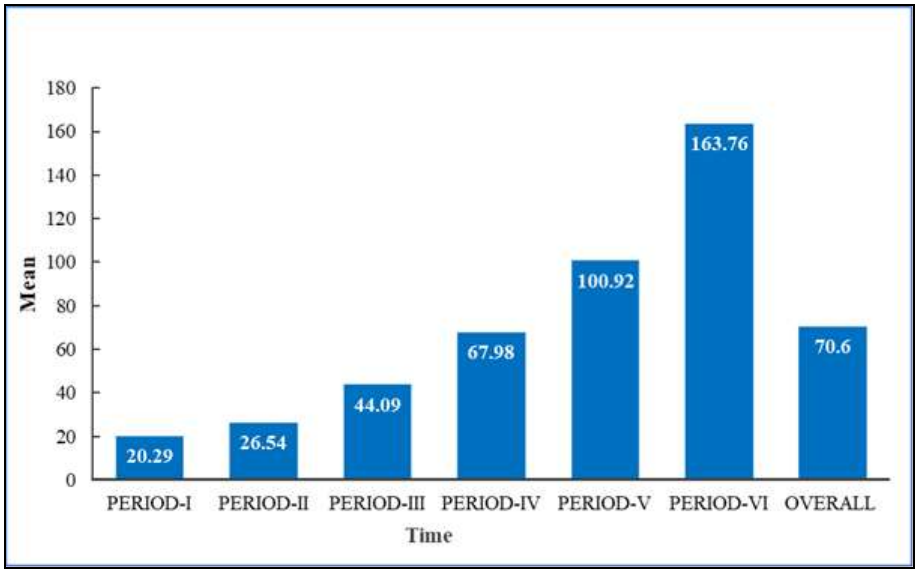

Fig 1: Period-wise mean milk production in India

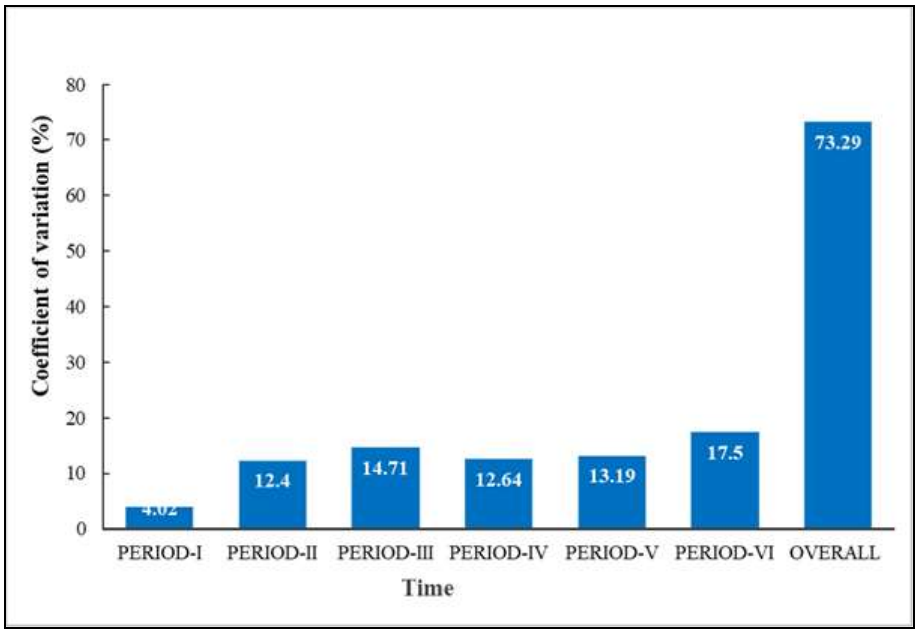

Fig 2: Period-wise coefficient of variation (CV%) of milk production in India

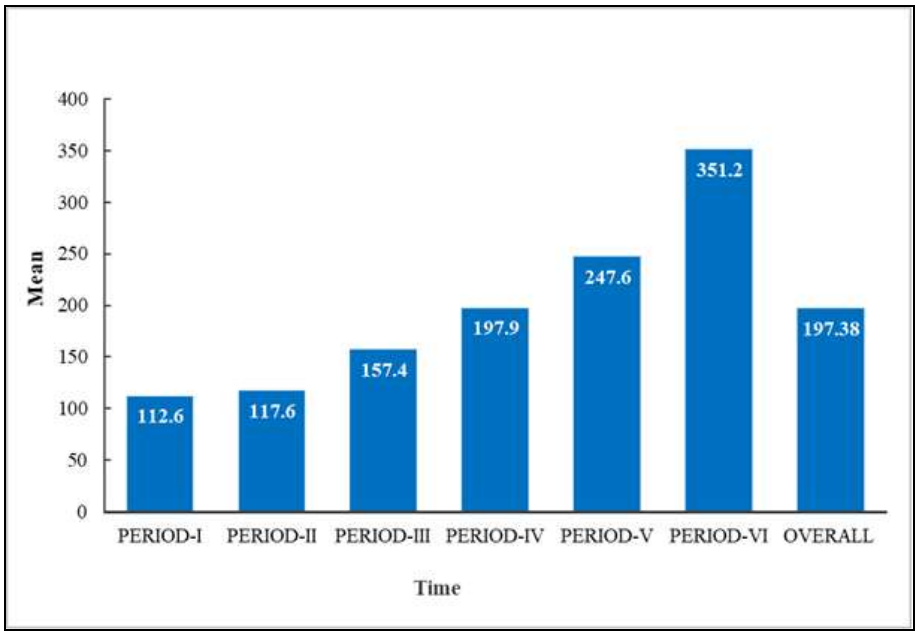

Fig 3: Period-wise mean per capita availability of milk in India

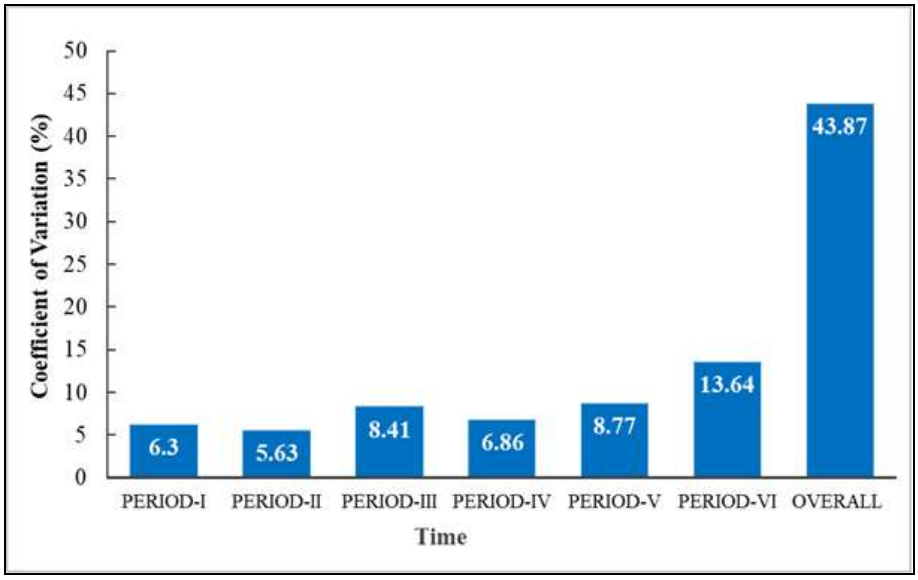

Fig 4: Period-wise coefficient of variation (CV%) of per capita availability of milk in India

The Simple Growth Rate (SGR) and Compound Growth Rate (CGR) were estimated for all India-level milk production and per capita availability of milk over the period under the study *i.e.* from 1961-62 to 2020-21 (60 years of overall data) and six different periods namely Period-I (1961-62 to 1970-71), Period-II (1971-72 to 1980-81), Period-III (1981-82 to 1990-91), Period-IV (1991-92 to 2000-01), Period-V (2001-02 to 2010-11), and Period-VI (2011-12 to 2020-21) of 10 years each and the results are presented in Table 3, and the same results are plotted in Fig.5.

Results from Table 3 reveal that the SGR% of the production of milk in India from 1961-62 to 2020-21 was found to be 3.92%, which is significant at a 5% level of significance demonstrating that statistically significant growth was achieved in milk production during the study period. The highest SGR% in the production of milk was observed during Period VI (5.74%) whereas the lowest SGR% in milk production (0.48%) was observed during Period-I. The CGR percent in production of milk in India from 1961-62 to 2020-21 was found to be 4.32%, which is significant at a 1% level of significance indicating significant growth was achieved during the study period. The highest CGR percent in the production of milk was observed during the same Period-VI (5.90%) whereas the lowest CGR percent in production (0.47%) was observed during Period-II.

From Table 3 the SGR% for the per capita availability of milk in India during 1961-62 to 2020-21 was found to be 2.36%, which is significant at a 5% level revealing that per capita availability of milk has increased significantly at the rate of 2.36% during the study period. The highest SGR% in per capita availability of milk was observed during Period-VI (5.58%) whereas the lowest SGR% in per capita availability of milk (-1.65%) was observed during Period-I. The CGR percent of per capita availability of milk in India from 1961-62 to 2020-21 was found to be 2.34%, which is significant at 5%. The highest CGR percent in per capita availability of milk was observed during Period-VI (4.57%) whereas the lowest CGR percent in per capita availability of milk (-1.60%) was observed during the same Period-I. Thus, the growth rate of milk production and per capita availability of milk has significantly increased during the last 60 years.

