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Inter-State Growth and Dynamics of Maize Production in North -East Himalayan States of India

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Abstract: Maize (*Zea mays L.*), the third most valued cereal after rice and wheat, plays a vital role in livestock feed and industrial applications. This study examines the state-wise growth trends, variability, and drivers of maize production in the North-East Region (NER) of India using time-series data from 1975 to 2019, categorized into three phases. Structural breaks in maize production trends were identified through the Bai-Perron test. Results indicate robust growth in area and production during Phase III, particularly in Tripura and Manipur, with all states except Mizoram showing positive annual growth. Nagaland consistently demonstrated strong growth across variables, while Arunachal Pradesh, Meghalaya, and Sikkim exhibited lower variability, signalling stability in maize production. Decomposition analysis revealed that changes in maize production were driven by both area expansion and productivity improvements. Structural breaks identified in 1980, 1987, 2001, and 2013 correlate with increased demand for maize in livestock feed and industrial sectors. To capitalize on the region's potential, policies should focus on scaling up hybrid seed adoption, improving seed replacement ratios, and promoting balanced nutrient management. Strengthening extension services and investing in irrigation infrastructure for maize cultivation can further enhance productivity. Addressing the unique needs of shifting cultivation systems with sustainable practices will stabilize production. With targeted interventions, the NER can emerge as a key contributor to India's maize economy, fostering rural livelihoods and regional agricultural growth.

Keywords: Production • Yield • Growth • Instability • Maize • Structural break.

Introduction

Maize (*Zea mays* L.) is the second most widely grown crop in the world having wider adaptability under varied agro-climatic conditions (Sabagh *et al*., 2020). When it comes to adaptation, crop types, and applications, maize is a crucial crop since it provides food, animal feed, and raw materials for industries to use. In 2019, nearly 1423.23 million tonnes of maize being produced together by over 170 countries from an area of 243.28 million ha with 5.85 t/ha average productivity (FAOSTAT 2022, http://www.fao.org/faostat). In the entire world, 61 per cent of maize is used for feed, 17 per cent for food, and 22 per cent for industry. It is now qualifies as an industrial crop because 83 per cent of its worldwide production is used in the feed, starch, and biofuel industries (IIMR 2022, https://iimr.icar.gov.in/?page_id=51).

Additionally, more than 3000 goods are produced directly or indirectly using maize, offering numerous opportunities for value addition. Due to its wide range of applications, it is a key driver of the worldwide agricultural economy. (Dass 2013).

Globally, maize is known as the queen of cereals because of its highest genetic yield potential among cereals (Dass *et al.*, 2012). The United States of America (USA) is the largest producer of maize contributing nearly 25% of the total production in the world (FAOSTAT 2022, http://www.fao.org/faostat) and maize is the driver of the US economy. The USA has the highest productivity (10.79 t/ha), which is almost double the global average whereas the average productivity in India is 3.06 t/ha. In India, maize is the third most important food crop after rice and

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wheat. It is cultivated in 9.57 mha (2020) mainly during the Kharif season which covers 80% area. Maize in India, contributes nearly 9.7% of the national food basket and more than Rs. 450 billion to the agricultural GDP at current prices apart from generating employment to over 600 million man-days at the farm and downstream agricultural sectors. The bulk of the maize production in India, approximately 47%, is used as poultry feed. Of the rest of the produce, 13% is used for livestock feed and food purposes each, 12% for industrial purposes, 14% for the starch industry, 7% for processed food, and 6% for export and other purposes (IIMR 2022, https://iimr.icar.gov.in/?page_id=51). In addition to staple food for human beings and quality feed for animals, maize serves as a basic raw material as an ingredient in thousands of industrial products that include starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceuticals, cosmetics, film, textile, gum, package and paper industries etc. (Kumar *et al.*, 2012; Orhun 2013; Ranum *et al.*, 2014)

Maize is cultivated in all seasons and all over the states of the country for various purposes viz. grain, fodder, feed, raw materials etc. The principal maize growing states that contribute more than 70% of the total maize production are Karnataka (16.9%), Madhya Pradesh (12.3%), Maharashtra (11.1%), Tamil Nadu (8.1%), West Bengal (7.7%) Rajasthan (7.2%) and Bihar (6.6%) (DES, GoI 2022). Apart from these states maize is also grown in North-Eastern states and Jammu and Kashmir.

