Changing Pattern of Agricultural Productivity in the Brahmaputra Valley, Assam, India

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Abstract

Introduction of green revolution technology has many variants for agricultural land use intensification and increasing agricultural production as well. The authors have tried to probe into the changing pattern of agricultural productivity which is not only result of agro-ecological conditions of land but also of the use of improved seed-fertilizer technology. Such scenario is a recently emerging phenomenon in the Brahmaputra valley.

Comparing inter- and intra- zone differences of agricultural productivity, a profile of agricultural productivity is examined with a focus on isolating the effects of seed-fertilizer technology. It is found that the use of HYVs has significant effects on enhancement of agricultural productivity in the lower parts and use of fertilizer in the central as well as upper parts of the Brahmaputra valley. As a result, two areally differentiated scenarios of the change of agricultural productivity have been observed. First, the scenario of per humid weather conditions with floods and natural calamities prevailing in the upper northern and lower parts of the valley restricts productivity level and also creates variations in its areal pattern. And the second one is related to the scenario of sub-humid climate of fertile alluvial soils (Morigaon - Dibrugarh area of upper southern part of the valley) in which the processes of diffusion of seed-fertilizer technology are operated through the market centers and intensification of rural road network. These conditions of agricultural practices increase productivity fast with diversifying its areal patterns. Consequently, the obliterated pattern of productivity change is observed in the valley.

Key Words: Seed fertilizer technology, Diversified pattern, Point concentrated effect, Line-aligned features.

Introduction:

Agricultural sector is dominant in the economy of the Brahmaputra Valley which shares more than 50 percent to total Gross Domestic Product and employs about 70 percent share of workforce in it. In spite of favorable agro-ecological (soil-weather) conditions for agricultural development and growth, the landuse trends were being observed stagnant and steady during the 1970s and 1980s. However, there was a marginal increase in the Net Sown Area (NSA) and crop yields during the mid 1990s when the processes of expansion and intensification in agricultural land use were accelerated under the significant impact of green revolution in this part of the country (Singh and Sharma 2003). There are many dimensions of viewing intensification in the agricultural practices as studied by Nath (1969), Bhat and Learnmonth (1968), Singh (1974), Bhalla and Tyagi (1989) and Singh (1994) giving regional perspectives of Indian agriculture for its development and planning. Such studies seek and search the weakness of agricultural growth and development processes in its regional context highlighting the areas of weak infrastructure, suitable cropping pattern in relation to existing agro-ecological conditions, the emerging production pattern in its socio-economic setup and the optimal spatial organization of agricultural landuses. Such issues of regional variations in agricultural production are basically linked with a variety of questions for raising economic efficiency of production processes. They are: does agro-ecological conditions intensify agricultural practices and is it true in the case of Brahmaputra Valley? Does unlimited supply of labour boost agricultural intensity? Thirdly, does green revolution technology help in increasing productivity, if so, why does it fail in certain areas of the country? Many reasons behind it and one of them is a type of agriculture performed in the areas where subsistence agriculture is being practiced with little scope of implementation of modern technology because 'confined' vicious circle of agricultural production in which agricultural enterprises, decision-making and decision implementing are around a family (Wharton Jr. 1969, Das 1984: 131-138; Das 1995). The factors of production and their combinations are intensified to fulfil the family requirements. As a result, the pattern of subsistence agriculture is food-grain dominated and labour intensive with little use of modern technology (Wharton, Jr 1969). A similar scenario of agricultural development prevails in the Brahmaputra valley where subsistence farmers are unable to use modern inputs intensively, especially the High Yielding Varieties (HYVs) of seeds, the chemical fertilizer and pesticides/weedicides to increase their farm production (Nath 1983).

Such relevant questions and issues relating to agricultural intensification and productivity increase were taken up by way of testing the validity of Boserup's (1965, 1981) thesis of population-production nexus in agricultural activities. After the use of regression analysis of increasing density of rural population (as independent variable) and crop-intensity (as dependent variable), Das (1984: 90-95) concluded that the thesis is valid for the plains of Assam during the 1970s when there was not much use of modern technology in the agricultural practices interpreting that there is about 50 percent variation in crop-intensification subject to the variation of population pressure in the valley. More or less similar findings are drawn also by Barah (2003) establishing relationship between agricultural productivity and population pressure for the district of Jorhat located in the Upper part and Bhagabati (2000) for the lower parts of Brahmaputra Valley. In fact, increasing population pressure in rural areas increases labour intensity in agricultural practices and if there is no record shift of rural labour to non-agricultural sectors, it diminishes the labour productivity in agricultural practices as widely accepted (Bhalla and Alagh 1979, Singh 1994:87-99). It is also true for the cultivated areas of Manipur and Assam valleys (Singh 1998, Sharma 2003). However, increasing crop-yield is likely to be possible because either changes in agro-ecological conditions or implementation of new technology schemes by the governmental agencies in the valley (Goswami 1988: 83-96). The effects of ecological and technological production factors may be isolated to use homogeneous agro-ecological zones as base and to observe changes of agricultural productivity within and between them.

The present research thus addresses to the issues of emerging areal pattern of agricultural productivity in the Brahmaputra Valley by analyzing its inter- and intra- zonal variations to find out the causes of such changes.

What is Agricultural Productivity and its Measurements?

