

Agricultural Growth and Regional Convergence in India

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Abstract

Agriculture is one of the major sectors in India, providing more than half of the total workforce. The present study examines the regional growth and tendency of convergence in agricultural sectors, considering area, production and yield of the foodgrains. Covering 30 years of data from 1990-91 to 2019-20, the study has used standard compound annual growth rate formula and sigma convergence analysis. It is observed that for all the six regions, the majority of states have significant growth rates. Like the growth of area-wise food and non-foodgrains, the growth of production of various crop types of foodgrains and non-foodgrains for the majority of states is high in case of rice than the other crops. Further, the convergence test shows a similar tendency of convergence or divergence for the variables of area, production and estimates of yield of foodgrains and non-foodgrains. The area of total or all the types of foodgrains and non-foodgrains have constant and a tendency of convergence over time, but in terms of production and yield of foodgrains have high fluctuation and non-foodgrains items have more tendency of divergence than the foodgrains items.

Key words: Agricultural growth, Agricultural foodgrains, Regional convergence, Sigma convergence

Agriculture is a vital component of the economy and the primary source of livelihood for a substantial portion, ensuring food security, employment, and income generation for the rural population in the majority of Indian states. The Indian states have distinct geographical regions with unique socio-economic and agro-ecological characteristics [5]. However, the agricultural sector in some regions has faced numerous challenges, including inadequate infrastructure, limited access to markets, traditional farming practices, and susceptibility to climate change impacts [3]. These challenges have led to variations in agricultural growth trajectories across the states, with some states witnessing relatively higher growth rates compared to others [9], [13]. Further, the agricultural sector's growth is closely associated with overall economic development and poverty reduction. By analyzing agricultural growth trends and convergence across the states, will help to identify the strategies, that promote sustainable agricultural practices, enhance productivity, and reduce inter-state income disparities. The Indian states exhibit varying levels of development and growth within the agricultural sector [18]. Exploring convergence trends can shed light on the factors contributing to disparities and help design interventions to bridge the gap. Finally, studying agricultural growth trends and convergence across the regions of India is of paramount importance for promoting sustainable development, enhancing food security, improving rural livelihoods, building climate resilience, and reducing regional disparities. Such research can serve as a foundation for evidence-based policies and strategies that contribute to the overall socio-economic progress of the

region. Convergence, in the context of agricultural development, refers to the narrowing of disparities in productivity, income, and overall progress among different states or regions. Investigating whether the regions or states of India are moving towards convergence or experiencing persistent divergences in their agricultural growth is a critical analytical endeavor. This exploration sheds light on the effectiveness of development policies, the impact of technological interventions, and the role of local dynamics in shaping the agricultural landscape [7]. This study aims to delve into the agricultural growth trends and convergence patterns across the six regions of India. By examining annual time series data, evaluating recent developments, and considering socio-economic factors, the research seeks to achieve the following specific objectives: (i) Analyze the trajectory of agricultural growth across the Indian states over a defined period; (ii) Examine the concept of convergence by assessing whether disparities in agricultural development are narrowing or persisting across states and the types of agricultural foodgrains and non-foodgrains. The present study will help to identify key drivers and constraints influencing agricultural productivity and also investigate the role of policy interventions, technological advancements, and market access in shaping growth trends and convergence dynamics to foster sustainable and equitable agricultural development across the region.

Further, the agricultural growth trends and convergence across the states of India is a pivotal step towards promoting inclusive and balanced development [16]. By uncovering the nuances of these trends, we gain insights into the challenges and

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opportunities that define the region's agricultural landscape, paving the way for evidence-based policy decisions and

informed strategies to propel agricultural growth and improve livelihoods.

Review of literature			
Author (s)	Objective (s)	Time period	Result (s)
Ghosh [9]	Measuring regional convergence in agriculture for the 15 Indian states	1960-61 to 2001-02	Divergence
Murtaza and Masood [15]	Examine the convergence in agricultural Productivity for 17 Indian states	1971 to 2010	Convergence
Anwer <i>et al.</i> [2]	Examine spatio-temporal variations in agricultural divergence in 20 Indian states.	1990-91 to 2013-14	Divergence
Mukherjee and Kuroda [13]	Explores the question of convergence in total factor productivity in agriculture across fourteen major agricultural states of India.	1973-1993	Conditional convergence
Balaji and Pal [3]	Examines the question of convergence in land and labour productivity in agriculture for the 20 Indian states	1991 to 2011	Convergence
Cherodian and Thirlwall [8]	Examine the regional disparities in per capita income of 32 states and UTs in India	1999-2000 to 2010-11	Divergence
Raman and Kumari [17]	Analyses district and regional level disparity in agriculture development in Uttar Pradesh on a number of agricultural parameters.	1990-91 and 2008-09	Divergence
Kumar [11]	Examine growth of Per Capita Income, sectors of economy and Net State Domestic Product for 23 major states of India.	1980-81 to 2019-20	Divergence
Nagaraj <i>et al.</i> [16]	Study the growth performance of 18 Indian States	1970-94	Conditional convergence
Birthal <i>et al.</i> [6]	Investigate the agricultural growth convergence among 15 major Indian states.	1980-81 to 2004-05	Divergence
Akram and Ali [1]	Assesses the per capita output convergence hypothesis across 33 Indian states/UTs at the aggregate and sectoral level.	2011-12 to 2018-19	Divergence
Kar and Sakthivel [10]	Analyses the impact of reforms on regional inequality in India, both at the aggregate and the sectoral level.	1980-81 to 1999-00	Divergence
Kumar <i>et al.</i> [12]	Assess convergence tendency of agricultural economic growth in the context of globalisation and economic liberalisation of the Indian economy.	1980-81 to 2009-10	Convergence
Banerjee and Kuri [4]	Examine the trends of convergence/divergence of per capita value of agricultural output across 21 Indian states/UTs.	1970-71 to 2007-08	Conditional convergence
Mukhopadhyay and Sarkar [14]	Investigates the convergence hypothesis in productivity of foodgrains in terms of output per unit of cropped area across 18 foodgrains producing states of India	2000-01 to 2012-13	Convergence

MATERIALS AND METHODS

For the present study, the secondary data is collected from “Handbook of Statistics on Indian States”, RBI for the period of 30 years from 1990-91 to 2019-20). Twenty-six Indian states categorized under six regions, namely Northern, Eastern, Central, Western, Southern, and North-Eastern are studied, by using 27 agricultural variables related to area, production and yield of foodgrains and non-foodgrains.

