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Spatio-Temporal Pattern of Foodgrain Production in North Eastern Region of India

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ABSTRACT

This paper investigates the disparity in area, production and yield of foodgrain across the states of north eastern India from 1966-67 to 2014-15 and the period has been divided into five periods: 1965-66 to 1974-75, 1975-76 to 1984-85, 1985-86 to 1994-95, 1995-96 to 2004-05 and 2005-06 to 2014-15 to understand decadal performance among the states. Growth rate performance of the period 2005-06 to 2014-15 was highly appreciable and regarded as boom stage in food grain production in NER. The comparison of production growth rates in all the periods reveals that Nagaland exhibits better performance followed by Arunachal Pradesh while states like Mizoram and Sikkim are running behind. Growth performance of Nagaland has shown even better than that of north east total and national average. The decomposition analysis reveals that sources of output growth in the states of the region are due to yield improvements (54%) followed by interaction effect (26%) and area expansion (20%). Respective degree of risk of area, production and yield in growing foodgrain in the region is indicated by the instability analysis where Meghalaya followed by Assam was found more stable while Nagaland and Mizoram were least stable. Considering that foodgrain are irreplaceable staple of the region and states like Mizoram and Sikkim showing decreasing growth rates in area under foodgrain during the last decade, the scope of meeting the foodgrain requirement of the region depend highly on productivity improvement and there is need for action oriented programs for the rainfed and hilly ecosystems of the region with concerted efforts from all line departments to minimize the disparity in foodgrain production.

1. Introduction

In the eight states of the region namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura, foodgrain occupies 3965 thousand hectares which accounts for around 64 per cent of the total cropped area of the region and 3.2 per cent of the total foodgrain area in India while its share in national foodgrain production is 3.1 per cent as per triennium ending 2015 (GOI, 2016). The total foodgrain production of North Eastern Region (NER) is 7927 thousand tones with average productivity of 1999 Kg/ha, which is below the national average of 2092 Kg/ha as per triennium ending 2015 (GOI, 2016). During the post-green revolution period due to introduction of improved varieties, the rice yield in NEH region has been enhanced up to 40% (Rice Knowledge Management Portal, 2015) that plays a pivotal role in increasing the productivity of foodgrain. According to World Bank Strategy Report 2007, the region's agriculture sector has been declining and diversification into services and manufacturing has been inadequate. The renowned agricultural scientist Dr. M. S. Swaminathan describes the region as a cultural and genetic paradise and granary of mega biodiversity in terms of flora and fauna as well as micro-flora and micro-fauna. Under these circumstances, if resources are not properly developed and managed, the food security in the predominant agrarian economy will be endangered. Agriculture has been the mainstay of the North-East economy from ancient times, and the situation has not changed much until recently. By the year 2050 the total food grain demand would go up to 13.28 million tons, further widening the demand and supply gap. Therefore, production should increase almost two-folds from

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the same or less land resources (ICAR 2013). Government of India should consider the attributes that are threatening the food security and livelihoods of millions of marginal and small farmers who entirely depend upon monsoon (Sonnad *et al,* 2011). In the field of agriculture, growth rates are widely employed as these have important policy implications (Panse, 1964). The exponential compound annual growth rates are estimated by using log linear functions on the time series data on area, production and productivity of foodgrain. Analyzing the growth rate trends in the agricultural area, production and productivity across space and time have remained issues of significant concern for researchers as well as policy makers. It has been argued that analysis of the growth rate trends helps us to identifying the changing pattern of crops and land use pattern under different crop and rate of change in area production and productivity of a crop and further help in designing the appropriate agricultural policy for a region or state (Kumar and Singh, 2014). Temporal variations of growth rate in area, production and yield of foodgrain, decomposition of source of output growth and variability among the states over the study years in a state wise comparative mode has been investigated in the paper.

2. Materials and Methods

Data on area, production and productivity for the states, Arunachal Pradesh (AR), Assam (AS), Manipur (MN), Meghalaya (ML), Mizoram (MZ), Nagaland (NL), Sikkim (SK), and Tripura (TR)(from the year 1966 to 2015) was retrieved from Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Govt. of India. To estimate the growth performance of area, production and yield of foodgrain in state wise comparative mode during the period1966-67 to 2014-15, time series data on area, production and productivity were analyzed. The whole period was divided into five decades to understand the decadal performance. The periods 1966-67 to 1974-75, 1975-76 to 1984-85, 1985-86 to 1994-95, 1995-96 to 2004-05 and 2005-06 to 2014-15 have been referred to as period 1, period 2, period 3, period 4 and period 5, respectively.