Maize is one of the principal coarse cereals next to rice grown in NER states. There has been a consistent increase in the area under maize due to the extension of its cultivation. Even though the contribution of the NER region is only 2.4% of total India's maize production, it plays a significant role in meeting the local livestock feed. Most maize farmers in NER states used non-financial inputs, with hybrids and HYVs being used just partially. Farmers grow maize because their options are highly constrained given their available resources and their reluctance to take a chance on the weather (Tripathi *et al.* 2003; Ansari *et al.* 2018). The NER has the potential to revolutionize the maize production of the country, given its naturally fertile soil having high organic carbon content (1-3.5%), a wide range of pH, diverse micro flora and fauna, and a good amount of drainage, the abundant water resources from the plenty of rainfall and a coordinal climatic conditions from an altitude of 20 m to more than 3000 m from sea level (Ansari *et al.*, 2015). A wide pedo-climatic variation provides an opportunity for year round cultivation of maize in NER. In this regard, we sought to investigate the historical dynamics of growth and stability in maize production across the mountainous north-eastern states and Assam as well as to shed some insight on the prospects of maize production in the region

Methodology

Data: The time series data on area, production and yield of maize were collected from the Directorate of Economics and Statistics, Government of India for the period 1966-2019 (55 years). The analysis spanned periods from 1975 to 2019 data points across four phases viz., Phase I (1975-89); Phase II (1990-2004) and Phase III (2005-2019) and Pool (1975-2019) to have a better understanding. However, due to unavailability of data for Sikkim and Tripura, the analysis commenced from 1990 onwards.

Structural break analysis using Bai-Perron test

A structural break is a sudden or gradual change in a time series, such as a change in the mean, variance, trend or autocorrelation. Structural breaks can be caused by many factors, including wars, and major changes in government policy, economic shocks, technological innovations etc. To document the sudden variation in area, production, and productivity of maize and to find out the possible reasons for declining or increasing trend Bai- Perron test was employed and it was done in free R software. The methodology proposed by Bai &Perron (1998, 2003) allows estimating structural breaks endogenously. In other words, it determines the points of break with no prior knowledge. Consider following linear regression with m breaks (m+1 regime)

$$y_t = x_t \beta + z_t\delta_j + \mu_t \; t = Tj\text{-}1, \ldots T \ldots\ldots\ldots \quad (1)$$
$$(j = 1, \ldots, m+1, T_0 = 0 \text{ and } T_m+1 = T)$$

where y_t is the observed dependent variable, x_t and z_t are vectors of covariates, β and δ_j are the corresponding vectors of coefficients with $\delta_i \neq \delta_{i+1}$ $(1 \leq I \leq m)$ and μ_t is the stochastic term at time t. The break dates $(T_1, \ldots, T_m)$ are explicitly regarded as unknown. It is noted that this is a partial structural change model in so far as β does not shift and it is effectively estimated over the entire sample. Then the rationale is to estimate the unknown regression coefficients and the break dates, that is to say $(\beta, \delta_1, \ldots, \delta_{m+1}, T_1, \ldots, T_m)$, when T observations on (y_t, x_t, z_t) are available. Note that this is a partial change model in the sense that β is not subjected to shifts and is effectively estimated using the entire sample.

Bai and Perrron (1998) developed a method of estimation based on the ordinary least square principle. For an m-partition $(T_1, \ldots, T_m)$, denoted $\{T_j\}$, the associated least square estimator of δ_i is obtained by minimizing the sum of squared residuals.

Minimizing the sum of squared residuals $\sum_{i=1}^{m+1} \sum_{t=Ti=1}^{ti} \; [yt - xt\beta + zt\delta j]^2$

Under the constraint $\delta_i \neq \delta_{i+1} (1 \leq i \leq m)$. Let δ $(\{T_j\})$ be the resulting estimate. Substituting it in the objective function and denoting the resulting sum of squared residuals as ST $(T_1, \ldots, T_m)$, the estimated break dates $(T_1, \ldots\ldots T_m)$ are such that

$(T_1, \ldots T_m)$ = argmin $(T_1 \ldots T_m)$ ST $(T_1, \ldots, T_m)$ (2)

Where argmin denotes algorithm minimum and the minimization is taken over all partitions $(T_1, \ldots, T_m)$ such as $Ti - Ti\text{-}1 \geq [\varepsilon T]$. The term $[\varepsilon T]$ is interpreted as the minimal number of observations in each segment. Thus, the breakpoints estimators are global estimators are global minimizers of the objective function. Finally, the regression parameter estimates are obtained using the associate least-squares estimates at the estimated m-partition, $\{Tj\}$ *i,e.* $(\{Tj\})$.

