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Impact of Climate Change on Agricultural Productivity in India's North-Eastern Region: A Panel Data Analysis

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Abstract

Performance of agriculture largely varies across different agro-climatic situation and thereby the prospects of food security, employment, income of various developing countries. During 2nd half of the last century, significant changes in agricultural productivity, diversity and agro-technology have been observed with varied climatic conditions. This paper examines the growth of agricultural productivity, crop diversity and their regional convergence pattern across the districts of Assam, the largest agricultural state in North East India. Also, impacts of changing climatic factors on crop diversity and agricultural productivity have been examined through a longitudinal data analysis.

Despite the growth of productivity and changing cropping pattern, a significant regional divergence is observed. Also, temperature, both in Khariff & Rabi seasons and the level of precipitation throughout the year, is found to positively affect the crop diversity along with the use of chemical fertiliser. However, in case of composite productivity index;

rainfall and temperature in the Khariff season have positive impact on diversity along with chemical fertiliser. But the temperature in the Rabi season is found to have negative impact on the growth of productivity in the region. In both the cases of diversity and composite productivity, regional differences in agro-climatic conditions and soil characteristics make significant differences in the growth of agricultural productivity over time.

Keywords: Crop Diversification, Herfindahl Index, Modified Diversity Index, Composite Productivity, Regional Convergence, Climate Change, Impact of Climate Change

AMS Classification: 62-07.

1. Introduction

Productivity growth, trend of diversity and regional convergence are closely linked with agricultural prosperity and hence economic development of a country (Kasem & Thapa 2010, Hutagaol 2006, Pingali 2004, FAO/RAP 2000, Rahman 2009 and Van den Berg et al. 2007). Besides existing production conditions, application of modern technology (Rogers, 1995; De, 2003) and infrastructure of the respective areas (De & Chattopadhyay, 2010); changes in productivity, pattern of diversity across the region have been subject to the changing agro-climatic conditions of the respective region (IPCC, 1995; Peng, et al., 2004; Aufhammer, Ramanathan, and Vincent, 2006, 2011; Kar et al. 2004; Wejnert, 2002; Deschenes and Greenstone 2007; Feng, Krueger and Oppenheimer, 2010; De & Bodosa, 2014). As changing production condition leads to the variation in productivity of crops, it also affects the farmer’s option for diversification of land use in an optimum manner. However, uncertainty arising out of lack in the market information may not allow farmers to diversify crops in full swing (Ellis, 1989;

Anderson, 2003) and adopt new technology (Rasul et al., 2004; Knowler and Bradshaw, 2007; Teklewold et al., 2006).

Crop diversification is an important instrument for ensuring food and nutrition security, growth of income and employment, poverty alleviation, judicious use of land, water and other resources, sustainable agricultural progress as well as sustainable environmental management (Singh 2001, De 2003). More is the crop diversity, better is the agricultural performance in terms of return from limited land, spread of risk and thus reduction in chance of failure (Minhas & Vaidynathan, 1965; Sagar, 1980). Allocation of land towards various crops for cultivation is an important factor through which higher overall agricultural productivity can be achieved. Land use pattern in turn depends on relative productivity, suitability of cultivation and demand for agro-poducts. Agricultural production can be increased either through the expansion of area under cultivation or through raising yields of crops. In either case, total returns from agriculture can be increased further through diversification of area under cultivation from lower to higher remunerative crops (De, 2003; De and Chattopadhyay, 2010). Since, there is a limit of diversification of areas under different crops across regions; it calls for looking at the regional convergence of all these factors.

In order to examine the benefit accrued to the farmers due to diversification of crops, one needs to compute a diversity index and examine its trend over time. It is generally observed that with the growth of agriculture, the initially developed areas experience a deceleration in growth of productivity and in scope of diversification without further jump in technology. While, the late starter zones are expected to continuously grow so far as the productivity and diversity are concerned, to catch up the erstwhile developed zones. But, a significant difference may still exist due to the spatial variation in agro-climatic condition and changes in its regional pattern over time.

This paper tries to analyse the regional pattern of growth in agricultural productivity and crop diversity in Assam, India. Thereafter, regional convergence is examined for both the diversification index and productivity of agriculture. Finally, impacts of various factors (climatic and technological) on the spatio-temporal variation in productivity as well as diversity are analysed by using a longitudinal data.

2. Materials and Methods

Productivities of different crops are non-comparable in quantitative terms for their heterogeneity. It is possible only if they are converted into value terms. But data on prices of crops for all the years are not available. Here the term agricultural productivity is used to denote a composite unit, which is based upon the yields of different crops as well as allocation of land for the cultivation of various crops. The index is constituted to describe the overall productivity of the districts vis-a-vis the state average. First, a yield relative has been calculated for each crop across districts as $R_{ij} = (Y_{ij}/Y_{i0}) \times 100$, where Y_{ij} is the average yield of ith (i = 1, 2, 3 ... N) crop in the jth (j =1, 2, 3, ...,10) district and Y_{io} is the average yield of ith crop in the state. R_{ij} is the yield relative for ith crop in jth district. In order to have inter-district comparison, a Composite Productivity Index (CPI) is computed for each district separately by taking into account the relative importance of various crops in different districts in terms of the proportion of area under each crop to total cropped area in the district and then added up over the crops. CPI for jth district is written as $CPI_j = \sum_i (Y_{ij}/Y_{i0}) \times (A_{ij}/A_{i0}) * 100$, where $A_{0j} = \sum A_{ij}$ and A_{ij}/A_{0j} = proportion of area under ith crop to total cropped area in jth district. A_{ij} is the area under i^{th} crop in j^{th} district. Inter-district disparity in CPI has been examined by coefficient of variation.

There are several methods of examining crop diversification. The very crude measure of diversity is the number of crops cultivated and proportion of area under various crops. The simple measure of number of crops however does not speak about the evenness of the distribution of the cultivated area. Measures of crop diversification are usually proposed by modifying the indices of concentration in industry or indices of inequality in income, which are already available in the literature. Prominent measures of diversification are the Herfindahl index, Simpson or Shannon index, Entropy & Modified Entropy indices, etc. The most simple and widely used method is the Herfindahl index (HI) of diversification, which is defined as

$$\mathrm{HI} = 1 - \sum_{i=1}^{N} \mathrm{P}_i^2 \qquad (1)$$

where N is the total numbers of crops, P_i is the proportion of area under i^{th} crop to total cropped area (Theil, 1967; Hou and Robinson, 2006). This value of HI ranges from 0 (for perfect specialization) to 1 (for perfect diversification). This index however cannot assume theoretical maximum value especially in case of smaller number of crops. Also, it gives more weight to the larger shared crops.

The Simpson Index is defined as $\mathrm{E} = \frac{1}{\mathrm{N}} \times \frac{1}{\sum_{\mathrm{i}=1}^{\mathrm{N}} \mathrm{W}_\mathrm{i}^2}$ (Simpson, 1949), which is almost identical to the Hirschman-Herfindahl Index (Herfindahl, 1950; Hirschman, 1964). W_i is the population weight of each species, firm, industry, or other unit of measurement. Here, E refers to the evenness of distribution in the population, sample, or portfolio. E can have a maximum value of one in a situation where species, or industries, are equally weighted. Values decreasing below one indicate increasing dominance of a relatively few species, or industries. *N* is the number of species, or industries, in the population.

Entropy Index (EI) and Modified Entropy Index (MEI) have also been widely used in agricultural diversification literature (Shannon, 1948; Hackbart and Anderson, 1975; Singh et al 1985; Shiyani and Pandya, 1998).

EI is defined as $\mathrm{EI} = -\sum_{i=1}^{N} P_i \operatorname{Log} P_i$ (2)

Its value varies from 0 (perfect concentration) to Log N (perfect diversity). Thus the value of EI is not restricted by the upper bound 1, which is assumed to be desirable criterion for a good index. In case of MEI, number of crops N is considered as the base of logarithm. Symbolically,

$$\mathrm{MEI} = -\sum_{i=1}^{N} (P_i \,.\, \operatorname{Log}_N P_i) \quad (3)$$

Lower and upper values of MEI are zero (when only one crop is cultivated in the whole area) and one (perfect diversification) respectively. Though it has desirable bounds, it does not properly capture changes in number of crop activities.

Notwithstanding these measures satisfy the general characteristics of a concentration or diversification measure, it is necessary to improve upon such indices in order to capture the interdependencies among the variables. Here, following our suggested method, an alternative measure of diversification is used by taking into account the bivariate correlation coefficients of the shares of crops or crop groups in terms of total area under cultivation (Bharati, De and Pal, 2014). The Modified Diversity Index (MDI) is defined as

$$\mathrm{MDI} = 1 - \sum_{i=1}^{n} \sum_{j=1}^{n} s_i \rho_{ij} s_j = 1 - s' R s \quad (4)$$

Where R is the matrix of ρ_{ij} values and s is the column vector of shares of area under each crop to total cropped area for the current period. The symbol ρ_{ij} stands for the correlation between shares of areas under i^{th} and j^{th} production over time. Correlations between agricultural variables should reduce the diversity index. It should be noted that s′Rs is a concentration index, and thus is subtracted from one to arrive at the index of diversification.

The salient feature of this index is that it is bounded by 0 and 1, i.e., $0 \leq MDI \leq 1$. It is 0 when $\rho_{ij} = 1$ for all i and j, i.e., when any two variable move in the same direction without any error. In this case s′Rs becomes $(\Sigma s_i)^2 = 1$. It is HI when the variables are completely independent of each other, $\rho_{ij} = 0$ for all i and j. To prove that MDI ≥ 0, we use the fact that $s'Rs \leq s'\underline{1}s = (\sum s_i)^2 = 1$, where $\underline{1}$ is the matrix consisting of 1's only. On the other hand, since R is a symmetric non-negative definite matrix, we have $s'Rs \geq 0$. This gives MDI ≤ 1.

There are several methods of examining convergence of the series. *Beta* (β) and *Sigma* (σ) convergence have been popularly used by the researchers (Barro and Sala-i-Martin, 1992; Mankiw, Romer and Weil, 1992). *Beta*-convergence comes from the Baumol's (1986) work on real convergence between economies. It is basically a conventional approach to convergence, where it is examined whether the initial values across the zones are correlated with the rate of growth during the period of study. For this purpose, the following equation can be used:

$$(1/T) \text{ Ln } (Y_{iT}/Y_{i0}) = \alpha + \beta \text{ Ln } Y_{i0} + \varepsilon_i \qquad (5)$$

Here T is the end of time period, Y_{iT} is the value of the variable (CPI or MDI in this case) in i^{th} zone at the end of the period of study, Y_{io} is the value of the same variable at the beginning of the period and ε is statistical error term.