Compound annual growth rate (CAGR)

The CAGR is widely used method that helps to analyze the growth of any unit in a specific time period. The following exponential function has been used for computing the CAGR of area, production and yield of agricultural foodgrains:

$$Y = ab^{e^{ut}} \dots\dots\dots (i)$$

Where, Y = Number of states, a = intercept, b = coefficient.

After taking log to equation (i), the transformed equation can be written as:

$$\ln Y = \ln a + t \ln b + u_t \dots\dots\dots (ii)$$

After estimation of coefficient ‘b’, the CAGR is calculated as:

$$g = (b - 1) 100 \dots\dots\dots (iii)$$

Where, g = CAGR in per cent per annum, b = Anti log of ln b.

Sigma convergence analysis

The agriculture sectoral convergence has been analyzed in terms of variables, comprising area, production and yield across the six regions of India over time by using Sigma Convergence approach. The sigma convergence method implied that the dispersion of variables in terms of Coefficient of Variation across the regions or states fall over time. The following equation has been applied to calculate Coefficient of Variation (CV):

$$CV_t = \frac{(\frac{1}{n} \sum_{i=1}^n (y_{it} - \bar{y}_t)^2)^{1/2}}{\bar{y}_t} \dots\dots\dots (iv)$$

Where, ‘n’ is the number of states, ‘t’ is time period, ‘i’ represents individual states considered in turn, ‘y’ is the total agricultural factors.

RESULTS AND DISCUSSION

Area and intensity of agriculture sector

Agriculture forms the backbone of India's economy, providing livelihoods to a significant portion of its population and contributing substantially to its GDP. However, agricultural growth trends across Indian states have shown significant variations due to diverse factors such as agro-climatic

conditions, technological adoption, policy implementation, and infrastructure development. This comprehensive overview examines the agricultural growth trends in different Indian states, highlighting key patterns and factors influencing their

trajectories. The present section analyses the compound annual growth rate (CAGR) of the agricultural net sown area, net irrigated area and cropping intensity for the six regions of India, from 1990-91 to 2019-20.

Table 1 CAGR of area and intensity of agriculture sector (1990-91 to 2019-20)

States	Net sown area (NSA) #	Net irrigated area (NIA) #	Cropping intensity (CI) @
Northern region			
Haryana	-0.025	0.622***	0.542***
Himachal Pradesh	-0.198***	0.502***	-0.027
Jammu and Kashmir	0.037	0.195*	0.275***
Punjab	-0.085***	0.267***	0.186***
Rajasthan	0.468***	2.428***	0.744***
Eastern region			
Bihar	-1.560***	-0.608***	0.289***
Odisha	-1.782***	-1.887***	-1.148***
West Bengal	-0.203***	1.706***	0.641***
Central region			
Madya Pradesh	-1.107***	2.966***	1.200***
Uttar Pradesh	-0.226***	0.979***	0.337***
Western region			
Gao	-0.283***	1.124**	0.083
Gujrat	0.241***	2.594***	0.555***
Maharashtra	-0.234***	0.686***	0.516***
Southern region			
Andhra Pradesh	-1.929***	-1.204***	0.064
Karnataka	-0.139**	2.081***	0.310***
Kerala	-0.473***	0.708***	-0.240***
Tamil Nadu	-0.828***	-0.049	0.065
North-Eastern region			
Arunachal Pradesh	1.691***	2.136***	-0.593***
Assam	0.056**	-1.064	0.115***
Manipur	4.179***	0.433	-1.004***
Meghalaya	1.182***	2.827***	0.065**
Mizoram	2.463***	3.041***	-0.381
Nagaland	2.694***	2.471***	0.928***
Skim	-1.210***	0.684	1.701***
Tripura	-0.380***	3.129***	1.118*
All India	-0.075**	1.303***	0.366***

Source: Handbook of Statistics on Indian States, RBI (1990-91 to 2019-20)

Note: # and @ indicate Thousand Hectares and Per Cent, respectively; ***, ** & * show 1, 5 and 10% of significance

Data depicted in (Table 1) shows that, in case of northern region, except Jammu and Kashmir and Rajasthan, other three states have negative and significant compound annual growth rate (CAGR). All states in NSA, and except Himachal Pradesh in CI (though it is insignificant), have positive and significant growth rates. In eastern region, the state Odisha, has negative growth rate for all the three variables, while Bihar has negative growth in NSA and NIA and West Bengal has positive growth, except NSA. From central region, Madhya Pradesh and Uttar Pradesh, have negative growth in NSA and positive growth in terms of NIA and CI. Among western region, Goa and Maharashtra have negative growth in NSA, but all the three states have positive and significant growth, except CI. In case of southern region, all the four states have negative and significant growth, but for other two variables, except Andhra Pradesh and Tamil Nadu, positive growth rate has been observed in NIA and except Kerala and Tamil Nadu in CI. Further, for the north-eastern region, all states, except Sikkim and Tripura have positive growth in NSA. In NIA, Assam, Manipur and Sikkim have positive, while Arunachal Pradesh, Manipur and Mizoram have negative growth rates. In India, NSA is negative and NIA and CI are positive over time. Declining growth trend in NSA, for the majority of states, indicates that the states might have shifted their cultivation to

other crops like horticulture.

Area, production and yield of total agriculture foodgrains

The compound annual growth rate (CAGR) of the area, production and yield of total agricultural foodgrains for the six regions of India, from 1990-91 to 2019-20 in (Table 2). It is observed that, in case of northern region, only Haryana and Punjab have positive significant growth in AOTF, and all the states from the five regions, except north-eastern region, have negative and significant growth over time. For the north-eastern region, Assam, Mizoram and Sikkim have negative growth rates and other five states have positive growth rates. Further, in terms of POTF and YOTF, all the states from the six regions have positive and significant growth rates at different levels over time, except Goa, Maharashtra, Andhra Pradesh, Kerala, Tamil Nadu, Mizoram and Sikkim for POTF and Goa, Manipur and Mizoram for YOTF. In India, AOTF is negative and FOTF and YOTF are positive over time. Thus, it is clear that, though there is negative growth in area of total foodgrains across the states, but majority of states have shown positive growth in production and yield of total foodgrains over time. It might show that the states have facilitated some advancements in agricultural practices like seed varieties, better irrigation and enhanced fertilizers.