Table 3: Simple Growth Rate (SGR) and Compound growth Rate (CGR) of production and per capita availability of Milk in India during 1961-62 to 2020-21

Time	Milk Production (Million tonnes)		Milk Per Capita availability (Gram/day)	
	SGR	CGR	SGR	CGR
Period I (1961-62 to 1970-71)	0.48**	0.47**	-1.65^{NS}	-1.60^{NS}
Period II (1971-72 to 1980-81)	4.06**	4.15**	1.80**	1.81**
Period III (1981-82 to 1990-91)	4.83**	5.04**	2.70*	2.78**
Period IV (1991-92 to 2000-01)	4.17**	4.29**	2.26**	2.90**
Period V (2001-02 to 2010-11)	4.33**	4.42**	2.86*	2.74**
Period VI (2011-12 to 2020-21)	5.74*	5.90**	4.48^{NS}	4.57^{NS}
Overall	3.92*	4.32**	2.36*	2.34*

Note- NS: Non-Significant, **Significant at 1% level of Significance, *Significant at 5% level of Significance.

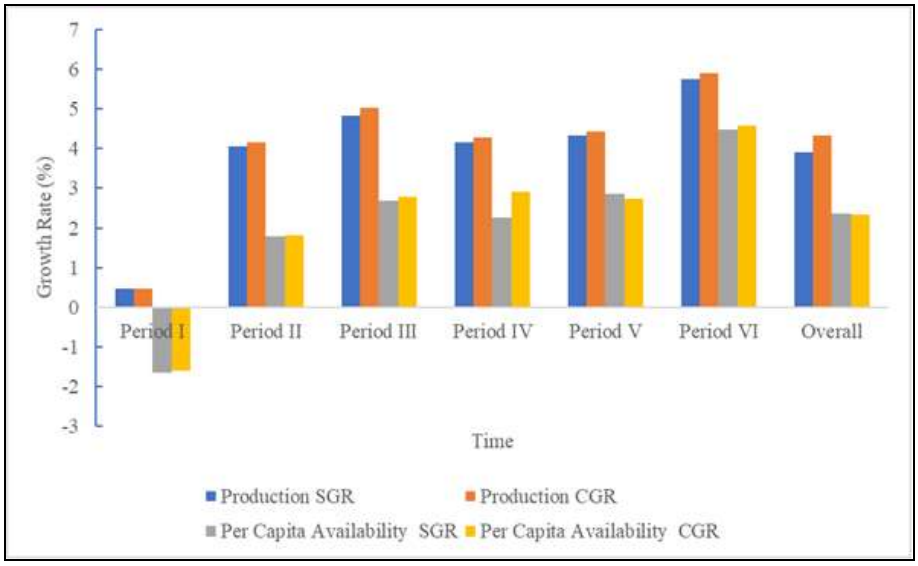

Fig 5: The computed SGR and CGR values for Production and Per Capita Availability of Milk in India during 1961-62 to 2020-21

Similarly, the SGR and CGR of milk production and per capita availability of milk are computed for different states of India for the overall period under consideration *i.e.* from 1991-92 to 2020-21 (30-year whole) and three different periods *viz.* Period-I (1991-92 to 2000-01), Period-II (2001-02 to 2010-11) and Period-III (2011-12 to 2020-21) of 10 years each and the results are presented in Tables 4 & 5.

The highest SGR and CGR in milk production were found to be 6.12 and 6.45%, respectively in Rajasthan, however, the milk production SGR was non-significant, CGR was found to be significant at 1% which is followed by Tripura at 5.59 and 6.29% and Andhra Pradesh at the rate of 5.41 and 6.28% respectively. The lowest SGR and CGR in milk production were found in Manipur at 0.17 and 0.21%, followed by Kerala at 0.78 and 0.81% respectively. All the states of India have shown positive growth rates (both SGR & CGR) in milk production indicating that milk production in India has increased production and showed an upward trend.