The question pertaining to definition and measurement of productivity is always debatable on the floor of agricultural scientists, economists and other concerned researchers. Reviewing the literature on such aspects of production aggregation of different crops that are grown in different agro- ecological conditions and also have differentiations in their economic importance (the market forces and use of modern technology) as well as social status (family requirements), Kendall (1939) used factor analytic approach and calculated latent roots (or eigen vectors) to assign weight of individual crop-production for the assessment of agricultural productivity patterns which emerged in England during the 1930s. Further, a simple ranking coefficient technique of calculation of agricultural production was used first by Stamp (1960) for 20 countries of the world and later on by Shafi (1960) for the state of Utter Pradesh in India. Bhatia's (1967) yield-weight method, Singh and Chauhan's (1977) crop-equivalent coefficient method and Bhalla and Tyagi's (1989) method of production aggregation in terms of money are noticeable measurements of productivity for showing diversification in agricultural production patterns emerging in India. However, there is still a question among scientists whether total crop-production produced by a piece of land is a product of many factors like agro-ecological conditions of land, technological enhancement and labour employed for agriculture. If it is a result of the combination of all such geographic factors, the question of isolating effects of such different production-factors is still debatable. Economists conceive productivity a relative concept and assess productivity in respect to land, labour and capital (technological) considering them as production inputs and detecting the effects of such factors of production in a variety of ways. The production function and the regression analysis are common techniques to interpret the isolated effects of production factors. In the areas of under developed and developing economies as prevalent in the Brahmaputra Valley, it is assumed while calculating agricultural productivity that it is highly influenced by agro-ecological conditions of land rather than technology. As a result, agricultural productivity is more related to the physical factors of land. Thus, agricultural productivity refers to total production in its physical term (or even money term without showing the effects of the market forces) per unit of cultivated land. It is called land productivity by many scientists (Singh 1994:15-16, Sharma 2003) and written as:

$$Yc = \left[\left(\sum_{i=1}^{n} Yi\ Ai\ Pi\right) / \left(\sum_{i=1}^{n} Ai\right)\right], \qquad i = 1, 2, 3, \ldots, nth\ crops, \qquad \ldots \qquad \ldots \quad (1)$$

where Yc = aggregated crop production per unit of cultivated land, that is defined as agricultural productivity in the present case (in rupees per hectare, Rs/ha), Yi = yield of ith crop (in kg/ha), Ai = area under ith crops (in ha), and Pi = price per unit of quantity of a particular crop (in Rs/kg). Note that the crop- price is used as 'converter' of crop production to put all crops on their uniform scale considering them at their market importance (Singh and Chauhan 1977). The base year's crop-prices are used as constants to observe the changes in physical production of agriculture over time.

Method and Data Collection:

In order to describe changes in agricultural productivity and impact of agro-ecological conditions of land on it, a regional frame of almost homogeneous agro-ecological attributes (based on soils and weather conditions) is constructed to denote the agro-ecological zones of the study area, which have the most stable regional base of agricultural development (Taher 1975 and 1986, Gopalakrishnan 2000). Based on the homogeneous characteristics of these attributes, the entire Brahmaputra Valley is divided into five agro-ecological zones, namely, the Lower Brahmaputra Valley, Middle-lower valley, Central Brahmaputra valley, Upper Northern and the Upper Southern plains of the Brahmaputra Valley (Fig-1). The administrative sub-division (that is smaller unit than the district) is considered as an areal unit to show agricultural productivity pattern in general and also their changes within the agro-ecological zones.

Prior to the period of early 1990s, the agricultural practices were under the control of agro- ecological conditions. The modern technology was intensively introduced in the valley only during the 1990s (Singh and Sarma 2003). So the changes in agricultural productivity in each sub- division and its emerging pattern were visualized by considering two points of time as the average values of the crop area and crop- yield of the years 1989-90, 1990-91 and 1991-92 called base year representing the agricultural conditions of the early 1990s and the average of the years 1998-99, 1999-2000 and 2000-01 as current year representing the agricultural production for the early 2000s. Sub-division wise statistics of the crop area, crop yield, fertilizer used and the area under HYVs have been collected from the Directorate of Statistics and Economics and the Directorate of Agriculture, Government of Assam, Guwahati for the years under consideration. The attributes relating to irrigation that are major elements of green revolution especially for the arid and semi-arid conditions prevalent in the western parts of country, do not have much importance in the per- humid conditions of Brahmaputra Valley. As a result, irrigated area has declined from 7.1 percent to 3.3 percent in the valley during the nineties. It is not included in the present study because of insignificant impact of irrigation on the changes in agricultural productivity. The cause-effect relationship is analyzed here to consider the variables related to seed-fertilizer technology because they have significant impact on agricultural productivity (Singh and Sharma 2003). The Gazetteers, Statistical Hand Books, Basic Statistics and other published relevant records of the Government of Assam, Guwahati have also been used for the purpose.

Agricultural Productivity Pattern and Changes Therein:

Taking into account the crop-area, crop-yield and prices of 10 principal crops of Brahmaputra Valley and applying equation (1) as given above, agricultural productivity in rupees per hectare of gross cropped land was calculated for each sub-division for the early 1990s (1989-92) and early 2000s (1998-2001) to visualize the changing productivity pattern. Calculated productivity values were grouped into eight categories for the sake of convenience and to show its general pattern.

The depicted patterns revealed that there were considerable differences in the areal patter of agricultural productivity ranging from Rs.3,952 per ha in the Barpeta-Bajali area of the lower Brahmaputra to Rs.12,271 per ha in Dhanseri area of the Upper - Southern part of valley. It was recorded at the time of early 1990s when the use of seed-fertilizer technology was very low. At that time, the pattern was generally under the direct impact of agro-ecological and physiographic factors of land (Bhagabati, et al. 2001). However, there have been record changes in productivity levels as well as in its areal patterns during the 1990s as highlighted below:

(a) The productivity level rose to 14.95 percent from Rs.6,250 per ha (1989-92) to Rs.7,156 per ha (1989-01) in the valley during this initial period of the application of seed-fertilizer technology with the marginal increase of 8.00 percent in crop intensity. The chemical fertilizer consumption in agricultural practices rose 172.85 percent from

1.51 kg/ha (1989-92) to 4.12 kg/ha (1998-01). The NSA under the use of HYVs increasedly 3.67 percent from 41.48 to 44.53 percents during the same period of time (Table-1). Expansion of area under HYVs and intensification of the use of chemical fertilizer during the 1990s had fairly significant impact on crop intensification which increased agricultural productivity significantly. Increase in the level of productivity might have expected more in this first phase of application of seed-fertilizer technology in the valley because of fast return of the use of production factors. However, increase in productivity appears to be slower (1.49 percent annually) during the decade. Causes of slow increase in productivity are many and varied. One of the important causes is land tenure system, the *raiyatwari* system and the small size of operational land holdings (Das 1984: 151-173). On prevailing subsistence agriculture, peasants wish to adopt modern technology in their farm practices but they are not able to apply it properly because of their inelastic family income, low income and 'confined' decisions on farm operations (Nath 1983).