Estimation of Growth Rate and Instability in maize Production

Logistic regression growth rate is employed for the estimation of annual growth rate (Dhandekar, 1980; Rehman *et al.*, 2011). Instability in agricultural area, production, and yield measured by Cuddy -Della Valle Index (CDVI) (Bezabeh *et al.*, 2014; Kumar *et al.*, 2017; Bisht and Kumar, 2018; Baviskar *et al.*, 2020) method which is of modification of CV to measure variability in time series data. The CDVI de-trends the CV by using a coefficient of determination and showing the exact direction of instability (Cuddy and Valle, 1978). Thus, the present study used CDVI to measure instability in maize production in Northeastern states. The CDVI is estimated using the following formula:

$$CDVI = CV \times \sqrt{1 - R^2}$$

Where, CV is the coefficient of variation, and R^2 is the coefficient of determination from a time-trend regression adjusted for its degrees of freedom. The higher value of the index shows higher instability and vice-versa. CDVI is categorized into low (0<CDVI>=15), medium (15<CDVI >=30) and high (CDVI >30) instability (Rakesh Sihmar, 2014).

Decomposition Analysis

Any change in production of a crop in physical terms depends fundamentally on changes in the area under the crop and its average yield. A decomposition analysis model was used to measure the relative contribution of area and yield and the interaction of the two in total maize production. As used by many researchers (Dupare *et al.*, 2014; Pattnaik and Shah, 2015; Sharma *et al.*, 2017; Uttam Singh *et al.*, 2018; Laitonjam *et al.*, 2018), the decomposition analysis was performed for the present study, using the following equation:

$$\Delta P = Y_b \Delta A + A_b \Delta Y + \Delta A \Delta Y$$

where, ΔP (change in production)= P_c-P_b; ΔY (change in yield) = Y_c-Y_b; ΔA (change in area) = A_c-A_b; P_b, Y_b, and A_b are the production, yield and area for the base year, respectively; and P_c, Y_c, and A_c are the production, yield and area under maize for the current year, respectively. The contributions of yield, area, and their interaction are estimated by applying the formula $A_b\Delta Y/\Delta P$, $Y_b\Delta A/\Delta P$, and $\Delta A\Delta Y/\Delta P$, respectively.

Results and Discussion

Status of Maize area, production and productivity growth in North-Eastern Region

All the states except Assam and Manipur showed growth in area and production during the first phase. The region had 5.01 per cent annual growth in area and 7.18 per cent in production. Arunachal Pradesh and Nagaland are the main contributors to the overall growth in the region. Nagaland had the highest growth in area (5.83%) and production (5.02%) followed by Arunachal Pradesh (area: 4.77% and production: 5.53%). Both the states together contributed more than 35% in area and production for the NER (Table 1).

Table 1: State-wise Growth in Area, Production and Yield of Maize in NE Region of India (1975 - 2019)

State	Phase I (1975-1989)			Phase II (1990-2004)			Phase III (2005-2019)			Overall (1975-2019)		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Assam	-1.46	-0.8	0.67	0.36	1.27	0.91	5.58	21.85	15.42	0.68	3.74	3.03
Arunachal Pradesh	4.77	5.53	0. 72	0.67	1.55	0.88	1.45	2.52	1.05	2.23	2.96	0.71
Manipur	-5.65	-2.23	3.62	0.02	-0.65	-0.67	13.45	11.90	-1.39	1.63	2.08	0.44
Meghalaya	1.18	6.09	4.85	-0.46	1.24	1.71	0.61	5.13	4.5	0.08	2.31	2.23
Mizoram	1.24	4.11	2.84	0.83	2.28	1.44	-4.23	0.93	5.39	1.13	1.8	0.66
Nagaland	5.83	5.02	-0.76	4.44	9.81	5.14	1.05	2.66	1.6	4.62	7.96	3.19
Sikkim	-	-	-	-0.59	-0.07	0.53	0.02	1.29	1.27	-0.09	0.94	1.03
Tripura	-	-	-	-0.34	3.2	3.55	18.52	22.70	3.53	6.46	9.50	2.86
Northeast	5.01	7.18	2.07	0.96	2.68	1.71	2.32	5.41	3.02	2.41	4.25	1.80
All India	-0.10	1.86	1.97	1.52	3.66	2.11	1.50	4.65	3.10	1.30	3.80	2.48