In Andhra Pradesh state, milk production showed a significant CGR at the rate of 6.28% during the overall period under the study *i.e.* from 1991-92 to 2020-21, Period-I has a higher growth rate (7.81%) than Period-II (7.14%) & III (3.32%). In Arunachal Pradesh, milk production showed a significant CGR at the rate of 1.84% during the overall period under the study, Period-I has a higher growth rate (11.26) and negative CGR (-7.07) in Period-II. In Assam state, milk production showed a significant positive CGR at the rate of 1.04% during the overall period under the study, milk production increased at the rate of 1.96% during Period-III whereas Period-I had a lower growth rate. In Bihar state, milk production showed a significant positive CGR at the rate of 4.77% during the overall period under the study, milk production declined at the rate of 1.30% during Period-I whereas Period-III had a higher growth rate (10.95%). In Chhattisgarh state, milk production showed a significant positive CGR at the rate of 4.52% during the overall period under the study, whereas Period-III had a higher growth rate (5.38%) and less in Period-II. In Goa state, milk production showed a significant positive CGR at the rate of 1.89% during the overall period under the study, milk production declined at the rate of 1.11% during Period-III whereas Period-II had a higher growth rate (3.35) and less in Period-II. In Gujarat state, milk production showed a significant positive CGR at the rate of 5.39% during the overall period under the study, milk production was less at the rate of 4.97% during Period-I whereas highest (5.64%) in Period-II. Haryana state has the highest positively significant CGR at the rate of 3.86% during the overall period under the study as compared to all the other states. The highest growth rate was achieved during Period-III at the rate of 7.50. In Himachal Pradesh, milk production significantly increased at the rate of 3.23 during the study period and the highest milk production was found during Period-III at the rate of 4.38%. In Jammu and Kashmir state, milk production increased at the rate of 4.81% from 1991-92 to 2020-21, which is more (11%) in the first decades (Period-I). Similarly, in Jharkhand state, milk production increased at the rate of 4.60 from 2001-02 to 2020-21, which is more in Period-II. In Karnataka state, milk production increased significantly at the rate of 3.85% from 1991-92 to 2020-21 which is more (7.78%) during the Period-I. In Kerala state, milk production increased significantly at the rate of 0.81% from 1991-92 to 2020-21 which is more (3.74%) during Period I whereas Period-III showed a decline in milk production at the rate of 0.98%. In Madya Pradesh, milk production continuously increased significantly at the rate of 4.34% from 1991-92 to 2020-21 whereas production was more (9.77%) during the Period-III. In Maharashtra state, milk production increased significantly at the rate of 33.79% from 1991-92 to 2020-21 which is more (4.61%) during the Period-III. In Manipur state, milk production increased significantly at the rate of 0.21% from 1991-92 to 2020-21 showing the lowest growth rate in milk production among all the states. Period-I had shown a decreased growth rate at the rate of 3.78. In Meghalaya state, milk production increased significantly at the rate of 2.12% from 1991-92 to 2020-21, which is more (3%) during Period-I and less during Period-III. In Mizoram state, milk production increased significantly at the rate of 2.32% from 1991-92 to 2020-21 which is more (8.25%) during Period-III and negative in Period-II. In Nagaland state, milk production increased at the rate of 1.5% from 1991-92 to 2020-21 which is more (1.48%) during Period-II and a negative growth was found in the remaining periods. In Orissa state, milk production increased significantly at the rate of 5.94% from 1991-92 to 2020-21 which is more (7.77%) during the Period-II. In Punjab state, milk production increased significantly at the rate of 2.82% from 1991-92 to 2020-21 which is more (4.53%) during the Period-III. In Rajasthan state, milk production continuously increased significantly at the rate of 6.45% from 1991-92 to 2020-21, which shows the first state having the highest growth rate among all the states. The maximum growth rate

(8.86%) was found during the Period-III. In Sikkim state, milk production increased at the rate of 2.26% from 1991-92 to 2020-21, max production was found (3.44%) during Period-III. In Tamil Nadu, a significant increase in milk production was found at the rate of 3.23% from 1991-92 to 2020-21 which is more (5.14%) during Period-II and less during Period-III. Since the Telangana state was formed in 2014, data was used from 2013-14 to 2020-21, during this period, a significant increase in milk production was found at the rate of 5.90%. In Tripura, milk production increased significantly at the rate of 6.29% from 1991-92 to 2020-21 which is the second second-highest growth rate among all the states. Period-I showed the highest production (11.95%) and period-II had the lowest production. In Uttar Pradesh, milk production increased significantly at the rate of 4.28% from 1991-92 to 2020-21. Period-III showed the highest production (5.66%) and period-I lowest production. In Uttarakhand, milk production increased significantly at the rate of 3.28% from 2001-02 to 2020-21. Period-II showed the highest production (3.87%). In West Bengal, milk production increased significantly at the rate of 2.04% from 1991-92 to 2020-21. Period-III showed the highest production (2.94%) and Period-I had the lowest production growth rate (0.78%).

