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Growth and Instability Analysis of Pulses in India- A Study

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ABSTRACT

Background: Pulses play a crucial role in a healthy and sustainable food system, providing essential protein, fiber and nutrients. In 2024-25, India's total pulse production was estimated at 252.38 lakh tonnes which is around 7.13% of foodgrains, while 6.7 million tonnes were imported. This study investigates the expansion and volatility of pulse farming across various Indian states from 2000 to 2024, concentrating on key crops such as Lentil, Green gram, Bengal gram and total pulse.

Methods: The analysis employs Compound Annual Growth Rate and Cuddy-Della Valle Index to measure growth trends and production variability, respectively.

Result: Results reveal positive and stable growth in pulse cultivation in states such as Assam, Uttar Pradesh, Karnataka, Madhya Pradesh and Nagaland, driven by improved technology and policy support. On the contrary, states like Haryana, Rajasthan, Andhra Pradesh and Punjab exhibit declining trends and high instability, attributed to climatic challenges, market fluctuations and infrastructural constraints.

Key words: Cuddy-Della Valle Index, Growth rate, Instability analysis, Pulse.

INTRODUCTION

Food grains, including cereals and pulses, are essential for food security, nutrition and economic stability, but pulses hold special significance due to their high protein content, environmental benefits and role in sustainable agriculture. Pulses are a rich source of plant-based protein (20 to 25%), fiber and essential amino acids. Additionally, pulses play a crucial role in ensuring nutritional security, particularly in a cereal-based vegetarian diet consumed by a large population (Pathak *et al.,* 2017).

The main pulses cultivated in India include bengal gram, red gram, lentil, black gram, green gram, lablab bean, moth bean, horse gram, pea, grass pea, cowpea and broad bean. Among these, chickpea, pigeon pea, mung bean, urd bean and lentil are the most popular and widely consumed varieties (Gowda *et al.,* 2013). In the year 2024-25, India's total pulse production was estimated to be 252.38 lakh tonnes (Ministry of Agriculture and Farmers Welfare, 2025), reflecting the country's significant role in global pulse production. Despite being the largest producer, domestic demand continues to outpace supply. As a result, India imported approximately 6.7 million tonnes of pulses in 2024-25 (Business Standard, 2025) to bridge the gap between production and consumption, ensuring food security and price stability in the market. The present study aims to determine the compound annual growth rate of the area, production and productivity of pulses in India for the period 2000-01 to 2023-24 and to analyze the instability in pulse production.

MATERIALS AND METHODS

This study was conducted in the Department of Agricultural Economics, Uttar Banga Krishi Viswavidyalaya, Majhian, Patiram, D. Dinajpur, West Bengal, India during 2024-25.

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The study is based on secondary data collected over a span of 24 years, from 2000-01 to 2023-24. To effectively capture variations and trends over time, the study period has been systematically divided into two distinct sub-periods: 2000-01 to 2011-12 and 2012-13 to 2023-24. Information on the area, production and productivity of crops was collected from the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India. To examine the growth rate and instability in different variables, the compound annual growth rate and the Cuddy-Della Valle Index were used, respectively.

Compound annual growth rate

CAGR is a measure used to calculate the average annual growth of a value over a specified period. CAGR was employed by fitting exponential growth function of the form:

$$Y_t = ab^t$$

Where,

Y_t = Dependent variable (area/production/productivity).

a = Intercept term.
b = Regression coefficient.
t = Time trend.

The per cent compound annual growth rate was derived using the relationship:

$$CAGR (r) = (Antilog\ b - 1) * 100$$

Where,
r = Compound growth rate.

Cuddy-della valle index

CDVI is a statistical measure used to quantify the instability or fluctuations in time-series data. It is expressed as:

$$CDVI = CV * \sqrt{(1 - R^2)}$$

Where,
CV = Coefficient of Variation = (SD/ Mean) *100.
R^2 = Coefficient of determination from time trend regression adjusted by the number of degrees of freedom.

RESULTS AND DISCUSSION

Growth of area, production and productivity of lentil in India

Data in Table 1 shows major state-wise growth rates of Lentil. Strong growth has consistently been shown by Jharkhand, with a notable increase in all the aspects. Rajasthan's positive growth in Phase I followed by negative growth in Phase II is consistent with prior evidence of high instability in pulses within the state (Sood *et al.*, 2020). A massive decline in area and production has been observed in the Haryana, which might be attributed to several reasons, such as adverse weather patterns, fluctuations in market prices, competition from alternative crops and rising cultivation expenses (Kumar *et al.*, 2018).