The sign of slope coefficient, β indicates the pattern of convergence. If the sign is positive and significant, it means that the regions are experiencing divergence in the growth of the variable Y. Conversely, a negative sign of β is an indication of the convergence of the regions in terms of growth of Y. The problem of this measure is that it depends only on the two end values and ignores the pattern of changes in all other intervening years. Just the extreme values at the end of the period can reverse the true result. Quah (1993), Bernard and Durlauf (1996), Evans (1997), Sala-i-Martin's (1994, 1995) thus criticized this method on the ground of methodological flaw and its reliability and suggested the time series methods of unit root and co-integration techniques for examining convergence in case of the time series data (Quah 1992, Bernard and Durlauf 1995, Li and Papell 1999). Also, panel unit root test is suggested by Levin and Lin (1992, 1993), Quah (1994), Im *et al*. (1997), Taylor and Sarno (1998), Choi and Ahn (1999). Im *et al*. (1997) proposed a Lagrange multiplier (LM) statistic to test for the presence of unit roots in the panel framework.

In this respect, sigma-convergence can reveal a much better picture of the inter-zonal variations over the years. Thus, here the convergence of growth is examined by using σ-convergence. The concept of σ-convergence also comes from the neoclassical growth theory. It is defined as decline of variance (in logarithm) of composite productivity across the districts with time (Dalgaard and Vastrup, 2001; Lucke, 2008; Miller and Upadhyay, 2002; De, 2014). Sigma convergence is then described as the catching up effect. The same is also applied in case of Modified Diversity index (MDI).

Also, the convergence is examined by unit root test of coefficient of variation (Dickey and Fuller 1979). The test is done on the basis of the following regression equation.

$$\Delta Y_{it} = \alpha_i + \beta_i \,.\, t + \gamma_{i0}\, Y_{i,\, t-1} + \sum_{j=1}^{p_i} \delta_{i,j}\, \Delta Y_{i,\, t-j} + \varepsilon_{it} \tag{6}$$

where t = 1 …… T

Here, Y_{it} is the value of i^{th} (Where i= 1, 2 … ... 10) variable at time t. The inference is based on the usual *Mackinnon* τ-statistic of γ_{i0}, which has a non-standard distribution. If the value of the coefficient γ_{i0} is found to be less than zero and is statistically significant then the series is stationary. The Akaike information criterion has been used to determine the lag length parameter p_i. This equation has been estimated without taking the time trend into consideration. Also co-integration among the CPI and MDI across the districts is examined by Johansen's method (1988) to understand convergence.

Choice of regressors to explain index of diversity and CPI was made in a prudent manner. We first computed bivariate correlations of index of diversity and CPI with various potential explanatory variables (Appendix-1). Looking at the correlation structure, we chose some of the most important variables. At the same time we examined multicollinearity. We then eliminated some of the less important variables (with non-significant coefficient, i.e., with p-value close to 1 or very high) and variables responsible for multicollinearity (having VIF > 10). However, we tried to maintain uniformity of choice of variables so that comparison becomes easy. The procedure was not very troublesome, since the behaviour of the variables was similar for each regression.

Both the multivariate regression model and Fixed Effect Models (FEM) are used to compare the effects of various climatic factors on diversification and productivity. At first, we estimated the equation

$$Y_{it} = a_t + \sum b_i^j X_{it}^j + €_{it} \qquad (7)$$

where Y_{it} represents the value of the dependent variable (CPI, MDI) of i^{th} zone at time t, X_{it}^j represents value of j^{th} explanatory variables of region i at time t. $€_{it}$ is the value of random disturbance term of zone i at time t and b_i^j is the effect of j^{th} explanatory variable in zone i.

The time variable, year, was used as an explanatory variable to capture the trend component in all cases of diversity index and composite productivity index. This is to incorporate the learning effect. Also, regional dummies are included to capture the effect of specific regional characteristics (geographical location, climatic condition, land quality etc). $€_{it}$ has two components. A part of $€_{it}$ (= α_i) depends on the variation in zonal characteristics (unit) and that remains more or less same over time in Assam; while the other part is purely random. As the inter-zonal variation remained more or less same over time and after Hausman test the FEM is considered to be more suitable and used to know the impact of inter-zonal variation (η_{it}) on the observed variation in diversity. One time specific dummy variable, γ is introduced (Green, 2003). The FEM model considered for estimation is $Y_{it} = \sum b_i^j X_{it}^j + \alpha_i + \eta_{it}$ (8)

Here α_i represents zone specific fixed effects and related to inter-zonal variations in weather factors.

Also, separate regression is conducted for all the zones to examine the temporal impact of climate related variables in each zone. Looking at the pattern of variation in CPI and MDI over time and in order to make a comparison between pre and post Green Revolution period, the whole period is divided into two sub-periods, 1951-52 to 1976-77 and 1977-78 to 2010-11 and multivariate regressions are conducted for all the ten zones. Though the Green Revolution started in developed agricultural areas of India in the mid-1960s, this technology came to the state of Assam after mid-1970s.

3. Description of Data and Calculations

The analysis is based on the secondary data on area under various crops since 1951 to 2011 collected from various issues of *Statistical Hand Book* of Assam, *Economic Survey of Assam* and Reports from Directorate of Agriculture, Government of Assam. Though several studies used earnings from the production of crops in order to compute the diversity index, here we use area under crops for the purpose. This is because the farmers try to maximise the returns from their limited land keeping in view the sustainable income possibilities. The land allocation to different crops reflects the intention of the farmers which may not be realized in the same way through production. Moreover, the area of crop cultivation is more robust than the actual production, which is subject to technology available at the time of production and to the climatic behaviour of nature.

The analysis is done for the 10 composite districts of Assam, which were in existence before 1990. Since several times, the erstwhile districts were divided to create smaller districts, data on all aspects are not available for all the present 27 districts of the state. Data were regrouped and computed for those erstwhile 10 districts of the state.

4. Results and Discussion

Composite Productivity and Modified Diversity Index and their Relations:

The *Composite Productivity Index* (CPI) calculated for different districts are displayed in Table 1. Here, significant inter-district variation in composite agricultural productivity per hectare is revealed. The range of variation in index in percentage term for all crops when taken together was 82.22 to 124.96, in 1951-52, 79.79 to 148.87 in 1971-72, 87.0 to 116.93 in 1991-92 and 83.38 to 106.0 in 2010-11 respectively. The range of index first increased from 1951-52 to 1971-72 and thereafter it declined and stabilized (Table 1).

From the table, it is also noticed that Lakhimpur, Karbi Anglang and N.C. Hills were at the top three positions in respect of CPI during 1951-52, to 1981.82. Kamrup was at the bottom position in the relative ranking. Remarkable achievement in composite productivity index has been found in case of Cachar, which has jumped over many other districts in respect of CPI during 2001-02. Also, Kamrup progressed a lot in this respect. Lakhimpur and N.C. Hills were lagging behind in their relative ranking in this case. Fig.1 shows the stable inter-district variation in CPI except an increase in variability in the middle of the period.

Table 1: Growth of Composite Productivity Index of Various Districts of Assam during 1951-52 to 2010-11

Year	Dibrugarh	Sibsagar	Lakhimpur	Darrang	Kamrup	Goalpara	Cachar	Nagaon	KarbiAnglong	NC Hills
1951-52	NA	102.79	124.96	104.53	82.22	97.85	105.38	99.91	101.89	NA
1952-53	NA	114.97	107.47	108.12	82.85	98.82	92.32	108.70	100.97	NA
1953-54	NA	100.43	121.86	116.07	84.39	103.75	80.93	101.02	100.18	NA
1954-55	NA	104.24	113.02	124.69	84.80	95.85	103.22	85.29	99.42	NA
1955-56	NA	109.56	101.10	114.81	85.88	96.48	95.43	104.59	100.91	NA
1956-57	NA	92.96	121.27	104.10	87.37	96.04	106.51	106.18	99.88	NA
1957-58	NA	112.07	116.29	107.10	83.17	105.48	107.38	82.52	99.56	NA
1958-59	NA	108.84	112.70	104.17	88.98	98.38	98.96	96.86	100.87	NA
1959-60	NA	106.69	113.05	112.71	74.27	98.98	102.73	109.82	98.89	NA
1960-61	NA	102.04	112.19	103.68	81.58	100.22	114.36	102.99	99.45	NA
1961-62	NA	114.44	117.06	105.49	78.11	91.99	116.12	97.60	99.59	NA

1962-63	NA	115.94	119.52	111.07	82.60	93.89	95.66	92.55	116.46	NA
1963-64	NA	107.58	113.40	107.58	88.01	95.01	102.26	94.06	117.96	NA
1964-65	NA	106.76	112.93	117.04	85.70	88.44	113.60	90.99	104.52	NA
1965-66	NA	109.67	112.90	113.52	76.42	101.35	119.78	86.95	102.73	NA
1966-67	NA	103.45	115.69	108.35	81.30	95.76	113.39	92.06	139.73	NA
1967-68	NA	118.60	113.19	111.43	81.25	86.93	117.88	86.98	123.67	NA
1968-69	NA	105.51	117.41	109.90	82.45	91.43	98.68	102.36	134.02	NA
1969-70	NA	107.91	124.06	103.44	83.68	98.64	96.63	86.42	140.51	NA
1970-71	NA	109.33	108.55	105.91	86.11	92.52	106.93	91.65	144.80	169.86
1971-72	109.34	119.12	117.51	99.54	79.79	89.63	123.77	92.99	123.63	148.87
1972-73	107.62	97.98	121.55	112.44	86.91	90.62	101.04	98.46	124.97	129.10
1973-74	117.52	107.88	115.71	110.92	84.96	82.82	113.28	97.94	115.85	144.03
1974-75	111.22	103.82	123.32	107.69	87.34	89.06	106.61	91.32	117.95	139.59
1975-76	107.06	109.14	120.00	101.92	83.80	88.75	105.85	107.29	107.69	134.70
1976-77	120.47	102.95	118.87	94.52	80.06	94.59	98.71	99.27	107.30	143.46
1977-78	120.12	104.71	110.61	89.29	84.69	91.14	111.32	90.47	115.54	120.34
1978-79	120.15	112.75	111.61	96.24	86.86	78.63	100.80	91.26	125.07	116.91
1979-80	109.15	113.78	110.46	93.25	90.16	81.85	94.70	95.55	119.68	117.42
1980-81	114.37	110.25	118.42	89.49	80.06	82.11	122.13	85.14	133.66	120.85
1981-82	127.20	121.27	104.53	91.66	81.96	86.74	89.57	88.16	110.39	128.20
1982-83	108.76	112.32	111.01	94.84	89.43	86.11	105.36	81.24	115.62	120.30
1983-84	110.26	116.51	99.15	94.20	85.46	91.35	99.72	87.18	108.04	110.56
1984-85	112.61	117.30	106.21	99.31	82.69	81.23	95.39	94.63	106.50	107.50
1985-86	107.34	107.23	100.76	102.81	86.18	80.66	96.85	107.43	104.48	91.93
1986-87	112.27	112.15	108.59	102.01	79.30	86.89	99.39	93.29	99.17	99.92
1987-88	109.23	109.77	93.93	96.69	79.70	82.52	116.13	107.24	101.07	90.62
1988-89	120.44	108.83	101.07	95.12	79.95	85.39	114.38	88.38	111.46	114.35
1989-90	122.07	111.02	95.69	94.01	86.31	87.69	101.28	89.65	98.79	113.97
1990-91	107.93	120.29	81.92	92.91	84.38	83.14	108.86	97.85	105.33	97.56
1991-92	112.08	116.93	89.17	88.32	78.16	87.00	112.30	102.05	100.25	94.44
1992-93	117.16	103.50	83.90	90.79	85.87	82.33	114.07	102.56	101.45	97.17
1993-94	108.55	105.18	104.79	99.40	84.07	86.83	88.38	100.53	98.67	97.05
1994-95	104.62	104.20	88.55	95.55	82.36	88.43	108.02	96.98	112.77	108.78
1995-96	110.65	111.86	99.16	91.96	79.85	82.60	108.10	101.13	101.03	116.19
1996-97	115.86	106.05	80.08	88.70	86.16	85.22	119.68	96.37	97.56	114.13
1997-98	109.10	101.50	83.56	94.19	91.71	79.62	104.89	103.35	102.63	106.35
1998-99	108.05	107.67	81.33	92.90	83.21	84.86	112.35	103.21	97.67	107.16
1999-00	101.24	109.33	80.69	91.50	87.82	86.47	103.04	106.74	99.65	99.07
2000-01	101.38	109.17	76.04	90.29	85.10	87.37	120.94	105.04	96.34	90.97
2001-02	101.34	108.74	71.60	94.91	82.68	88.24	123.26	100.72	95.58	97.71
2002-03	94.23	108.54	66.11	91.60	83.48	95.18	124.82	98.78	99.50	99.34
2003-04	103.18	108.35	65.54	95.77	87.82	88.73	119.89	98.77	87.88	87.34
2004-05	107.31	109.11	71.56	95.88	87.66	88.45	108.31	96.56	92.18	99.77
2005-06	102.39	103.15	74.74	93.33	90.71	90.55	111.88	96.58	95.78	101.23
2006-07	94.84	119.12	76.17	93.29	97.08	86.09	104.81	86.34	90.09	103.70
2007-08	104.34	106.89	70.03	89.93	95.61	88.11	108.00	99.84	93.31	89.89
2008-09	99.88	107.42	77.22	86.85	94.67	89.15	115.49	105.05	74.99	91.98
2009-10	103.03	102.87	76.37	86.18	91.32	88.04	115.19	102.89	106.87	94.92
2010-11	106.00	88.61	86.68	98.75	101.19	95.25	94.80	88.63	93.84	83.38