Note: CAGR-Compound Annual Growth Rate in percentage, A- Area, P- Production and Y- Yield

Phase II witnessed a mixed growth response for all the variables. Only Nagaland showed a steady increase in area (4.44%) and production (9.81%) variables. Negative growth in the area was observed in Meghalaya, Sikkim and Tripura while, in production negative growth was experienced in Manipur and Sikkim. In the yield of maize, there was negative growth in Manipur during the same period (Phase II). In Phase III, the negative growth was observed only in areas under maize (Mizoram) and yield of maize (Manipur). In the overall period, the growth rate was negative only in the area under maize (Sikkim).

During Phase III (i.e., the latest phase), the annual growth in area and production of maize was highest in Tripura followed by Manipur. In Tripura, there was 18.52 per cent and 22.70 per cent growth in area and production of maize, respectively while, in Manipur, the annual growth rate was 13.45 per cent and 11.90 per cent in area and production, respectively. During the same period, the annual growth in yield was the highest in Assam (15.42%) followed by Mizoram (5.39%). During the whole study period (1975-2019), the growth in area and production was the highest in Tripura (6.46% growth in area and 9.50% growth in production) followed by Nagaland (4.62% growth in area and 7.96% growth in production). In yield of maize, the growth rate from 1975 to 2019 was highest in Nagaland (3.19%). The study showed that during Phase III (2005-2019) and the overall period (1975-2019), the percentage growth in area and production in the Northeastern state was higher than the all-India growth in area and production. During 1975-2019, there was 2.41 per cent, 4.25 per cent and 1.80 per cent growth in area, production and yield of maize in the region while there was 1.30 per cent, 3.80 per cent and 2.48 per cent growth, respectively in India. Kiran *et al.* (2015) reported that from 1950-51 to 2009-10, there was a growth of 1.17 per cent and 3.08 per cent in area and production of maize, respectively in India. Ayalew and Sekar (2016) also revealed that from 1980-81 to 2011-12, there was 1.88 per cent growth in the area under maize and 2.28 per cent growth in the yield of maize in India (Table 1). The study shows that states like Tripura and Manipur emerged as high-growth performers in the later phases. This dynamic shift underscores the importance of time-sensitive agricultural policies and innovations. Improved maize varieties, better extension services, and market linkages have contributed to recent successes, particularly in Tripura and Manipur. The consistently strong performance of Nagaland, particularly in yield growth, highlights the role of traditional agricultural knowledge and practices, which could serve as a model for other states in the region.

Stability of Maize Production in North-East Himalayan Region

In Arunachal Pradesh, Meghalaya and Sikkim, the instability in area, production and yield of maize was low (CDVI < 15) in all the periods (Phase I, II, III and Overall) indicating lower risk in the production of maize. In Assam, the instability in area, production and yield of maize was low during the initial phase (Phase I and II) and gradually increased in the later period (Phase III). The instability in production and yield was high during Phase III and Overall period (1975-2019) in Assam. Similarly in Manipur, there was medium instability (15<CDVI >=30) in area and production during Phase I, the instability gradually increased in the later phase and there was high instability in area and production in Phase II and III. In the Overall study period, there was high instability in area and production and medium instability in the yield of maize in Manipur. Furthermore, in Tripura, there was medium instability in production and low instability in the area but in phase III, there was high instability in the area and production of maize. In Meghalaya, there was medium instability in production and yield during Phase I, but over time the instability decreased and there was low instability in the area, production and yield of maize. During the whole study period (1975-2019), there was medium instability in yield while there was high instability in the production of maize. Similarly, in Nagaland, there was high instability in production and yield in the early period (Phase I) but instability decreased in the later period. There was medium instability in the production and yield of maize in Phase III.