Table 2 CAGR of area, production and yield of total agriculture foodgrains (1990-91 to 2019-20)

States	Area of total foodgrains (AOTF)#	Production of total foodgrains (POTF)\$	Yield of total foodgrains (YOTF)Δ
Northern region			
Haryana	0.565***	2.233***	1.642***
Himachal Pradesh	-0.622***	0.463**	1.035***
Jammu and Kashmir	-0.005	0.750***	0.681***
Punjab	0.569***	1.568***	0.947***
Rajasthan	0.199	2.926***	2.382***
Eastern region			
Bihar	-1.681***	0.715*	2.314***
Odisha	-1.271***	0.836**	1.879***
West Bengal	-0.317***	1.261***	1.505***
Central region			
Madhya Pradesh	-0.908**	1.973***	2.690***
Uttar Pradesh	-0.327***	1.085***	1.305***
Western region			
Gao	-1.509***	-1.267***	0.247
Gujrat	-0.555**	2.445***	2.847***
Maharashtra	-1.287***	0.042	1.171***
Southern region			
Andhra Pradesh	-2.762***	-0.331	2.159***
Karnataka	0.124	1.791***	1.469***
Kerala	-4.421***	-2.282***	2.174***
Tamil Nadu	-0.886***	0.706	1.345***
North-Eastern region			
Arunachal Pradesh	0.772***	2.592***	1.809***
Assam	-0.252***	1.479***	1.967***
Manipur	2.278***	1.554***	-0.708**
Meghalaya	0.184***	2.983***	2.794***
Mizoram	-2.129***	-2.431***	-0.309
Nagaland	2.475***	4.396***	1.887***
Sikkim	-1.353***	-0.435***	0.848***
Tripura	0.353**	2.499***	2.089***
All India	-0.213***	1.686***	1.705***

Source: Handbook of Statistics on Indian States, RBI (1990-91 to 2019-20)

Note: #, \$ and Δ indicates thousand hectares, thousand tonnes and Kg/ha, respectively; ***, ** & * shows 1, 5 and 10% of significance

Area of agriculture foodgrains

The compound annual growth rate (CAGR) of area of agricultural foodgrains and non-foodgrains, in terms of rice, wheat, pulses, coarse cereals, cotton, oilseeds and sugarcane for the six regions of India, from 1990-91 to 2019-20 in (Table 3). The results show that, in case of AOFR, all the twenty-six states have positive and significant growth rates, except Bihar, Madhya Pradesh, Kerala, Mizoram and Sikkim. Only Haryana, Bihar, Madhya Pradesh, Uttar Pradesh, Gujarat and Maharashtra from the five regions have positive and significant growth in AOFW, while among north-eastern region, all the states have shown negative growth trends, except Manipur and Nagaland. In respect of AOFP, all the states are showing negative growth trends, except Kerala, Arunachal Pradesh, Manipur, Meghalaya, Nagaland and Tripura. Only few states, namely West Bengal and all the north-eastern region states except Mizoram and Sikkim have positive growth in AOFCC. In India also the growth rate is negative for AOFCC. Further, among the six regions, Punjab, Uttar Pradesh, Kerala, Tamil Nadu, Assam, Meghalaya, and Tripura have negative growth rates in AONFC and other states have either positive growth or insignificant during time period. In respect of AONFO, Rajasthan, West Bengal, Madhya Pradesh, Maharashtra, Arunachal Pradesh, Manipur, Meghalaya, and Nagaland are having positive and significant growth rates. But, in India AONFO growth rate is insignificant. The states of Jammu and Kashmir, Bihar, Madhya Pradesh, Uttar Pradesh, Gujarat, Maharashtra, Kerala, Arunachal Pradesh, Manipur, Mizoram,

and Nagaland have positive growth rates in AONFS, across all the regions. India also has had positive and significant growth over time. Thus, it is observed that majority of states have positive growth of rice, but only few states have in other foodgrains. The majority of north-eastern states are having positive growth in all the foodgrains, except wheat, cotton, and oilseeds.

Production of agriculture foodgrains

The compound annual growth rate (CAGR) of production of agricultural foodgrains and non-foodgrains, in terms of rice, wheat, pulses, coarse cereals, cotton, oilseeds and sugarcane for the six regions of India, from 1990-91 to 2019-20 in Table 4. The results show that, in case of POFR, majority of the states have positive and significant growth rates, except Bihar, Madhya Pradesh, Goa, Kerala, Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, Mizoram and Sikkim. Again, the states, namely Punjab, Odisha, Uttar Pradesh, Andhra Pradesh, and Assam, from the five regions have negative growth in terms of POFW, while India has shown positive growth trend over time. In respect of POFP, only few states such as Himachal Pradesh, Rajasthan, Madhya Pradesh, Maharashtra, and Karnataka from the five regions, and all the north-eastern region states, except Mizoram and Sikkim have positive and significant growth rates. Only few states, namely Goa, Maharashtra, and Kerala, from the six regions, have negative growth in POFCC. In India also the growth rate is positive for POFCC.

Table 3 CAGR of area of agricultural foodgrains and non-foodgrains (1990-91 to 2019-20) (Thousand hectares)