Annual compound growth rate

By taking time as the independent variable and the concerned time series variable as the dependent variable, the compound growth rates were estimated by using the formula as given in Sonnad*et al*, 2011 and Edwin Kenamu *et al,* 2014:

$Y = A\ (1 + r)^t$

where,

Y = Dependent variables like area, production and productivity in the year t for which growth rate is estimated

A = Constant

r = Rate of annual increment

t = Time element which takes the value of *1, 2, 3……. n*

After transforming the model into a linear form by taking logarithms to base e,

$ln\ Y = ln\ A + t\ ln\ (1 + r)$

Let, $ln\ A = a$

$ln\ (1+r) = b$

So, $ln\ Y = a + bt$

$(1 + r) = Anti\ ln\ of\ b$

$r = (Anti\ ln\ of\ b)-1$

The semi log function is linear in parameters (linear relationship between Y and t), and hence, it can be fitted by the method of Ordinary Least Squares (OLS) Technique. The compound growth rate (r) is obtained by the following formula and generally expressed in terms of percentage.

$r = [(Anti\ ln\ of\ b)-1] * 100$

Inlogformbhasbeencalculatedbythe followingformula:

$$ln\ b = \frac{\sum t\ lnY - (\sum t \sum lnY)N}{\sum t^2 - (\sum t)^2/N}$$

This equation presumes that a change in agriculture output in a given year would depend upon the output in the preceding year (Deosthali *et al*, 2004). The significance of growth rate was tested by applying student t test statistic

$t = [r / S.E.(r)]$ with $(n-2)$ df

where,

$S.E.\ (r) = 100\ b \times S.E.\ (log\ b)/\ log10e$

r = the compound growth rate

n = number of years

$S.E.\ (r)$ = standard error

df = degrees of freedom

$t = r / S.E.\ (r)$ follows student t distribution with $(n-2)$ degrees of freedom.

According to log base rule, ln_e10 is worked out to be 2.3025 which follow t distribution with $(n-2)$ degree of freedom, n is number of years considered under study.

Decomposition of growth components

To measure the relative contribution of area and yield towards the total production change with respect of individual crop, Hazells decomposition model was adopted. In the literature, several researchers have used this model to study growth performance of the crops (Basitine *et al*, 1994; Bhatnagar et al, 1994; (Gupta *et al*, 1997; Kakali *et al,* 2006; Siju *et al,* 2001 and Singh *et al* 1998). The change in the production of crop between any time periods can be expressed as

Change in production = Yield effect + Area effect + Interaction effect

$$\Delta P = A_0 \Delta Y + Y_0 \Delta A + \Delta A \Delta Y$$

where,

$\Delta P = A_t Y_t - A_0 Y_0$

$\Delta A = A_t - A_0$

$\Delta Y = Y_t - Y_0$

A_t= Area in current year

A_0= Area in base year

Y_t= Yield in current year

Y_0= Yield in base year

Thus, the total change in production is attributed due to area and yield that can be decomposed into three effects viz; yield, area and interaction effects.

Instability index

Instability is estimated for area, production, and yield by using the following index (Ramesh Chand *et al*, 2008)

Instability index = Standard deviation of natural logarithm (X_{t+1} / X_t)

where, $X_t$refers to area (A), production (P), yield (Y), in the year t; and X_{t+1} denotes these for the next year. This index is unit free and robust and measures deviations from the underlying trend (log linear in this case). When there are no deviations from the trend, the ratio of X_{t+1} and X_t remains same and their standard deviation is zero. As deviation from the underlying trend increases, the standard deviation also increases.

3. Results and Discussion

Growth rate of area, production and productivity

State-wise foodgrain growth in area, production and yield were estimated for NER during five different periods (1966-67 to 1974-75, 1975-76 to 1984-85, 185-86 to 1994-95, 1995-96 to 2004-05 and 2005-06 to 2014-15) and overall period 1966-67 to 2014-15 and have been presented in table 1.

Period 1 (1966-67 to 1974-75): In this period Meghalaya and Mizoram had only five data points starting from 1970-71 and Sikkim with no data. Highest growth in area (38.93%) and production (29.42%) were observed in Mizoram while highest yield (11.28%) was achieved in Nagaland. Manipur had the lowest area expansion with negative production and yield while, Mizoram had highest decline in yield. None of the growth rate figures were significant in this period except the area expansion in Tripura. With regard to NER and India, area, production and yield had positive growth rates.

