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Growth and Fluctuation of Productivity of Total Food Grain for the State of Assam VIS-A-VIS All India since 1950-51 to 2009-10

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Abstract
The paper makes an attempt to estimate the nature of growth, break and fluctuation of productivity of total foodgrain in Assam as compared to all India, in the period 1950-51 to 2009-10. Breaks in the growth paths have been evaluated by the modified Bai-Perron methodology and fluctuations around the growth path have been decomposed into year to year fluctuation and cyclical fluctuation by using modified Cuddy-Della Valle and modified Coppock methodologies. The entire research work is based on secondary data of productivity of total foodgrain in India collected from "Directorate of Economics and Statistics", Ministry of Agriculture, and different issues of Statistical Abstract, Govt. of India.

Keywords: food grain, productivity, growth, break, fluctuation

1. Introduction
In Indian economy agriculture has got a prime role. It is described as the back bone of the Indian economy, because agriculture in India is the most important source of employment. Presently, agriculture offers employment to nearly 52.1 percent of the working population. Agriculture sector contributes a significantly large share to the national income of India, although it has come down from 56 percent to 14.6 percent in between 1950 to 2010. In Assam majority of the population (86 percent) lives in the rural areas where the mainstay of business is production of agriculture (Gogoi *et al*, 2013) [14]. The economy of Assam is mainly a rural based economy and this economy basically depends on agriculture, which accounts for the livelihood of about four-fifths of the state's population and more than 75 percent of the workforce directly and indirectly is engaged in agriculture and allied activities. Out of total geographical of 78.43 lakh hectares, 41.60 lakh hectares are the total cropped area and 35.83 is under net sown area covering 28.11 lakh hectares (2011 census). Although Assam is world famous for tea but it also has a significant role in the food grain production in India.
According to the 2011 census in India, population growth and declining land-man ratio, the density of population in the country is 382/ km^2 against 117/ km^2 in 1951. Now, India is a densely populated country. The economists are more concern about rapid growth of population over the years. It creates pressure on agricultural land but the agricultural land is limited. Therefore to meet the needs of the growing population productivity can play a crucial role. We may increase agricultural productivity through various measures like irrigation, new technology, high yielding varieties seeds, fertilizer, etc.
A number of studies are available in the literature on various aspect of agricultural development such as growth in area, production and yield of different crops, source of growth, changes in the cropping pattern, input uses, extent of inequality source of instability and so on, Boyce has shown that the approach for the measurement of sub-period growth rates used so far suffers from "discontinuity bias". To overcome this difficulty Boyce has introduced a new approach in which "kinked exponential model" is fitted for estimating sub-period growth rates. D. Mondal and S. De concluded that the growth of productivity of total foodgrain has significantly decreased after the adoption of new economic policy in India and they also observed that in the recent years (2003-04 to 2009-10) growth of productivity of total foodgrain has significantly increased. In the Indian context, Dev found that besides variations in rainfall the differences in the extent and quality of irrigation were also important to explain interstate disparities in growth and stability.