(b) There was a record increase of more than 20 per cent in the agricultural productivity during the decade especially in some of the areas of Upper-Southern and Central parts of the valley (Figs- 2, 3 and 4). Extremely high increase in agricultural productivity was recorded in Golaghat Sub-division (Rs 7,098 per ha), followed by Jorhat (Rs.1,785 per ha), Sibsagar (Rs.1,356 per ha), Margherita Sub-division (Rs.1,997 per ha) and Marigaon (Rs. 1,734 per ha) that are situated in the Upper-South part of the Valley and in Guwahati Sub-division (Rs. 2,577 per ha) followed by Rangia Sub-division (Rs.1,833 per ha) in the central part of Brahmaputra Valley (Table- 1). Emergence of market centres and positive role of central places in diffusion of agricultural innovations to their surroundings might be the major causes of fast increase in productivity in the Central and Upper-Southern parts of the valley. We have a good deal of faith in Binswanger’s (1978a, 1978b) thesis of the use of tractor as multipurpose tool for agricultural development, which is valid in the scenario of substantial increase in productivity in the areas of Punjab – Haryana plains of semi-arid climatic conditions in India (Singh 1994: 55-100). Such scenario of productivity increase may be visualized in Marigaon- Dibrugarh area where fast growing market-economy and well-connected transport-routes influence the productivity. A section of farmers generate more agricultural surplus with their income-elasticity, and spend savings to buy a tractor of 20 HP for tillage, irrigation in dry winters and transportation purpose. The farms located in the close vicinity of market centres have advantage of accessible market with less transport costs and thereby farm gate prices of the production become comparatively higher in its spatial context which fasten growth in the productivity and production in the area. The question of 'appropriate' technology in such subsistence agriculture with humid agro-ecological conditions prevalent in the valley is to be answered some where else in detail. But it is fact that the farmers economy at household level is more determined by the farm size. The heterogeneous environmental conditions of larger farm sizes determine the economies and diseconomies of the farm production with diversifying the crop pattern and providing a way to use intensively the modern techniques on the farm (Visser 1999). It is also true for tea production produced in the upper parts of the Brahmaputra valley as stated by Singh and Daimari (2005). The larger farm size holders have started gradually adopting the small- engine technology in Brahmaputra valley also.As a result, there is a noticeable change in their cropping pattern from subsistence to semi-commercial, while semi-subsistence and dual-farmers of small farm size are also interested to use altered- oxen-drawn plough for increasing tillage area per worker and intensive seed-fertilizer technology in increasing crop-yield per hectare as concluded in the Report on the Agricultural Survey of the Farm Production conducted for the district of Jorhat, Assam (Gogoi 2003). Such technological inducements create a scenario of producers surplus and production input requirements that is more influenced by the road network and growing market forces in the area. A good deal of detail review on spatial structure of agricultural production function has been produced some where else (Singh 2002). It is, however, widely accepted that the market forces influence productivity pattern and the spatial structure of agricultural production function has been altering fast in such areas of high productivity.

(c) Market centres have point-concentrated effects and the development of road network is line-aligned features over space. If this common infra-structure is provided to an area for the agricultural development, it would enhance overall productivity levels but would create areal diversity in the productivity pattern (Singh 1994). A fairly substantial increase in the use of chemical fertilizer and in the extension of under HYVs had been observed due to development in road-network and increasing role of central places, namely, the Jorhat, Sibsagar, Guwahati and Dibrugarh as diffusion centres of agricultural inputs in the valley. Such processes of intensification had consequently widened the areal gaps in the distributional patterns of productivity from its coefficient of variation of 33.23 percent to 38.94 percent during the decade. The impact of agro- ecological conditions and isolation of the effects of seed- fertilizer technology in such areally differentiated scenario of agricultural development were thus analysed in detail by considering inter- and intra- zone variations of agricultural productivity separately in the following paragraphs.

Inter- and Intra-Zone Variations in Productivity:

The effects of agro-ecological conditions were obviously visible in the inter-zonal variations of agricultural productivity. The zones, namely, Lower Brahmaputra Valley, Middle-Lower and Upper Northern Plains, are characterized with more or less similar kind of agro- ecological conditions as they have high mean annual rainfall (3000 to 5000 mm), high soil moisture, severe occasional floods and, resultantly, more soil erosion (NBSS and LUP 2003). As a result, these zones had less inter- zone differences at their agricultural productivity levels in the early as well as the late nineties (Table-2). The most favourable scenario of agro-ecological conditions with relatively less average annual precipitation (1,500 to 2,500 mm), less flood, less erosion and well-built up alluvial soils is prevalent in the Upper-South Plains of Jorhat- Moriani- Sibsagar areas, where fast growing market forces with intensive road network (National Highway 37 passes through the area) have been emerging. Such situation of agricultural production growth created substantially high inter-zone productivity differences in both the periods.