States	Area of foodgrains – rice (AOFR)	Area of foodgrains – wheat (AOFW)	Area of foodgrains – pulses (AOFPP)	Area of foodgrains - coarse cereals (AOFCC)	Area of non-foodgrains – cotton (AONFC)	Area of non-foodgrains – oilseeds (AONFO)	Area of non-foodgrains – sugarcane (AONFS)
Northern region							
Haryana	5.914***	1.150***	-6.708***	-1.627***	0.468*	-0.239	-1.670***
Himachal Pradesh	1.050***	-0.438***	-2.264***	-0.518***	7.646***	-2.464***	-2.068***
Jammu and Kashmir	2.149***	0.805***	-4.233***	-0.158	7.208***	-1.178	5.961***
Punjab	5.424***	0.313***	-6.441***	-2.538***	-2.786***	-6.240***	-2.730***
Rajasthan	3.121***	1.399***	0.106	-0.211	-0.216	1.468***	-1.117***
Eastern region							
Bihar	0.174	0.172***	-4.815***	-1.098***	3.870***	-2.922***	2.891***
Odisha	1.244***	-13.380***	-2.834***	-2.666***	12.995***	-5.023***	-4.750***
West Bengal	2.644***	-1.136*	-1.092	4.588***	9.862***	2.133***	0.274
Central region							
Madya Pradesh	-2.340**	1.464***	-0.269	-6.623***	0.759***	1.603***	3.606***
Uttar Pradesh	2.708***	0.382***	-2.198***	-1.905***	-10.27***	-1.591***	0.631***
Western region							
Gao	1.407***	--	-1.024	-6.260***	--	0.919	-2.572***
Gujrat	4.004***	3.064***	-1.537***	-2.830***	3.634***	-0.234**	0.865***
Maharashtra	1.836***	1.324***	-0.577*	-2.470***	1.840***	2.336***	3.324***
southern region							
Andhra Pradesh	1.492**	-3.835***	-2.553***	-4.950***	-0.947	-4.585***	-2.239***
Karnataka	2.606***	-0.828***	1.204***	-0.790***	0.160	-3.307***	1.501***
Kerala	-1.274	--	-11.670***	-12.670***	-10.460***	-13.310***	-6.777***
Tamil Nadu	2.403***	--	-1.034*	-0.705**	-2.239***	-4.916***	-0.746
North-eastern region							
Arunachal Pradesh	1.989***	-0.560**	3.201***	1.198***	--	1.900***	2.740***
Assam	1.942***	-5.513***	-0.468	0.592**	-2.918***	-0.230	-0.750***
Manipur	3.195***	3.546***	16.823***	7.186***	7.208***	11.349***	5.635***
Meghalaya	2.632***	-10.530***	2.878***	0.086	-8.604***	1.762***	0
Mizoram	-1.114*	--	-0.486	-0.558	-0.356	-5.456***	2.917***
Nagaland	3.242***	6.489***	5.061***	3.349***	8.431***	5.649***	2.992***
Skim	-0.647**	-13.200***	-2.444***	-0.182*	--	-1.496***	-6.480***
Tripura	3.296***	-10.860***	0.808	6.662***	-0.687*	-0.716	-2.576***
All India	2.749***	0.854***	-0.558	-1.293***	1.958***	0.175	1.075***

Source: Handbook of Statistics on Indian States, RBI (1990-91 to 2019-20)

Note: ***, ** & * shows 1, 5 and 10% of significance, respectively

Table 4 CAGR of production of agricultural foodgrains and non-foodgrains (1990-91 to 2019-20) (Thousand hectares)

States	Area of foodgrains – rice (AOFR)	Area of foodgrains – wheat (AOFW)	Area of foodgrains – pulses (AOFPP)	Area of foodgrains - coarse cereals (AOFCC)	Area of non-foodgrains – cotton (AONFC)	Area of non-foodgrains – oilseeds (AONFO)	Area of non-foodgrains – sugarcane (AONFS)
Northern region							
Haryana	3.408***	2.139***	-6.396***	1.608***	2.351***	1.192***	-0.096
Himachal Pradesh	0.673***	0.366	5.580***	0.337	6.340***	-0.923	-1.575*
Jammu and Kashmir	0.654**	1.752***	-3.305***	0258	4.394***	0.206	-9.268***
Punjab	2.289***	-25.990***	-5.726***	-0.021	-0.536	-5.421***	-0.126
Rajasthan	4.245***	4.519***	2.282**	3.293***	2.646***	3.901***	-4.486***
Eastern region							
Bihar	0.677	1.126***	-3.988***	1.942***	3.841***	-0.424**	4.019***
Odisha	1.220***	-5.130***	-1.728	0.662	17.436***	-4.081***	-4.464***
West Bengal	1.102***	1.235***	0.237	9.040***	7.870***	3.833***	1.854***
Central region							
Madya Pradesh	-1.914	4.088***	1.605***	1.577***	7.926***	2.872***	5.341***
Uttar Pradesh	1.235***	-25.940***	-2.168***	-0.054	-9.910***	-1.100***	1.379***
Western region							
Gao	-1.242***	--	0.098	-7.581***	--	2.369	-5.794***
Gujrat	3.728***	4.609***	1.076	-0.085	8.012***	3.244***	0.489*
Maharashtra	0.959***	2.428***	1.404***	-1.465***	6.224***	4.010***	3.323***
Southern region							
Andhra Pradesh	-0.691	-7.410***	-0.073	1.053*	2.082***	-4.365***	-2.025***
Karnataka	0.518	1.032**	3.83***	1.747***	3.435***	-2.397***	1.435***
Kerala	-2.104***	--	-10.990***	-11.370***	-12.450***	-12.100***	-5.392***

Tamil Nadu	-0.303	1.757	0.561	4.221***	0.113	-2.059***	-0.851
North-eastern region							
Arunachal Pradesh	2.981***	0.010	3.971***	1.844***	--	1.915***	4.171***
Assam	1.829***	-5.585***	1.077**	5.947***	0.413	0.717**	-1.083***
Manipur	0.854**	--	16.516***	6.181***	7.156***	14.775***	5.576*
Meghalaya	3.252***	-4.634***	5.475***	2.166***	-7.377***	3.882***	-6.845***
Mizoram	-2.601***	--	-1.651***	-1.969	-4.330***	-5.032***	7.994***
Nagaland	3.677***	-0.206	6.468***	6.420***	6.552***	6.325***	2.863***
Skim	-0.854***	14.086**	-2.129***	0.791***	--	-0.927**	--
Tripura	2.482***	-3.038	2.245**	9.631***	-1.244**	-0.548	-2.255***
All India	1.550***	-11.810***	0.891**	1.604***	5.387***	1.921***	1.515***

Source: Handbook of Statistics on Indian States, RBI (1990-91 to 2019-20)

Note: ***, ** & * shows 1, 5 and 10% of significance, respectively

Further, among the six regions, all the states have positive growth rates, except Uttar Pradesh, Kerala, Meghalaya, Mizoram, and Tripura, and other states have either negative growth or insignificant during study period. In respect of PONFO, Punjab, Bihar, Odisha, Uttar Pradesh, Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu have negative, while all the north-eastern region states have positive growth, except Mizoram, Sikkim and Tripura. India also has positive and significant growth rate in terms of PONFO. As like AONFS, from all the six regions, the states of Bihar, West Bengal, Madhya Pradesh, Uttar Pradesh, Gujarat, Maharashtra, Karnataka, Arunachal Pradesh, Manipur, Mizoram, and Nagaland have positive growth rates in PONFS. India also has

had positive and significant growth over time. Majority of states have positive and significant growth in production of foodgrains and non-foodgrains such as rice, wheat, and cotton. For other crops, there is either negative growth or insignificant across the states. The declining trends across the states might be due to decrease in soil fertility, traditional methods of irrigation, and reduction in agricultural land.