Growth of area, production and productivity of green gram in India

Table 2 represents major state-wise growth rates of Green gram. A significant increase in production and productivity is being led by Madhya Pradesh. Balanced growth across all the aspects has been shown by Odisha. A decline in production is being experienced by states like Andhra Pradesh, Bihar, Chhattisgarh, Gujarat and Maharashtra. The cultivation area for green gram in Andhra Pradesh, Chhattisgarh and Maharashtra is being decreased due to several factors, such as competition from alternative crops, economic and market limitations and environmental issues such as climatic conditions and drought spells (Mohan, 2017; Wasnik, 2022 and More and Khairnar, 2023).

Growth of area, production and productivity of bengal gram in India

Table 3 embodies major state-wise growth rates of Bengal gram. Gujarat's Bengal gram gains reinforce national trends indicating enhanced pulse stability in the post-2015 era (Singh *et al.*, 2022). Maharashtra also demonstrates strong performance, with notable gains in area, production and productivity. In contrast, decline in area and production but modest productivity gains, are being experienced by Punjab, Uttar Pradesh and Haryana. A steady decrease in the cultivation area has been recorded in Haryana and Punjab over the past two decades because of the prevailing preference for the wheat-rice cropping system, which is supported by policies and infrastructure (Ankita *et al.*, 2018 and Singh and Bansal, 2020).

Growth of area, production and productivity of total pulses in India

Table 4 displays major state-wise growth rates of total pulses. Significant gains in productivity are being exhibited by the North-Eastern states like Assam, Meghalaya, Arunachal Pradesh and Manipur due to improved production technologies (Gogoi *et al.*, 2022 and Kumar *et al.*, 2025). Positive growth in area, production and productivity is being shown by the western states of India, including Gujarat, Rajasthan and Maharashtra (Mohre and Mitra, 2022). However, challenges are being faced by states like Andhra Pradesh, Bihar, Goa, Haryana, Jammu and Kashmir, Kerala and Sikkim, with declines in area.

Table 1: Major state-wise growth rates of Lentil.

States	2000-2001 to 2011-2012			2012-13 to 2023-24			Overall		
	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
Assam	1.09*	0.34	-0.73*	-1.91**	0.15	1.92*	1.3**	3.57**	2.24**
Bihar	0.65	1.01	0.36	-2.05**	-4.76**	-2.78*	-1.23**	-0.65	0.58
Chhattisgarh	0.1	0.88	0.78	5.25	-0.83	1.2	1.21	0.58	1.45**
Haryana	-6.15**	-6.43*	-0.29	-23.07**	-26.53**	-1.27	-11.23**	-11.92**	0.19
Jharkhand	12.84**	15.03**	2.02	6.16*	5.38	-1.07	9.31**	11.03**	1.5**
Madhya Pradesh	1.91**	0.54	-1.35	-1.57	5.88*	5.34**	0.00	5.08**	4.51**
Rajasthan	7.24*	5.88	-1.27	-7.6*	-3.78	4.11**	2.29	3.73*	1.41**
Uttar Pradesh	-0.97	-0.15	0.82	2.05*	-4.16	3.59*	-1.2**	-3.28	1.18*
Uttarakhand	-0.71	0.2	0.93	-1.11*	10.03	0.98	-2.38**	3.54**	2.62**
West Bengal	-2.93**	-1.35	1.63	10.41**	9.21**	-1.11	4.9**	6.75**	1.55**
Others	-4.09*	-3.31	0.81	15.6**	19.53	3.4	1.59	2.85	1.25
India	0.47	0.93	-0.01	0.46	4.22**	3.27**	0.05	-1.99	-2.04

Note: ** and * indicate significance at 5% and 10% levels of probability, respectively.

Instability index of lentil

Instability of area, production and productivity of Lentil is represented on Table 5. States like Haryana, Rajasthan and Jharkhand are facing high fluctuations in area and production, due to a combination of environmental factors like drought and erratic rainfall, limited access to improved seeds and inputs (Ahmad *et al.*, 2018 and Kumar *et al.*, 2023). In contrast, states like Assam and Bihar are relatively more stable. Though the instability of area under lentil at national level is low, states like Chhattisgarh, Haryana, Rajasthan and West Bengal are exhibiting high level of instability in area.