It was assumed that on account of insignificant impact of modern agricultural technology on the agricultural productivity pattern in the valley during the early 1990s, the inter- zone variability in productivity at that point of time (in the early 1990s) must have been observed due to the areal variability occurring in the agro- ecological factors. Agricultural practices were perhaps operated under the complete influence of ecological factors in the early 1990s. An additional increase in the use of modern technology is attributed to the higher degree of inter- zone variability in productivity during the 1990s (1989-92 to 1998-01) as agro-ecological conditions were assumed constant during the same period of time. So the fast increasing productivity differences were found between two main scenarios of production changes in the valley: first, the areas of per- humid zone of low productivity with reducing degree of inter- zonal differences (that are Lower, Middle-Lower and Upper North Brahmaputra Valley) and secondly, the areas of semi-humid zones of Upper Southern plains with a moderate increase of about 8.5 percent to 69.9 percent in the inter- zone differences in productivity(Table-2). The second scenario of increasing inter- zone differences might have emerged due to the enhancement of productivity level by way of intensification of seed-fertilizer technology during the nineties. The effect of technology may further be elaborated in detail by analyzing intra-zone productivity variations. The main observations are depicted in Table- 3 and analysed in the following manner.

(a) Intra-zone mean values of agricultural productivity had been recorded increasing in almost all zones except Upper-North plains with the slight decrease in its areal variability, especially in the per- humid agro-ecological zones of Low, Middle-low and Central Brahmaputra Valley during the period stipulated for the present study. It means that the areal patterns of productivity became marginally more uniform with no effects of agricultural technology in these zones.

(b) The agricultural productivity in the zone of Upper-North plain of humid and *tarai* conditions shrinks marginally its mean with a significant increase of about 13.2 percent in its areal variability from 17.89 percent (1989-92) to 31.07 percent (1998-01) because of the effects of flood and high rainfall with high soil erosion. The catastrophic events explicitly create variability in the pattern of agricultural productivity within this zone of low productivity.

(c) A substantial decadal increase of about 20.0 percent in the mean agricultural productivity in Upper-Southern plains zone of its sub-humid conditions rose about 9.5 percent areal variability from 22.05 percent (1989-92) to 31.62 percent (1998-99) because a few sub-divisions of this zone have well-established market centres with well connected rural roads in order to diffuse seed- fertilizer technology within the zone. As a result, the emerging pattern of agricultural productivity within this zone was more diversified while the market centres played great role in disseminating agricultural innovations in this zone. It created income inequality within the farmers and evolved areal variations in agricultural productivity as highlighted by Poleman and Freedbairn (1973) also.

(d) In order to understand the extent of the degree of scatterness in the values of agricultural productivity subject to the use of chemical fertilizer in each agro-ecological zone for both the points of time (the early as well as late nineties), it was observed that the degree of scatterness of the productivity became too high to explain any relationship between them (Fig-5). It means that areal pattern of the distribution of fertilizer intensification did not match with the areal pattern of agricultural productivity. However, fertilizer had direct impact on productivity. The degree of scatterness was recorded very high because it appeared to be the combined effects of the expansion of the areas under HYVs and intensification of fertilizer use on the productivity. In order to isolate the effects of changes occurred in input intensification especially in the fertilizer used and the area under HYVs of seeds on the changes of agricultural productivity during the nineties for the different agro-ecological conditions, a multivariate linear regression analysis was used. It is found that the expansion in the area under HYVs has significantly positive effects in the areas of most flood and humid conditions, especially in the Low and Middle-lower zones of the Brahmaputra Valley where resistant summer paddy HYVs like *Sali* paddy, IR- 8, IN-1, Jaya varieties which are locally developed and popular among the peasants of Assam, are encouraged (Table-4). In the Central and Upper Southern plain zones where market centres and transport network help to disseminate the fertilizer to the farmers, the effect of fertilizer intensification has prominently been seen. For example, increase in one kilo of chemical fertilizer in its use on one hectare of agricultural land increased fairly substantial amount of about 295 kilograms of agricultural production on the same piece of land in the zone of Upper-Southern plains. However, this rate of increase was marked lesser (i.e., 116kg/ha) in the Central Brahmaputra Valley in spite of the effect of Gawahati market Centre (Table- 4).

(e) Coefficient of determination (R^2) shows the degree of scatterness of the distribution in general and degree of areal variability in particular in the present case. Lesser the value of R^2, greater is the degree of areal variation and *vice versa*. The areas of Central as well as Upper Brahmaputra plains have low value of R^2 with very high values of Standard Error varying from 540 kg/ha in Central parts to 2127 kg/ha in the Upper –Southern parts in the distribution of agricultural productivity changes (Table-4). It means that the process of agricultural productivity increase has been accelerated by the application of seed – fertilizer technology as also interpreted by Shiyani and Pandya (1998) for the agricultural development in the state of Gujarat. In fact, the diversification was observed in the areal patterns of agricultural productivity especially in Upper-South plains of the valley because Jorhat town has emerged as major feeder centre of modern technology to boost the productivity in the Upper-Southern plains and Guwahati as a regional market centre of the Central Brahmaputra Valley to play a significant role in increasing agricultural productivity in these areas.

Conclusions:

The presently employed techniques offer some insights into the changing pattern of agricultural productivity in Brahmaputra Valley. In general, it may be concluded that the smoothness of general land use trends became fluctuating under the use of modern agricultural technology. As a result, intensification in agricultural practices has been started especially during the last decade of the last century. However, effects of the enhancement of seed- fertilizer technology vary areally. There are four important deductions drawn from the present analysis.

(a) Application of seed-fertilizer technology has fairly good deal of impact on increasing agricultural productivity in the initial phase of agricultural development (i.e., 1990s) as it has been seen in the productivity pattern emerging in Brahmaputra Valley. At the same time, it diversifies the areal pattern of productivity substantially. It creates an areally-differentiated development scenario in the regional structure of agrarian economy.

(b) The increasing use of chemical fertilizer has direct impact on the changing agricultural productivity pattern in semi- humid conditions of the valley and the expansion of cultivated land under HYVs increases productivity marginally in the most humid parts of Lower as well as upto some extent in the Central areas in the valley.

(c) Increasing inter-zone differences of agricultural productivity provide the evidence of the emergence of obliterated productivity patterns in the Brahmaputra Valley. They show the concentration of high agricultural productivity areas in the surroundings of market centres.