The growth performance of agriculture at the national level was splendid during the 1980s and its deceleration during the 1990s was attributed to the reduction in and/or stagnation of public expenditure on agricultural infrastructure, defunct extension services and economic reforms. Parikh argued that "though after 1980's, India achieved self-sufficiency in food grain production but there is no surety that this achievement would be sustained". G. Bhala and G. Singh concluded that the growth rate of crops yields as well as total agricultural output in most of the states have decreased in the post reform period(1990-93 to2003-06) than the pre reform period (1980-83 to 1990-93). R.P.S Mallik has found that the trend of growth of the agricultural production as well as the crops productivity has decreased after the adoption of liberalization policy. S K. Goyal and J. P. Singh have observed that the food grains production has increased during the period of 1960-1999. Higher growth in agriculture assumes great importance and is a matter of concern for policy planners and research scholars in recent times. An instability measure has mainly been evolved as a related issue to the growth measurement in agriculture. In regard to the measurement of instability in Agricultural production we set broadly two technique, summary measure and trend measure. The summary measure of instability was adopted by Barker *et al*. Other attributed that instability in agriculture production had increased with the adoption of new technology. Ray found that the pattern of growth and instability was due to an increase in the variability of rainfall and prices. Likewise, Rao *et al* concluded that instability in agriculture production had increased in the post green revolution period on account of rise in the sensitivity of output to variations in rainfall which was traceable to high complementary of new seed-fertilizer technology with water and inadequate expansion of irrigation facilities. But Dev reported progressive but marginally declined instability in food grain production at the all India level and mixed result as state level. All these studies covered the initial phase of the green revolution technology (late 1970s or mid 1980s). Larson *et al* concluded that the green revolution has been instrumental in increasing production of food grain and other crops in India but this has come at a cost of greater instability in production and yield, he covered a longer post green revolution period. Sharma *et al* attributed that the production of individual crops and total food grains had become more stable during 90's compared to 80's. The study by Sharma *et al*, started from year 1980-81; it did not cover the initial phase of green revolution nor did cover the pre green revolution period. According to Ramesh *et al* variability in yield of food grains as well as that of non-food grains was much lower in the first phase of green revolution period. Deviation of observed yield from trend witnessed decline during 1989-2007. Amongst the various important crops in the state, the area under rice dominated the position, sharing about 60.7 percent of the total cropped area in 2005-06 (Dhar, 2007) [13]. The state started to produce varieties of new crops along with traditional crops. The Assam Agriculture is diversifying towards high valued horticultural crops and cash crops (Deka *et al*.2013) [11]. The varying natural, socio-economic and cultural environments exercise a critical and differential effect on the adoption of modern farm technology which has resulted to disparity in agriculture (Das *et al*, 2012) [10]. The above study of literature reveals that no comprehensive study has so far been made for measuring growth, break and fluctuation in agricultural productivity at the national level. In this paper we attempt to estimate the nature of growth and fluctuation in productivity of total food grains in the state of Assam vis-à-vis all-India level. It also tries to examine whether there is any significant difference or not in the growth and fluctuation of productivity of total food grain in different sub periods. This paper also estimates the nature and extent of fluctuation of productivity of total food grain in different sub periods and for the whole period in the state of Assam vis-à-vis all India level. Fluctuations around the growth path have been decomposed into year to year fluctuation and cyclical fluctuation by using modified Cuddy-Della Valle and modified Coppock methodologies. We also calculate the length of cyclical fluctuation of productivity of total food grain for the whole period and for different sub-periods in the state of Assam vis-à-vis all-India level. Some researchers in this area use same data set and take breaks arbitrarily or at the dates of policy changes (for example, introduction of green revolution, introduction of new economic policy etc.) without examining whether they are able to produce significant breaks at those points or not. Here we identify breaks from the data and try to analyze changes in pattern of growth, and nature and extent of fluctuation in the productivity of total food grain in the different sub-periods in the state of Assam vis-à-vis all India. If policy changes actually create breaks then that will automatically incorporated in our method.

In this paper we use time series data of productivity of total food grain for all-India since 1950-51 to 2009-10, collected from "Directorate of Economics and Statistics", Ministry of Agriculture, and different issues of Statistical Abstract, Govt. of India.

Methodology

Growth and fluctuations are two common elements of time series. A uniform growth rate for the whole period is generally calculated from the log-linear regression $\ln X_t = a + rt$. (r being the rate of exponential growth) and fluctuations are generally calculated by the residuals obtained from the above regression. In majority of time series we observe different growth rates in different sub periods leading to breaks in the growth path. We get break in trend or growth path due to policy changes and this break in trend is normally estimated by separate regressions for different sub periods or by a single regression with dummy variables for different sub periods or different policy regimes.

For a data set of T years, t = 1,2….T, if we have two regimes as 1, 2, …, k and k+1, k+2, …, T, we can estimate two growth rates from a single regression with dummy variables D_1 and D_2 such that $D_1=1$ and $D_2=0$ for the first sub period and $D_1=0$ and $D_2=1$ for the second sub period. The regression equation cab be taken in the form,

$\ln X_t = a + r_1D_1t + a_2D_2 + r_2D_2t$

Here D_1t and D_2t are slope dummies for two sub periods and D2 is the intercept dummy for the second sub period. In the 1st sub period when $D_1=1$ and $D_2=0$ the equation reduces to $\ln X_t = a + r_1t$, implying that r_1 is the growth rate of the first sub period. In the second sub period when $D_1=0$ and $D_2=1$ the equation reduces to $\ln X_t = (a+a_2) + r_2t$, implying that r_2 is the growth rate in the second sub period. D2 is accommodated or a_2 is estimated to adjust the change in the intercept with a break in between two sub periods. Intercept

dummy D1 for the first sub period cannot be used. When both D_1 and D_2 are used in the same model as D_1+D_2 is always equal to 1 we shall be caught into a dummy variable trap because of perfect multicollinearity between D_1 and D_2. We can reformulate the model by totally avoiding D_1 (Many econometricians suggest to use dummy variable one less in number from the number of sub periods present). The new model takes the following form,

$\ln X_t = a + r_1t + a_2D_2 + r_2D_2t$

Where D_2 is the intercept dummy for the second sub period and D_2t is the slope dummy for the same. In the first sub period the equation reduces to $\ln X_t = a + r_1t$ as before. But in the second sub period it reduces to $\ln X_t = (a + a_2) + (r_1 + r_2)t$. Thus $(r_1 + r_2)$ is now the growth rate for the second sub period or r_2 is the difference between the growth rates of two sub periods. The advantage of this second model over the first is that in this second model we are able to test the significance of r_2, the difference between growth rates in two sub periods.

