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Pulses Production in North-East India: Trend and Decomposition Analysis

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ABSTRACT

The North-Eastern Region (NER) of India offers ideal soil and agro-climatic conditions for growing pulses, however the region falls short of its needs for pulses by over 82%. The average pulses productivity in NER, however, is greater than the national average (764 kg/ha), demonstrating the potential for pulses production in this area (848 kg/ha). The study attempts to look at the state-by-state growth scenario, production variability, and break down the impact of production in the North East Region. The relative contribution of area, yield, and their interplay to the production of all pulses was calculated using a decomposition analysis model. The study analysis spanned across four periods viz., Phase I (1978-79 to 1991-92); Phase II (1992-93 to 2005-06) and Phase III (2006-07 to 2019-20) and Pool (1978-79 to 2019-2020). The study revealed that there was positive significant growth in area (5.02%), production (7.56%) and yield (2.42%) of pulses during Phase I of the study period. For the Phase II, the growth was positive and significant only in yield of pulses (1.62%). The result of analysis of overall data (1966-67 to 2019-20) revealed that Arunachal Pradesh, Meghalaya and Nagaland showed a positive significant growth in area under pulses in, while in production and yield of pulses, it was observed in Arunachal Pradesh, Assam, Meghalaya, Nagaland and Tripura. The study revealed that during the whole study period there was significant positive growth in area (1.53%), production (3.47%) and yield (1.91%) of pulses in NE India indicating that time trend had significant influence on change in area, production and yield of pulses.

1. Introduction

India produced 23.02 million tonnes of pulses from an area of roughly 27.98 million hectares in the 2019–20 crop year, accounting for 25% of global production and 27% of global consumption (Tiwari & Shivhare 2016 & Department of Agriculture, Cooperation & Farmers' Welfare, Annual Report 2021). Although the FAO recommends 80g of protein per day, the availability of protein per person is only 28g per day (Nagy *et al.,* 2013; Prasad *et al.,* 2013; Saroj *et al.,* 2013). With only 359 litres of water needed to produce 1 kg of pulses, compared to 1,802 for soybeans and 3,071 for groundnuts, pulses are one of the most sustainable crops (Singh *et al.,* 2017). Being the cheapest source of protein it occupies an important position in balancing human dietary needs. In India, food grains account for over 62% of all gross cropped area, with cereals accounting for 51% and pulses for roughly 11%. Additionally, gram accounts for 4%, arhar 2%, and the remaining pulses account for around 5% of the total gross cropped area. (Ministry of Agriculture & Farmers Welfare, Doubling Farmers Income 2022).

In the North East Region (NER), pulses are grown in the states of the region as minor crops. Green gram (*Vigna radiata*), black gram (*V. mungo*), pigeon pea (*Cajanus cajan*), cowpea (*V. unguiculata*), french bean (*Phaseolus vulgaris*), chickpea (*Cicer arietinum*), lentil (*L. culinaris*) and field pea (*Pisum sativum*) are the major pulses cultivated in NE (Gupta

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et al., 1998 & Roy *et al.,* 2017). Only 216.6 thousand tonnes (1.19%) of the nation's 18.4 million tonnes of total pulse production (2013–14) come from the Northeast region (mt) (Das *et al.,* 2016). With this amount of production, NER has only about 12.5g of pulses available per person, compared to 43.3g nationally. Given the 50g of necessary daily pulses consumption per caput, this region's pulses production would need to almost ten times increase to become pulses-self-sufficient. The region is ideally suited for producing pulses, as evidenced by the fact that its pulses productivity (848 kg/ha) is higher than the nation's (764 kg/ha) (Das *et al.,* 2016). Pulses production in the area has gotten more attention under the National Food Security Mission (NFSM), but more work is still needed to feed our own population. In light of this situation, the present paper sought to investigate the historical dynamics of growth and stability in the pulses production and area across the north-eastern states and shed some insight on those dynamics' potential futures.