(d) The questions pertaining to the application of 'appropriate' technology in humid tropical areas of the country like Brahmaputra Valley where subsistence-peasant agriculture is prevalent, are still debatable and may be answered in applying an appropriate agricultural production function in which agro-ecological as well as technological factors are to be integrated implicitly for the analysis of observing the effects of these factors in the emerging areally-differentiated scenarios of agricultural development.

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Table- 1 : Values of Different Variables of Agricultural Productivity for Two Points of Time .

Sl. No.	Sub-divisions	Area in sq km	Land Productivity(Rs/ha)		Fertilizer (Kg/ha)		Area under HYV %		Change in Land Productivity		Change in HYV Area (%)
			1989-92	1998-01	1989 - 1992	1998 - 2001	1989 - 1992	1998 - 2001	Total (Rs/ha)	%	
1	Dhubri	901.30	4208.06	5547.74	0.89	4.31	40.71	38.65	1339.68	31.84	-2.06
2	Bilasipara	646.30	4208.06	4822.15	0.89	4.31	40.71	38.65	614.09	14.59	-2.06
3	South Salmara	783.80	4227.96	4908.56	0.89	4.31	40.71	38.65	680.60	16.10	-2.06
4	Kokrajhar	1839.00	4785.56	5265.39	1.22	4.65	52.11	39.02	479.83	10.03	-13.09
5	Gossaingaon	1240.00	4102.18	4202.18	1.22	4.65	52.11	39.02	100.00	2.44	-13.09
6	Bongaigaon	448.20	4789.24	4918.88	0.83	5.15	45.59	46.33	129.64	2.71	0.74
7	Bijni	1115.00	4789.24	4669.24	0.83	5.15	45.59	46.33	-120.00	-2.51	0.74
8	North Salmara	551.90	4789.24	5289.24	0.83	5.15	45.59	46.33	500.00	10.44	0.74
9	Goalpara	1673.00	5748.30	5528.00	1.66	6.33	22.12	40.00	-220.30	-3.83	17.88
10	Barpeta	1930.00	3952.61	5157.37	0.41	4.49	66.77	48.12	1204.76	30.48	-18.65
11	Bajali	1139.00	3952.61	5254.09	0.41	4.49	66.77	48.12	1301.48	32.93	-18.65
12	Nalbari	2158.00	5572.40	4619.00	0.98	5.98	39.05	53.39	-953.40	-17.11	14.34
13	Guwahati	2677.00	5238.93	7816.12	1.07	4.89	52.18	43.97	2577.19	49.19	-8.21
14	Rangia	1085.00	2889.69	4722.42	1.07	4.89	52.18	43.97	1832.73	63.42	-8.21
15	Pragjyotishpur	215.90	6063.15	7792.46	1.07	4.89	52.18	43.97	1729.31	28.52	-8.21
16	Mangaldoi	1921.00	5524.79	6475.82	0.94	4.17	30.71	41.44	951.03	17.21	10.73
17	Udalguri	1396.00	6390.33	6588.91	0.94	4.17	30.71	41.44	198.58	3.11	10.73
18	Tezpur	3179.00	7371.91	8667.82	0.66	1.86	50.91	48.04	1295.91	17.58	-2.87
19	Biswanath Chariali	1920.00	7524.06	7651.48	0.66	1.86	50.91	48.04	127.42	1.69	-2.87
20	North Lakhimpur	1941.00	4559.48	6766.65	0.77	1.03	37.48	34.50	2207.17	48.41	-2.98
21	Dhakuakhana	889.90	4559.48	2999.73	0.77	1.03	37.48	34.50	-1559.75	-34.21	-2.98
22	Dhemaji	1547.00	4802.58	5020.99	0.13	0.33	31.07	24.04	218.41	4.55	-7.03
23	Jonai	964.30	6448.00	4898.34	0.13	0.33	31.07	24.04	-1549.66	-24.03	-7.03
24	Dibrugarh	2965.00	7036.60	7125.80	2.61	4.36	36.53	32.44	89.20	1.27	-4.09
25	Tinsukia	1772.00	8177.89	8865.22	1.31	5.17	25.42	33.59	687.33	8.40	8.17
26	Margherita	1081.00	5792.36	7789.23	1.31	5.17	25.42	33.59	1996.87	34.47	8.17
27	Sadiya	775.00	7820.00	8757.57	1.31	5.17	25.42	33.59	937.57	11.99	8.17
28	Morigaon	1426.00	5103.39	6837.28	3.12	9.50	54.34	77.02	1733.89	33.98	22.68
29	Nogaon	1783.00	8220.79	8961.73	5.92	7.47	47.38	68.22	740.94	9.01	20.84
30	Hojai	1057.00	9117.56	9985.69	5.92	7.47	47.38	68.22	868.13	9.52	20.84
31	Kaliabar	665.80	9117.56	10242.71	5.92	7.47	47.38	68.22	1125.15	12.34	20.84
32	Golaghat	1997.00	10078.53	17176.65	1.93	2.03	54.57	45.36	7098.12	70.43	-9.21
33	Dhansiri	1002.00	12270.96	13206.72	1.93	2.03	54.57	45.36	935.76	7.63	-9.21
34	Jorhat	1770.00	8818.99	10604.50	0.44	1.43	20.53	48.85	1785.51	20.25	28.32
35	Majuli	1047.00	6704.69	7210.63	0.44	1.43	20.53	48.85	505.94	7.55	28.32
36	Sibsagar	914.00	8715.62	10071.99	2.04	2.62	39.11	38.62	1356.37	15.56	-0.49
37	Charaideo	1467.00	7798.06	8370.59	2.04	2.62	39.11	38.62	572.53	7.34	-0.49
Mean		--	**6250.56**	**7156.46**	**1.50**	**4.12**	**41.96**	**44.08**	**905.89**	**14.95**	**2.13**
Standard Deviation		--	**2077.17**	**2786.87**	**1.48**	**2.15**	**12.06**	**11.46**	**1395.15**	**21.35**	**12.68**
Coefficient of Variation (%)		---	**33.23**	**38.94**	**98.42**	**52.14**	**28.73**	**26.00**	**154.01**	**142.78**	**595.88**

Source : Directorate of Statistics and Economics, Govt. of Assam, Guwahati.