The problem with both of the above two models is that they may create discontinuity between the two growth paths estimated. To overcome this, restriction for continuity or kink is posed for the double dummy model as, $a + r_1k = (a + a_2) + r_2k$ or $a_2= (r_1 – r_2)k$. The model now reduces to,

$\ln X_t = a + r_1D_1t + (r_1- r_2)kD_2 + r_2D_2t$

or, $\ln X_t = a + r_1(D_1t + kD_2) + r_2(D_2t – kD_2)$

or, $\ln X_t = a + rJ_1 + r_2J_2$

Where, $J_1 = D_1t + kD_2$ and $J_2 = D_2t – kD_2$

This model will henceforth be called the J–Model.

In the same way restriction for continuity in the single dummy model is $a + r_1k = (a+a_2) + (r1+r_2)k$ or $a_2 = –r_2k$. The model now reduces to,

$\ln X_t = a + r_1t - r_2kD_2 + r_2D_2t$

or, $\ln X_t = a + r_1t + r_2(D_2t – kD_2)$

or, $\ln X_t = a + rH_1 + r_2H_2$, where, H1 = t and $H2 = D_2t – kD_2$

This model will henceforth be called the H–Model.

In this way we can formulate dummy variable models for calculating growth rates of three or more sub periods and for comparing growth rates between two consecutive sub periods or between two sub periods leaving one or two small sub periods in between them.

In case of measurement of fluctuation in a time series X_t, fluctuation is frequently interpreted in terms of fluctuation around the trend line. Fluctuation around the trend is generally estimated by the deviation of observed values from the estimated values in the regression mentioned above and it is denoted by e_t. The fluctuation index is obtained through the residuals sum square (RSS) $=\Sigma\ e_t^{\ 2}$ in the following way.

$$I_{RSS} = \sqrt{\frac{1}{T}\sum e_t^2} \,/\, \overline{lnX}_t$$

The numerator of the above expression is the SD of e_t and the denominator is the mean of $\ln X_t$. It is a measure very close to coefficient of variation of e_t multiplied by the square root of $(1-R^2)$ as proposed by Cuddy-Della Valle (1978).

Coppock (1962) has advocated an important methodology of measurement of fluctuation in a time series X_t. Coppock measurement of the index of fluctuation is given by $I_{coppock} = \text{Exp}(\text{SD}(\ln(\frac{Xt+1}{Xt})))$, this measurement is based on year to year fluctuation. Now, in case of comparison between the two above mention methods, we face a problem. The RSS base measure has a zero lower limit and it can go beyond one – actually it has no upper limit. The coppock measure has a lower limit at one and it has no upper limit.

To overcome this difficulty, Mondal and Mondal Saha (2008) [20] have proposed some adjustment to the above measures. The adjusted Coppock measure of fluctuation is given by $I_{coppock}' = \frac{\text{SD}(\ln(\frac{Xt+1}{Xt}))}{2\,(\overline{lnX}t)}$. This index is comparable to the RSS base index. The length of cyclical fluctuation can be calculated by squaring the value of the ratio of residuals base index divided by adjusted coppock index and then it is multiplied by 2.

In this paper we use the data set of productivity of total food grain from 1950-51 to 2009-10, for the state of Assam as well as all-India level. Some researchers in this area use same data set and take breaks arbitrarily or at the dates of policy changes (for example, introduction of green revolution, introduction of new economic policy etc.) without examining whether they are able to produce significant breaks at those points or not. Here we identify breaks from the data by assuming break at any point if it is found to be significant. A program is formulated to identify optimum break point in a line proposed by Bai and Perron (1998) [1]. Bai and Perron have proposed a minimum length of a regime/sub period of at least 5 years and developed the corresponding programme. We have developed our own programme by keeping minimum length of a regime at 5 years or so but allowing truncated regime on two ends and also short term fluctuations of one to two years in between two consecutive regimes. After identifying the break points we try to analyze changes in pattern of growth, and nature and extent of fluctuation in the productivity of total food grain in the different sub-periods for all India. If policy changes actually create breaks then it will be automatically incorporated in our method.

For the state of Assam the study period has been divided into three phases with the help of modified Bai-perron methodology. The sub periods are: sub period-I (1950-51 to 1978-79), sub period-II (1978-89 to 1989-90) sub period-III (1990-91to 2009-10), but in case of all India, the study period (1950-51 to 2009-10) has been divided into four phases. The sub periods are: sub period – I (1950-51 to 1964-65), sub period – II (1967-68 to 1979-80), sub period – III (1979-80 to 1993-94) and sub period –IV (1993-94 to 2009-10). In between sub periods – I & II, we observed a double kink of short duration. In 1965-66 there was a short downfall from 1964-65 figures and the figures were revived in next two years, because of this reason, we have excluded these three years in the determination of sub periods.