The modified diversity index however at all Assam level declined from .672 in 1951-52 to .605 in 2010-11 (Table 2). It increased for a few intervening years during 1980s. The range was 0.512 to 0.728 in 1951-52 and increased to 0.511 to 0.831 in 2010-11. Fig. 2 reveals that variation in modified diversity index across the districts is found to have a more or less similar pattern as that of CPI.

Table 2: Modified Diversity Index of Various Districts of Assam during 1951-52 to 2010-11

Year	Dibrugarh	Sibsagar	Lakhimpur	Darrang	Kamrup	Goalpara	Cachar	Nagaon	KarbiAnglong	NC Hills	Assam
1951-52	NA	0.726	0.468	0.709	0.605	0.728	0.612	0.667	0.512	NA	0.672
1952-53	NA	0.718	0.533	0.706	0.591	0.709	0.606	0.619	0.598	NA	0.663
1953-54	NA	0.729	0.530	0.697	0.587	0.685	0.603	0.583	0.654	NA	0.659
1954-55	NA	0.694	0.539	0.710	0.607	0.691	0.579	0.597	0.657	NA	0.660
1955-56	NA	0.688	0.542	0.691	0.595	0.713	0.571	0.642	0.664	NA	0.656
1956-57	NA	0.703	0.560	0.702	0.598	0.690	0.570	0.613	0.659	NA	0.658
1957-58	NA	0.691	0.566	0.696	0.607	0.700	0.566	0.640	0.656	NA	0.657
1958-59	NA	0.683	0.568	0.670	0.585	0.687	0.573	0.643	0.637	NA	0.644
1959-60	NA	0.668	0.548	0.699	0.593	0.678	0.553	0.645	0.637	NA	0.640
1960-61	NA	0.647	0.560	0.685	0.580	0.678	0.548	0.621	0.623	NA	0.629
1961-62	NA	0.643	0.560	0.703	0.578	0.668	0.539	0.635	0.640	NA	0.627
1962-63	NA	0.645	0.580	0.686	0.579	0.639	0.539	0.648	0.636	NA	0.624
1963-64	NA	0.644	0.594	0.690	0.574	0.666	0.540	0.660	0.646	NA	0.630
1964-65	NA	0.640	0.603	0.681	0.570	0.660	0.536	0.657	0.652	NA	0.625
1965-66	NA	0.643	0.610	0.681	0.553	0.648	0.538	0.679	0.654	NA	0.622
1966-67	NA	0.642	0.605	0.686	0.547	0.630	0.544	0.648	0.594	NA	0.612
1967-68	NA	0.644	0.610	0.672	0.538	0.625	0.535	0.672	0.578	NA	0.607
1968-69	NA	0.648	0.620	0.666	0.511	0.591	0.528	0.613	0.567	NA	0.595
1969-70	NA	0.651	0.600	0.662	0.518	0.600	0.534	0.639	0.537	NA	0.592
1970-71	NA	0.631	0.608	0.678	0.518	0.596	0.532	0.618	0.530	0.835	0.585
1971-72	0.834	0.660	0.808	0.666	0.518	0.611	0.539	0.671	0.520	0.810	0.597
1972-73	0.824	0.646	0.818	0.681	0.502	0.570	0.526	0.638	0.512	0.681	0.579
1973-74	0.776	0.623	0.848	0.698	0.515	0.572	0.521	0.607	0.530	0.757	0.579
1974-75	0.750	0.664	0.811	0.637	0.464	0.572	0.524	0.590	0.511	0.737	0.565
1975-76	0.725	0.637	0.832	0.623	0.436	0.506	0.499	0.534	0.533	0.722	0.544
1976-77	0.757	0.672	0.840	0.657	0.494	0.532	0.535	0.602	0.581	0.720	0.583
1977-78	0.943	0.680	0.390	0.638	0.501	0.564	0.534	0.620	0.584	0.733	0.591
1978-79	0.941	0.688	0.414	0.640	0.506	0.564	0.542	0.618	0.586	0.716	0.594
1979-80	0.949	0.709	0.481	0.659	0.518	0.590	0.543	0.661	0.545	0.708	0.617
1980-81	0.950	0.699	0.448	0.692	0.517	0.568	0.548	0.655	0.566	0.688	0.614
1981-82	0.954	0.674	0.515	0.733	0.570	0.574	0.563	0.628	0.535	0.687	0.631
1982-83	0.959	0.721	0.554	0.725	0.581	0.641	0.567	0.662	0.520	0.675	0.657
1983-84	0.954	0.729	0.564	0.724	0.591	0.612	0.606	0.678	0.532	0.670	0.666
1984-85	0.940	0.733	0.553	0.728	0.605	0.689	0.600	0.696	0.506	0.633	0.680
1985-86	0.944	0.714	0.570	0.711	0.573	0.692	0.570	0.679	0.500	0.597	0.660
1986-87	0.958	0.740	0.571	0.762	0.640	0.663	0.594	0.682	0.494	0.600	0.688

1987-88	0.937	0.764	0.582	0.771	0.637	0.687	0.560	0.667	0.517	0.607	0.690
1988-89	0.929	0.743	0.578	0.745	0.640	0.726	0.581	0.636	0.513	0.645	0.684
1989-90	0.925	0.724	0.523	0.697	0.615	0.672	0.595	0.602	0.524	0.656	0.651
1990-91	0.911	0.691	0.552	0.695	0.614	0.689	0.554	0.586	0.533	0.644	0.642
1991-92	0.901	0.707	0.537	0.694	0.627	0.694	0.570	0.601	0.586	0.834	0.649
1992-93	0.912	0.715	0.525	0.650	0.625	0.676	0.560	0.611	0.588	0.816	0.642
1993-94	0.902	0.686	0.545	0.626	0.597	0.672	0.565	0.598	0.574	0.802	0.630
1994-95	0.918	0.702	0.546	0.671	0.612	0.706	0.541	0.631	0.578	0.794	0.647
1995-96	0.927	0.714	0.534	0.669	0.595	0.685	0.546	0.611	0.581	0.790	0.639
1996-97	0.929	0.747	0.578	0.679	0.592	0.684	0.555	0.643	0.591	0.805	0.654
1997-98	0.932	0.710	0.597	0.672	0.588	0.694	0.580	0.655	0.598	0.793	0.652
1998-99	0.927	0.721	0.632	0.722	0.607	0.673	0.570	0.629	0.637	0.830	0.663
1999-00	0.929	0.663	0.550	0.687	0.575	0.643	0.550	0.592	0.632	0.804	0.628
2000-01	0.928	0.661	0.544	0.659	0.567	0.656	0.568	0.588	0.611	0.783	0.622
2001-02	0.934	0.669	0.558	0.694	0.587	0.645	0.574	0.629	0.613	0.750	0.638
2002-03	0.925	0.674	0.559	0.657	0.572	0.631	0.562	0.618	0.598	0.731	0.623
2003-04	0.926	0.634	0.585	0.689	0.593	0.617	0.562	0.604	0.590	0.758	0.627
2004-05	0.931	0.628	0.578	0.691	0.545	0.642	0.567	0.627	0.589	0.705	0.624
2005-06	0.875	0.614	0.569	0.688	0.519	0.610	0.554	0.605	0.590	0.680	0.593
2006-07	0.870	0.708	0.610	0.773	0.583	0.642	0.567	0.708	0.674	0.703	0.654
2007-08	0.860	0.691	0.620	0.704	0.529	0.658	0.558	0.685	0.683	0.686	0.631
2008-09	0.853	0.620	0.623	0.680	0.496	0.660	0.549	0.666	0.680	0.692	0.608
2009-10	0.838	0.604	0.634	0.654	0.468	0.672	0.535	0.653	0.693	0.673	0.596
2010-11	0.831	0.591	0.643	0.661	0.511	0.671	0.535	0.662	0.690	0.662	0.605
Source: Economic Survey of Assam, Directorate of Economics and Statistics, Govt. of Assam.											