In Mizoram, there was high instability in the area, production and yield of maize in the early phase (Phase I). Instability gradually declined in Phase II but again in Phase III, the instability increased. There was medium instability in the area under maize and high instability in the production and yield of maize in Phase III. Uttam *et al*. (2018) reported that Manipur and Tripura depicted higher instability while Meghalaya was relatively stable in area, production and yield of maize during 1975-2014 which was in a similar line to the finding of the present study. The author also revealed that the area, production and yield of maize in Assam were relatively stable while instability was high in Nagaland during 1975-2014 which was contrary to the results of the present study. In the Northeast, there was low instability in the area, production and yield of maize in all the periods (Phase I, II, and III) while in India, there was medium instability in the production and yield of maize in Phase I, the instability decreased in later periods and there was low instability in the area, production and yield of maize (Fig.1). Despite high instability, the North East as a region demonstrates low overall instability compared to the national average. This suggests opportunities to leverage the relative stability in states like Meghalaya and Arunachal Pradesh to pilot scalable, risk-reducing agricultural interventions. Promoting maize cultivation during the winter season in lowland areas with adequate water

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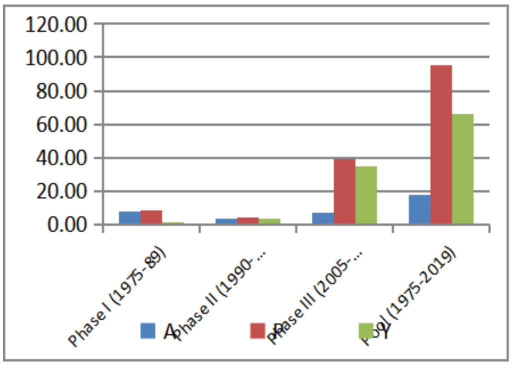
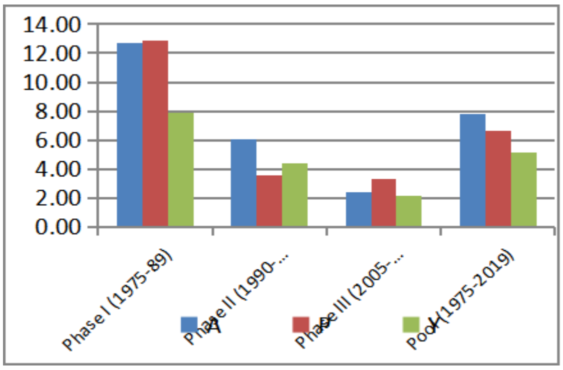
availability can provide farmers with a sustainable source of income.



a) Assam



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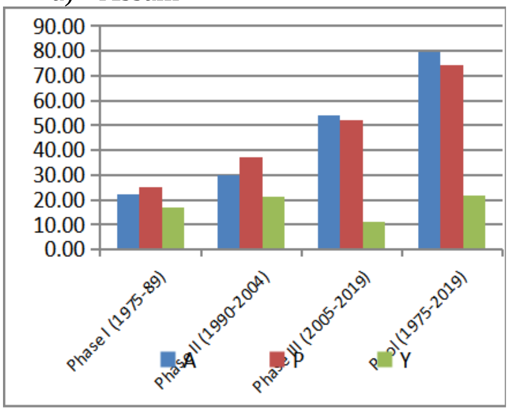

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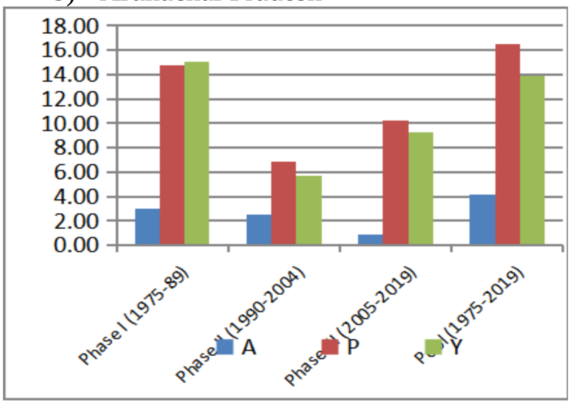
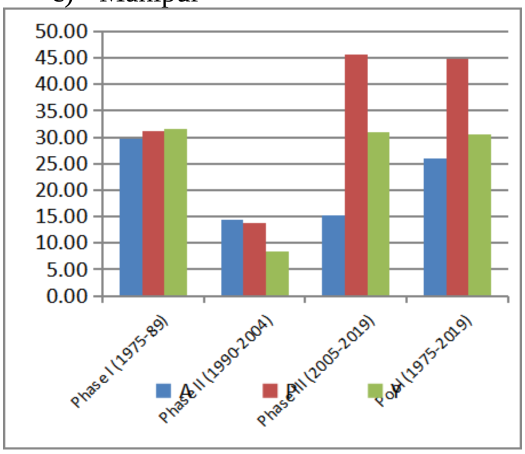
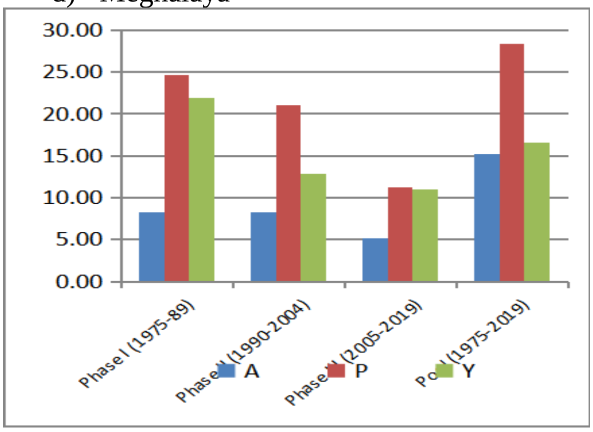