Result and Discussion

For the state of Assam (From Table – I), the growth rate of productivity of total food grain (TFG) for the whole period (1950-51 to 2009-10) was 0.91 percent, significant at 8.87E-22 level of significance. In case of sub period – I (1950-51 to 1978-79), it is estimated that the growth rate of productivity of total food grain was 0.18 percent but this growth rate was not significant. Now for the sub period – II (1978-79 to 1989-90) the growth rate of productivity was 1.22 percent and it was significant. Thus, it is observed that the growth rate of productivity has significantly increased from 0.18 percent to 1.22 percent in this period than the previous period and the difference between two sub periods growth rate also significant. In this periods Assam government was gave the importance about research and

development as well as in this period HYV technology spread properly all over the state. After the adoption of HYV technology, initially it does not work in this state because in this state maximum farmers are small and marginal they always do not have sufficient capacity to adopt this technology. Now, in case of sub periods – III (1990-91 to 2009-10), it is found that the growth rate of productivity has significantly decreased compared to the sub period – II, although the difference between two sub period growth rate was not significant. Thus we can say that after the adoption of new economic policy the growth rate of productivity of total food grain has decreased significantly. But in this phase we noticed that foodgrain productivity steep up in larger amounts then it follows an increasing trend, the main reason is that in this time Assam government was launched 'The special Foodgrain Production Programme' (SFPP).

In case of all India, it is observed that the growth rate of productivity of total food grain for the whole period (1950-51 to 2009-10) was 2.21 percent and it was highly significant at 1.01E-47 level of significance. In the sub periods – II (1967-68 to 1979-80), the growth rate of productivity has decreased from 2.09 percent (sub period – I) to 1.88 percent, although the difference between two sub periods growth rates was not significant. Thus, we can say that after the adoption of green revolution technology (HYV seed, fertilizer technology) growth rate of productivity has decreased, actually initially this technology does not implemented properly in every state of India. In case of sub period –III (1979-80 to 1993-94), it is calculated that the growth rate of productivity has highly increased from 1.88 percent to 3.13 percent and the difference between two sub periods growth rate was significant. Therefore, in the later phase of green revolution the growth rate has increased rapidly because in this phase green revolution technology was spread almost in every state. Now, in the sub period – IV, (1993-94 to 2009-10) the growth rate of productivity was 1.27 percent, thus in the comparison to the previous period the growth rate of productivity has highly decreased and this fall was significant. Thus, after the adoption of new economic policy in India, agricultural sector was neglected.

Table I: Growth of productivity of total food grain for the state of Assam and all India

Assam			
Periods	**Growth Rates (%)**	***T-Value***	***P-Value***
Full period (1950-51 to 2009-10)	0.91	15.38	3.87E-22
Sub period- I(1950-51 to 1978-79)	0.18	1.85	0.0694
Sub period- II(1978-79 to 1989-90)	1.22	4	0.0001
Sub period- III(1990-91 to 2009-10)	0.86	4.44	0.0047

Difference between Sub periods growth rates (Assam)			
Difference	**Growth Rates (%)**	***T-Value***	***P-Value***
Difference between Sub period-I & II	1.03	2.78	7.30E-03
Difference between Sub period-II &III	-0.35	-0.97	0.3329

All India			
Periods	**GROWTH RATES (%)**	***T-VALUE***	***P-VALUE***
Full period (1950-51 to 2009-10)	2.21	46.71	1.01E-47
Sub period- I(1950-51 to 1964-65)	2.09	7.73	2.95E-10
Sub period- II(1967-68 to 1979-80)	1.88	7.09	3.29E-09
Sub period- III(1979-80 to 1993-94)	3.13	16.71	8.85E-23
Sub period- IV(1993-94 to 2009-10)	1.27	6.85	7.59E-09

Difference between Sub periods growth rates (all India)			
Difference	**Growth Rates (%)**	***T-Value***	***P-Value***
Difference between Sub period-I & II	-0.22	-0.57	0.5662
Difference between Sub period-II &III	1.25	3.06	0.0033
Difference between Sub period-III &IV	-1.85	-5.52	1.03E-06