Period 2 (1975-76 to 1984-85): Growth rates of Sikkim were calculated on only four data points starting from 1971-72 and the state recorded highest growth in area (5.93%), production (13.28%) and yield (6.95%) followed by Arunachal Pradesh in area with significant production growth while, highest yield was achieved in Mizoram (4.89%). But, Mizoram had highest negative significant growth rates in area (27.84%) and production (24.31%) followed by Nagaland that showed negative growth in area, production and yield. Production growth in Meghalaya was also positive and significant. For NER and India growth of area, production and yield were positive but non-significant.

Period 3 (1985-86 to 1994-95): Mizoram and Nagaland witnessed changed scenario in this period where these states had the highest growth in area, production with significant growth in yield. Meghalaya, Manipur, Sikkim and Tripura had negative growths in area while Arunachal Pradesh registered negative in yield growth. In NER, area, production and yield were all positive and significant while, production and yield of India were also positively significant in the period.

Period 4 (1995-96 to 2004-05): Highest area and production growths were achieved in Nagaland in this period, with significant figures while highest significant yield was achieved in Meghalaya with its significant production growth. Assam, Mizoram, Sikkim and Tripura had declining growth in area. Sikkim had negative growth in production too. For NER the increase in area was nil and the increase in production was due to significant increase in yield while, India had positive growth except in area.

Period 5 (2005-06 to 2014-15): All the states except Mizoram and Sikkim registered positive growth of area where only Arunachal Pradesh (8.7%) and Meghalaya (0.81%) had significant growth in area. Production and yield of all the states registered positive growths except yield growth in Manipur and production growth in Sikkim. Statistically significant positive production growths were observed in Arunachal Pradesh, Assam, Meghalaya and Tripura. For NER, all the figures were positive with significant growth of production and yield while India had significant positive growth except in area. Hence, in this period highest area growth was noticed in Manipur, production and yield growth in Arunachal Pradesh followed by Assam while lowest performance in area and production growth were shown inSikkim and yield growth in Manipur.

Entire period (1966-67 to 2014-15): Among the states Nagaland registered the highest significant growth in area (3.73%), production (7.03%) and yield (3.19%) followed by

Arunachal Pradesh. All the states registered positive and almost significant figures in area except Sikkim and Tripura. Production and yield growth were all positive and almost significant in all the states. NER and India as a whole had significant positive growth in area, production and yield except the negative growth of area in all India. Almost all components of the climate influence the production of foodgrain crops. Climate change is a reality. Under the vagaries of extreme temperature and heat wave the surface temperature is raising alarmingly which will have a bearing on the crop health, thereby affecting the production and productivity of agricultural crops *(Rehman, 2015)* ultimately it hindrances the production of foodgrain in the country.

In the region, among the five periods, period 1 achieved the highest growth in area followed by period 3. Lowest growth in area was observed in period 4 followed by period 2. Highest significant growth in production and yield were achieved by period 5 followed by period 3. Lowest growth in production and yield were observed in period 2 followed by period 4 in production and period 1 in yield. In the entire period the growth performance of yield of all the states were highly significantly accelerating except Mizoram and Tripura. The similar result was also observed in the study Growth performance of agriculture and allied sectors in the North East India (Roy et al., 2014).

Table 1. Spatial and Temporal growth rate in area, production and productivity of food grains in NER.

State	AR	AS	MN	ML	MZ	NL	SK	TR	NER	India
Period 1: 1966-67 to 1974-75										
AREA	3.7	0.3	0.9	0.9	38.9	-9.1	NA	2.3***	1.2	0.5
PRDN	3.4	1.4	-2.0	0.9	29.4	1.2	NA	6.0	2.6	2.7
YIELD	-0.2	1.1	-2.9	0.0	-6.8	11.3	NA	3.6	1.4	2.2
Period 2: 1975-76 to 1984-85										
AREA	5.2	0.9	-1.4	1.2	-27.8**	-15.3*	5.9	-0.9	0.6	0.1
PRDN	6.9**	2.0	-0.5	1.7*	-24.3**	-16.2*	13.3	1.0	1.8	2.6
YIELD	1.6	1.1	0.9	0.6	4.9	-1.0	6.9	1.9	1.2	2.5
Period 3: 1985-86 to 1994-95										
AREA	2.8	0.9	-0.9	-0.8**	18.4	13.5	-0.6	-0.3	1.2**	0.1
PRDN	1.3	3.4	3.6	0.0	25.1	22.2	0.9	2.1	3.6**	3.3**
YIELD	-1.5	2.5	4.5	0.8	5.7***	7.6*	1.4	2.4	2.4*	3.2**
Period 4: 1995-96 to 2004-05										
AREA	0.9	-0.4	0.7	0.4	-1.9	3.9***	-1.0	-0.3	0.0	-0.8
PRDN	2.0	1.2	1.4	4.7**	0.1	8.1*	-0.6	4.3	1.9	0.4
YIELD	1.1	1.5	0.7	4.3**	2.0	4.2	0.5	4.6	1.9**	1.3
Period 5: 2005-06 to 2014-15										
AREA	0.9*	1.0	5.4	0.8**	-7.4	1.3	-2.0	1.0	1.1	0.1
PRDN	6.9**	6.0**	1.8	5.6**	0.8	5.2	-0.1	3.0**	5.2**	2.5*
YIELD	6.0**	5.0**	-3.4	4.9**	8.	3.8	2.0**	2.0**	4.1***	2.3**
Entire Period: 1966-67 to 2014-15										
AREA	2.9***	0.4***	0.5	0.2*	1.7***	3.7**	-0.5	-0.22	0.7***	-0.0
PRDN	4.1***	2.0***	1.6***	1.9***	2.9	7.0***	0.6	2.4	2.3***	2.3***
YIELD	1.2***	1.5***	1.1**	1.7***	1.7	3.2***	1.1***	2.6	1.6***	2.3***