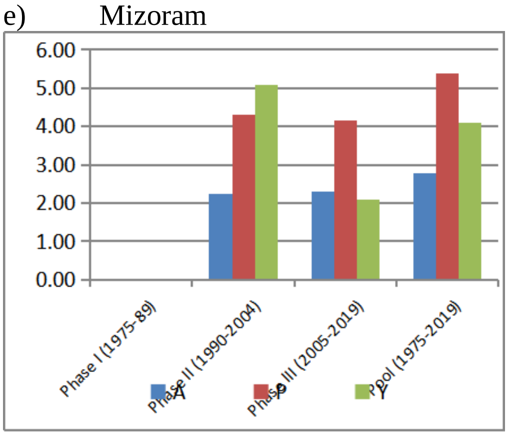
d) Meghalaya



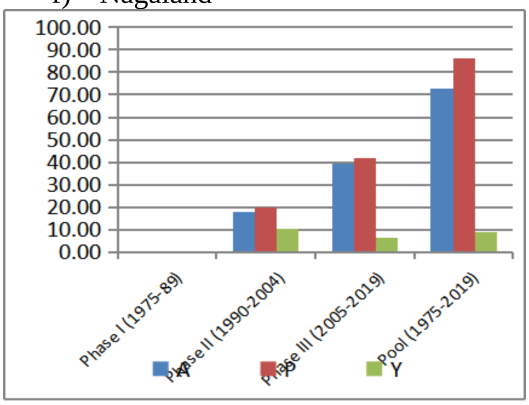
e) Mizoram



f) Nagaland



g) Sikkim



h) Tripura

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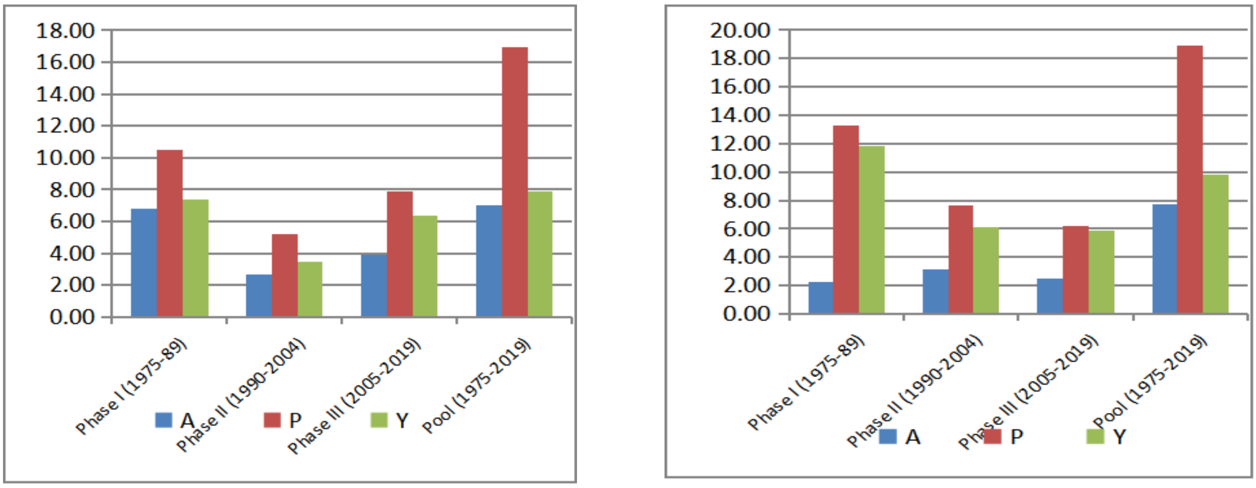

i) North East Region j) All India

Fig. 1: Instability index of area, production and yield of maize in NER.