Table 4: Simple Growth Rate (SGR) and Compound Growth Rate (CGR) of State production of milk from 1991-92 to 2020-21

State		Milk production (Million tonnes)			
		Period-I	Period-II	Period-III	Overall Period
Andhra Pradesh	SGR	7.81	6.91	3.35	5.41^{NS}
	CGR	7.88	7.14	3.32	6.28**
Arunachal Pradesh	SGR	9.44	-6.59	9.12	1.75**
	CGR	11.26	-7.07	11.38	1.84**
Assam	SGR	0.56	1.23	1.96	1.06^{NS}
	CGR	0.58	1.25	1.96	1.04**
Bihar	SGR	-1.08	9.37	5.90	4.75^{NS}
	CGR	-1.30	10.95	6.10	4.77**
Chhattisgarh$^{\#}$	SGR	NA	2.63	5.32	4.52^{NS}
	CGR	NA	2.60	5.38	4.52**
Goa	SGR	1.61	3.17	-1.15	1.79**
	CGR	1.57	3.35	-1.11	1.89**
Gujarat	SGR	4.82	5.26	5.46	5.09^{NS}
	CGR	4.97	5.40	5.64	5.39**
Haryana	SGR	3.12	2.30	7.30	4.00^{NS}
	CGR	3.22	2.33	7.50	3.86**
Himachal Pradesh	SGR	2.23	4.12	4.32	3.23^{NS}
	CGR	2.32	4.23	4.38	3.23**
Jammu & Kashmir$^{\#\#\#}$	SGR	10.52	1.95	5.75	4.29^{NS}
	CGR	11.00	1.94	6.22	4.81**
Jharkhand$^{\#}$	SGR	NA	5.70	4.37	4.32^{NS}
	CGR	NA	6.23	4.35	4.60**
Karnataka	SGR	7.54	1.28	6.58	3.81^{NS}
	CGR	7.78	1.27	6.55	3.85**
Kerala	SGR	3.57	0.61	-0.99	0.78^{NS}
	CGR	3.74	0.66	-0.98	0.81**
Madhya Pradesh	SGR	0.28	4.23	9.05	4.74^{NS}
	CGR	0.28	4.32	9.77	4.34**
Maharashtra	SGR	4.18	3.07	4.49	3.69^{NS}
	CGR	4.31	3.10	4.61	3.79**
Manipur	SGR	-3.63	1.59	1.57	0.17^{NS}
	CGR	-3.78	1.64	1.55	0.21**
Meghalaya	SGR	3.00	2.04	1.09	2.01**
	CGR	3.00	2.07	1.10	2.12**
Mizoram	SGR	5.44	-1.69	7.37	2.42**
	CGR	5.29	-2.08	8.25	2.32**
Nagaland	SGR	-0.67	1.72	-0.98	1.43**
	CGR	-0.60	1.48	-0.99	1.50**
Orissa	SGR	6.18	7.10	4.56	5.22*
	CGR	6.25	7.77	4.58	5.94**
Punjab	SGR	4.22	2.01	4.49	2.74^{NS}
	CGR	4.35	2.05	4.53	2.82**
Rajasthan	SGR	6.50	6.76	8.32	6.12^{NS}
	CGR	6.61	6.96	8.86	6.45**
Sikkim	SGR	1.80	0.08	3.18	2.22**
	CGR	1.88	0.17	3.44	2.26**
Tamil Nadu	SGR	3.29	4.97	3.23	3.12^{NS}
	CGR	3.40	5.14	3.21	3.23**
Telangana$^{\#\#}$	SGR	NA	NA	NA	5.70^{NS}
	CGR	NA	NA	NA	5.90**
Tripura	SGR	11.54	2.34	7.71	5.59**
	CGR	11.95	2.34	8.03	6.25**

Uttar Pradesh	SGR	3.84	4.02	5.66	4.20^{NS}
	CGR	3.93	4.12	5.61	4.28**
Uttarakhand[#]	SGR	NA	2.61	3.86	3.26^{NS}
	CGR	NA	2.64	3.87	3.28**
West Bengal	SGR	0.71	2.60	2.94	2.11^{NS}
	CGR	0.78	2.63	2.94	2.04**

Note: NA-Not Available, NS: Non-Significant, **Significant at 1% level of Significance, *Significant at 5% level of Significance.

1. Chhattisgarh, Jharkhand, and Uttarakhand data is available only from 2001-02 to 2020-21 (since these States were formed in 2000).
2. Telangana data is available from 2013-14 to 2020-21 (since this State was formed in 2014),
3. Before 2019, there were 29 States and 7 Union Territories in India. In 2019, Jammu and Kashmir was bifurcated into 2 union territories *i.e.*, Jammu and Kashmir, and Ladakh.