***, ** and * refer to significant at 1%, 5% and 10%, respectively. NA: Not applicable

When table 1 is looked state-wise over the different periods, the following discussions can be drawn.

Arunachal Pradesh: Best performance of growth in area, production and yield among the five periods was found in Period 5(2005-06 to 2014-15) due to gradual increase of production without any break in the period. While, the least performance was noticed in period 3 (1985-86 to 1994-95) where negative growth was observed in yield due to sharp downfall of production in 1994-95. Growth in area, production and productivity in the entire period was significantly positive. Hence, period 5 performed best followed by period 2 (1975-76 to 1984-85).

Assam: Assam achieved the highest significant growth in area, production and yield during period 5 due to the dramatic increase in production during the last three years of the period. Period 1 performed least though figures are not significant. Production and yield had positive growth rates in every period while there was negative growth of area in period 4 which are statistically non-significant. Growth in area, production and productivity in the entire period was significantly positive.

Manipur: Growth in production and yield in period 1 were negative. Yield showed positive growth in period 2, but area and production remained negative. Both yield and production became positive in period 3 and when it reaches period 4 all the entities became positive. But in period 5 situations again changed resulting in negative growth rate of yield. However as far as entire period is concerned all are positive with significant production and yield growth.

Meghalaya: Period 4 and 5 may be regarded as the best two decades in the foodgrain growth history of Meghalaya. Though, growth in area, production and yield during the first three decades did not perform well, there was a significant positive growth in production and yield during the last two decades.

Mizoram: Period 3 may be regarded as the best performing one among the five study periods in terms of growth inarea, production and yield while period 2 has negatively significant growth in area and production. Decrease in growth of area was witnessed in the last two decades i.e. period 4 and 5. However in the entire period, growth of area was found significant which is due to dramatic increase in area during period 1 and 3.

Nagaland: Nagaland's performance in period 1 and 2 were worse. But period 3 onwards growth performance of the state in area, production and yield of foodgrain was consistent and the state performs best among the states of the region as far as growth of area, production and yield of foodgrain in the entire period is concerned. Highest growth in area, production and yield were observed in period 3. In the entire period too all the figures are significantly positive.

Sikkim: Sikkim started from period 2 where area, production and yield growths were positive. From period 3 onwards area and yield become negative growth. Even in the entire period, area showed negative growth while production and yield were positive. Hence growth rates of area, production and yield of foodgrain in Sikkim are not well performed as compared to other states except Mizoram.

Tripura: Period 5 was the best performed decade in case of Tripura when growth in area, production and yield of foodgrain are concerned where figures are all positive with significant growth in production and yield. However, Tripura had negative growth in area during period 2, 3 and 4. In the entire period too significant negative growth in area was observed.

NER: When NER is considered all the figures of growth rate of area, production and yield are positive except the area growth in period 4. Here also period 5 was the best performing followed by period 3. Growth in area, production and yield of the entire period was found positive and significant though there was disparity among the individual states. Similar results were also observed during the study of dynamics of cereals production in the states of north eastern region of India by N. U Singh et al. (2018).

India: In case of India period 3 was performing best among the periods. . The rationale for focusing towards foodgarins was for triggering agricultural development is on account of its contribution to poverty reduction through higher employment generation, higher potential for value addition and for generating foreign exchange (Singh, 2008). Decrease in the area of foodgrain was found in the period 4 and entire period. Growth in production and yield of the entire period was found positive and significant.