Note: Blue bar- Area (A); Red bar- Production (P); Green bar-Yield (Y)

Contribution of area, yield, and their interaction effect on change in maize production in North-East Region

In Arunachal Pradesh, Manipur, Mizoram Nagaland and Tripura, the area effect made a major contribution to the change in maize production during Phase III (The latest period). On the other hand, in Meghalaya, Sikkim and Assam, the major contribution to change in maize production was the yield effect. In the overall Northeast and India, the yield effect had a major contribution to the change in the production of maize during Phase III of the study period. Similarly, Ayalew and Sekar (2016) reported that the production of maize increased from 6.49 mt in 1980-81 to 21 mt in 2011-12 which was mainly due to an increase in yield of maize from 1100 kg/ha to 2279 kg/ha, respectively. During the whole study period (1975-2019), Arunachal Pradesh, Manipur and Mizoram, the area effect had a major contribution to the change in maize production while in Assam, Meghalaya and Sikkim yield effect had a major contribution. In Nagaland and Tripura, both area and yield effects contribute to the overall change in the production of maize. Interestingly, during the first phase, the increase in production was due to an increase in area (area effect: 66.65%), in the second phase, it was due to an increase in productivity (yield effect: 68.68%) and in recent phase, increase in production is attributed to both area (48.74%) and yield (37.17%) effect in entire North East Himalayan Region (Table 2).

Structural changes in area, production productivity of maize NE states of India

The shift from area-driven to yield-driven contributions highlight improved productivity in maize cultivation across the Northeast. However, the combined role of area and yield in Phase III signals untapped potential for intensification. Policies should focus on promoting high-yield varieties, enhancing input efficiency, and expanding maize cultivation in lowland areas with adequate water. Strengthened extension services can bridge knowledge gaps for sustainable production growth.

The Bai-Perron test was used to examine the sudden variation or structural breaks in time series data of area, production and productivity of maize for the NER region during 1975-76 to 2019-20. Structural breaks were found to analyse the abrupt shift in the data which would help to understand the specific reasons for the breaks in the data series.

Table 2: Percentage contribution of area, yield, and their interaction effect on maize production in NE India

Particular	Phase I (1975-1989)	Phase II (1990-2004)	Phase III (2005-2019)	Overall (1975-2019)
Assam				
Yield effect	277.66	201.35	46.09	53.20
Area effect	-159.24	-87.67	11.12	7.62
Interaction effect	-18.42	-13.68	42.79	39.18
Arunachal Pradesh				
Yield effect	5.30	96.87	31.55	13.44
Area effect	89.72	2.61	61.02	63.94
Interaction effect	4.97	0.52	7.42	22.61
Manipur				
Yield effect	-117.65	-55.75	47.99	-3.66
Area effect	151.81	138.78	63.60	100.74
Interaction effect	65.84	16.97	-11.58	2.92
Meghalaya				
Yield effect	75.96	1236.09	83.47	85.14
Area effect	13.26	-1029.19	10.26	4.51
Interaction effect	10.78	-106.91	6.27	10.35
Mizoram				
Yield effect	-24.13	59.04	21.26	13.10
Area effect	144.99	32.91	88.46	77.52
Interaction effect	-20.87	8.05	-9.72	9.38
Nagaland				
Yield effect	20.95	35.93	21.41	11.11
Area effect	54.31	30.24	71.32	26.88
Interaction effect	24.74	33.83	7.27	62.01
Sikkim				
Yield effect	-	-983.65	92.40	146.79
Area effect	-	984.80	6.40	-38.12
Interaction effect	-	98.85	1.19	-8.67
Tripura				
Yield effect	-	61.73	6.03	9.40
Area effect	-	24.84	59.85	40.14
Interaction effect	-	13.42	34.12	50.45
Northeast Region				
Yield effect	18.21	68.68	48.74	21.57
Area effect	66.65	24.40	37.17	37.36
Interaction effect	15.14	6.92	14.09	41.07
All India				
Yield effect	107.88	44.14	57.64	50.55
Area effect	-5.81	44.45	27.32	19.79
Interaction effect	-2.07	11.41	15.04	29.66

The results of Bai-Perron test are presented (Fig 1, Fig.2 and Fig 3). For the break periods, the growth rate was estimated using the exponential growth function. The Bai-Perron test identified five break periods in area viz. 1980, 1987, 1999, 2005 and 2012. Five break points for production were observed during the years 1980, 1987, 2001, 2007 and 2013. In productivity, four breaks were identified during 1982, 1994, 2001 and 2013. The initial two break points 1980 and 1987 appeared for both area and production. These two break points come under the phase I category and growth rate analysis showed that there was a significant increase in area and production annually about more than five per cent. Similarly, decomposition analysis also showed that during the first phase increase in area was the major contributor to increase in the maize production. The next breakpoint appeared during 2001 for both production and the yield variables which indicate sudden change in the production of maize is mainly because of variation in the yield component.