Table-2: Inter- Zone Differential Characteristics of Agricultural Productivity for Base as well as Current Years.

.Agro-Ecological Zones	Years and Inter-Zonal Difference Change	Lower Brahmaputra Valley	Middle Lower Brahmaputra Valley	Central Brahmaputra Valley	Upper Northern Plain	Upper Southern Plain
Lower Brahmaputra Valley	1989-92	0	-15.9	2668.8	464.9	3693.9
	1998-01	0	876.8	3159.6	-95.4	4901.1
	Absolute Change	0	892.7	490.8	-560.3	1207.2
	Rela. Change(%)	0	5614.4	18.4	-120.5	32.7
Middle Lower Brahmaputra Valley	1989-92		0	2684.7	480.8	3709.8
	1998-01		0	2282.8	-972.2	4024.3
	Absolute Change		0	-401.9	-1453.0	314.5
	Rela. Change(%)		0	-15.0	-302.2	8.5
Central Brahmaputra Valley	1989-92			0	-2203.9	1025.1
	1998-01			0	-3255.0	1741.5
	Absolute Change			0	-1051.1	716.4
	Rela. Change(%)			0	-47.7	69.9
Upper Northern Plain	1989-92				0	3229.0
	1998-01				0	4996.5
	Absolute Change				0	1767.5
	Rela. Change(%)				0	54.7
Upper Southern Plain	1989-92					0
	1998-01					0
	Absolute Change					0
	Rela. Change(%)					0

N.B.: 1. The figures show values of mean Zone Differences of Agricultural Productivity in Rs. per hectare. The values of Relative changes are in percents

2. The negative values show as decreasing and positive as increasing Inter- Zone differences in Agricultural Productivity.

Table- 3: Intra-Zone Variations in Agricultural Productivity (Rs./ha).

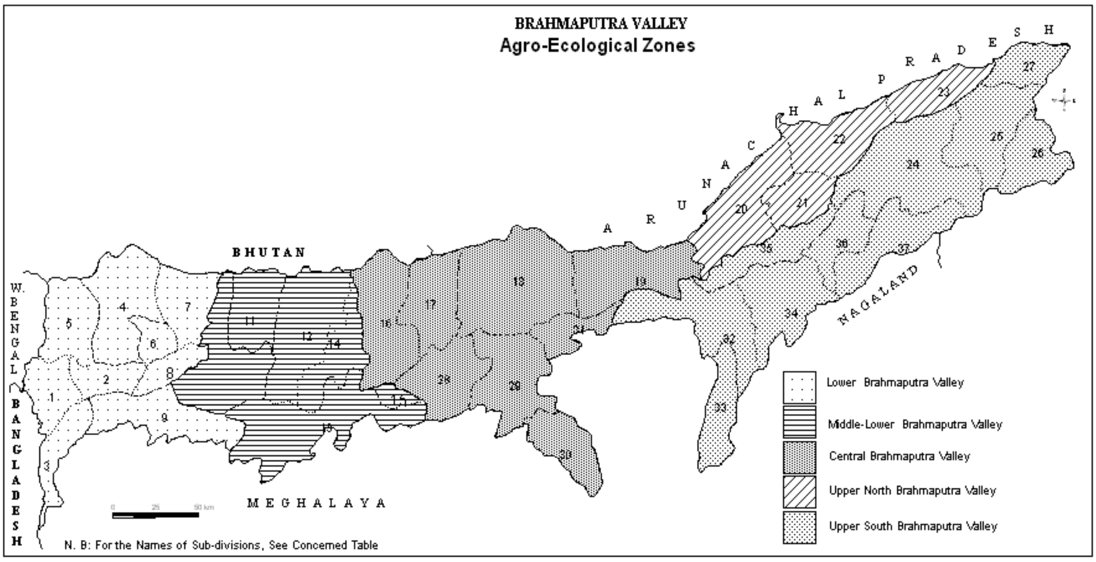
Agro-Ecological Zones	Years	Minimum	Maximum	Difference	Mean	Standard Deviation	Coefficient of Variation (%)
Lower Brahmaputra Valley	1989-92 1998-01	4102.2 4202.2	5748.3 5547.7	1646.1 1345.5	4627.5 5016.8	518.0 436.3	11.19 8.70
Middle Lower Brahmaputra Valley	1989-92 1998-01	2889.7 4619.0	6063.1 7816.1	3173.4 3197.1	4611.6 5893.6	1204.7 1499.9	26.12 25.45
Cenntral Brahmaputra Valley	1989-92 1998-01	5103.4 6475.8	9117.6 10242.7	4014.2 3766.9	7296.3 8176.4	1526.6 1506.3	20.92 18.42
Upper Northern Plain	1989-92 1998-01	4559.5 2999.7	6448.0 6766.6	1888.5 3766.9	5092.4 4921.4	911.0 1529.3	17.89 31.07
Upper Southern Plain	1989-92 1998-01	5792.4 7125.8	12271.0 17176.6	6478.6 10050.8	8321.4 9917.9	1834.7 3136.0	22.05 31.62