2. Methodology

Data

The time series data on area, production and yield of pulses were collected from Directorate of Economics and Statistics, Government of India for the period 1978-79 to 2019-2020 (41 years). The analysis spanned across four periods viz., Phase I (1978-79 to 1991-92); Phase II (1992-93 to 2005-06) and Phase III (2006-07 to 2019-20) and Pool (1978-79 to 2019-2020) to have a better understanding. However, due to unavailability of data for Arunachal Pradesh, Manipur and Sikkim, the analysis commenced from 1992-93, 2006-07 and 1981-82, respectively.

Analysis of Data

Estimation of Growth Rate

Linear Growth Rate (LGR) and Compound Annual Growth Rate (CAGR) are two methods usually utilise by researchers for estimating growth rate in production. The LGR is not convincing when used to compare growth rates across eras, avoids seasonal and cyclical swings, and fails to take into account compound effects in time series data (Dandekar, 1980). Therefore, CAGR is a better tool to utilise when analysing growth rate. The CAGR in pulse output, yield, and area was calculated for the current study for four periods. By fitting the following semi-log trend equation, which is based on the method provided by Rehman et al. (2011), the CAGR was calculated as below:

$y=ab^te$ ....(i)

Equation (i) is converted to logarithmic form as below:

$lnY = lna + t(lnb) + e$ ....(ii)

where 'Y' is area (000'ha)/ production (000'tonne)/ yield (kg/ha); 't' is the number of years; 'a' is the constant; 'b' = (1+r) is the slope coefficient that measures relative change in Y for absolute change in explanatory variable; 'r' is growth rate; 'ln' is the natural logarithm and 'e' is error term.

The CAGR is estimated by using the following equation:

*CAGR = (antilog b -1)*100* ....(iii)

Instability in pulses production

Different techniques can be used to measure the instability of an agricultural region, its productivity, and its yield. Coefficient of variation (CV), Cuddy-Della Valle Index (CDVI), and Coppock Instability Index are the three often employed techniques (CII). Each of these approaches has benefits and drawbacks of its own. The CV is simple to compute, but because it overestimates instability, it has received much criticism. If CV is used to measure instability, for instance, a region with a steady rate of growth will have a high instability rating. In order to measure variability in time series data, many researchers have used the CDVI approach, which is a modicifcation of CV (Bezabeh et al., 2014; Kumar et al., 2017; Bisht and Kumar, 2018; Baviskar et al., 2020). The CDVI de-trend the CV by using coefficient of determination and showing the exact direction of instability (Cuddy and Valle, 1978). Thus, in order to quantify the instability in pulse production in North Eastern states, CDVI was used in the current study. The CDVI is estimated using the following formula:

$CDVI=CV\times\sqrt{1-\bar{R}^2}$ ....(iv)

Where, CV is the coefficient of variation, and $\bar{R}$ is the coefficient of determination from a time-trend regression adjusted for its degrees of freedom. 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

Changes in the area under a crop and its average yield are fundamentally what determine any change in production. The relative contribution of area, yield, and their interplay to the production of all pulses was calculated using a decomposition analysis model. The following equation was used to carry out the decomposition analysis for the current study (Dupare *et al.,* 2014; Pattnaik and Shah, 2015; Sharma *et al.,* 2017; Singh *et al.,* 2018; Laitonjam *et al.,* 2018):

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

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 pulses for the current year, respectively.

By applying the following formula $A_b\Delta Y/\Delta P$, $Y_b\Delta A/\Delta P$, and $\Delta A\Delta Y/\Delta P$, respectively, he contributions of yield area, and their interaction are estimated.

Analysis of surplus or deficit

To have an idea regarding the sufficiency of pulses production in NE India with the growing population, the surplus or deficit analysis was made. The requirement was estimated in each census year beginning from the year 1981 till 2011. This requirement of pulses in the year 2022 was estimated by multiplying the population of the year 2022 (NCP, 2020) with the per capita requirement of pulses (29.2 kg) recommended ICMR.