It is supported by the decomposition analysis results which revealed that during the second phase, the effect of yield much greater than the area expansion on production. Further, the next breaks ensue simultaneously for production, area and productivity during 2012-13. The third study phase which comprises these breakpoints showed that the area expansion as well as an increase in yields both factors had contributed to the growth of the production of maize during this phase. During the 1990s and 2000s adoption of improved maize varieties especially composite varieties and hybrids in major growing states might have played a vital role in the expansion of maize in NER. In 2010s booming in the livestock sector which in turn created the derived demand for maize in the livestock feed sector could be the major reason for significant growth in maize production (Paroda and Kumar 2000; Joshi *et al.*, 2005; Kumar *et al.*, 2007; Feroze *et al.*, 2010).

Conclusion

Maize, the third most valued cereal after rice and wheat, plays a crucial role in the livestock feed industry and has emerged as a key crop in the North-East Himalayan Region (NER) of India. The region's relatively low instability in maize area, production, and productivity compared to the national average underscores its suitability for maize cultivation. States like Arunachal Pradesh, Meghalaya, Nagaland, and Sikkim exhibit stable growth, while in Tripura, Nagaland, Manipur, Mizoram, and Arunachal Pradesh, area expansion has driven maize production, with recent growth also reflecting improved technologies and practices. climate-resilient practices and mechanization can further enhance productivity. With these strategic measures, the NER has the potential to become a leading maize producer, significantly contributing to the regional and national agricultural economy. Policy efforts should focus on increasing the adoption of high-yielding hybrid maize varieties and improving the seed replacement ratio to boost productivity. Expanding maize cultivation in lowland areas with adequate water and integrating balanced nutrient management in shifting cultivation systems are critical.

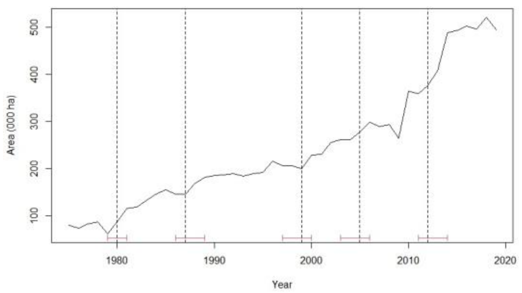

Fig 2. Structural breaks in the area under maize crop in the NE Region

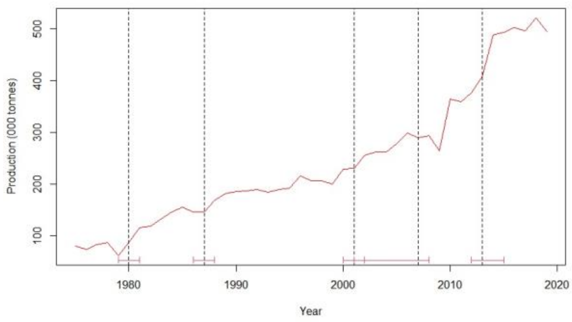

Fig 3. Structural breaks in maize production in the NE Region

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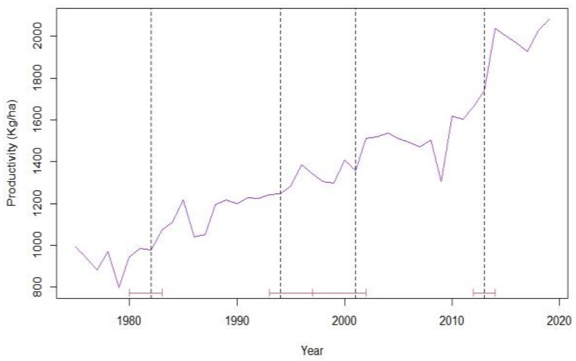

Fig 4. Structural breaks in the productivity of maize crop in the NE Region

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