Figure 1: Over Time Variation in Composite Productivity Index

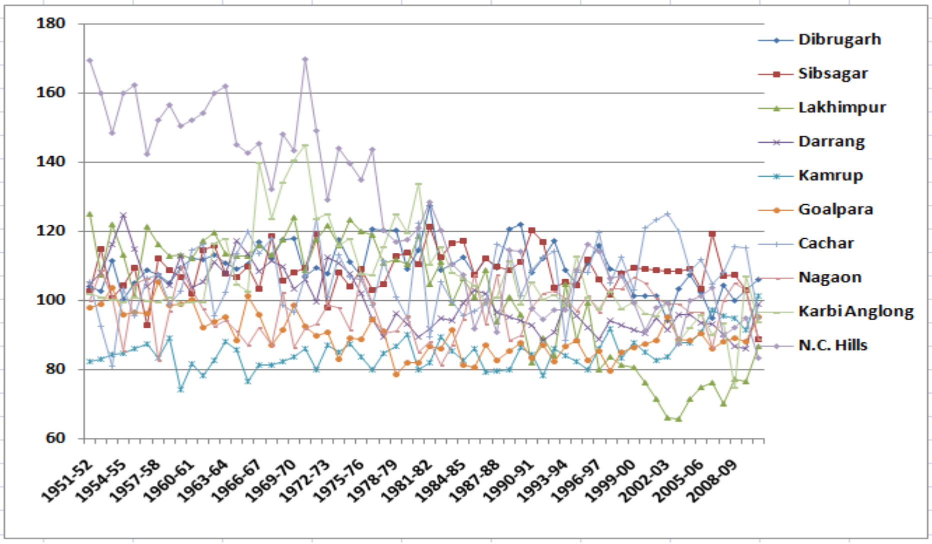
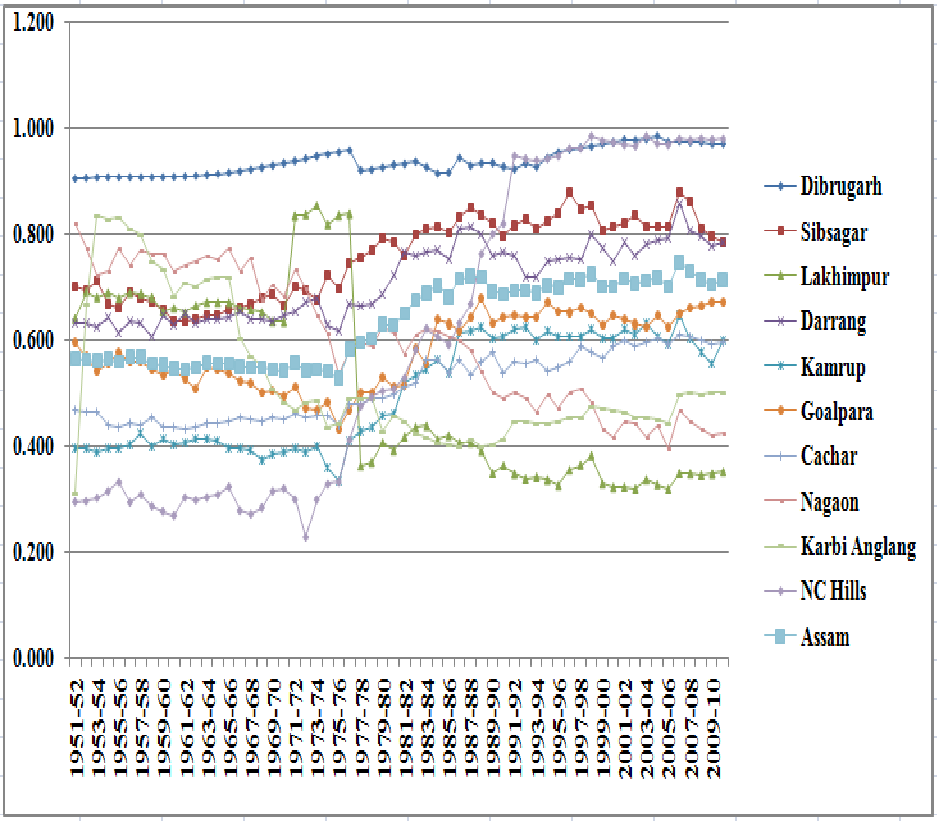


Figure 2: Over Time Variation in Modified Diversity Index



5. Convergence of CPI and MDI in Assam

Except for a few cases the correlations between CPI growths of various districts are significant. It means, even if the yield of crops increased in majority of the districts, there is dissimilarity in the changes of proportional allocation of area under crops and that may be due to the inter-crop variation in relative profitability owing to differences in rate of growth of yield and prices of crops. Thus it is observed that the diversification of crops has not taken place uniformly amongst the districts and the productivity and growth of area also not uniformly correlated across various districts in Assam.

Figure 3: Over Time Changes in Coefficient of Variation across the Districts of Modified Diversity Index (MDI) and Composite Productivity Index (CPI)

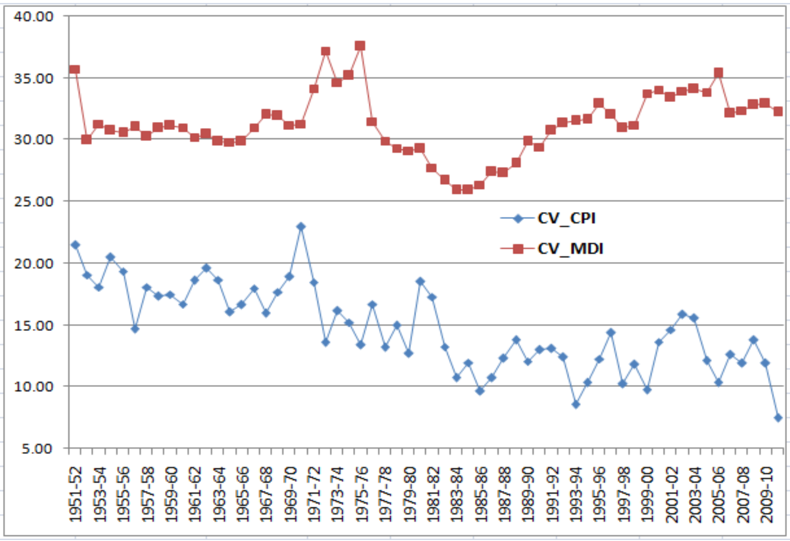


Fig. 3 reveals a close relation between the inter-district variation in CPI and MDI. Here the proportions of area under crops are considered in the computation of CPI along with yield relative. The farmers are expected to diversify more towards the crops having high relative yield. Hence the diversity is expected to be low with high CPI. All the farmers across the zones are expected to follow the same provided the production conditions prevail. From Fig. 3, it is clear that the coefficient of variation in CPI across the districts declined till mid-1970 but with high fluctuation. It then remained more or less stable. On the other hand, the coefficient of variation in MDI across the districts first increased till the middle of 1970s and then declined for a few years and again increased from the mid 1980s consistently.

As the variation is observed fluctuating (from Fig. 3) Sigma convergence is examined for two sub-periods (1951-52 to 1976-77 and 1977-78 to 2010-11) and presented in Table 3. During first sub-period from 1951-52 to 1976-77 significant convergence of CPI across the districts (significant negative slope) is observed, while during 1977-78 to 2010-11 negative trend of CV is insignificant. But, in case of MDI we observe significant regional divergence (positive slope) during both the sub-period though it declined in some intervening years.

Table 3: Estimated value of Sigma Convergence of CPI and MDI in Assam

Period		Intercept	t-value	Slope Coef	t-value	$AdjR^2$, F
1951-52 to 1976-77	CPI	2.966***	63.40	-0.0075**	-2.48	0.171, 6.148**
1977-78 to 2010-11		2.598***	39.95	-0.0049	-1.497	0.040, 2.24**
1951-52 to 1976-77	MDI	3.403***	136.87	0.0043***	2.69	0.199, 7.22***
1977-78 to 2010-11		3.298***	173.82	0.0071***	7.51	0.63, 56.40***

Note: *** & ** indicate the coefficient is significant at 1% & 5% level respectively

The unit root test of CV for both the CPI and MDI is presented in Table 4. The result shows an overall convergence for CPI during 1951-52 to 2010-11. But the coefficient of MDI is found to be insignificant. It means, virtually there is no convergence of MDI during the whole period, which goes against the result sigma convergence.

Table 4: Unit Root Test of CV of CPI and MDI in Assam by ADF Test for the whole Period (1st Difference)

		Coef.	t-value	Trend	t-value
CPI	Without Trend	-0.2772**	-2.99		
	With Trend	-0.6119***	-4.94	-.0877***	-3.67
MDI	Without Trend	-0.2153	-2.812		
	With Trend	-0.229	-2.972	0.0144	1.25

Note: *** & ** indicate the coefficient is significant at 1% & 5% level respectively

Because of differences in result in regard to the convergence, it is further checked by cointegration of CPI and MDI across the districts by using both the Cointegration Rank Test of Trace Statistic and Maximum eigen-value. The test results are presented in Tables 5a and 6a. It shows that both the CPI and MDI across the districts are cointegrated to a certain extent. We obtain at least one cointegrated equation in both cases (Tables-5b and 6b). The cointegration result thus shows some sort of convergence despite significant inter-district variation in growth of composite agricultural productivity and modified diversity index.

Table 5a: Test of Cointegration of CPI across the Districts of Assam using Unrestricted Cointegration Rank Test (Trace) and including Linear Deterministic Trend

Hypothesized No. of CE(s)	Eigen-value	Trace Statistic	0.05 Critical Value	Prob.**
None *	**0.663927**	**281.9222**	**273.1889**	**0.0201**
At most 1	0.574306	218.6774	228.2979	0.1275
At most 2	0.533695	169.1435	187.4701	0.2877
At most 3	0.476328	124.8944	150.5585	0.5390
At most 4	0.363412	87.37485	117.7082	0.7789
At most 5	0.297895	61.18015	88.80380	0.8240
At most 6	0.254088	40.66714	63.87610	0.8263
At most 7	0.164812	23.66459	42.91525	0.8514
At most 8	0.151831	13.21886	25.87211	0.7210
At most 9	0.061279	3.667718	12.51798	0.7895

Notes: Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 5b: Estimated 1 Cointegrating Equation(s) for CPI: Log likelihood = -1762.080

Cachar	Darrang	Dibrugarh	Goalpara	Kamrup	KarbiAng	Lakhimpur	N.C. Hills	Nagaon	Sibsagar	@Trend(2)
1.00	5.3731	17.987	7.651	8.616	-0.153	-2.1791	-2.388	2.204	-5.339	-0.53386
	(1.780)	(2.326)	(2.735)	(2.728)	(0.914)	(1.3611)	(0.926)	(1.940)	(2.561)	(1.93857)

Note: Normalized cointegrating coefficients (standard error in parentheses)

Table 6a: Test of Cointegration of MDI across the Districts of Assam using Unrestricted Cointegration Rank Test (Trace) and including Linear Deterministic Trend

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	**0.719794**	**316.9799**	**273.1889**	**0.0002**
At most 1 *	**0.621377**	**243.1906**	**228.2979**	**0.0082**
At most 2	0.521643	186.8601	187.4701	0.0537
At most 3	0.431619	144.0911	150.5585	0.1092
At most 4	0.415140	111.3232	117.7082	0.1183
At most 5	0.397529	80.21300	88.80380	0.1775
At most 6	0.266526	50.82348	63.87610	0.3780
At most 7	0.206302	32.84564	42.91525	0.3442
At most 8	0.183610	19.44460	25.87211	0.2553
At most 9	0.124000	7.678560	12.51798	0.2791