For Arunachal Pradesh, Assam, Meghalaya and Tripura, period 5 i.e. 2005-06 to 2014-15 was the best performing period where it was found significant positive growths in production and yield for the said states while Mizoram and Nagaland showed better performance of growth in period 3. Though growth performance of Manipur was better in period 4, rest of the periods did not show any significance. Sikkim was found least performing among the states while Nagaland, on an average, may be regarded best performer over the five study periods as far as growth of area, production and yield are concerned. Hence on an average period 5 is leading among the periods while period 1 or 2 is the most behind. The findings were almost similar with the findings of the study on Food Security in North-East Region of India by Roy et al., (2015).

Relative contribution of area, productivity and their interaction to the change of production growth

The growth analysis (area, production and yield) of foodgrain revealed the general pattern of growth and direction of changes in yield and area. But does not evaluate the contribution of area and yield towards the production growth. So, it is necessary to examine the sources of output growth. To appraise the sources of output growth, the change in production was divided into three effects i.e., area effect, yield effect and interaction effect. With the help of this additive decomposition model the relative contribution of area, productivity and their interaction on foodgrain production in the states of NER for different periods (1966-67 to 1974-75, 1975-76 to 1984-85, 1985-86 to 1994-95, 1995-96 to 2004-05 and 2005-06 to 2014-15 and overall period 1966-676 to 2014-15) had been estimated and presented in table 2.

Table 2 can be viewed in two distinct parts. First part is Period 1 and 2 where the relative contribution to the change of foodgrain production is dominated almost equally by area effect and yield effect though area effect has little more dominancy. Second part is period 3, 4 and 5 where yield effect is the major contribution to the change of foodgrain production. Hence, change in production growth of foodgrain in period 1 was due to area expansion in Arunachal Pradesh, Manipur, Meghalaya, and Mizoram while it was yield improvement in Assam, Nagaland and Tripura. In period 2 area effect had more control, only Manipur Sikkim and Tripura had yield effect as main contribution to the change in output growth. In period 3 except Mizoram and Nagaland, rest of the states revealed that relative contribution of yield was more than that of area and interaction. Again, in period 4, all the states showed yield effect more contributory except Sikkim where main contribution was area effect. In period 5, all the states, NER and India registered yield effect as major contributor except in Manipur and Mizoram where the effect was due to area expansion. In the entire period Assam, Meghalaya, Nagaland, Tripura, NER and India had yield effect as main contributor and that of Manipur, Mizoram and Sikkim were area effect while Arunachal Pradesh had interaction effect as their main effect to the change of production of foodgrain. Managing demand supply imbalances and potential elimination of inefficiency along the supply chain would positively influence the foodgrain production in the country.

Table 2. Relative percentage contribution of area, yield and their interaction in the change of foodgrain production in NER

State	AR	AS	MN	ML	MZ	NL	SK	TR	NER	India
Period 1: 1966-67 to 1974-75										
ΔP	100	100	100	100	100	100	NA	100	100	100
$A_0\Delta Y$	15	53	-531	-81	-12	459	NA	57	42	81
$Y_0\Delta A$	75	43	718	183	147	-183	NA	32	52	14
$\Delta A\Delta Y$	10	4	-87	-2	-34	-176	NA	11	6	4
Period 2: 1975-76 to 2014-15										
ΔP	100	100	100	100	100	100	100	100	100	100
$A_0\Delta Y$	22	13	202	38	-8	12	48	866	46	107
$Y_0\Delta A$	65	86	-80	58	101	97	43	-674	51	-6
$\Delta A\Delta Y$	13	1	-22	4	7	-9	9	-92	3	-1
Period 3: 1985-86 to 1994-95										
ΔP	100	100	100	100	100	100	100	100	100	100
$A_0\Delta Y$	-1371	93	115	63	2	6	84	132	60	80
$Y_0\Delta A$	2138	6	-10	40	67	60	14	-27	35	16
$\Delta A\Delta Y$	-667	1	-5	-4	31	34	1	-5	5	4
Period 4: 1995-96 to 2004-05										
ΔP	100	100	100	100	100	100	100	100	100	100
$A_0\Delta Y$	52	3001	37	89	2638	39	-100	81	148	247
$Y_0\Delta A$	45	-2645	56	7	-2129	48	191	16	-43	-125
$\Delta A\Delta Y$	3	-255	7	4	-409	13	9	2	-6	-22
Period 5: 2005-06 to 2014-15										
ΔP	100	100	100	100	100	100	100	100	100	100
$A_0\Delta Y$	80	88	-454	79	20	53	880	76	78	87