Estimates of yield in agriculture foodgrains

The compound annual growth rate (CAGR) of yield in agricultural foodgrains, in terms of rice, wheat, pulses, coarse cereals, cotton, oilseeds and sugarcane for the six regions of India, from 1990-91 to 2019-20 in (Table 5).

Table 5 CAGR of estimates of yield in agriculture foodgrains (1990-91 to 2019-20) (kg ha⁻¹)

States	Estimates of yield – rice (EYR)	Estimates of yield- wheat (EYW)	Estimates of yield- pulses (EYP)	Estimates of yield- coarse cereals (EYCC)	Estimates of yield- cotton (EYC)	Estimates of yield- oilseeds (EYO)	Estimates of yield- sugarcane (EYS)
Northern region							
Haryana	0.833***	0.958***	0.292	3.289***	1.872***	1.736***	1.601***
Himachal Pradesh	1.231***	0.917**	7.867***	0.861***	-9.684***	1.586***	0.482
Jammu and Kashmir	0.578**	1.032*	0.915	0.417*	--	1.392***	-12.720***
Punjab	0.107	0.886***	0.731***	2.581***	2.315***	0.873***	1.002***
Rajasthan	4.511***	1.466***	1.562***	3.512***	2.870***	2.397***	2.142***
Eastern region							
Bihar	2.749***	0.941***	0.765***	3.074***	--	2.573***	1.096***
Odisha	1.784***	0.658**	0.932***	3.420***	3.930***	0.990***	0.308
West Bengal	1.460***	6.579***	1.294***	4.256***	2.321**	1.663***	1.576***
Central region							
Madhya Pradesh	2.367***	2.511***	1.519***	4.261***	7.108***	1.248***	1.674***
Uttar Pradesh	1.038***	1.135***	0.196	1.879***	0.393	0.499*	0.743***
Western region							
Gao	0.117	--	5.595**	-2.897***	--	1.537***	1.278***
Gujrat	15.662**	1.396***	2.305***	2.824***	4.228***	3.485***	-0.640
Maharashtra	0.994***	1.008***	1.861***	1.031***	4.307***	1.636***	-0.001
southern region							
Andhra Pradesh	1.448***	-2.030***	2.628***	6.315***	3.056***	0.230	0.218**
Karnataka	1.104***	1.970***	1.973***	2.556***	3.267***	0.939***	-0.064
Kerala	0.663	--	0.751**	1.427***	-1.078***	1.291	1.498***
Tamil Nadu	0.529	--	1.636***	4.960***	2.410***	3.005***	-0.106
North-eastern region							
Arunachal Pradesh	-8.057	0.655**	0.746***	0.640***	--	0.016	8.602***
Assam	1.971***	0.297	1.521***	5.321***	0.003	0.948***	-0.333***
Manipur	-0.479	4.166***	5.627***	-0.939***	--	3.078**	2.610***
Meghalaya	3.185***	1.233***	2.538***	2.081***	0.307	2.079***	-7.544***
Mizoram	-0.076	--	-1.165**	-1.408	1.818	0.457	4.960***
Nagaland	1.817***	-1.126	1.338***	2.971***	-5.780***	0.711***	-0.125
Skim	4.362*	-1.836***	0.106	0.973***	--	0.584**	--
Tripura	2.258***	0.427	1.291***	2.765***	1.228***	0.178	0.394***
All India	1.469***	1.224***	1.246***	2.928***	3.364***	1.780***	0.435***

Source: Handbook of Statistics on Indian States, RBI (1990-91 to 2019-20)

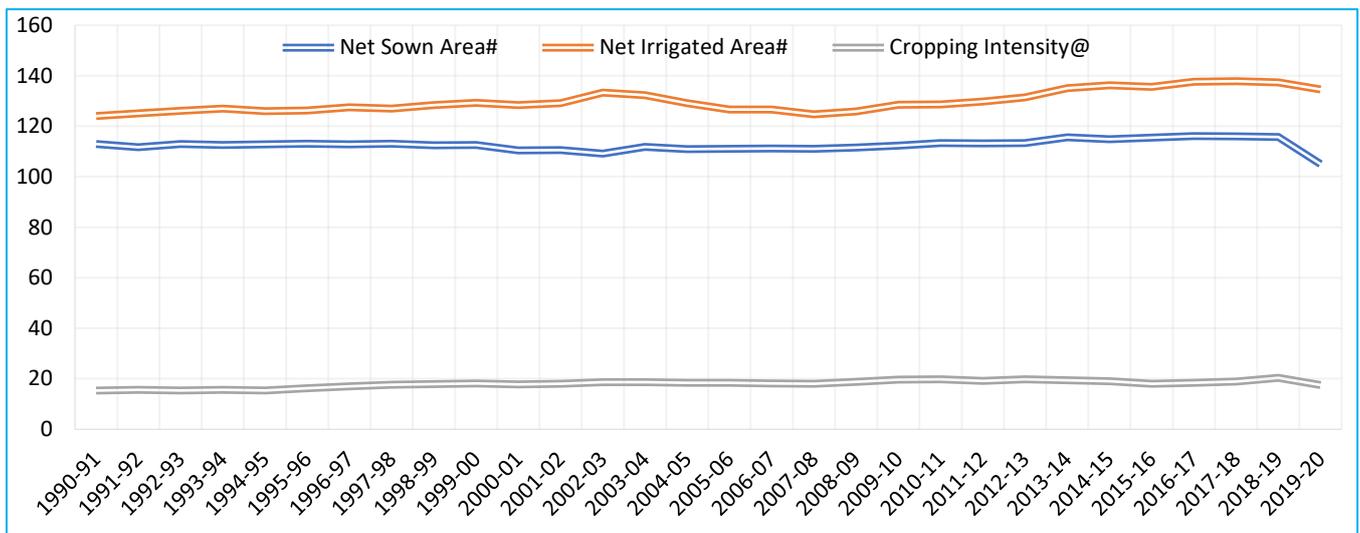
Note: ***, ** & * shows 1, 5 and 10% of significance, respectively