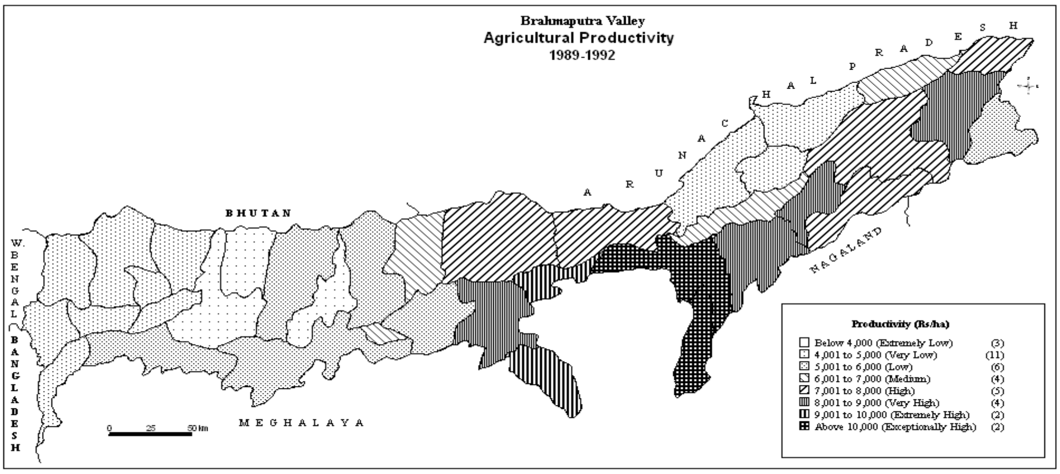
N.B.:The figures show the Agricultural Productivity values in Rs. Per hectare.

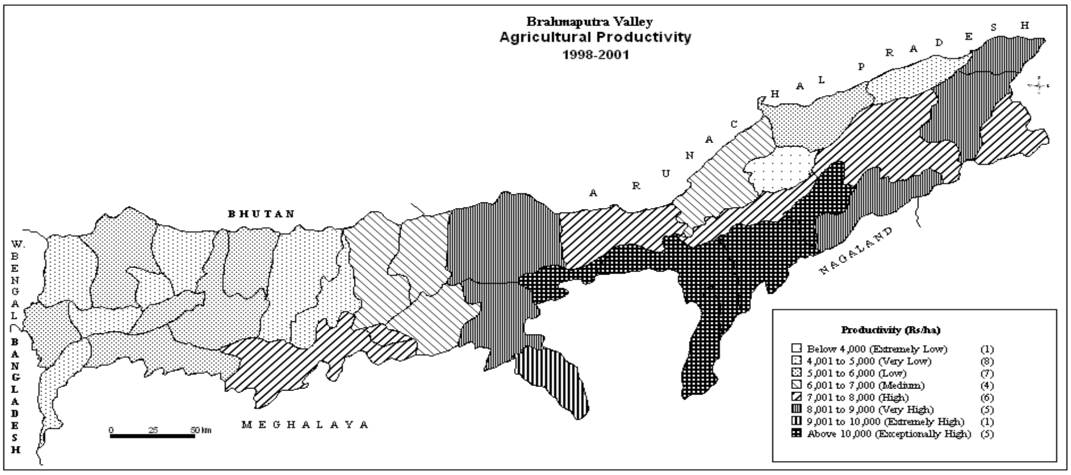
Table-4: Changes in Agricultural Productivity (Y) as Dependent Variable Regressing with Changes in the Use of Fertilizer (X1) and in Percentage of HYVs Area (X2) as Independent Variables during Nineties in Different Agro-ecological Zones.

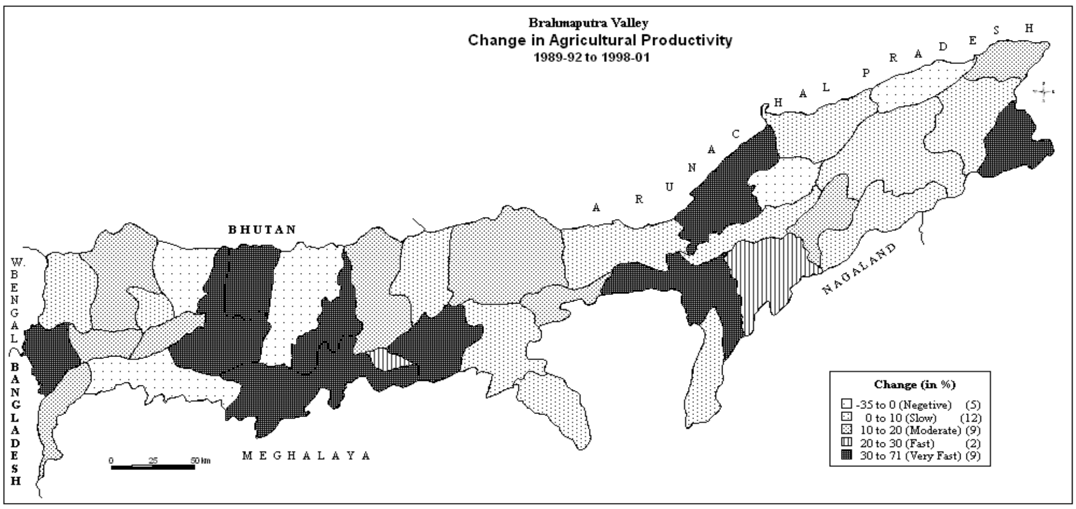
Agro-Ecological Zones	Constant (a)	Coefficient (b1)	Coefficient (b2)	R^2	Slandered Error
Lower Brahmaputra Valley (N=9)	3884.50	-897.40	22.213	.5190	384.32*
Middle Lower Brahmaputra Valley(N=6)	12455.02	-2706.31	8.587	.9400	379.74*
Cenntral Brahmaputra Valley(N=8)	439.336	115.84	12.110	.2790	539.33
Upper Northern Plain(N=4)	1051.66	244.28	3.321	.1020	2080.61
Upper Southern Plain(N=10)	2295.181	294.81	35.94	.1380	2126.92

*significant at 5.0% level

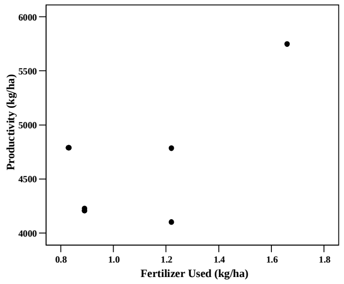



Brahmaputra Valley
Agricultural Productivity
1989-1992
ARUNACHAL PRADESH
BHUTAN
W. BENGAL
BANGLADESH
MEGHALAYA
NAGALAND
0 25 50 km
Productivity (Rs/ha)
Below 4,000 (Extremely Low) (3)
4,001 to 5,000 (Very Low) (11)
5,001 to 6,000 (Low) (6)
6,001 to 7,000 (Medium) (4)
7,001 to 8,000 (High) (5)
8,001 to 9,000 (Very High) (4)
9,001 to 10,000 (Extremely High) (2)
Above 10,000 (Exceptionally High) (2)