3. Result and Discussion

Growth in area, production and yield of pulses

The state-wise CAGR in area, production and yield of pulses in NE India during 1966-67 to 2019-20 is presented in Table 1. During Phase I (1966-67 to 1983-84), the CAGR in yield of pulses was negative in Meghalaya and Sikkim but it was not statistically significant. Among the states, the CAGR in area under pulses were positive and statistically significant in Meghalaya (4.39%), Sikkim (14.80%) and Tripura (12.40%), respectively. The growth in production was positive and significant in Meghalaya (4.01%), Nagaland (30.15%) and Tripura (15.01%). There was positive significant growth in yield of pulses only in Tripura (2.32%). In NER, there was positive significant growth in area (5.02%), production (7.56%) and yield (2.42%) of pulses during Phase I of the study period. Thus, this implies that during this time, the time trend had a substantial impact on changes in the area, production, and yield of pulses.

During Phase II (1984-85 to 2001-02), there was significant negative growth in area (Assam, Sikkim and Tripura), production (Assam and Tripura) and yield (Mizoram) of pulses. During this phase positive significant growth in area was observed in Meghalaya (3.90%) and Nagaland (11.84%) while significant positive growth in production was experienced in Arunachal Pradesh (2.93%), Meghalaya (3.94%) and Nagaland (13.21%). In Arunachal Pradesh and Tripura there was significant positive growth in yield of pulses at the rate of 1.65% and 1.57%, respectively. In NER, the growth was positive and significant only in yield of pulses (1.62%) during the study period.

During Phase III (2002-03 to 2019-20), there was significant negative growth in area and production of pulses in Sikkim (-6.68% and -6.32%, respectively) while positive significant growth was observed in Arunachal Pradesh (5.04%), Assam (2.86%), Manipur (8.62%), Meghalaya (7.92%) and Tripura (13.40%). In production of pulses, there was positive significant growth in Arunachal Pradesh (4.39%), Assam (6.05%), Manipur (14.84%), Meghalaya (14.41%) and Tripura (14.49%), while in yield of pulses the significant positive growth was experienced in Assam (3.10%), Manipur (5.73%) and Meghalaya (6.01%) during Phase III of the study period.

The results of the overall period (1966–1967 to 2019–20) reveals positive considerable rise in the area under pulses in Arunachal Pradesh, Meghalaya, and Nagaland, as well as in the production and yield of pulses in those states as well as Assam, Tripura, Meghalaya, and Nagaland. The study found that in NE India there was considerable positive growth in the area (1.53%), production (3.47%), and yield (1.91%) of pulses throughout the course of the study period, indicating that temporal/time trend had a significant impact on these changes.

The instability index in area, production and yield of pulses in all the phases (Fig. 1.) viz., Phase I (1966-67 to 1983-84), Phase II (1984-85 to 2001-02), Phase III (2002-03 to 2019-20) and over all period (1966-67 to 2019-20) was analysed.

In Arunachal Pradesh, there was low instability in area, production and yield of pulses in all the sub-periods. One of the interesting finding in instability analysis is that in Nagaland, there was high instability in early phase (Phase I) while in the later phase, the instability reduced and there was medium and low instability in Phase II and Phase III, respectively in area, production and yield of pulses. Assam experienced medium production and area instability along the same lines, however there was minimal instability in the last period (Phase III). In Manipur, Meghalaya and Mizoram, there was low instability in early period but in the later period, medium instability was observed in area, production and yield of pulses. In Sikkim and Tripura, medium instability in area and production was observed in all the sub-periods (Phase I, II and III).