Instability index of green gram

Instability under green gram is shown in table 6. The high instability in Rajasthan's green gram matches recent studies

Table 2: Major state-wise growth rates of Green gram.

States	2000-2001 to 2011-2012			2012-13 to 2023-24			Overall		
	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
Andhra Pradesh	-10.3**	-9.03*	1.44	-7.52**	-4.43*	2.98	-9**	-4.16**	5.31**
Assam	-0.18	-5.95	0.1	3.02*	5.04**	2.2**	3.26**	0.51	2.95**
Bihar	-1.58**	-1	0.55	0.3	1.81	1.2	-0.56**	2**	1.07**
Chhattisgarh	-0.93	-1.01	0.37	-13.14**	-6.59	3.86*	-4.15**	10.34**	2.29**
Gujarat	4.4*	8.34*	3.77	0.74	12.23*	5**	-1.65*	24.32**	3.79**
Haryana	5.87	16.33**	10.73**	2.84	5.21	1.33	4.9*	4.45**	5.56**
Jharkhand	27.12**	24.14**	1.61	0.24	14.48	2.45**	8.93**	-1.92	2.64**
Karnataka	-0.41	-0.82	-0.44	5.08*	28.96*	5.43*	0.19	10.46**	3.69**
Madhya Pradesh	-0.08	11.72	13.15	19.63**	53.76**	11.4**	12.97**	3.71	10.61**
Maharashtra	-4.8**	-3.1	1.82	-3.69	21.29	3.3	-3.93**	-3.86	-0.8
Odisha	3.94*	6.84**	2.75**	-0.55	1.7	0.4	1.41**	3.91**	2.46**
Punjab	-11.74**	-9.45**	3*	-0.12	2.57	2.16*	4.45*	11.55*	1.88**
Rajasthan	7.36**	3.77	6.02	11.62**	39.22*	1.12	7.17**	3.33**	4.33*
Tamil Nadu	2.96**	1.07	-1.83	-1.7	-4.7	-3.84	1.55**	18.99**	0
Uttar Pradesh	1.12	5.28*	4.14**	2.12	5.64**	1.49	1.66**	6.43**	1.67**
West Bengal	3.37	4.95	2.16	22.05*	25.04*	-0.89	10.95**	1.55	2.19**
Others	23.94	24.53	0.47	-11.68**	-0.35	12.85*	16.5**	13.45**	2.14
India	0.74	2.52	1.77	6.34**	14.66**	7.83*	2.57**	5.56**	2.91**

Note: ** and * indicate significance at 5% and 10% levels of probability, respectively.

Table 3: Major state-wise growth rates of Bengal gram.

States	2000-2001 to 2011-2012			2012-13 to 2023-24			Overall		
	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
Andhra Pradesh	7.92**	9.05**	0.47	-2.77*	-3.78	-0.11	0.57	-0.19	-0.75
Assam	-1.55	-3.14	0.35	4.56*	4.62**	1.24	0.31	3.56**	2.48**
Bihar	-2.88**	-1.39	1.6	-0.16	-1.81	-1.68	-1.03**	-0.6	0.44
Chhattisgarh	4.69**	9.46**	4.54**	0.76	-1.87	-2.63	2.96**	3.52**	0.53
Gujarat	18.78**	27.69**	7.47**	19**	24.92**	4.96**	11.08**	16.57**	4.93**
Haryana	-1.55	0.25	1.83	-9.83**	-8.06**	2	-7.47**	-5.59**	2.05**
Karnataka	8.38**	9.69**	1.2	-4.04**	-3.97**	0.07	3.42**	4.55**	1.09**
Madhya Pradesh	2.75**	4.51**	1.71	-4.8**	-1.66	3.3**	-0.33	2.45**	2.78**
Maharashtra	6.33**	11.49**	4.85**	7.5**	12.12**	4.31**	5.91**	9.08**	2.99**
Odisha	6.15**	9.61**	3.11**	-2.6*	-2.61*	-0.02	1.05	2.51**	1.44**
Punjab	-12.27**	-9.67**	2.59**	-3.71**	-3.14	-0.18	-7.24**	-5.48**	1.82**
Rajasthan	7.08**	8.11**	0.96	4.87**	7.2**	2.23*	4.6**	7.55**	2.81**
Tamil Nadu	1.96**	2.37**	-0.5	-6.1**	-1.69	4.47**	-1.96**	-0.13	1.69**
Uttar Pradesh	-4.37**	-3.73**	0.66	2.83	-26.49	4.95**	-1.44**	-11.05**	1.7**
West Bengal	-9.3**	-7.34	2.04**	5.1**	5.98	0.89	-0.71	1.07	1.78**
Telangana	NA	NA	NA	4.31	5.65	1.28	-	-	-
Others	3.65**	4.06**	3.00	3.30	-0.09	-2.85	1.80**	1.86**	0.69
India	4.06**	5.95**	1.81**	1.52*	3.71**	2.16*	2.54**	4.52**	1.93**