The results show that, in case of EYR, all the states are having positive and significant growth rates, except Punjab, Goa, Kerala, Tamil Nadu, Arunachal Pradesh, Manipur, and Mizoram. Only Andhra Pradesh and Sikkim have negative and significant growth in EYW, while Assam, Nagaland, and Tripura have insignificant growth over time. In respect of EYP, positive growth has been achieved by all the states, except Mizoram, but the states, namely Haryana, Jammu & Kashmir, Uttar Pradesh, and Sikkim are showing insignificant growth trends. Again, in terms of EYCC, all the states, from the six regions have positive and significant growth, except Goa, Manipur, and Mizoram. Further, among the six regions, Himachal Pradesh, Kerala, and Nagaland have negative growth rates in EYC, and other states have either positive growth or insignificant during study period. In respect of EYO also, all the states are having positive and significant growth rates, except Andhra Pradesh, Kerala, Arunachal Pradesh, Mizoram, and Tripura. The states of Jammu & Kashmir, Assam, and

Meghalaya have negative and significant growth and states like, Himachal Pradesh, Odisha, Gujarat, Maharashtra, Karnataka, Tamil Nadu, and Nagaland have either positive or negative growth rates, but it is insignificant across the regions and other states have positive and significant growth over time. At all India level, the growth of estimates of yield in terms of rice, wheat, pulses, coarse cereals, cotton, oilseeds, and sugarcane is positive and significant over time.

Sigma convergence analysis

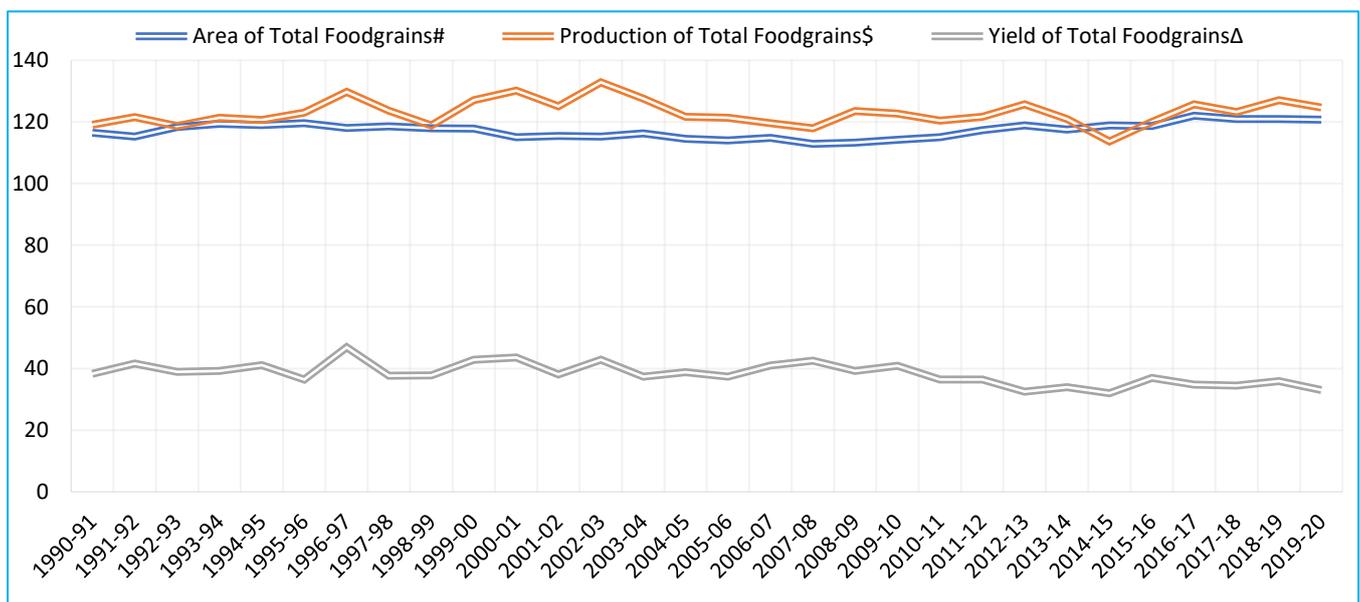
The present section analyzes the sigma convergence analysis of the agricultural net sown area, net irrigated area and cropping intensity for the six regions of India, from 1990-91 to 2019-20. (Fig 1) shows that, in terms of net sown area and cropping intensity, the states have constant variation over time and it slightly declined in 2019-20. The states have constant variation, although it has minor fluctuation in case of net irrigated area.



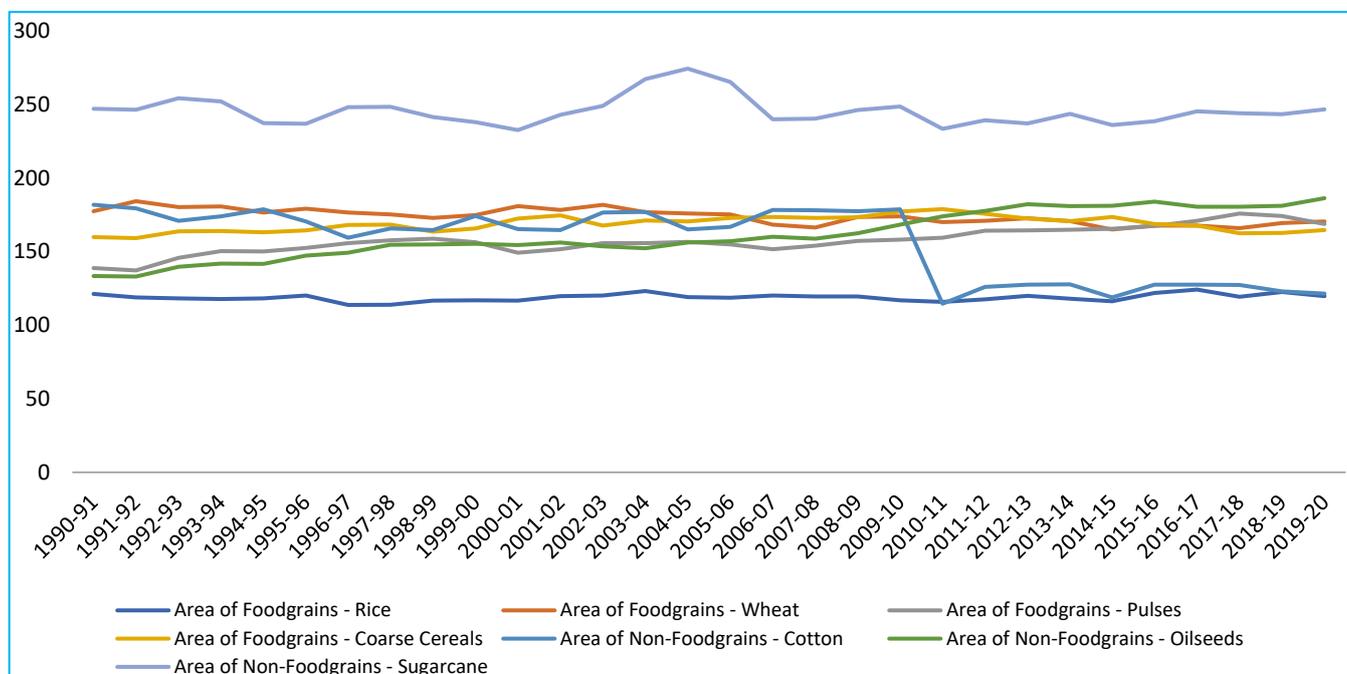
Source: Handbook of Statistics on Indian States, RBI (1990-91 to 2019-20)
 Fig 1 Agricultural convergence in terms of area and cropping intensity: Indian States