State	AR	AS	MN	ML	MZ	NL	SK	TR	NER	India
$Y_0\Delta A$	13	8	823	12	87	37	-668	19	16	11
$\Delta A\Delta Y$	7	4	-269	9	-7	10	-111	5	6	2
Overall Period: 1966-67 to 2014-15										
ΔP	100	100	100	100	100	100	100	100	100	100
$A_0\Delta Y$	15	66	-30	78	17	47	105	90	54	90
$Y_0\Delta A$	37	14	150	9	50	8	-3	3	20	3
$\Delta A\Delta Y$	48	19	-20	13	33	45	-2	7	26	7

ΔP: Change in Production. $A_0\Delta Y$: Yield Effect. $Y_0\Delta A$: Area Effect. $\Delta A\Delta Y$: Interaction Effect. NA: Not applicable.

When table 2 is viewed state wise over the five periods, it is observed that yield effect is more contributory in all the states except in Mizoram in which period 4 is the only period where yield effect is dominating. The distribution of these effects in the five periods among the eight states of the region with reference to table 2 is in the ratio 22:16:1 for yield effect: area effect: interaction effect. Hence, production in the region has increased as a result of yield improvements closely followed by area expansion.

From the above discussions, an idea of instability, rather fluctuation in the growth of area, production and yield of each state over the different five periods can be vividly captured. In the entire period, though, Nagaland witnessed highest growth rates in area, production and yield; its fluctuation is just second to Mizoram. Also, it's clear from the figures that area is more fluctuated than production and in turn production is more fluctuated than yield. Again, if we go year wise, it can be shown that instability in the growth of area, production and yield decreases over the span of years. However, detailed instability analysis on area, production and yield can be made using appropriate instability index.

Instability analysis

State-wise instability was estimated to find dispersion and compare the change in instability over time among the states of NER. Variability in agricultural production consists of variability in area and yield and their interactions. Different events may affect area and yield in the same, opposite or different way. Instability in area, production and yield of foodgrain experienced at the state level in NER during the study period have been presented in table 3.

Period1 (1966-67 to 1974-75): Highest instability in area and production were observed in Mizoram (50.99 and 54.13) followed by Nagaland in area (46.70) and Arunachal Pradesh in Production (43.11) while, highest instability in yield was observed in Nagaland (46.78) followed by Arunachal Pradesh. The most stable state in NERwas Tripura (1.87) followed by Meghalaya (2.90) while production and yield were found most stable in Meghalaya (4.71 and 3.18). In case of NER Production (8.14) was comparatively more instable than area (5.03) and yield (4.77). NER was more stable in production and yield than Nation as a whole during this period.

Period 2 (1975-76 to 1984-85): Instability in area, production and yield were highest in Mizoram (area: 61.37, production: 67.20 and yield: 44.46) followed by Nagaland (area: 41.33, production: 48.94 and yield: 23.27) while, the most stable state in NER was Assam (3.01) followed by Sikkim (3.08). Meghalaya was most stable with regard to production (4.72) and yield (4.34) followed by Sikkim (production: 9.20 and yield: 6.34). Similar to period 1,in NER production (11.72) was comparatively more instable than area (3.47) and yield (9.48). Similar pattern was also found for India as a whole.

Period 3 (1985-86 to 1994-95): Mizoram was still persisting with highest instability in area (67.41) and production (64.09) followed by Nagaland (area: 53.48 and production: 47.73) while least stable state in yield was Manipur (21.82) followed by Nagaland (15.59). Meghalaya was found most stable in area (1.17) and production (9.27) followed by Assam (area: 3.12 and production: 9.61) while yield of Sikkim (4.20) was most stable followed by Mizoram (6.33). As usual, in NER, area (1.71) was more stable than yield (6.73) and production (7.16).

Period 4 (1995-96 to 2004-05): Mizoram, in this period too was having highest fluctuation in area (13.18) followed by Manipur (7.52) while highest instability in production (30.01) and yield (31.91) were observed in Tripura followed by Nagaland (production:18.68 and yield: 18.05). Least fluctuation in area (2.84) was found in Meghalaya followed by Sikkim (3.12) while least instability in production (6.68) was found in Sikkim followed by Arunachal Pradesh (6.99). Yield was least fluctuated in Assam (3.89) followed by Manipur (4.07). In NER, production and yield were more stable than previous periods while, fluctuation in India was not less than the previous periods.