Note: ** and * indicate significance at 5% and 10% levels of probability, respectively.

that say these fluctuations are mainly due to cost and profitability problems (Sharma *et al.*, 2024). In contrast, Bihar and Odisha demonstrate relative stability, with productivity instability below 12%. Assam's productivity is stable (9.39%), but its production is marked by high volatility (70.27%). Overall, states of West Bengal, Punjab and Haryana are exhibiting higher instability in respect of area and production, which is exorbitantly higher than that of instability prevailing at national level.

Table 4: Major state-wise growth rates of total pulses.

States	2000-2001 to 2011-2012			2012-13 to 2023-24			Overall		
	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
Andhra Pradesh	-2.76**	0.54	5.21**	-2.42	-2.44	0.61	-2.85**	-1.04*	2.02**
Arunachal Pradesh	14.13**	11.4**	-2.44	5.85**	2.49**	-0.53	3.81**	3.79**	-0.05
Assam	6.52*	8.94*	2.25	1.44	2.85**	1.37**	2.04**	4**	1.92**
Bihar	-0.79	-1.56*	-0.76	-1.61**	-2.99**	-1.28	-2.16**	-1.53**	0.67*
Chhattisgarh	-4.34	-3.52	0.87	-4.22**	-5.14**	-0.89	-1.18	0.4**	1.63**
Goa	-1.31	0.07	1.53	-3.89	-4.69	-0.38	-5.63**	-5.95**	-0.18
Gujarat	2.54**	9.42**	5.31**	8.12**	13.56**	5.23**	2.22**	7.15**	4.43**
Haryana	0.09	1.69	2.43	-5.73**	-4.48	0.63	-4.6**	-3.43**	1.3**
Himachal Pradesh	0.4	9.37**	8.18**	0.96	2.33	1.79	0.08	7.36**	7.2**
Jammu and Kashmir	0.28	1.05	0.72	-1.85	0.74	2.18	-2.41**	-0.61	1.69
Jharkhand	15.35**	16.58**	2.33	3.52**	3.72**	0.66	9**	11.62**	3.01**
Karnataka	2.52**	5.69**	0.9	2.32**	3.51**	1.5	2.28**	4.86**	1.88**
Kerala	-6.9*	-6.58	2.4	-2.91	-3.23	-0.34	-8.68**	-7.36**	2.19**
Madhya Pradesh	2.43**	3.73**	0.55	-1.23	1.37	2.16**	1.64**	4.16**	2.09**
Maharashtra	0.1	3.63**	3.48**	3.01**	7.46**	4.04**	1.33**	4.04**	2.57**
Manipur	16.13**	21.3**	3.97*	0.01	0.27	0.14	9.13**	13.66**	3.95**
Meghalaya	-0.74	0.6	2.32	7.11**	9.5**	2.32**	4.18**	7.96**	3.99**
Mizoram	2.38	2.13	0.8	0.17	0.99	0.95	-0.31	0.78	1.48*
Nagaland	1.23	4.05**	2.36*	1.37	-1.32	0.6**	0.78	1.82**	1.05**
Odisha	3.04**	6.16**	0.59	0.61	1.84**	0.9**	0.98**	3.27**	1.35**
Punjab	-10.26**	-8.65**	3.76*	-0.66	1.21	1.8**	0.22	1.51	1.95*
Rajasthan	5.25**	8.47*	0.37	6.02**	6.95**	1.26*	3.88**	7.32**	2.51**
Sikkim	5.77**	6.2**	3.51	-2.08**	-1.52**	0.52**	-2.1**	-1.74**	1.4*
Tamil Nadu	-0.47	-0.31	-2.22	0.97	0.79	-0.1	1.85**	4.83**	2.11**
Uttar Pradesh	-1.45**	-1.24	0.87	-7.3	-3.38	3.77**	-3.49	-2.63	1.27**
Uttarakhand	6.82**	8.87**	1.26	12.15	10.76	1.97**	5.72*	7.58**	1.96**
West Bengal	-3.65**	-3.24**	0.7	7.35**	7.39**	0.09	3.81**	5.05	1.3**
Others	2.69**	2.51**	-1.43*	13.65	17.76*	3.36**	21.65	23.76	1.74**
India	21.26	3.86**	2.05**	1.69	-4.02	1.47	1.59	4.14*	2.21

Table 5: Instability under Lentil.