Notes: Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 6b: Estimated 1 Cointegrating Equation(s) for **MDI**: Log likelihood = 1527.117										
Normalized cointegrating coefficients (standard error in parentheses)										
Cachar	Darrang	Dibrugarh	Goalpara	Kamrup	KarbiAng	Lakhimpur	Nagaon	N.C.Hills	Sibsagar	@Trend(2)
1.00	0.0833	-0.8859	0.589	-0.7607	-0.0821	0.0345	-0.5239	0.0413	-0.4402	-0.0033
	(0.195)	(0.2869)	(0.144)	(0.174)	(0.045)	(0.0367)	(0.110)	(0.092)	(0.107)	(0.0012)
Estimated 2 Cointegrating Equation(s) for **MDI**: Log likelihood = 1555.282										
Normalized cointegrating coefficients (standard error in parentheses)										
Cachar	Darrang	Dibrugarh	Goalpara	Kamrup	KarbiAng	Lakhimpur	Nagaon	N.C.Hills	Sibsagar	@Trend(2)
1.00	0.0000	-0.8673	0.51245	-0.6696	-0.0557	0.0332	-0.473	0.0237	-0.3797	-0.00275
		(0.260)	(0.1327)	(0.118)	(0.038)	(0.033)	(0.103)	(0.062)	(0.087)	(0.0008)
0.00	1.0000	-0.2239	0.9192	-1.093	-0.3173	0.0152	-0.609	0.2114	-0.727	-0.00685
		(0.3092)	(0.158)	(0.140)	(0.045)	(0.0396)	(0.123)	(0.074)	(0.104)	(0.001)

6. Impact of Climate Change:

Results of multivariate Regression CPI on annual rainfall, maximum temperature in Kharif (April-Sept.) and Rabi season (Oct.-March), intensity of chemical fertilizer use across regions are shown in Table 7. Because of high multicollinearity (Appendix-1) between chemical fertiliser and irrigation, and lack of information on irrigation for all the years, irrigation despite being an important variable is not included here. Like temperature, rainfall during Khariff and Rabi are not considered as two separate variables. This is because major rainfall, that occurs during Khariff season also control to certain extent irrigation during Rabi season (through preservation in bills, lakes, ponds and groundwater recharge). However untimely and more winter rainfall sometimes adversely affects the productivity of Rabi crops. Moreover, we see significantly high correlation between the Khariff and Rabi season rainfall.

The results reveal that chemical fertilizer has significant positive impact on the composite productivity. Annual average rainfall and maximum temperature in the Khariff (April-June, main paddy cultivating season) have significant positive impacts on the composite productivity. On the other hand, maximum temperature of winter season and time adversely affect the composite productivity through the loss in yield in winter crops in particular. All the zonal dummies in case of CPI have negative coefficients due to specific regional adversities of weather and other associated factors (Table 7).

Table 7: Results of Multivariate Regression of CPI, SI & MDI on Various Explanatory Variables

Dep. Var., $\overline{\overline{R}}^2$, F	CPI, 0.566, 56.79***			MDI, 0.53, 48.84		
Expl. Var	Coeff.	t	Sig.	Coeff.	t	Sig.
(Constant)	980.244	14.543	.000	-2.483	-3.001	.003
Rain_Annual	.002	1.956	.051	-.000044	-3.256	.001
MaxT_Khariff	2.490	3.198	.001	.002	.175	.861
MaxT_Rabi	-1.949	-2.652	.008	.026	2.838	.005
Fert_Intensity	.223	8.042	.000	-.001	-1.532	.126
Year	-.448	-13.150	.000	.001	3.051	.002
D_Zone1	-18.767	-8.255	.000	.301	10.769	.000
D_Zone2	-17.304	-7.286	.000	.122	4.184	.000
D_Zone3	-24.011	-9.552	.000	-.170	-5.509	.000
D_Zone4	-25.536	-10.009	.000	.028	.906	.365
D_Zone5	-41.918	-15.954	.000	-.181	-5.607	.000
D_Zone6	-38.666	-14.603	.000	-.104	-3.198	.001
D_Zone7	-20.186	-8.171	.000	-.149	-4.916	.000
D_Zone8	-28.431	-9.203	.000	-.002	-.053	.957
D_Zone9	-16.294	-7.857	.000	-.053	-2.082	.038

Notes: D_Zone i represents dummy for the i^{th} Zone.
Zone1-Dibrugarh, Zone2-Sibsagar, Zone3-Lakhimpur, Zone4-Darrang, Zone5-Kamrup, Zone6-Goalpara, Zone7-Cachar, Zone8-Nagaon, Zone9-KarbiAnglong, Zone10-NC Hills.

Table 7 also reveals that rainfall has significantly negative impact on MDI, but maximum temperature in rabi season and time have significant positive effects on it. Also, fertiliser intensity has some negative impact on MDI. The coefficients of dummy of tea dominated valleys of Dibrugarh and Sibsagar are found to positive while in case of other areas except Darrang and Nagaon it is significantly negative. Those regions due to the lack of opportunities, access to capital and technology gone for specialisation more than the farmers of other region.

It is natural that if some factors positively affect productivity of some crops, farmers will allocate proportionately more land towards those crops and thus overall composite productivity will be positively impacted. It means a the diversity index is expected to be affected negatively (more specification of crops) by those factors or may be indifferent due to other constraints including farmers attitude, farmers' need in a subsistence structure, lack of access to capital or other institutional bottlenecks.

In case of panel regression Fixed Effect model is found to be appropriate since the Hausman test result gives Chi^2 values 13.35 and 216.57 for the CPI and MDI respectively and both are significant at 5 per cent level of significance. The FE regression results obtained (as presented in Table 8) reveal the same as is in Table 7. Thus the important effects of changes in climatic variables on CPI and MDI are revealed. Also, technological and regional variations in agro-climatic characteristics are found to play important role in the determination of productivity and diversity pattern, as explained above.

Table 8: Results of FE Regression of CPI & MDI on Various Explanatory Variables

	Dep. Var. = CPI, R^2 (Within = 0.268, Between = 0.209, Overall = 0.093), F(5, 585) = 42.91***			Dep. Var. = MDI, R^2 (Within = 0.091, Between = 0.008, Overall = 0.013), F(5, 585) = 11.67***		
Exp. Var.	Coef.	t	Prob	Coef.	t	Prob
Rain_Ann	.00214	1.96	0.050	-.000044	-3.26	0.001
MaxT_KH	2.490	3.20	0.001	.00166	0.17	0.862
MaxT_RAB	-1.949	-2.65	0.008	.02562	2.84	0.005
Fert_Int.	.2230	8.04	0.000	-.00052	-1.53	0.125
YEAR	-.4475	-13.15	0.000	.001276	3.05	0.002
Cons	957.13	14.29	0.000	-2.505	-3.00	0.002

District level regression reveals that in the low lying flood prone areas of Lakhimpur, Dhemaji, Darrang etc rainfall in khariff season adversely affected the CPI while the positive impact is found in Kamrup valley during 1951 to 1976

(App. 2a). Impact of Khariff season rainfall on CPI became significantly positive during 1977-2010 in Lakhimpur, Dhemaji, Darrang. On the other hand, rainfall in the rabi season has adverse impact on CPI in both the sub-periods in Kamrup and in the latter period in Lakhimpur. Maximum temperature in the rabi season has significant positive effect on the same in Kamrup and Karbi Anglong during 1950-76. Intensity of fertiliser use has positive impacts on CPI in Kamrup, Lakhimpur, Goalpara in the post 1977 period while it is negative in case of Nagaon.

Insignificant impacts of fertiliser use on productivity in most areas have been due to poor growth of fertiliser use, which has been due to the lack of irrigation expansion and prevalence of monsoon dependence of agriculture in Assam. In winter season, instead of helping much, the erratic rainfall rather adversely affected productivity of Rabi crops, including potato, mustard, summer rice etc. Only, because of some control over Khariff rainfall in the management and diversifying crops to short period varieties or cultivation practices in Kamrup and Lakhimpur its impact became positive in the later periods.

App. - 2c reveals that rainfall in Khariff season adversely affected MDI in Dibrugarh, Nagaon during 1951 to 1976 and positively in Dibrugarh, North-Cachar Hills during 1977 to 2010. Rabi season rainfall however had positive impacts on MDI in Dibrugarh, Lakhimpur and negatively in Karbi Anglong during 1951 to 1976. It has positive impact on MDI in North-Cachar Hills during 1977-2010. Similarly, Khariff season maximum temperature had negative impacts on MDI in Goalpara, Nagaon during 1951 to 1976 and in Kamrup during 1977 to 2010. Maximum temperature in Rabi season also adversely affected MDI in Kamrup but positively in Dibrugarh, Sibsagar and Karbi Anglong during 1951 to 1976. Fertiliser, an important component of agricultural development, affected MDI positively in Cachar valley and negatively in Lakhimpur during 1951 to

1976. But it affected negatively in North-Cachar Hills, Cachar, Goalpara, kamrup, Sibsagar and positively Nagaon, Lakhimpur and Dibrugarh during 1977 to 2010. Thus the impacts of climatic variables are different in various zones and at different times. Still now the agriculture is mostly weather dependent and now in the relatively progressive areas, rainfall helps in promoting specialisation and backward areas it causes diversification to avoid risk. Chemical fertiliser also reflects mixed result. It helps in specialisation in the valley zones, but diversification in the flood affected areas and tea dominated areas in the previous three decades.

7. Concluding Remarks:

The state of Assam has been undergoing significant climate changes during last few decades (De, Pal and Bodosa, 2013). Short term extreme changes in weather significantly affect the output of crops and force farmers to think of alternative crops that are more weather resistant. Hence, their actions are supposed to be reflected in crop diversity over time. Notwithstanding yield of individual crops, composite productivity index (CPI), which is composed of yield relatives, and proportions of areas under crops is expected to be affected by both the changes in weather variables and technological factors across the region. Experiences across regions of India reveal that because of changing rainfall patterns and depletion of water resources, the existing cropping pattern is becoming less productive (Venkateswarlu, 2009; Pachauri, 2009; Guiteras 2007). Thus intensification of crops through mixed cropping and integration of high-value crops such as horticultural production is gaining prominence as a climate change adaptation strategy, especially in the hill regions, as well as for future growth of agriculture (Joshi et al, 2007; Adger, 2007; IPCC, 2007).

This paper shows dwindling agricultural productivity in Assam over time, which has been associated with high regional variation. In some cases also changes in CPI is inconsistent with the diversity of crops. Overall, there is regional divergence in the early part in terms of composite productivity growth though in the later part of the study period there is regional convergence in terms of both composite productivity index and modified diversity index. However, there is cointegration among temporal variation in CPI as well as MDI across the districts of Assam. Thus some sort of convergence is revealed. The contradictory and inconsistent relation of Simpson Index with various climatic variables reveals the superiority of MDI over it.