Similarly, the highest and most significant positive SGR and CGR in per capita availability of milk were found to be 6.51 and 6.73%, respectively in Andhra Pradesh which is followed by Telangana at 4.89 and 5.04% and Tripura at the rate of 4.56 and 5.01% respectively. The highest decline in the per capita availability of milk was found in Manipur at the rate of 3.72% of SGR and 0.95% of CGR followed by Assam at the rate of 0.45 and 0.43% of SGR and CGR respectively. All the states of India have shown positive growth rates (both SGR & CGR) in the per capita availability of milk except Manipur, Assam, and Meghalaya, which have a negative growth rate in the per capita availability of milk.

In Andhra Pradesh state, the per capita availability of milk showed a significant CGR at the rate of 6.73% during the overall period under the study, Period-III has a higher growth rate (9.89%) than Period-I & II. In Arunachal Pradesh, the per capita availability of milk showed a significant CGR at the rate of 0.15% during the overall period under the study, Period-I had a higher growth rate and Period-II had a negative growth rate. In Assam state, the per capita availability of milk showed a negative CGR at the rate of 0.43% during the overall period under the study, and the per capita availability of milk declined at the rate of 0.96 and 0.15% during Period-I & II respectively, whereas Period-I had a positive growth rate. In Bihar state, the per capita availability of milk showed a negative CGR at the rate of 3.86% during the overall period under the study, the highest per capita availability of milk was found at the rate of 9.08% during Period-II. In Chhattisgarh state, the per capita availability of milk showed a significant positive CGR at the rate of 2.61% during the overall period under the study, whereas Period-III had a higher growth rate and found less growth rate in Period-II. In Goa state, the per capita availability of milk showed a significant positive CGR at the rate of 1.35% during the overall period under the study but had a negative growth rate at the rate of 0.08 during Period-III. In Gujarat state, the per capita availability of milk showed a significant positive CGR at the rate of 3.58% during the overall period under the study, whereas the highest positive growth rate was found at 3.77 in Period-III. The per capita availability of milk in Haryana state has a positively significant CGR at the rate of 1.99% during the overall period under the study. The highest growth rate was achieved during Period-III at the rate of 5.59%. In Himachal Pradesh, the per capita availability of milk was significantly increased at the rate of 2.21% during the study period. In Jammu and Kashmir state, the per capita availability of milk increased at the rate of 2.48 from 1991-92 to 2020-21, which is much less in the first decades (Period-II) and maximum in Period-I. Similarly, in Jharkhand state, the per capita availability of milk increased at the rate of 2.72 from 2001-02 to 2020-21. In Karnataka state, the per capita availability of milk increased significantly at the rate of 2.41% from 1991-92 to 2020-21 which is more (6.02%) during the Period-II. In Kerala state, per capita availability of milk increased significantly at the rate of 0.29% from 1991-92 to 2020-21 which is more (3.46%) during Period-I whereas Period-II & III showed a declined in milk production at the rate of 0.98%. In Madya Pradesh, the per capita availability of milk continuously increased significantly at the rate of 3.85% from 1991-92 to 2020-21, whereas the per capita availability of milk was more (8.02%) during the Period-III. In Maharashtra state, the per capita availability of milk continuously increased significantly at the rate of 2.22% from 1991-92 to 2020-21 which is more (3.40%) during the Period-III. In Manipur state, the per capita availability of milk declined at the rate of 0.95% from 1991-92 to 2020-21 more decline rate (4.67%) was found to be during Period-I & III. In Meghalaya state, the per capita availability of milk decreased continuously at the rate of 0.0.06% from 1991-92 to 2020-21, more decline was found (0.94%) during Period-III as compared to other periods. In Mizoram state, the per capita availability of milk increased significantly at the rate of 1.32% from 1991-92 to 2020-21 which is more (6.71%) during Period-I and a negative growth rate was found at the rate of 3.31% in Period II. In Nagaland state, the per capita availability of milk increased at the rate of 0.42% from 1991-92 to 2020-21, except Period-II (0.33%) other periods had negative per capita availability of milk. In Orissa state, the per capita availability of milk increased significantly at the rate of 4.66% from 1991-92 to 2020-21 which is more (6.76%) during Period-II. In Punjab state, the per capita availability of milk increased significantly at the rate of 1.40% from 1991-92 to 2020-21 which is more (3.44%) during Period-III. In Rajasthan state, the per capita availability of milk increased significantly at the rate of 4.27% from 1991-92 to 2020-21, whereas Period-III had the highest growth rate of 7.08%. In Sikkim state, the per capita availability of milk increased at the rate of 0.86% from 1991-92 to 2020-21, but negative growth was found during Period-I & II but the per capita availability of milk increased at the rate of 2.32% during Period-III. In Tamil Nadu, a significant increase in the per capita availability of milk was found at the rate of 2.54% from 1991-92 to 2020-21 which is more (4.42%) during Period-II and less during Period-III. Since the Telangana state was formed in 2014, data was used from 2013-14 to 2020-21, during this period, a significant increase in the per capita availability of milk was found at the rate of 5.05%. In Tripura, the per capita availability of milk increased significantly at the rate of 5.01% from 1991-92 to 2020-21. Period-I showed the highest per capita availability of milk (10.29%) and period-II had lowest the per capita availability of milk. In Uttar Pradesh, the per capita availability of milk increased significantly at the rate of 2.57% from 1991-92 to 2020-21. Period-III showed the highest production (4.69%) and Period-II had the lowest per capita availability of milk. In