States	2000-2001 to 2011-2012			2012-13 to 2023-24			Overall		
	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
Assam	5.59	5.25	3.25	5.92	10.99	6.38	10.54	16.81	10.21
Bihar	11.42	18.96	12.74	9.13	15.54	14.67	11.11	20.74	16.66
Chhattisgarh	10.68	15.64	8.17	11.33	27.76	16.38	12.96	21.95	13.29
Haryana	21.14	25.84	11.58	45.75	23.10	19.72	36.25	29.46	16.08
Jharkhand	34.66	40.46	10.77	17.01	16.10	10.17	30.01	33.24	12.57
Madhya Pradesh	6.32	15.54	14.72	16.74	29.41	14.67	13.48	29.03	22.94
Rajasthan	38.36	43.47	13.04	27.59	17.82	9.40	36.77	31.70	15.24
Uttar Pradesh	6.31	9.87	10.71	7.24	42.24	14.27	9.82	26.70	14.49
Uttarakhand	16.16	24.34	26.10	8.71	20.89	12.47	14.15	21.72	20.01
West Bengal	6.81	19.98	16.68	17.97	18.07	6.88	31.84	31.07	13.47
Others	17.77	20.22	15.94	36.62	45.29	25.30	41.12	52.08	23.00
India	5.41	6.89	6.62	6.95	16.07	13.57	6.35	23.65	21.86

Calculated by authors from secondary data.

Instability index of bengal gram

Instability under Bengal gram is displayed in Table 7. Gujarat's area and production instability witnessed highest instability which might be due to farmers are shifting from pulses like Bengal gram to more profitable crops like cotton, leading to fluctuations in pulse production and cultivated area (Mehta, 2013). In contrast, Odisha, Tamil Nadu, Madhya Pradesh and West Bengal have relatively low instability, with productivity CDVI values below 12%. Though the instability of all the three aspects at national level are low, state like Gujarat is exhibiting very high level of instability in area as well as production.

Table 6: Instability under green gram.

States	2000-2001 to 2011-2012			2012-13 to 2023-24			Overall		
	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
Andhra Pradesh	20.39	34.85	27.17	20.56	22.75	13.39	21.80	35.87	24.42
Assam	10.62	14.15	5.55	13.43	15.40	3.53	15.45	70.27	9.39
Bihar	3.26	9.90	9.58	3.59	10.24	9.42	4.91	10.95	9.30
Chhattisgarh	14.61	9.92	20.41	22.51	43.41	13.90	25.05	30.37	17.34
Gujarat	18.07	30.08	22.98	19.35	31.93	10.99	27.57	37.93	18.32
Haryana	60.53	38.07	23.46	59.06	54.48	11.55	62.47	57.59	20.90
Jharkhand	51.66	41.02	14.87	18.37	32.30	6.85	39.28	43.62	11.24
Karnataka	24.49	56.18	46.22	20.16	42.14	22.26	24.72	56.03	34.27
Madhya Pradesh	6.95	30.51	30.05	20.81	19.81	14.39	36.94	55.93	45.27
Maharashtra	11.19	34.05	28.07	18.37	44.91	41.49	16.08	50.16	34.62
Odisha	14.64	16.83	5.41	11.21	22.44	12.53	14.12	20.95	11.21
Punjab	12.66	16.00	13.47	45.11	49.25	10.05	59.45	62.06	12.09
Rajasthan	13.18	66.53	57.83	16.04	42.58	19.77	20.16	68.33	37.67
Tamil Nadu	8.07	28.13	24.96	20.01	52.43	32.34	18.27	51.95	32.26
Uttar Pradesh	17.65	22.34	10.45	11.66	9.67	11.42	14.44	17.85	12.27
West Bengal	34.18	47.50	18.65	32.65	34.84	19.27	60.80	65.26	20.62
Others	47.03	49.41	31.60	16.38	37.35	26.03	69.19	63.67	32.10
India	7.34	27.12	22.34	6.88	17.11	15.10	12.24	27.38	19.42

Calculated by authors from secondary data.