Relation between climatic variables and composite productivity and diversification index reveal a mixed result. Above analysis also reveals specialization towards some fertilizer intensive commercial crops in some parts of Assam, while diversification is observed in some regions with some irrigation improvement towards traditional crops, which may be explained in terms of crop risk, scarcity of credit, and lack of infrastructure in the hilly backward NC Hills and Karbi Anglang (De and Bodosa, 2015). The current unusual result is supported by the growing uncertainty in seasonal rainfall, growth of fertilizer use, across the region and rising temperature particularly in monsoon period, which is shown in regression results. The Khariff season rainfall affects composite productivity in a positive direction through the specialisation towards flood resistant crops in the flood prone areas. Untimely erratic rainfall in the Rabi season also adversely affects the productivity of crops and force farmers to diversify in order to avoid risk. Khariff season maximum temperature due to natural reason affects the productivity by enhancing the productivity of major rice crop of the region. Assam is still subject to significant weather dependence and lack of technological involvement in the agriculture.

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Appendix-1

App.1A: Correlations of SI across Ten Zones of Assam with Various Explanatory Variables (1951-1976)

Zone	Year	MinT _KH	MinT _RAB	MaxT _KH	MaxT _RAB	R_Rab	Fert _Int	R_KH	Irrig _Int	Avg_Kh _Temp	Avg_ Rabi_Temp
Dibrugarh	.782**	.228	-.215	-.270	-.211	-.044	.178	.245	.825**	-.047	-.243
Sibsagar	.534**	.016	.287	-.021	.026	-.126	.574**	.175	.551**	-.005	.151
Lakhimpur	.774**	-.214	.057	-.390*	-.446*	-.134	.504**	-.125	.736**	-.336	-.311
Darrang	.868**	.290	.314	.598**	.493*	-.235	.509**	-.521**	.889**	.607**	.447*
Kamrup	.949**	.840**	.635**	.813**	.785**	-.578**	.889**	-.605**	.942**	.829**	.796**
Goalpara	.900**	-.218	.237	-.217	-.376	.176	.770**	.278	.769**	-.237	-.112
Cachar	.883**	.318	.679**	.151	.230	-.123	.812**	-.130	.884**	.364	.656**
Nagaon	.694**	-.227	.292	.616**	.367	-.046	.526**	-.150	.807**	.394*	.391*
Karbi Anglong	-.695**	.238	-.209	.329	.280	-.174	-.268	.305	-.787**	.306	.110
NC Hills	-.514**	.653**	-.252	.647**	.597**	.157	-.425*	.135	-.547**	.706**	.544**

Notes: * and ** indicates that the correlation is significant at 5 and 1 per cent level by two tail test. MinT_Kh- Minimum Temperature of Khariff Season, MinT_RAB- Minimum Temperature of Khariff Season, MaxT_KH- Maximum Temperature of Khariff Season, MaxT_RAB- Maximum Temperature of Khariff Season, R_Rab- Average Monthly Rainfall in Khariff Season, R_Rab- Average Monthly Rainfall in Rabi Season, Fert_Int.- Fertiliser Intensity, Irrig_Int- Irrigation Intensity, Avg_Kh_Temp- Average Temp. in Khariff season, Avg_Rabi_Temp- Average Temp. in Rabi Season.

App.1B: Correlations of SI across Ten Zones of Assam with Various Explanatory Variables (1977-2010)

Zone	Year	MinT _KH	MinT _RAB	MaxT _KH	MaxT _RAB	R_Rab	Fert _Int	R_KH	Irrig _Int	Avg_Kh _Temp	Avg_Rabi _Temp
Dibrugarh	-.910**	-.749**	-.770**	-.175	-.479**	.034	-.926**	.094	-.918**	-.467**	-.722**
Sibsagar	-.703**	.110	.226	-.257	-.146	.032	-.756**	-.282	-.749**	-.085	.055
Lakhimpur	.270	.608**	.587**	.385*	.373*	-.053	.046	-.222	.310	.533**	.564**
Darrang	.662**	-.124	.177	.446**	.430*	-.272	.696**	-.240	.711**	.201	.418*
Kamrup	.761**	.678**	.671**	.209	.153	-.037	.777**	-.125	.781**	.556**	.635**
Goalpara	.941**	.527**	.223	.275	.443**	.032	.793**	-.049	.241	.453**	.359*
Cachar	-.786**	-.733**	-.641**	-.489**	-.250	.183	-.571**	.373*	.092	-.729**	-.584**
Nagaon	.706**	.458**	.466**	.278	.177	.153	.418*	-.132	.595**	.394*	.364*
Karbi Anglong	.235	.384*	.304	.325	.281	-.221	.290	-.337	.329	.365*	.310
NC Hills	-.742**	-.381*	-.345*	-.265	-.203	.259	-.003	.471**	-.658**	-.346*	-.328

Notes: Same as App.1A

App.1C: Correlations of CPI across Ten Zones of Assam with Various Explanatory Variables (1951-1976)

Zone	Year	MinT_KH	MinT_RAB	MaxT_KH	MaxT_RAB	R_Rab	Fert_Int	R_KH	Irrig_Int	Avg_Kh_Temp	Avg_Rabi_Temp
Dibrugarh	.510**	.359	.076	.027	-.211	-.310	.163	.027	.410*	.201	-.093
Sibsagar	.081	.104	-.366	.121	-.306	.384	.085	-.069	.077	.120	-.391*
Lakhimpur	.262	-.058	-.031	-.061	.012	-.127	-.123	-.386	.328	-.064	-.006
Darrang	-.382	-.254	-.125	-.414*	-.283	.195	-.216	.164	-.385	-.446*	-.227
Kamrup	-.012	.092	.172	.032	.194	-.143	.031	.266	.020	.058	.201
Goalpara	-.657**	.227	-.150	.295	.359	-.361	-.421*	-.426*	-.625**	.287	.155
Cachar	.342	-.140	.005	.099	.035	-.149	.266	-.209	.274	-.021	.027
Nagaon	-.183	-.183	.100	.058	.023	.442*	-.221	.255	-.054	-.043	.058
KarbiAnglong	.603**	-.202	.058	-.363	-.305	-.167	.823**	-.214	.561**	-.312	-.208
NC Hills	-.583**	.282	-.230	.162	.214	.270	-.562**	.258	-.585**	.234	.148

Notes: Same as App.1A

App.1D: Correlations of CPI across Ten Zones of Assam with Various Explanatory Variables (1977-2010)

Zone	Year	MinT_KH	MinT_RAB	MaxT_KH	MaxT_RAB	R_Rab	Fert_Int	R_KH	Irrig_Int	Avg_Kh_Temp	Avg_Rabi_Temp
Dibrugarh	-.711**	-.669**	-.615**	-.158	-.438**	.310	-.732**	.205	-.710**	-.418*	-.604**
Sibsagar	-.469**	-.030	.070	-.276	-.152	.121	-.518**	-.222	-.375*	-.174	-.041
Lakhimpur	-.876**	-.375*	-.342*	-.332	-.392*	-.265	-.683**	-.269	-.883**	-.381*	-.417*
Darrang	-.237	-.021	-.106	-.194	-.170	-.070	-.229	.435*	-.230	-.133	-.181
Kamrup	.558**	.442**	.467**	.313	.032	-.137	.708**	-.229	.677**	.460**	.404*
Goalpara	.481**	.048	.013	.082	.271	.067	.562**	.028	.411*	.074	.139
Cachar	.341*	.279	.349*	.129	-.011	-.137	.253	-.027	-.287	.249	.227
Nagaon	.392*	.370*	.424*	.150	.336	.032	.218	-.042	.306	.280	.417*
Karbi Anglong	-.777**	-.427*	-.532**	-.304	-.366*	.159	-.605**	.324	-.651**	-.376*	-.474**
NC Hills	-.673**	.085	-.139	.266	.040	.234	-.435*	.515**	-.587**	.191	-.062

Notes: Same as App.1A

App.1E: Correlations of MDI across Ten Zones of Assam with Various Explanatory Variables (1951-1976)

Zone	Year	MinT_KH	MinT_RAB	MaxT_KH	MaxT_RAB	R_Rab	Fert_Int	R_KH	Irrig_Int	Avg_Kh_Temp	Avg_Rabi_Temp
Dibrugarh	-.077	.013	-.089	-.110	-.507**	-.234	-.044	-.283	-.345	-.060	-.364
Sibsagar	-.749**	-.309	-.024	.174	.689**	.175	-.614**	-.131	-.738**	-.037	.487*
Lakhimpur	.877**	.045	.295	-.256	-.334	-.254	-.135	-.143	.910**	-.136	-.114
Darrang	-.762**	-.012	-.425*	-.512**	-.388	.386	-.468*	.426*	-.769**	-.404*	-.446*
Kamrup	-.925**	-.837**	-.619**	-.811**	-.861**	.546**	-.785**	.602**	-.936**	-.827**	-.851**
Goalpara	-.955**	.385	-.204	.282	.254	-.156	-.632**	-.509**	-.945**	.359	.047
Cachar	-.899**	-.285	-.326	-.010	.122	.398*	-.728**	.397*	-.835**	-.221	-.158
Nagaon	-.203	.242	-.263	-.409*	-.233	-.051	.002	-.399*	-.392*	-.216	-.280
KarbiAnglong	-.631**	.257	-.170	.256	.220	-.115	-.463*	.270	-.705**	.268	.083
NC Hills	-.212	.235	-.237	.031	.162	.488*	-.360	.136	-.166	.132	.092

Notes: Same as App.1A

App.1F: Correlations of MDI across Ten Zones of Assam with Various Explanatory Variables (1977-2010)

Zone	Year	MinT_KH	MinT_RAB	MaxT_KH	MaxT_RAB	R_Rab	Fert_Int	R_KH	Irrig_Int	Avg_Kh_Temp	Avg_Rabi_Temp
Dibrugarh	-.774**	-.586**	-.656**	-.148	-.385*	-.008	-.736**	-.087	-.785**	-.374*	-.604**
Sibsagar	-.619**	.158	.099	-.211	-.312	-.007	-.741**	-.369*	-.610**	-.033	-.111
Lakhimpur	.749**	.130	.233	.127	.339	.019	.656**	.354*	.701**	.139	.320
Darrang	-.129	-.138	-.024	-.042	.057	.150	-.156	.014	-.140	-.111	.035
Kamrup	-.209	-.378*	-.282	-.273	-.132	.114	-.497**	.123	-.315	-.397*	-.300
Goalpara	.320	.312	.198	.056	.062	.099	-.063	.114	-.426*	.207	.160
Cachar	-.190	-.321	-.330	-.313	-.009	-.073	-.303	.176	.037	-.369*	-.226
Nagaon	-.048	-.030	-.157	.022	-.081	-.136	.152	-.070	.025	-.005	-.134
KarbiAnglong	.786**	.777**	.679**	.687**	.645**	-.394*	.769**	-.647**	.855**	.754**	.702**
NC Hills	.227	.365*	.255	.292	.140	.134	-.374*	.099	.113	.353*	.237