Uttarakhand, the per capita availability of milk increased significantly at the rate of 1.71% from 2001-02 to 2020-21. Period-III showed the highest per capita availability of milk (2.32%) and Period-II had lowest the per capita availability of milk. In West Bengal, the per capita availability of milk increased significantly at the rate of 1.13% from 1991-92 to 2020-21. Period-III showed the highest production (2.09%) and Period-I had the lowest per capita availability of milk.

Table 5: Simple Growth Rate (SGR) and Compound Growth Rate (CGR) of State-wise per capita availability of milk from 1991-92 to 2020-21

State		Milk per capita availability (gram/day)			
		Period-I	**Period-II**	**Period-III**	**Overall Period**
Andhra Pradesh	SGR	4.96	5.93	9.00	6.51**
	CGR	5.27	6.06	9.89	6.73**
Arunachal Pradesh	SGR	7.89	-7.54	7.45	0.08^{NS}
	CGR	9.14	-8.04	9.29	0.15**
Assam	SGR	-0.92	-0.15	0.74	-0.45^{NS}
	CGR	-0.96	-0.15	0.74	-0.43^{NS}
Bihar	SGR	1.06	7.90	3.67	3.71**
	CGR	0.83	9.08	3.72	3.86**
Chhattisgarh$^{\#}$	SGR	NA	1.01	3.52	2.66**
	CGR	NA	0.98	3.52	2.61**
Goa	SGR	2.68	0.36	-0.15	1.30**
	CGR	2.59	0.39	-0.08	1.35**
Gujarat	SGR	2.77	3.71	3.69	3.50**
	CGR	2.87	3.76	3.77	3.58**
Haryana	SGR	0.79	0.36	5.51	2.15^{NS}
	CGR	0.80	0.35	5.59	1.99**
Himachal Pradesh	SGR	0.79	3.04	3.38	2.25**
	CGR	0.78	3.10	3.40	2.21**
Jammu & Kashmir$^{\#\#\#}$	SGR	7.04	0.48	5.73	2.35*
	CGR	7.59	0.48	6.27	2.48**
Jharkhand$^{\#}$	SGR	NA	4.21	2.23	2.56**
	CGR	NA	4.56	2.18	2.72**
Karnataka	SGR	5.79	0.07	5.36	2.45**
	CGR	6.02	0.14	5.28	2.41**
Kerala	SGR	3.36	-0.21	-1.26	0.27^{NS}
	CGR	3.46	-0.08	-1.24	0.29**
Madhya Pradesh	SGR	3.01	2.36	7.52	4.03**
	CGR	2.91	2.38	8.02	3.85**
Maharashtra	SGR	2.36	1.53	3.33	2.44**
	CGR	2.45	1.53	3.40	2.22**
Manipur	SGR	-5.11	0.45	-0.26	-1.04^{NS}
	CGR	-4.67	0.46	-0.26	-0.95^{NS}
Meghalaya	SGR	-0.48	0.82	-0.98	-0.05^{NS}
	CGR	-0.48	0.83	-0.94	-0.06^{NS}
Mizoram	SGR	6.92	-2.86	5.31	1.26**
	CGR	6.71	-3.31	5.92	1.32**
Nagaland	SGR	-4.47	0.55	-1.54	0.43^{NS}
	CGR	-4.46	0.33	-1.58	0.42**
Orissa	SGR	4.68	6.21	3.74	4.22**
	CGR	4.72	6.76	3.70	4.66**
Punjab	SGR	2.08	0.76	3.43	1.41^{NS}
	CGR	2.12	0.77	3.44	1.40**
Rajasthan	SGR	3.38	4.83	6.74	4.30**
	CGR	3.42	4.90	7.08	4.27**
Sikkim	SGR	-0.46	-1.02	2.16	0.89*
	CGR	-0.48	-1.00	2.32	0.86**
Tamil Nadu	SGR	3.03	4.28	-1.56	2.49*
	CGR	3.04	4.42	-0.69	2.54**
Telangana$^{\#\#}$	SGR	NA	NA	NA	4.89**
	CGR	NA	NA	NA	5.04**
Tripura	SGR	10.24	1.18	6.55	4.56**
	CGR	10.29	1.19	6.76	5.01**
Uttar Pradesh	SGR	1.79	2.07	4.77	2.63**
	CGR	1.79	2.10	4.69	2.57**
Uttarakhand$^{\#}$	SGR	NA	0.98	2.34	1.73*
	CGR	NA	0.98	2.32	1.71**
West Bengal	SGR	0.16	1.51	2.10	1.16**
	CGR	0.16	1.51	2.09	1.13**

Note: NA-Not Available, NS: Non-Significant, **Significant at 1% level of Significance, *Significant at 5% level of Significance.