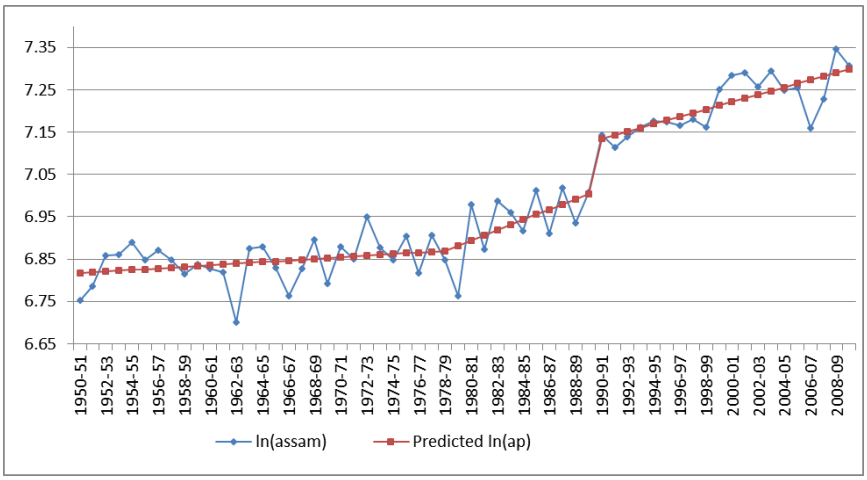

Fig 1a: Growth of productivity of total food grain for the state of Assam

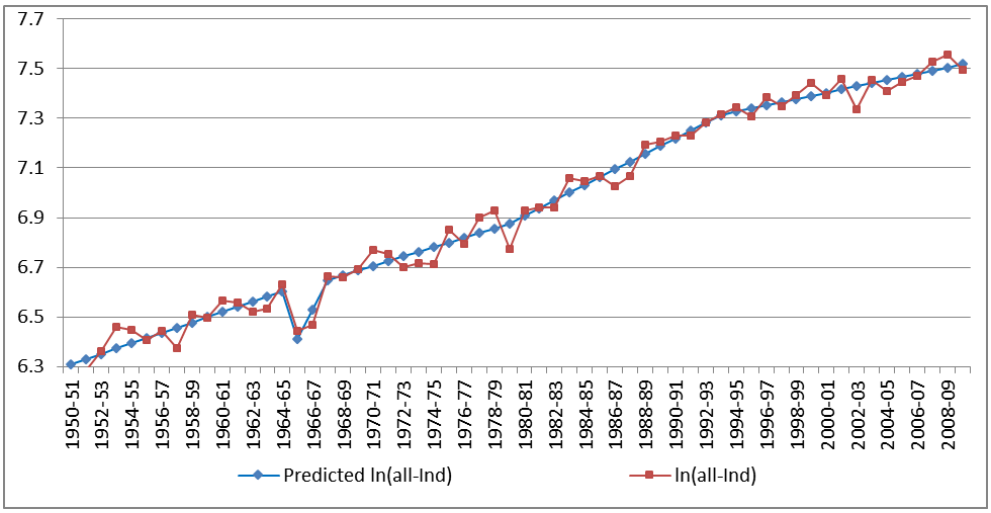

Fig 1b: Growth of productivity of total food grain for all India

In the Table – II, for the state of Assam, it is observed that the growth rate of productivity of total food grain for the whole period was 0.91 percent, where as in case of all India it was 2.21 percent. Therefore, in comparison to all India the growth rate of productivity for the state of Assam was much lower since 1950 to 2010. In case of sub period – II, the growth rate of productivity of total food grain has increased significantly than the sub period – I, for the state of Assam (from 0.18% to 1.22%) as well as in the case of all India (1.92% to 3.01%) also. Now, in the sub period – III, that is from 1990-91 to 2009-10 the growth rate of productivity has significantly decreased than the previous period for the state of Assam (from 1.22% to 0.86%) as well as all India (3.01% to 1.41%), but in the case of all India growth rate has decreased more than proportionately than the Assam. Therefore, after the adoption of new economic policy in India growth rate has significantly decreased in all India as well as Assam.

Table II: Growth of productivity of total food grain for the state of Assam and all India according to optimum breaks found in Assam

Assam			
Periods	**Growth Rates (%)**	***T-Value***	***P-Value***
Full period (1950-51 to 2009-10)	0.91	15.38	3.87E-22
Sub period- I(1950-51 to 1978-79)	0.18	1.85	0.0694
Sub period- II(1978-79 to 1989-90)	1.22	4	0.0001
Sub period- III(1990-91 to 2009-10)	0.86	4.44	0.0047

Difference between Sub periods growth rates (Assam)			
Difference	**Growth Rates (%)**	***T-Value***	***P-Value***
Difference between Sub period-I & II	1.03	2.78	7.30E-03
Difference between Sub period-II &III	-0.35	-0.97	0.3329

All India			
Periods	**GROWTH RATES (%)**	***T-VALUE***	***P-VALUE***
Full period (1950-51 to 2009-10)	2.21	46.71	1.01E-47
Sub period- I(1950-51 to 1978-79)	1.92	17.64	2.6E-24
Sub period- II(1978-79 to 1989-90)	3.01	9.2	1E-12
Sub period- III(1990-91 to 2009-10)	1.41	6.77	8.86E-09

Difference between Sub periods growth rates (All India)			
Difference	**Growth Rates (%)**	***T-Value***	***P-Value***
Difference between Sub period-I & II	1.09	2.73	8.20E-03
Difference between Sub period-II &III	-1.59	-4.1	0.0001

Table III: Growth of productivity of total food grain for the state of Assam and all India according to optimum breaks found in all India

ALL INDIA			
Periods	**Growth Rates (%)**	***T-Value***	***P-Value***
Full period (1950-51 to 2009-10)	2.21	46.71	1.01E-47
Sub period- I(1950-51 to 1964-65)	2.09	7.73	2.95E-10
Sub period- II(1967-68 to 1979-80)	1.88	7.09	3.29E-09
Sub period- III(1979-80 to 1993-94)	3.13	16.71	8.85E-23
Sub period- IV(1993-94 to 2009-10)	1.27	6.85	7.59E-09