Contribution of area, yield and their interaction effect on pulses production

The growth of pulses production in NE India was shown in Table 2 by the roles that area and yield played. This was accomplished by dividing the change in pulses into three effects: area, yield, and interaction (both area and yield). In all the sub-periods (Phase I, Phase II and Phase III), area effect contributes the most to change in production of pulses in the states of NE India except in Mizoram. In Phase I, interaction effect i.e., both area and yield effect contribute to increase in production of pulses but in the later phase (Phase II and III) it was yield effect which contribute the most. The analysis of the overall study period revealed that in all the states area effect contribute the most to the change in production of pulses except Assam, Mizoram and Nagaland where contribution to change in production comes from yield

effect in case of Assam and interaction effect in case of Mizoram and Nagaland.	

Table 1. State-wise CAGR in Area, Production and Yield of pulses in NE India (1966-67 TO 2019-20)

State	Phase I (1966-67 to 1983-84)			Phase II (1984-85 to 2001-02)			Phase III (2002-03 to 2019-20)			Over all (1966-67 to 2019-20)		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y
AR	-	-	-	1.26	2.93*	1.65*	5.04***	4.39***	-0.62	3.20***	3.97***	0.75*
AS	2.49	3.22	0.71	-5.26***	-4.54**	0.76	2.86***	6.05***	3.10***	0.13	1.62**	1.49***
MN							8.62*	14.84*	5.73*			
ML	4.39**	4.01*	-0.37	3.90*	3.94*	0.04	7.92*	14.41**	6.01***	2.78***	4.15***	1.33**
MZ				-0.41	-4.71	-4.31*	-1.80	1.98	3.84	-0.77	-1.76	-1.01
NL	23.52	30.15*	5.37	11.84***	13.21***	1.22	1.16	1.37	0.21	9.39***	11.37***	1.80***
SK	14.80**	13.48	-1.15	-4.08*	-3.84	0.26	-6.68*	-6.32*	0.38	-1.81	-1.30	0.53
TR	12.40***	15.01***	2.32*	-5.32*	-3.84*	1.57***	13.40***	14.49***	0.96	1.93	3.54**	1.58***
NER	5.02***	7.56***	2.42**	-2.72	-1.14	1.62**	3.41***	5.43***	1.95***	1.53***	3.47***	1.91***
India	4.62***	5.65***	0.99	-3.63*	-3.03	0.63	1.95*	4.13**	2.14**	-0.18	1.08*	1.27***

A: Area, P: Production, Y: Yield

AR: Arunachal Pradesh; AS: Assam; MN: Manipur; ML: Meghalaya; MZ: Mizoram; NL: Nagaland; SK: Sikkim; TR: Tripura; NER: North East Region

*Significant at 0.05 level

**Significant at 0.01 level

***Significant at 0.1 level

Instability in area, production and yield of pulses

Figure 1. State-wise instability index for area, production and yield of pulses in NE

Table 2. Percentage contribution of Area, Yield and their interaction effect on change in pulses production in NE India

Particular	Phase I (1966-67 to 1983-84)	Phase II (1984-85 to 2001-02)	Phase III (2002-03 to 2019-20)	Over all (1966-67 to 2019-20)
Arunachal Pradesh				
Area effect	-	50.47	137.34	92.72
Yield effect	-	41.63	-21.59	3.17
Interaction effect	-	7.90	-15.75	4.11
Assam				
Area effect	79.04	123.13	43.76	25.88
Yield effect	14.83	-43.57	41.13	51.97
Interaction effect	6.13	20.44	15.11	22.15
Manipur				
Area effect	-	-	43.90	43.90
Yield effect	-	-	19.85	19.85
Interaction effect	-	-	36.25	36.25
Meghalaya				
Area effect	190.55	90.56	40.66	62.12
Yield effect	-49.47	6.58	25.49	7.31
Interaction effect	-41.07	2.86	33.85	30.58
Mizoram				
Area effect	17.54	-11.87	-109.66	20.86
Yield effect	6.51	107.84	273.17	6.15
Interaction effect	75.95	4.02	-63.52	73.00
Nagaland				
Area effect	45.79	84.73	84.69	39.21
Yield effect	13.42	4.73	14.55	5.36
Interaction effect	40.79	10.54	0.76	55.43
Sikkim				
Area effect	77.71	117.76	109.18	196.09
Yield effect	8.54	-29.57	-15.72	-151.94
Interaction effect	13.75	11.81	6.54	55.85
Tripura				
Area effect	72.41	120.62	86.25	52.85
Yield effect	7.57	-41.54	4.15	8.65
Interaction effect	20.02	20.93	9.61	38.50
Northeast				
Area effect	55.56	235.39	61.28	34.25
Yield effect	24.00	-193.65	26.71	27.41
Interaction effect	20.44	58.25	12.01	38.34
All India				
Area effect	74.16	115.66	41.68	22.94
Yield effect	16.42	-23.37	47.31	62.11
Interaction effect	9.42	7.71	11.00	14.95