Period 5 (2005-06 to 2014-15): Till this last period of study, Mizoram could not escape from being the highest instability in area (36.16), production (67.62) and yield (62.93) followed by Manipur in area (25.93) and production (35.43); and Nagaland in yield (20.41). Most stable state in area was

Meghalaya (1.14) followed by Arunachal Pradesh (1.66) while most stable in production and area was found in Tripura (production: 4.28 and yield: 3.45) followed by Arunachal Pradesh in Production (5.52) and Sikkim in yield (3.89). For NER and India, patterns similar to previous periods were observed.

Entire period (1966-67 to 2014-15): As a consequence, in the entire period too, Mizoram was highest instable in area (50.92), production (57.39) and yield (34.42) followed by Nagaland (area: 37.18, production: 36.56 and yield: 25.97) while least instability in area (2.41) and production (8.44) were captured in Meghalaya again followed by Assam in area (4.20) and Sikkim in production (8.71). Least fluctuation yield was also observed in Sikkim (5.04) followed by Assam (7.62). For NER and India, in all the decades as well as the entire period, production was more fluctuating and area as expected was least fluctuated. Agriculture growth and instability have always been a major issue of concern to the agricultural economists in India. Increasing production crops is the need of the hour both at national and international levels for meeting food and nutrition requirements of the growing population. Increasing instability has adverse effect for several reasons. It up scales the production risks and affects the income of the farming community. It also restricts the cultivator from making investment in farming and adopting high paying technologies. Instability in agricultural and food production is also important for food management and macroeconomic stability (Chand *et al.* 2008).

Table 3. Instability in area, production and yield of foodgrain in NER.

State	AR	AS	MN	ML	MZ	NL	SK	TR	NER	India
Period 1: 1966-67 to 1974-75										
AREA	16.9	6.7	8.8	2.9	51.0	46.7	NA	1.9	5.0	3.9
PRDN	43.1	10.6	25.1	4.7	54.1	27.3	NA	27.8	8.1	11.1
YIELD	28.5	7.6	21.1	3.8	10.7	46.8	NA	26.6	4.8	8.0
Period 2: 1975-76 to 1984-85										
AREA	21.6	3.0	9.6	3.2	61.4	41.3	3.1	7.3	3.5	2.9
PRDN	11.2	13.2	15.6	4.7	67.2	48.9	9.2	13.4	11.7	11.2
YIELD	15.0	10.9	9.8	4.3	44.5	23.3	6.3	10.2	9.5	8.9
Period 3: 1985-86 to 1994-95										
AREA	12.4	3.1	4.1	1.2	67.4	53.5	8.7	6.9	1.7	4.4
PRDN	10.0	9.6	23.7	9.3	64.1	47.7	10.9	9.8	7.2	7.1
YIELD	14.4	7.8	21.8	9.7	6.3	15.6	4.2	9.7	6.7	6.0
Period 4: 1995-96 to 2004-05										
AREA	3.0	3.6	7.5	2.8	13.2	4.6	3.1	5.4	2.1	4.4
PRDN	7.0	7.1	10.8	10.8	11.2	18.7	6.7	30.0	5.1	10.8
YIELD	5.9	3.9	4.1	8.8	6.9	18.1	6.0	31.9	3.5	8.1
Period 5: 2005-06 to 2014-15										
AREA	1.7	4.4	25.9	1.4	36.2	4.8	5.1	3.9	3.5	2.5
PRDN	5.5	11.2	35.4	8.6	67.6	21.3	6.2	4.3	7.3	5.8
YIELD	6.7	7.6	14.4	8.1	62.9	20.4	3.9	3.5	5.1	4.8
Entire Period: 1966-67 to 2014-15										
AREA	13.2	4.2	12.8	2.4	50.9	37.2	5.9	5.5	3.3	3.6
PRDN	19.6	10.2	22.3	8.4	57.4	36.6	8.7	19.1	7.9	9.2
YIELD	15.7	7.6	15.1	7.7	34.4	26.0	5.0	18.9	6.1	7.1

NA: Not Applicable.