Table 7: Instability under Bengal gram.

States	2000-2001 to 2011-2012			2012-13 to 2023-24			Overall		
	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
Andhra Pradesh	20.00	26.74	16.91	16.00	26.69	20.56	25.68	35.81	18.42
Assam	12.15	41.78	2.23	10.41	20.47	11.37	12.62	19.23	11.11
Bihar	8.14	15.32	12.25	13.86	19.65	14.58	12.01	17.53	14.56
Chhattisgarh	7.18	15.79	14.16	11.19	26.58	27.62	10.74	27.78	24.24
Gujarat	31.74	33.68	10.96	43.16	30.68	8.27	55.99	43.60	11.47
Haryana	22.32	31.48	19.62	29.27	34.23	21.57	27.07	34.40	20.49
Karnataka	16.09	24.16	15.05	19.96	14.22	14.96	27.26	27.80	15.19
Madhya Pradesh	8.01	16.77	12.07	14.50	15.40	7.35	17.45	18.54	10.76
Maharashtra	13.65	20.93	9.40	12.82	23.03	14.41	14.13	25.02	13.85
Odisha	11.21	13.72	6.58	14.84	14.13	0.79	18.87	21.93	6.76
Punjab	7.90	15.33	11.63	14.13	22.00	9.64	23.38	26.17	11.28
Rajasthan	22.89	35.46	20.61	21.33	25.44	11.29	22.72	28.80	17.10
Tamil Nadu	9.74	12.07	3.45	15.08	20.70	8.73	17.65	17.93	11.84
Uttar Pradesh	8.78	17.33	13.51	18.05	57.79	19.34	18.70	38.76	19.12
West Bengal	9.94	13.75	9.54	5.56	8.70	3.65	28.27	26.44	7.95
Telangana	NA	NA	NA	23.14	33.24	21.65	-	-	-
Others	39.46	41.42	49.88	27.48	32.49	32.57	38.15	39.44	50.95
India	5.59	9.03	5.58	6.70	10.36	6.68	7.23	10.52	6.39

Calculated by authors from secondary data.

Instability index of total pulses

Instability of area, production and productivity of Total pulses is embodied on Table 8. Tamil Nadu, Rajasthan, Chhattisgarh, Odisha, Mizoram and Himachal Pradesh experience notable instability, indicating substantial fluctuations in yield levels. Jammu and Kashmir displays exceptionally high production and productivity instability, suggesting extreme volatility in yield performance, which might be due to due to unfavourable climate, cultivation on marginal lands and infrastructure challenges (Ahlawat *et al.*, 2016 and Kumar *et al.*, 2019). States such as Bihar, Uttarakhand, Nagaland and Jharkhand demonstrate relatively stable productivity, reflecting steadier agronomic or climatic conditions and possibly better adoption of improved technologies. States like Goa, Kerala, Punjab and Sikkim have seen significant fluctuations in pulse area and production might be due to climate change, socio-economic factors and agricultural infrastructure issues. Implementing region-specific interventions, such as enhanced irrigation facilities, soil health management and crop insurance schemes, may help mitigate instability and enhance pulse production nationwide.

Assam showed improvement in both lentil and bengal gram, with positive growth in area, production and productivity and instability indices below 20%. Similar results of positive growth rate of lentil and bengal gram, especially on the post 2010- period was reported by (Barman *et al.*, 2020). Uttar Pradesh performed well in green gram, combining moderate growth with low instability. For total pulses, Karnataka, Madhya Pradesh and Nagaland exhibited steady growth across all parameters with low variability, highlighting their potential for pulse-based agricultural development. These results are comparable with the results revealed by Mishra *et al.* (2022) and Nagaveni *et al.* (2024). The analysis shows that Jharkhand (for green gram area), has a non-significant growth rate with a very high instability index, indicating the area under green gram fluctuates a lot from year to year. Despite exhibiting the significant growth rates in all three aspects, the state of Jharkhand shows comparatively higher instability in area and production which

Table 8: Instability under total pulses.