1. Chhattisgarh, Jharkhand, and Uttarakhand data is available only from 2001-02 to 2020-21 (since these States were formed in 2000).
2. Telangana data is available from 2013-14 to 2020-21 (since this State was formed in 2014),
3. Before 2019, there were 29 States and 7 Union Territories in India. In 2019, Jammu and Kashmir was bifurcated into 2 union territories *i.e.*, Jammu and Kashmir, and Ladakh.

The present study concludes that milk production showed a positive growth rate in India, as well as in all the states of India. Similarly, the per capita availability of milk also showed a positive growth rate in India, as well as all the states of India except Manipur, Assam and Meghalaya, which have a negative growth rate in the per capita availability of milk. This study is supported by Ramesh *et al.* (2021) [7] who found a positive growth rate in the area, production and productivity of cotton crops in Dharwad district of Karnataka. This study result was supported by the findings of Shwetha *et al*. (2022)[8] reported a growth rate of production and productivity of cotton crops marked a significant increase after the introduction of Bt cotton across the cotton growing States of India.

4. Conclusion

The Simple Growth Rate (SGR) and Compound Growth Rate (CGR) of milk production and its per capita availability of milk were estimated by fitting linear and exponential functions for the data on milk production (million tonnes) and its per capita availability of milk (gram per day) at all India and state-level data. The average milk production during the study period (from 1961-62 to 2020-21) was found to be 70.60 million tonnes with a CV (%) of 73.29%. Further, the highest average milk production (163.76 million tonnes) was found during the last decades Period-VI (2011-12 to 2020-21) followed by Period-V (2001-02 to 2010-11) and the lowest average milk production (20.29 million tonnes) was found during Period-I (1961-62 to 1970-71) which is statistically on far with Period-II (1971-72 to 1980-81) milk production of 26.59 million tonnes. The average per capita availability of milk during the study period (from 1961-62 to 2020-21) was found to be 197.38 grams per day which is below the recommended level with CV (%) of 43.87%. Further, the highest average per capita availability of milk (351.20 grams per day) was found during the last decade i.e. Period-VI (2011-12 to 2020-21) which is higher than the recommended level of per capita available and the lowest average per capita availability of milk (112.60 gram per day) was found during Period-I which is statistically on far with Period-II (1971-72 to 1980-81) per capita availability of milk of 117.60 gram per day.

The CGR percent in production of milk in India from 1961-62 to 2020-21 was found to be 4.32%, which is significant at a 1% level of significance indicating significant growth was achieved during the study period. The highest CGR percent in the production of milk was observed during the same Period-VI (5.90%) whereas the lowest CGR percent in production (0.47%) was observed during Period-II. The CGR percent of per capita availability of milk in India from 1961-62 to 2020-21 was found to be 2.34%, which is significant at 5%. The highest CGR percent in per capita availability of milk was observed during the Period-VI (4.57%) whereas the lowest CGR percent in per capita availability of milk (-1.60%) was observed during the same Period-I. Thus, the growth rate of milk production and per capita availability of milk has significantly increased during the last 60 years.

The highest SGR and CGR in milk production were found to be 6.12 and 6.45%, respectively in Rajasthan, CGR was found to be significant at 1% which is followed by Tripura at 5.59 and 6.29% and Andhra Pradesh at the rate of 5.41 and 6.28% respectively. The lowest SGR and CGR in milk production were found in Manipur at 0.17 and 0.21%, followed by Kerala at 0.78 and 0.81% respectively. All the states of India have shown positive growth rates (both SGR & CGR) in milk production indicating that milk production in India has increased production and showing an upward trend. Similarly, the highest and most significant positive SGR and CGR in per capita availability of milk were found to be 6.51 and 6.73%, respectively in Andhra Pradesh which is followed by Telangana at 4.89 and 5.04% and Tripura at the rate of 4.56 and 5.01% respectively. The highest decline in the per capita availability of milk was found in Manipur at the rate of 3.72% of SGR and 0.95% of CGR followed by Assam at the rate of 0.45 and 0.43% of SGR and CGR respectively. All the states of India have shown positive growth rates (both SGR & CGR) in the per capita availability of milk except Manipur, Assam, and Meghalaya, which have a negative growth rate in the per capita availability of milk.

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