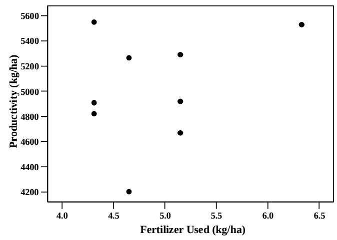

Brahmaputra Valley
Agricultural Productivity
1998-2001
ARUNACHAL PRADESH
BHUTAN
W. BENGAL
BANGLADESH
MEGHALAYA
NAGALAND
0 25 50 km
Productivity (Rs/ha)
Below 4,000 (Extremely Low) (1)
4,001 to 5,000 (Very Low) (8)
5,001 to 6,000 (Low) (7)
6,001 to 7,000 (Medium) (4)
7,001 to 8,000 (High) (6)
8,001 to 9,000 (Very High) (5)
9,001 to 10,000 (Extremely High) (1)
Above 10,000 (Exceptionally High) (5)


Brahmaputra Valley
Change in Agricultural Productivity
1989-92 to 1998-01
ARUNACHAL PRADESH
BHUTAN
W. BENGAL
BANGLADESH
MEGHALAYA
NAGALAND
0 25 50 km
Change (in %)
-35 to 0 (Negetive) (5)
0 to 10 (Slow) (12)
10 to 20 (Moderate) (9)
20 to 30 (Fast) (2)
30 to 71 (Very Fast) (9)

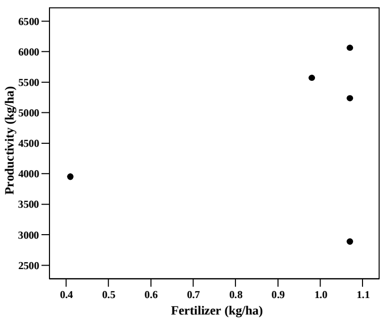
Lower Brahmaputra Valley (1989-92)



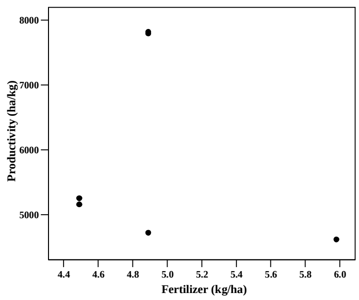
Lower Brahmaputra Valley (11998-01)



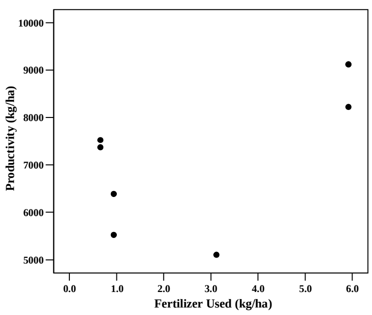
Middle-Lower Brahmaputra Valley (1989-92)



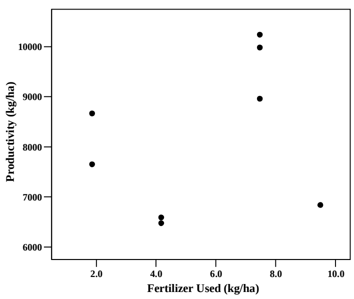
Middle-Lower Brahmaputra Valley (1998-01)



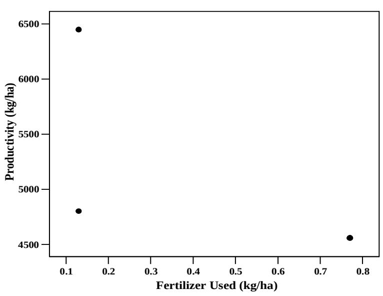
Central Brahmaputra Valley (1989-92)



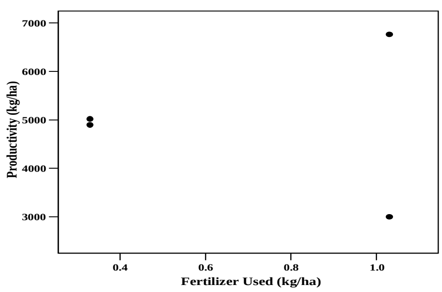
Central Brahmaputra Valley (1998-01)

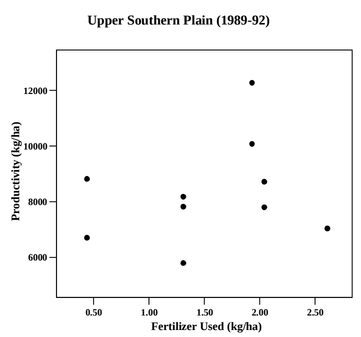


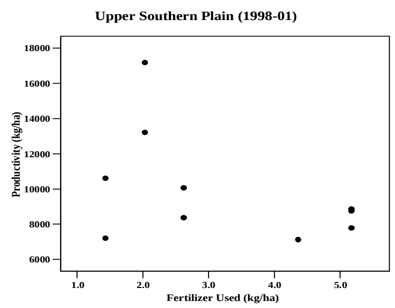
Upper Northern Plain (1989-92)



Upper Northern Plain (1998-01)




Upper Southern Plain (1989-92)
Productivity (kg/ha)
12000
10000
8000
6000
0.50
1.00
1.50
2.00
2.50
Fertilizer Used (kg/ha)


Upper Southern Plain (1998-01)
Productivity (kg/ha)
18000
16000
14000
12000
10000
8000
6000
1.0
2.0
3.0
4.0
5.0
Fertilizer Used (kg/ha)