Difference between Sub periods growth rates (all India)			
Difference	**Growth Rates (%)**	***T-Value***	***P-Value***
Difference between Sub period-I & II	-0.22	-0.57	0.5662
Difference between Sub period-II &III	1.25	3.06	0.0033
Difference between Sub period-III &IV	-1.85	-5.52	1.03E-06

Assam			
Periods	**Growth Rates (%)**	***T-Value***	***P-Value***
Full period (1950-51 to 2009-10)	0.91	15.38	3.87E-22
Sub period- I(1950-51 to 1964-65)	0.07	0.22	0.8204
Sub period- II(1967-68 to 1979-80)	0	0.02	0.978
Sub period- III(1979-80 to 1993-94)	2.07	9.36	8.06E-13
Sub period- IV(1993-94 to 2009-10)	0.96	4.36	5.99E-05

Difference between Sub periods growth rates (Assam)			
Difference	**Growth Rates (%)**	***T-Value***	***P-Value***
Difference between Sub period-I & II			
Difference between Sub period-II &III	2.06	4.28	7.78E-05
Difference between Sub period-III &IV	-1.11	-2.8	0.007

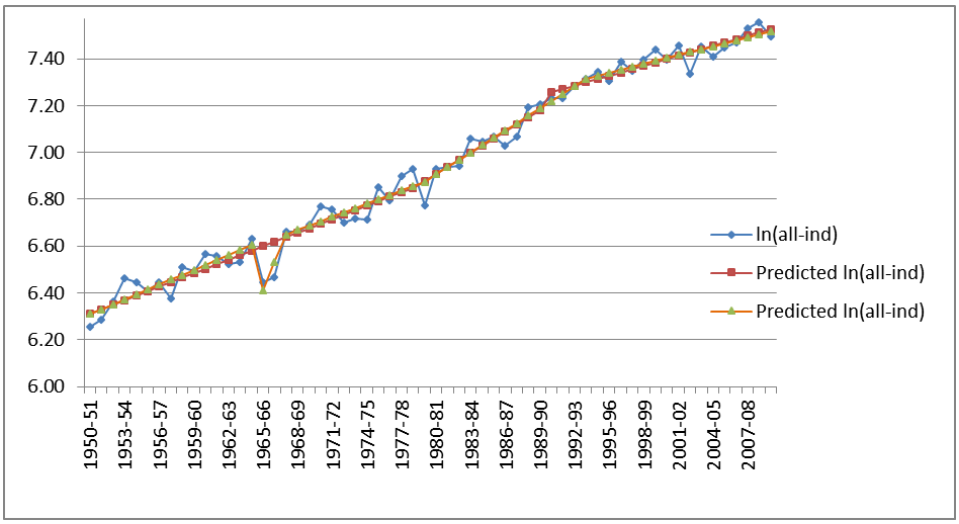

Fig 2: Growth of productivity of total food grain for all India according to optimum breaks found in Assam

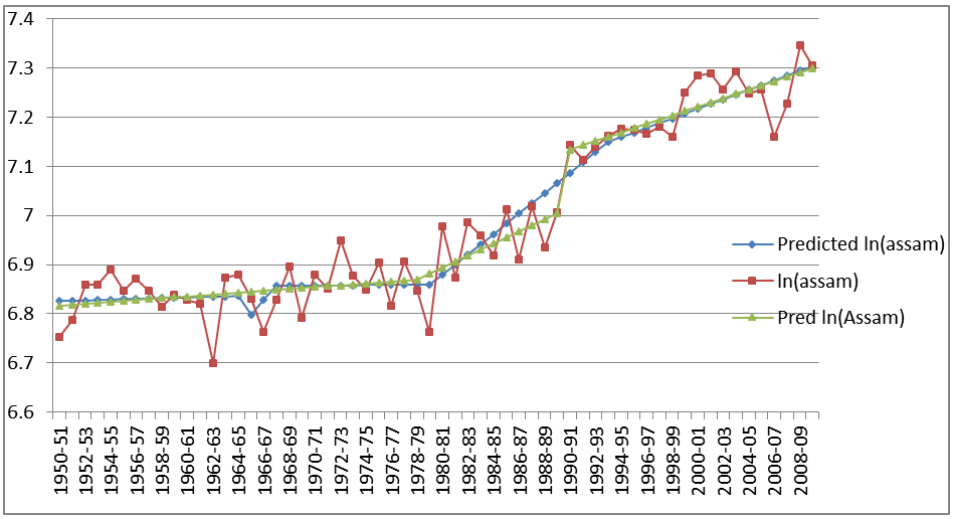

Fig 3: Growth of productivity of total food grain for the state of Assam according to optimum breaks found in all India