States	2000-2001 to 2011-2012			2012-13 to 2023-24			Overall		
	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
Andhra Pradesh	5.71	18.44	9.91	18.94	21.87	17.08	12.97	19.77	15.93
Arunachal Pradesh	9.60	9.50	1.81	18.53	7.37	6.30	30.71	25.06	4.64
Assam	3.99	4.85	1.62	15.54	15.26	5.31	19.63	29.73	9.60
Bihar	8.33	10.16	6.02	3.30	9.54	8.96	8.77	10.62	10.04
Chhattisgarh	9.58	20.09	15.30	5.46	22.20	22.21	15.15	23.29	21.09
Goa	10.86	24.37	15.22	40.76	42.69	8.02	31.68	39.05	13.38
Gujarat	10.08	19.31	18.41	22.52	26.71	8.18	27.99	39.04	17.04
Haryana	14.28	22.85	18.09	32.23	30.50	13.50	22.40	26.49	16.94
Himachal Pradesh	5.94	27.10	24.86	12.61	14.75	9.96	9.70	26.83	24.48
Jammu and Kashmir	5.27	5.59	3.53	28.76	76.02	85.69	17.48	51.73	71.40
Jharkhand	24.46	21.71	15.35	7.51	8.44	2.44	25.79	26.38	14.05
Karnataka	6.51	15.87	29.01	9.30	11.99	7.83	9.98	18.62	19.73
Kerala	27.87	29.10	20.43	22.12	20.96	6.87	36.44	37.96	15.18
Madhya Pradesh	5.54	15.46	9.92	16.71	18.85	7.06	14.50	19.44	10.34
Maharashtra	7.63	16.56	9.58	7.01	17.23	10.25	10.10	24.58	15.63
Manipur	13.14	18.81	8.19	5.22	6.94	2.16	26.78	36.18	17.74
Meghalaya	15.61	7.18	26.15	17.24	20.38	7.28	26.16	32.53	17.35
Mizoram	27.21	30.40	33.45	15.83	17.58	11.59	25.16	24.77	23.53
Nagaland	9.06	17.55	14.17	21.97	12.94	2.13	15.97	17.20	10.21
Odisha	10.36	13.26	35.47	9.48	7.64	2.42	11.09	13.45	21.82
Punjab	5.60	6.73	18.10	42.22	45.99	9.59	38.46	42.06	15.21
Rajasthan	14.60	37.71	39.00	10.01	13.42	5.00	18.49	34.43	26.14
Sikkim	26.64	28.72	22.99	4.22	3.31	0.79	33.18	35.35	16.18
Tamil Nadu	12.69	25.61	39.84	14.15	26.28	15.59	14.64	32.83	28.03
Uttar Pradesh	6.85	11.45	10.81	30.64	41.13	4.60	24.89	28.11	12.72
Uttarakhand	15.01	11.00	11.36	22.29	20.40	4.34	23.45	27.89	10.96
West Bengal	5.24	11.45	8.78	11.76	10.77	8.31	26.24	27.91	9.60
Others	53.11	46.18	7.87	25.12	28.60	14.83	29.81	31.47	15.90
India	5.83	8.50	5.33	6.54	12.50	10.19	12.49	22.87	16.30

Calculated by authors from secondary data.

may be attributed to the higher instability in area and production in the first phase of the study. Bihar (for lentil productivity) also has a non-significant positive growth rate with moderately high instability, these results align with results revealed by Ahmad *et al.*, 2018. Also, the analysis reveals that Haryana, Rajasthan andhra Pradesh and Punjab are the key states exhibiting both significant negative growth rates in pulses (area, production or productivity) and high instability indices, indicating that these states not only face declining trends but also experience large year-to-year fluctuations. Similar findings have been reported by Kumari and Malik (2023), who highlighted persistent negative growth and high instability in pulses production in Haryana andhra Pradesh and Rajasthan, whereas Punjab's pulses area and production have sharply declined over five decades (1970-71 to 2020-21), with summer moong being the only pulse showing positive growth (Aggarwal and Sharma, 2023). Pulse production still faces major bottlenecks, such as limited scope for area expansion and persistent yield gaps, even though new and improved varieties are available (Shukla *et al*., 2020). Addressing these structural issues through targeted interventions is essential for ensuring sustained growth.

CONCLUSION

The study concludes that negative significant growth rates in area, production and productivity of different states for various pulse crops are generally associated with comparatively higher instability in these parameters, whereas, positive growth rates are sometimes accompanied by lower levels of instability, but this is not a universal trend several instances show moderate to high fluctuations even with positive growth. There is no definite relationship between non-significant growth rate and instability of the three parameters for the period of study.

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Disclaimers

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Informed consent

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Conflict of interest

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