Notes: Same as App.1A

Appendix-2

App. 2a: Results of Regression of CPI on Explanatory Variables

	1951-52 to 1976-77					*1977-78 to 2010-11*				
Zone	Regressor	B	t	Sig.	Adj.R^2, F	Regressor	B	t	Sig.	Adj.R^2, F
Dibrugarh	(Constant)	-697.359	-2.028	.057	0.313, 2.90**	(Constant)	860.018	1.794	.084	0.526, 7.10**
	R_KH	-.006	-.280	.782		R_KH	.016	.645	.524	
	R_Rab	-.076	-1.418	.172		R_Rab	.129	1.681	.104	
	MaxT_KH	2.260	1.470	.158		MaxT_KH	-1.008	-.381	.706	
	MaxT_RAB	-1.408	-.756	.459		MaxT_RAB	.051	.026	.979	
	Fert_Int	-.150	-.284	.780		Fert_Int	-.079	-.702	.489	
	Year	.399	2.479	.023		Year	-.368	-1.534	.137	
Sibsagar	(Constant)	-75.758	-.081	.936	0.03, 1.129	(Constant)	-149.496	-.277	.784	0.209, 2.453**
	R_KH	.009	.193	.849		R_KH	-.021	-.865	.395	
	R_Rab	.104	1.526	.143		R_Rab	.035	.503	.619	
	MaxT_KH	2.775	1.156	.262		MaxT_KH	-4.390	-1.652	.110	
	MaxT_RAB	-3.613	-1.230	.234		MaxT_RAB	2.214	1.051	.302	
	Fert_Int	-.864	-.307	.762		Fert_Int	-.351	-1.653	.110	
	Year	.094	.208	.837		Year	.172	.623	.538	
Lakhimpur	(Constant)	-380.151	-.893	.383	0.02, 1.086	(Constant)	4028.746	7.372	.000	0.803, 23.44***
	R_KH	-.078	-1.806	.087		R_KH	.068	1.765	.089	
	R_Rab	.003	.034	.973		R_Rab	-.125	-1.503	.145	
	MaxT_KH	-.805	-.363	.721		MaxT_KH	5.770	1.682	.104	
	MaxT_RAB	1.993	.806	.430		MaxT_RAB	-.701	-.260	.797	
	Fert_Int	-.545	-.532	.601		Fert_Int	1.902	1.922	.065	
	YEAR	.251	1.310	.206		YEAR	-2.069	-6.937	.000	
Darrang	(Constant)	893.054	1.718	.102	0.022, 1.095	(Constant)	349.293	1.023	.315	0.057, 1.333
	R_KH	-.046	-.787	.441		R_KH	.044	2.246	.033	
	R_Rab	.020	.253	.803		R_Rab	-.014	-.226	.823	
	MaxT_KH	-2.906	-1.378	.184		MaxT_KH	.281	.176	.862	
	MaxT_RAB	.424	.204	.841		MaxT_RAB	-.916	-.725	.475	
	Fert_Int	1.790	.914	.372		Fert_Int	.053	.562	.579	
	YEAR	-.356	-1.338	.197		YEAR	-.127	-.767	.450	
Kamrup	(Constant)	437.334	1.171	.256	0.28, 2.622**	(Constant)	577.635	1.967	.060	0.579, 8.575***
	R_KH	.061	2.177	.042		R_KH	-.017	-.982	.335	
	R_Rab	-.068	-1.801	.088		R_Rab	-.103	-2.088	.046	
	MaxT_KH	-2.622	-2.064	.053		MaxT_KH	1.835	1.273	.214	
	MaxT_RAB	3.785	2.867	.010		MaxT_RAB	-1.505	-1.188	.245	
	Fert_Int	1.900	.762	.455		Fert_Int	.180	4.090	.000	
	YEAR	-.198	-1.023	.319		YEAR	-.254	-1.672	.106	
Goalpara	(Constant)	884.170	2.149	.045	0.361, 3.352**	(Constant)	116.242	.460	.649	0.204, 2.411**
	R_KH	-.015	-.455	.655		R_KH	.009	.889	.382	
	R_Rab	-.052	-.951	.353		R_Rab	.008	.344	.733	
	MaxT_KH	.295	.141	.890		MaxT_KH	.115	.071	.944	
	MaxT_RAB	1.602	.675	.508		MaxT_RAB	.706	.426	.674	
	Fert_Int	1.962	.360	.723		Fert_Int	.072	1.938	.063	
	YEAR	-.427	-2.019	.058		YEAR	-.030	-.223	.825	

Cachar	(Constant)	-1175.79	-.920	.369	-0.013, 0.516	(Constant)	-1321.00	-1.457	.157	-0.031, 0.835
	R_KH	-.021	-.505	.620		R_KH	.012	.422	.676	
	R_Rab	.003	.029	.977		R_Rab	-.035	-.545	.590	
	MaxT_KH	.170	.033	.974		MaxT_KH	1.770	.522	.606	
	MaxT_RAB	.018	.005	.996		MaxT_RAB	-.886	-.334	.741	
	Fert_Int	-1.543	-.467	.646		Fert_Int	-.270	-.979	.336	
	YEAR	.657	.982	.338		YEAR	.703	1.590	.124	
Nagaon	(Constant)	-446.705	-.567	.577	0.115, 1.540	(Constant)	-1782.431	-3.101	.004	0.239, 2.728**
	R_KH	-.001	-.014	.989		R_KH	.014	.448	.658	
	R_Rab	.327	2.090	.050		R_Rab	-.104	-1.202	.240	
	MaxT_KH	1.571	.695	.496		MaxT_KH	-1.315	-.448	.658	
	MaxT_RAB	1.571	.570	.575		MaxT_RAB	4.326	1.915	.066	
	Fert_Int	-5.185	-1.297	.210		Fert_Int	-.170	-2.459	.021	
	YEAR	.234	.579	.569		YEAR	.915	3.161	.004	
KarbiAnglong	(Constant)	-1166.913	-1.549	.138	0.725, 11.983***	(Constant)	2021.036	4.867	.000	0.634, 10.531***
	R_KH	.002	.067	.947		R_KH	-.030	-1.361	.185	
	R_Rab	-.012	-.134	.895		R_Rab	-.039	-.666	.511	
	MaxT_KH	-5.104	-1.280	.216		MaxT_KH	4.654	1.495	.146	
	MaxT_RAB	13.280	2.676	.015		MaxT_RAB	-.022	-.009	.993	
	Fert_Int	30.101	5.822	.000		Fert_Int	-.927	-1.069	.294	
	YEAR	.550	1.636	.118		YEAR	-1.019	-4.739	.000	
NC Hills	(Constant)	1836.851	1.472	.157	0.243, 2.34*	(Constant)	1357.519	3.093	.005	0.465, 5.777***
	R_KH	-.031	-.806	.430		R_KH	.010	.476	.638	
	R_Rab	.094	1.103	.284		R_Rab	-.040	-.602	.552	
	MaxT_KH	-2.010	-.523	.607		MaxT_KH	7.755	2.160	.040	
	MaxT_RAB	-.878	-.323	.750		MaxT_RAB	-.888	-.272	.788	
	Fert_Int	-8.397	-.626	.539		Fert_Int	-.315	-.290	.774	
	YEAR	-.811	-1.308	.207		YEAR	-.731	-3.390	.002	

App. 2b: Results of Regression of SI on Explanatory Variables

		1951-52 to 1976-77				*1977-78 to 2010-11*				
Zone	Regressor	B	t	Sig.	Adj.R^2, F	Regressor	B	t	Sig.	Adj.R^2, F
Dibrugarh	(Constant)	-12.066	-6.151	.000	0.672, 9.553***	(Constant)	4.090	2.369	.025	0.877, 40.04***
	R_KH	.000	-.973	.343		R_KH	-5.130E-005	-.592	.559	
	R_Rab	.001	1.678	.110		R_Rab	.000	-1.465	.154	
	MaxT_KH	-.007	-.806	.430		MaxT_KH	-.005	-.550	.587	
	MaxT_RAB	.022	2.084	.051		MaxT_RAB	.000	-.021	.983	
	Fert_Int	-.006	-2.115	.048		Fert_Int	-.002	-4.115	.000	
	YEAR	.006	6.729	.000		YEAR	-.002	-1.941	.063	
ibsagar	(Constant)	-2.884	-.976	.342	0.390, 3.668**	(Constant)	.306	.195	.847	0.572, 8.35***
	R_KH	.000	-1.099	.286		R_KH	.000	-1.450	.158	
	R_Rab	1.748E-005	.081	.936		R_Rab	-7.393E-005	-.367	.717	
	MaxT_KH	-.002	-.309	.761		MaxT_KH	-.014	-1.836	.077	
	MaxT_RAB	.025	2.649	.016		MaxT_RAB	.012	1.952	.061	
	Fert_Int	.011	1.275	.218		Fert_Int	-.002	-2.537	.017	
	YEAR	.001	1.012	.324		YEAR	.000	.236	.815	
La khim	(Constant)	-4.407	-4.433	.000	0.687, 10.141***	(Constant)	-3.669	-2.034	.052	0.253, 2.87**
	R_KH	-6.877E-005	-.681	.504		R_KH	.000	-1.499	.145	