Deficit/Surplus in pulses production

During 2035, the NE region will require an estimated production of 1669 thousand tonne of pulses for the projected population of 571.74 (Table 3). The estimated requirement of pulses production was highest in Assam (1143 thousand tonne) followed by Tripura (133 thousand tonne) and Meghalaya (107 thousand tonne) for the projected population of 391.58 lakh, 45.44 lakh and 36.70 lakh, respectively. Among the NE states during 2011, 2015 and 2019, there was huge deficit in pulses production in all the NE states. During 2019, the major deficit in pulses was observed in Assam (-899 thousand tonne) followed by Tripura (-98 thousand tonne) and Meghalaya (-82 thousand tonne). The total pulses deficit in the whole NE India was 1235 thousand tonne during 2019 (Table 4).

Table 3. Estimated requirement of pulses as per projected population during 2022, 2025, 2030, 2035 in NE States of India.

States	2022		2025		2030		2035	
	Population (Lakh)	Reqd. (000' tonne)	Population (Lakh)	Reqd. (000' tonne)	Population (Lakh)	Reqd. (000' tonne)	Population (Lakh)	Reqd. (000' tonne)
AR	15.51	45	15.94	47	16.59	48	17.12	50
AS	353.78	1033	363.82	1062	379	1107	391.58	1143
MN	32.01	93	32.89	96	34.24	100	35.32	103
ML	33.26	97	34.17	100	35.57	104	36.7	107
MZ	12.3	36	12.64	37	13.15	38	13.57	40
NL	22.18	65	22.79	67	23.72	69	24.47	71
SK	6.83	20	7.02	20	7.31	21	7.54	22
TR	41.18	120	42.32	124	44.05	129	45.44	133
NEH	517.05	1510	531.59	1552	553.63	1617	571.74	1669

Table 4. Surplus or deficit of pulses in NE states of India (IN 000'TONNE)

States	2011	2015	2019
Arunachal Pradesh	-30	-29	-30
Assam	-846	-853	-899
Manipur	-57	-57	-66
Meghalaya	-83	-79	-82
Mizoram	-27	-28	-29
Nagaland	-23	-17	-16
Sikkim	-12	-13	-14
Tripura	-102	-101	-98
NEH	-1180	-1179	-1235

4. Conclusion

The fact that the NE region's pulse productivity was higher than that of all of India points to the promising future of growing pulse production from this area. NER is one of the potential areas for boosting the output of pulses horizontally by utilising a portion of the 1.67 million ha of shifting agriculture *(Jhum)*. For improving the area under pulses with sufficient irrigation infrastructure, fallow rice and maize can be utilised. The acreage and output of pulses in this region may be raised vertically since they can coexist with other crops and are practical for relay farming with other crops. Short-duration pulses like mung bean and urd bean give the chance to take advantage of the spring and autumn seasons, which are often fallow in this region. Pulses would undoubtedly improve soil fertility in this region's rice and maize-based farming systems in a sustainable manner. Additionally, coordinated efforts from many ministries are required to transition the land under shifting cultivation to the production of pulses and other crops using conservation agriculture principles, which would ultimately help in soil conservation. To improve pulses production and ensure the nutritional security of our nation, particularly this region, extensive demonstrations and training programmes should be implemented at the farmer level.

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