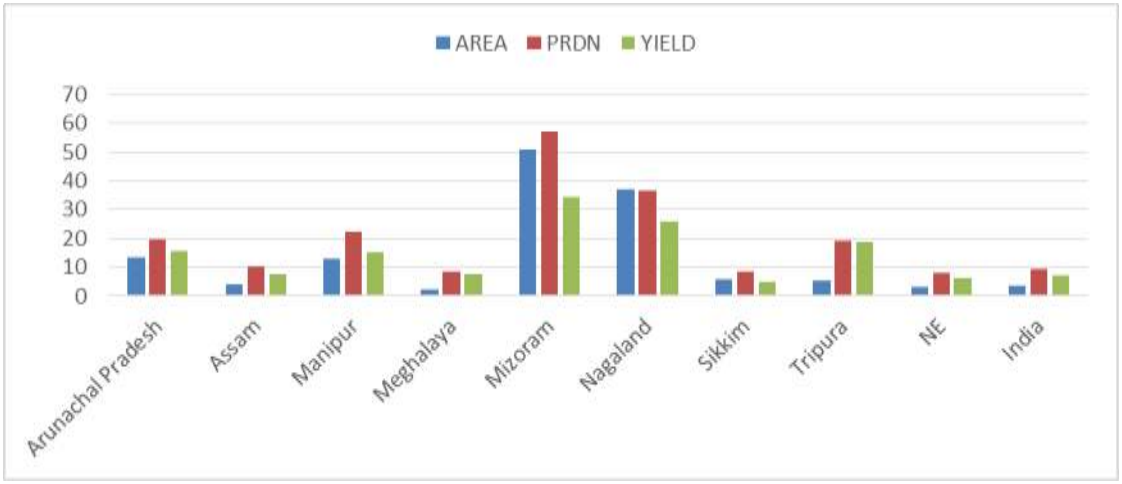

Figure 1. State wise instability index of area, production and yield of foodgrain during 1966-67 to 2014-15.

Mizoram followed by Nagaland registered comparatively highly instable in area, production and yield in all the periods while Sikkim, Meghalaya and Assam were found comparatively more stable. Arunachal Pradesh, Manipur and Tripura were lying in between the two situations (Figure 1).

It is clear that, production is more fluctuating and area is least fluctuating indicating the respective degree of risk of area, production and yield in growing foodgrain in the region. Among the five study periods, period 1 was found most fluctuated in area (5.03) followed by period 5 (3.48) while period 2 was found most fluctuated in production (11.72) and yield (9.48) followed by period 1 in production (8.14) and period 3 in yield (6.73). Period 3 had the most stable in area (1.71) followed by period 4 (2.06) while period 4 had most stable in production (5.12) and yield (3.51) followed by period 3 in production (7.16) and period 1 in yield (4.77). However, in all he periods instability index of area, production and yield of NER was below 9 except in period 2 where instability index of production and yield were 11.72 and 9.48 respectively.

4. Conclusion

Temporal analysis of five decades reveals that growth rate performance in the region, among the five periods, period 1 (1966-67 to 1974-75) has achieved the highest growth in area followed by period 3 (1985-86 to 1994-95). Lowest growth in area has been observed in period 4 (1995-96 to 2004-05) followed by period 2 (1975-76 to 1984-85). Highest significant growths in production and yield have been achieved by period 5 followed by period 3. Lowest growth in production and yield have been observed in period 2 followed by period 4 in production and period 1 in yield. On an average, period 5 (2005-06 to 2014-15) may be regarded as the best performer in the growth of foodgrain among the five study periods. In the entire period the growth performance of yield of all the states reveals highly significantly accelerating except in Mizoram and Tripura. On an average among the states Nagaland registered the highest significant growth in area (3.73%) production (7.03%) and yield (3.19%) followed by Arunachal Pradesh. In the entire period all the states witness positive and almost significant figures in area except Sikkim and Tripura while Production and yield growth are all positive and almost significant in all the states.The decomposition analysis has revealed that relative contribution of yield effect (54%) to the change of output growth is more than that of area effect (20%) and interaction effect (26%) for the region during the overall period from 1975-76 to 2014-15. Hence, production in the region has increased as a result of yield improvements followed by area expansion. Comparatively Meghalaya was more stable in foodgrain production while Mizoram and Nagaland were more instable. Also as expected, foodgrain production of the region is more instable as compared to area and productivityduring all the study periods. Though the production is improving over the years the states like Mizoram and Sikkim are behind in the overall performance of growth. Also the production patterns of states like Mizoram, Nagaland are comparatively very unstable and productivity of the region is below national average. The scope of meeting this requirement of the states depend highly on productivity improvement and introduction of state specific or location specific agricultural technologies and strategies that can adapt the respective individual nature in terms of soil, traditional farming practices, changing climatic conditions, socio-economic conditions, states own policies, etc.More effective and efficient ways of using land resources must be adopted. The abundant natural resources, congenial climate and rich human capital of the region should be of huge opportunities for societal welfare. In fact socio

economic development of the region is not dependent only on a single solution but on a complex set comprising socio-economic, geo-political, biophysical, technological and governance. Therefore, a synergy is needed among the interdisciplinary research community, policy planners and implementers, along with civil society to deal with the multifaceted situation.

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