In case of all India (From Table – III), the growth rate of productivity of total food grain was 2.09 percent for the sub period – I, and it was significant. In this phase the growth rate was very much lower (0.07) for the state of Assam. Thus, in the pre green revolution period growth rates of productivity for Assam much lower than the all India. Now, in the sub period – II, the growth rate of productivity has significantly decreased from 2.09 percent to 1.88 percent than the previous period, but in the state of Assam it is noticed that, in this phase the growth rate of productivity

was nil. Thus, in the initial phase of green revolution the growth rate of productivity has decreased in all India but for the state of Assam zero growth rates observed. Now, in the later phase of green revolution period that is in the sub period – III, the growth rate of productivity of total food grain has significantly and highly increased in case of all India (from 1.88% to 3.13%) as well as for the state of Assam (from 0.00% to 2.07%) also. Therefore, in the second wave of green revolution in all India level the growth rate of productivity has significantly increased, because in the later phase of green revolution the HYV technology spread properly in almost every state. Now, after the adoption of new economic policy in India that is in the fourth sub period (1993-94 to 2009-10) the growth rate of productivity of total food grain has decreased significantly in all India (from 3.13% to 1.27%) level as well as in the state of Assam (from 2.07% to 0.96%) also and the difference between two sub periods growth rate also significant for the state of Assam as well as all India.

With the help of the fluctuation from trend we can measure the fluctuation of productivity of total food grain. For the state of Assam (From Table - IV), the fluctuation of productivity of total food grain from the growth path of total food grain amounts to 0.0112(44.35%) for the whole period (1950-51 to 2009-10) and year to year fluctuation in total fluctuation in total variation of productivity of total food grain was 46 percent and rest 54 percent fluctuation was arises due to partly break in trend, partly cyclical fluctuation or irregular fluctuation. In case of sub period – I, the fluctuation in total variation of productivity of total food grain amounts to 95 percent of total variation and in the fluctuation in total variation of productivity, year to year fluctuation was 71 percent and rest percentage fluctuation was arises due to partly cyclical fluctuation or irregular fluctuation. For the sub periods – II, it is observed that the fluctuation in total variation of productivity in the total variation of productivity of total food grain has decreased from 95 percent to 78 percent with the comparison to the previous period but the year to year fluctuation has increased from 71 percent to 88 percent and it also observed that the length of cyclical fluctuation has increased than the sub periods – I, therefore, we can say that in the later phase of green revolution, although the fluctuation of productivity of total food grain has decreased but the length of cyclical fluctuation has increased because year to year fluctuation has increased in this phase compared to the previous periods (sub period - I). Now, in the sub period –III, it is found that the fluctuation in total variation of productivity of total food grain was decreased from 78 percent to 63 percent compared to the previous period out of total variation and the year to year fluctuation also decreased 10 percent from the sub period – II, and in this periods length of cyclical fluctuation also decreased. Thus, after the adoption of new economic policy in India, the fluctuation in productivity of total food grain was more stable than the previous periods.

Table 4: Nature and extent of fluctuation of productivity of total food grain for the state of Assam vis-à-vis all India according to optimum breaks found in Assam

Assam			
Periods	**Year to year fluctuation**	**Fluctuation from trend**	**Length of Cycle**
Full period (1950-51 to 2009-10)	0.0052(46.12%)	0.0112(44.35%)	9.39
Sub period- I(1950-51 to 1978-79)	0.0049(71.05%)	0.0069(94.74%)	3.96
Sub period- II(1978-79 to 1989-90)	0.0073(88.55%)	0.0083(78.31%)	2.55
Sub period- III(1990-91 to 2009-10)	0.0038(66.48%)	0.0057(63.70%)	4.52
All India			
Periods	Year to year fluctuation	Fluctuation from trend	Length of Cycle
Full period (1950-51 to 2009-10)	0.0051(56.68%)	0.0090(16.09%)	6.22
Sub period- I(1950-51 to 1978-79)	0.0057(61.66%)	0.0093(34.78%)	5.25
Sub period- II(1978-79 to 1989-90)	0.0056(76.89%)	0.0072(44.25%)	3.38
Sub period- III(1990-91 to 2009-10)	0.0037(75.72%)	0.0049(40.62%)	3.48