The convergence tendency of area, production and yield of total agricultural foodgrains for the six regions of India, from 1990-91 to 2019-20 in (Fig 2). It is observed that the states tend

toward convergent in terms of production and yield of total foodgrains over time. Further, the states had constant variation with respect to area of total foodgrains during the study period.



Source: Handbook of Statistics on Indian States, RBI (1990-91 to 2019-20)
 Fig 2 Agricultural convergence in terms of area, production and yield of total foodgrains: Indian States



Source: Handbook of Statistics on Indian States, RBI (1990-91 to 2019-20)

Fig 3 Agricultural convergence in terms of area of foodgrains: Indian States

The sigma convergence tendency of area of agricultural foodgrains and non-foodgrains, in terms of rice, wheat, pulses, coarse cereals, cotton, oilseeds and sugarcane for the six regions of India, from 1990-91 to 2019-20 in (Fig 3). The result shows that, the trend of area of foodgrains of rice stands at constant variation, while area of foodgrains of wheat is tending towards convergence. The states are having increasing variation in area of foodgrains of pulses, tending to convergence tendency. The area of foodgrains of coarse cereals trend shows high variation till 2010-11, and afterward, it tends to converge. In case of area of non-foodgrains of cotton, significant reduction has been observed over time. Further, the trend of area of non-foodgrains of oilseeds has shown divergence tendency across the states over time. The variation trend of area of foodgrains of sugarcane has fluctuated and tends to diverge.

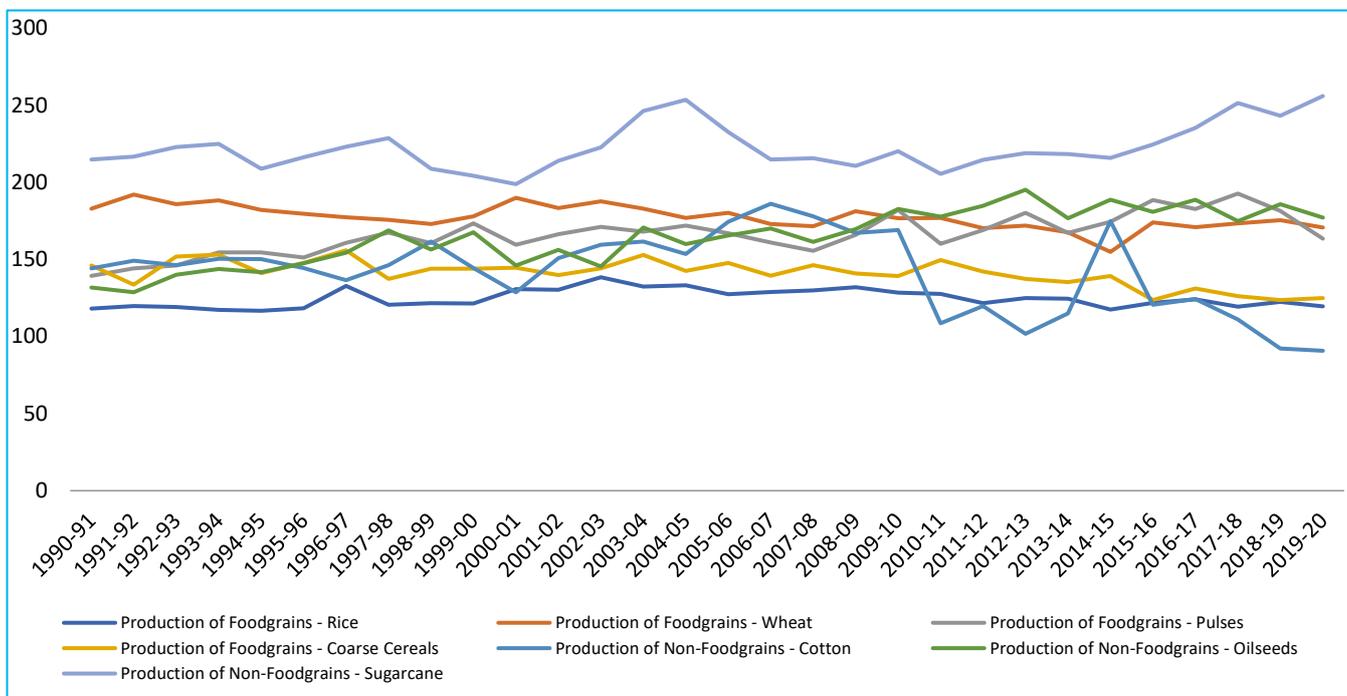
The convergence tendency of production of agricultural foodgrains and non-foodgrains, in terms of rice, wheat, pulses, coarse cereals, cotton, oilseeds and sugarcane for the six regions of India, from 1990-91 to 2019-20 in (Fig 4). The result shows that, like area of foodgrains of rice, the trend of production of rice demonstrated constant variation, while production of foodgrains of wheat is tending towards convergence. The states are having increasing variation in production of foodgrains of pulses, and it is declining and tending to convergence tendency during 2018-19 to 2019-20. The trend of production of foodgrains of coarse cereals also has a tendency of convergence. In case of production of non-foodgrains of cotton, shows high variation till 2014-15, and afterward significant reduction has been observed and tending toward convergence. Further, the trend of production of non-foodgrains of oilseeds has shown divergence tendency across the states over time. The variation trend of production of foodgrains of sugarcane has fluctuated and tends to diverge.