	R_Rab	.000	2.047	.055		R_Rab	.000	-.773	.446	
	MaxT_KH	-.008	-1.477	.156		MaxT_KH	.000	.043	.966	
	MaxT_RAB	.010	1.714	.103		MaxT_RAB	.016	1.818	.080	
	Fert_Int	.007	2.905	.009		Fert_Int	-.004	-1.229	.230	
	YEAR	.002	5.538	.000		YEAR	.002	1.981	.058	
Darrang	(Constant)	-6.377	-6.621	.000	0.799, 17.56***	(Constant)	.038	.041	.968	0.440, 5.321***
	R_KH	2.237E-005	.205	.840		R_KH	-2.076E-005	-.390	.700	
	R_Rab	.000	1.734	.099		R_Rab	.000	-1.410	.170	
	MaxT_KH	.003	.884	.388		MaxT_KH	.003	.698	.491	
	MaxT_RAB	.004	1.060	.303		MaxT_RAB	-.001	-.342	.735	
	Fert_Int	-.007	-2.049	.055		Fert_Int	.000	1.231	.229	
	YEAR	.003	6.999	.000		YEAR	.000	.643	.526	
Kamrup	(Constant)	-3.133	-4.148	.001	0.897, 37.43***	(Constant)	-.431	-.516	.610	0.605, 9.417***
	R_KH	6.680E-005	1.172	.256		R_KH	2.511E-006	.051	.960	
	R_Rab	2.390E-005	.314	.757		R_Rab	.000	-1.124	.271	
	MaxT_KH	.002	.832	.416		MaxT_KH	-.003	-.625	.537	
	MaxT_RAB	-.001	-.487	.632		MaxT_RAB	.004	1.186	.246	
	Fert_Int	.009	1.727	.100		Fert_Int	.000	1.957	.061	
	YEAR	.002	4.839	.000		YEAR	.001	1.268	.216	
Goalpara	(Constant)	-6.427	-4.487	.000	0.809, 18.65***	(Constant)	-4.379	-7.664	.000	0.893, 46.72***
	R_KH	.000	-.973	.343		R_KH	3.502E-005	1.502	.145	
	R_Rab	-9.882E-005	-.523	.607		R_Rab	1.819E-005	.352	.728	
	MaxT_KH	.001	.113	.911		MaxT_KH	-.001	-.148	.883	
	MaxT_RAB	-.011	-1.347	.194		MaxT_RAB	.007	1.822	.080	
	Fert_Int	.015	.803	.432		Fert_Int	-6.841E-005	-.816	.422	
	YEAR	.004	5.115	.000		YEAR	.002	8.168	.000	
Cachar	(Constant)	-4.493	-2.938	.008	0.801, 17.734***	(Constant)	8.759	9.932	.000	0.837, 29.30***
	R_KH	7.641E-005	1.555	.136		R_KH	1.869E-005	.657	.516	
	R_Rab	1.453E-005	.126	.901		R_Rab	4.170E-005	.671	.508	
	MaxT_KH	-.001	-.213	.834		MaxT_KH	-.011	-3.471	.002	
	MaxT_RAB	.007	1.399	.178		MaxT_RAB	-.003	-1.259	.219	
	Fert_Int	.005	1.219	.238		Fert_Int	.002	5.834	.000	
	YEAR	.002	3.077	.006		YEAR	-.004	-9.109	.000	
Nagaon	(Constant)	-2.523	-1.524	.144	0.498, 5.141***	(Constant)	-11.271	-8.858	.000	0.782, 20.771***
	R_KH	.000	.969	.345		R_KH	1.503E-005	.224	.825	
	R_Rab	.000	.843	.410		R_Rab	.000	-1.046	.305	
	MaxT_KH	.011	2.245	.037		MaxT_KH	.003	.416	.681	
	MaxT_RAB	-.007	-1.226	.235		MaxT_RAB	.000	-.038	.970	
	Fert_Int	.003	.326	.748		Fert_Int	-.001	-6.703	.000	
	YEAR	.001	1.762	.094		YEAR	.006	9.365	.000	
Karbi Anglon	(Constant)	19.932	5.324	.000	0.652, 8.798***	(Constant)	.527	.349	.730	-0.057, 0.705
	R_KH	.000	1.116	.278		R_KH	-5.343E-005	-.672	.507	
	R_Rab	-.001	-3.304	.004		R_Rab	-6.391E-005	-.299	.768	

	MaxT_KH	.008	.395	.697		MaxT_KH	.006	.502	.620	
	MaxT_RAB	-.063	-2.542	.020		MaxT_RAB	.002	.173	.864	
	Fert_Int	.028	1.083	.293		Fert_Int	.000	-.050	.960	
	YEAR	-.009	-5.493	.000		YEAR	-8.415E-005	-.107	.915	
NC Hills	(Constant)	2.795	.811	.427	0.339, 3.14**	(Constant)	5.994	6.862	.000	0.648, 11.143***
	R_KH	7.607E-005	.717	.482		R_KH	2.138E-005	.502	.620	
	R_Rab	-9.533E-006	-.041	.968		R_Rab	.000	-1.174	.250	
	MaxT_KH	.018	1.663	.113		MaxT_KH	-.007	-1.042	.306	
	MaxT_RAB	-7.648E-005	-.010	.992		MaxT_RAB	.001	.106	.917	
	Fert_Int	.025	.673	.509		Fert_Int	.006	2.930	.007	
	YEAR	-.001	-.798	.435		YEAR	-.003	-6.012	.000	

App. 2c: Results of Regression of MDI on Explanatory Variables for 1951 to 1976

		1951-52 to 1976-77					***1977-78 to 2010-11***			
Zone	Regressor	B	t	Sig.	Adj.R^2, F	Regressor	B	t	Sig.	Adj.R^2, F
Dibrugarh	(Constant)	-4.461	-10.430	.000	0.916, 46.65***	(Constant)	-1.454	-1.543	.134	0.814, 25.02***
	R_KH	-9.497E-006	-.345	.734		R_KH	-9.253E-005	-1.958	.061	
	R_Rab	.000	2.890	.009		R_Rab	9.555E-005	.635	.531	
	MaxT_KH	-.001	-.755	.460		MaxT_KH	-.005	-1.029	.313	
	MaxT_RAB	.010	4.514	.000		MaxT_RAB	.004	1.135	.266	
	Fert_Int	-.001	-1.077	.295		Fert_Int	.000	1.767	.088	
	Year	.003	13.128	.000		Year	.001	2.628	.014	
Sibsagar	(Constant)	-3.513	-.931	.363	0.192, 2.0*	(Constant)	-8.119	-3.730	.001	0.401, 4.676***
	R_KH	.000	-.986	.337		R_KH	.000	-1.689	.103	
	R_Rab	.000	1.265	.221		R_Rab	6.915E-005	.247	.807	
	MaxT_KH	-.010	-1.048	.308		MaxT_KH	-.007	-.654	.519	
	MaxT_RAB	.035	2.969	.008		MaxT_RAB	-.001	-.175	.863	
	Fert_Int	.006	.544	.593		Fert_Int	-.003	-3.048	.005	
	Year	.002	1.024	.319		Year	.005	4.160	.000	
Lakhimpur	(Constant)	-17.052	-8.714	.000	0.888, 34.18***	(Constant)	8.192	3.978	.000	0.490, 6.29***
	R_KH	1.990E-005	.100	.921		R_KH	.000	-.840	.408	
	R_Rab	.001	1.702	.105		R_Rab	.000	-1.406	.171	
	MaxT_KH	-.011	-1.035	.314		MaxT_KH	-.006	-.431	.670	
	MaxT_RAB	.011	.944	.357		MaxT_RAB	-.001	-.071	.944	
	Fert_Int	-.043	-9.180	.000		Fert_Int	.007	1.759	.090	
	Year	.009	10.325	.000		Year	-.004	-3.393	.002	
Darrang	(Constant)	-1.276	-.952	.353	0.107,1.50	(Constant)	-6.948	-2.331	.027	0.293, 3.275**
	R_KH	5.561E-006	.037	.971		R_KH	-4.348E-005	-.257	.799	
	R_Rab	.000	.832	.416		R_Rab	.001	1.077	.291	
	MaxT_KH	-.003	-.605	.552		MaxT_KH	-.005	-.394	.97	
	MaxT_RAB	.001	.118	.907		MaxT_RAB	.017	1.545	.134	
	Fert_Int	.005	1.075	.296		Fert_Int	-.001	-1.242	.225	
	Year	.001	1.472	.158		Year	.004	2.589	.015	
Kamrup	(Constant)	1.856	.979	.340	0.275, 2.583**	(Constant)	-20.734	-8.580	.000	0.744, 16.99***
	R_KH	-8.899E-006	-.062	.951		R_KH	-7.436E-005	-.519	.608	
	R_Rab	4.311E-005	.225	.824		R_Rab	7.761E-005	.191	.850	
	MaxT_KH	.009	1.393	.180		MaxT_KH	-.022	-1.853	.075	
	MaxT_RAB	-.018	-2.622	.017		MaxT_RAB	-.007	-.626	.537	

	Fert_Int	.012	.913	.373		Fert_Int	-.002	-6.491	.000	
	Year	-.001	-.668	.512		Year	.011	8.945	.000	
Goalpara	(Constant)	11.327	8.153	.000	0.854, 25.431***	(Constant)	-15.900	-8.234	.000	0.730, 15.87***
	R_KH	.000	-1.027	.318		R_KH	6.342E-005	.805	.428	
	R_Rab	.000	.788	.441		R_Rab	.000	.757	.456	
	MaxT_KH	-.016	-2.295	.033		MaxT_KH	-.016	-1.274	.214	
	MaxT_RAB	.006	.761	.456		MaxT_RAB	.000	.029	.977	
	Fert_Int	.027	1.488	.153		Fert_Int	-.001	-5.176	.000	
	Year	-.005	-7.450	.000		Year	.009	8.366	.000	
Cachar	(Constant)	1.516	1.181	.252	0.221, 2.185*	(Constant)	-8.175	-5.282	.000	0.786, 21.21***
	R_KH	5.285E-005	1.282	.215		R_KH	3.724E-005	.746	.462	
	R_Rab	6.696E-005	.690	.498		R_Rab	-8.168E-005	-.749	.460	
	MaxT_KH	.001	.248	.807		MaxT_KH	-.005	-.820	.419	
	MaxT_RAB	.005	1.329	.200		MaxT_RAB	.002	.360	.722	
	Fert_Int	.006	1.836	.082		Fert_Int	-.001	-1.542	.135	
	Year	-.001	-.983	.338		Year	.004	5.880	.000	
Nagaon	(Constant)	17.116	5.057	.000	0.775, 15.36***	(Constant)	19.791	7.074	.000	0.837, 29.34***
	R_KH	-.001	-3.012	.007		R_KH	.000	-.682	.501	
	R_Rab	-1.302E-005	-.019	.985		R_Rab	.000	.333	.741	
	MaxT_KH	-.021	-2.168	.043		MaxT_KH	.002	.126	.900	
	MaxT_RAB	-.002	-.183	.857		MaxT_RAB	-.005	-.462	.648	
	Fert_Int	.020	1.176	.254		Fert_Int	.001	2.169	.039	
	Year	-.008	-4.555	.000		Year	-.010	-6.850	.000	
KarbiAnglong	(Constant)	37.707	3.381	.003	0.407, 3.858**	(Constant)	-.247	-.152	.880	0.315, 3.53***
	R_KH	.000	.568	.577		R_KH	-6.789E-005	-.795	.433	
	R_Rab	-.002	-1.943	.067		R_Rab	.000	-.704	.487	
	MaxT_KH	-.001	-.018	.986		MaxT_KH	.002	.202	.841	
	MaxT_RAB	-.144	-1.961	.065		MaxT_RAB	.004	.419	.678	
	Fert_Int	-.037	-.484	.634		Fert_Int	.002	.647	.523	
	Year	-.017	-3.433	.003		Year	.000	.333	.742	
NC Hills	(Constant)	-6.729	-1.543	.139	-0.036, 0.856	(Constant)	-47.496	-17.707	.000	0.929, 72.74***
	R_KH	.000	1.161	.260		R_KH	.000	3.236	.003	
	R_Rab	-6.259E-005	-.210	.836		R_Rab	.001	3.067	.005	
	MaxT_KH	.002	.139	.891		MaxT_KH	.030	1.372	.181	
	MaxT_RAB	.007	.769	.451		MaxT_RAB	-.022	-1.126	.270	
	Fert_Int	-.023	-.480	.636		Fert_Int	-.019	-2.827	.009	
	Year	.003	1.584	.130		Year	.024	18.188	.000	