In case of all India (From Table - V), it is observed that the fluctuation in total variation of productivity amounts to 16 percent in the total variation and year to year fluctuation was amounts to 56 percent out of fluctuation in the total variation and rest 44 percent fluctuation was arises due to partly break in trend, partly cyclical fluctuation or irregular fluctuation. For sub period – I, (1950-51 to 1964-65), fluctuation in total variation out of total variation was amounts to 45 percent and out of this fluctuation year to year fluctuation was 65 percent and rest percentage fluctuation was arises due to partly cyclical fluctuation or irregular fluctuation. In case of sub period – II (1967-68 to 1979-80), it is observed that the fluctuation in total variation out of total variation has increased from 45 percent 67 percent than the previous period and year to year fluctuation has also increased slightly in this period. The length of the cyclical fluctuation has increased in this period than the sub period – I, because in this periods fluctuation from the trend increased more than proportionately than the year to year fluctuation. Thus, in the initial phase of green revolution period fluctuation from the growth path increased than the pre green revolution period but then length of cyclical fluctuation has increased marginally in this period compared to the previous period. For the sub period – III, it is calculated that the fluctuation in total variation of productivity out of total variation has decreased in larger amounts from 67 percent to 28 percent than the previous period, out of the fluctuation in total variation of productivity year to year fluctuation was 66 percent and rest percentage fluctuation was arises due to partly cyclical fluctuation or irregular fluctuation and this year to year fluctuation was also decreased marginally than the previous period (near about 2 percent). In this period length of the cyclical fluctuation has decreased than the previous period. Therefore, in the later phase of green revolution the length of the cyclical fluctuation has decreased and the fluctuation from the growth path also decreased. Therefore, in the later phase of green revolution productivity of total food grain was more stable than the previous periods. Now in the sub period – IV, we observed that the length of the cyclical fluctuation has increased larger amounts than the previous period (from 4.60 to 1.55). In this period we also observed

that the year to year fluctuation is more than hundred percent (118%), there was a larger amount irregular fluctuation and that is why we observed here more spike in the data set, due to this reason calculated year to year fluctuation was more than hundred percent thus after the adoption of new economic policy in India the productivity of total food grain was much more unstable than the previous periods.

Table 5: Nature and extent of fluctuation of productivity of total food grain for all India vis-à-vis for the state of Assam according to optimum breaks found in all India

All India			
Periods	**Year to year fluctuation**	**Fluctuation from trend**	**Length of Cycle**
Full period (1950-51 to 2009-10)	0.0051(56.68%)	0.0090(16.09%)	6.22
Sub period- I(1950-51 to 1964-65)	0.0045(65.46%)	0.0070(44.72%)	4.66
Sub period- II(1968-69 to 1979-80)	0.0055(67.14%)	0.0081(66.96%)	4.43
Sub period- III(1980-81 to 1993-94)	0.0038(65.87%)	0.0057(27.76%)	4.60
Sub period- IV(1993-94 to 2009-10)	0.0040(118.41%	0.0036(37.43%)	1.55
Assam			
Periods	Year to year fluctuation	Fluctuation from trend	Length of Cycle
Full period (1950-51 to 2009-10)	0.0052(46.12%)	0.0112(44.35%)	9.39
Sub period- I(1950-51 to 1964-65)	0.0045(63.29%)	0.0072(99.79%)	4.66
Sub period- II(1968-69 to 1979-80)	0.0055(77.11%)	0.0071(100.09%)	3.36
Sub period- III(1980-81 to 1993-94)	0.0067(78.94%)	0.0085(55.73%)	3.20
Sub period- IV(1993-94 to 2009-10)	0.0035(58.04%)	0.0061(76.10%)	5.93

Conclusion

In the state of Assam for the whole period, the growth rate of productivity of total food grain was 0.91 percent as compared to the all India figure of 2.21 percent. In the state of Assam as well as all India the growth rate of productivity of total food grain has significantly increased in later phase of green revolution period and it is notable that, after the adoption of new economic policy (1991 policy) in India the growth rate of productivity has decreased significantly for the state of Assam as well as in all India level.

The fluctuation is measured by the fluctuation in total variation. For the state of Assam fluctuation in total variation of productivity of total food grain was amounts to 44 percent out of total variation where as in case of all India this fluctuation was very low (16 percent). In case of Assam 44 percent fluctuation in total variation of productivity of total food grain was arises partly due to year to year fluctuation, partly due to cyclical fluctuation, partly due to break in trend and rest fluctuation was arises due to irregular fluctuation. Out of 44 percent fluctuation, year to year fluctuation was near about 50 percent and rest 50 percent fluctuation was arises due to break in trend, cyclical fluctuation or irregular fluctuation where as in case of all India out of 16 percent fluctuation year to year fluctuation was near about 60 percent and rest 40 percent fluctuation was arises due to other three types of fluctuation. It is observed that in the later phase of green revolution fluctuation in the productivity in total food grain was decreased for the state of Assam as well as for all India level also but it is noticed that in all India level productivity of total food grain was more stable than the state of Assam. In this phase, the length of the cycle has increased for the state of Assam but in all India level the length of the cycle has decreased compared to the previous period. Now, after the adoption of new economic policy in India fluctuation in total variation as well as year to year fluctuation of productivity of total food grain has decreased and the length of the cycle of productivity has increased for the state of Assam. Now, in all India level we observed that the opposite result in case of stability. Therefore, we can conclude that, after the adoption of new 1991 economic policy in India, productivity of total food grain was more unstable (i,e. more fluctuation or more cycle observed), although, in case of Assam it is noticed that the productivity of total food grain was more stable after the adoption of new economic policy.

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