The convergence tendency of yield in agricultural foodgrains, in terms of rice, wheat, pulses, coarse cereals, cotton, oilseeds and sugarcane for the six regions of India, from 1990-91 to 2019-20 in (Fig 5). The result shows that, the trend of estimates of yield of rice and estimates of yield of wheat is tending towards convergence over time. The states are having increasing variation in estimates of yield of pulses, tending to

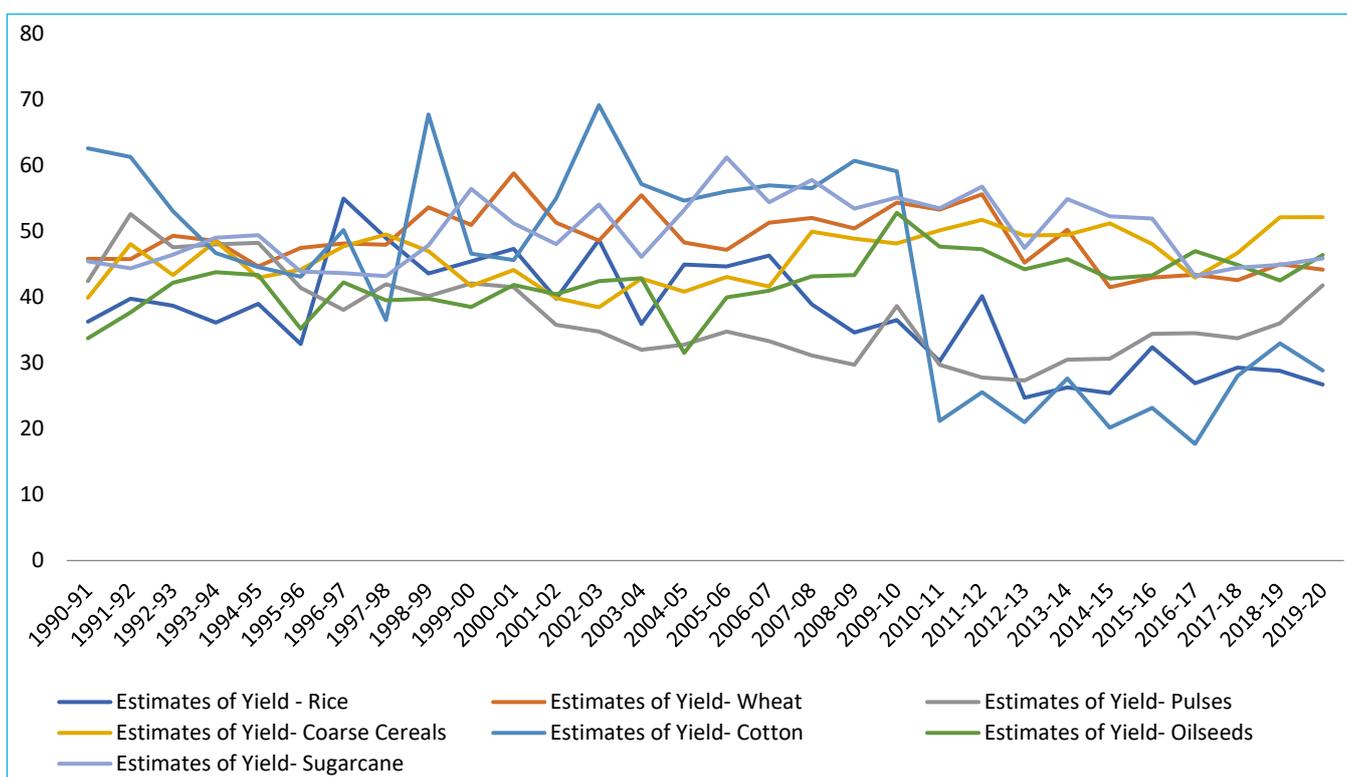
divergence tendency. Estimates of yield of coarse cereals trend show high variation and it tends to diverge. In case of estimates of yield of cotton, significant reduction has been observed over time. Further, the trend of estimates of yield of oilseeds has shown divergence tendency across the states over time. The variation trend of estimates of yield of sugarcane has fluctuated and tends to converge from 2005-06 to 2019-20.

CONCLUSION

Understanding the trends and patterns of agricultural growth and convergence across the states is essential for devising targeted policies and interventions that can contribute to the overall development of the region. It is observed from the study that for all the six regions majority of states have significant growth rates in terms of production and estimates of yield of total foodgrains, even after having negative growth in area of total foodgrains. The states of Manipur and Nagaland have positive growth in all types of mentioned crops of area and production of foodgrains and non-foodgrains over time. Like the growth of area-wise food and non-foodgrains, the growth of production of various crop types of foodgrains and non-foodgrains for the majority of states is higher in case of rice than the other crops. Further, the convergence test shows a similar tendency of convergence or divergence for the variables of area, production and estimates of yield of foodgrains and non-foodgrains. The area of total or all the types of foodgrains and non-foodgrains have constant and a tendency of convergence over time, but in terms of production and yield of foodgrains have high fluctuation and non-foodgrains items have more tendency of divergence than the foodgrains items. It may be due to a diverse tapestry of challenges, opportunities, and strategies across the states. While some states have leveraged technological advancements and policy interventions to achieve significant growth, others are gradually overcoming barriers to unlock their agricultural potential. A holistic approach that considers regional disparities, local conditions, and sustainable practices will be essential to ensure balanced and inclusive agricultural growth across the states or entire country.



Source: Handbook of Statistics on Indian States, RBI (1990-91 to 2019-20)
 Fig 4 Agricultural convergence in terms of production of foodgrains: Indian States



Source: Handbook of Statistics on Indian States, RBI (1990-91 to 2019-20)
 Fig 5 Agricultural convergence in terms of estimates of yield in foodgrains: Indian States

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