Determinants of Crop Intensity in the Assam Plains

Surendra Singh and Bimal Sharma
Department of Geography, North Eastern Hill University, Shillong

Abstract

Present paper examines the determinants of crop intensity for the agricultural practices being performed in the Assam plains where landuse pattern are stagnant with slow pace of agricultural development. Applying 'step-wise multiple regression analysis' for observing the effects of crop intensity determinants, it is found that crop intensity is still under the influence of physical factors of agricultural land. However, the summer paddy ratio is an important determinant which sensitizes crop intensity and alters it first.

Key Words: Crop Intensity, multiple regression, determinants.

Introduction

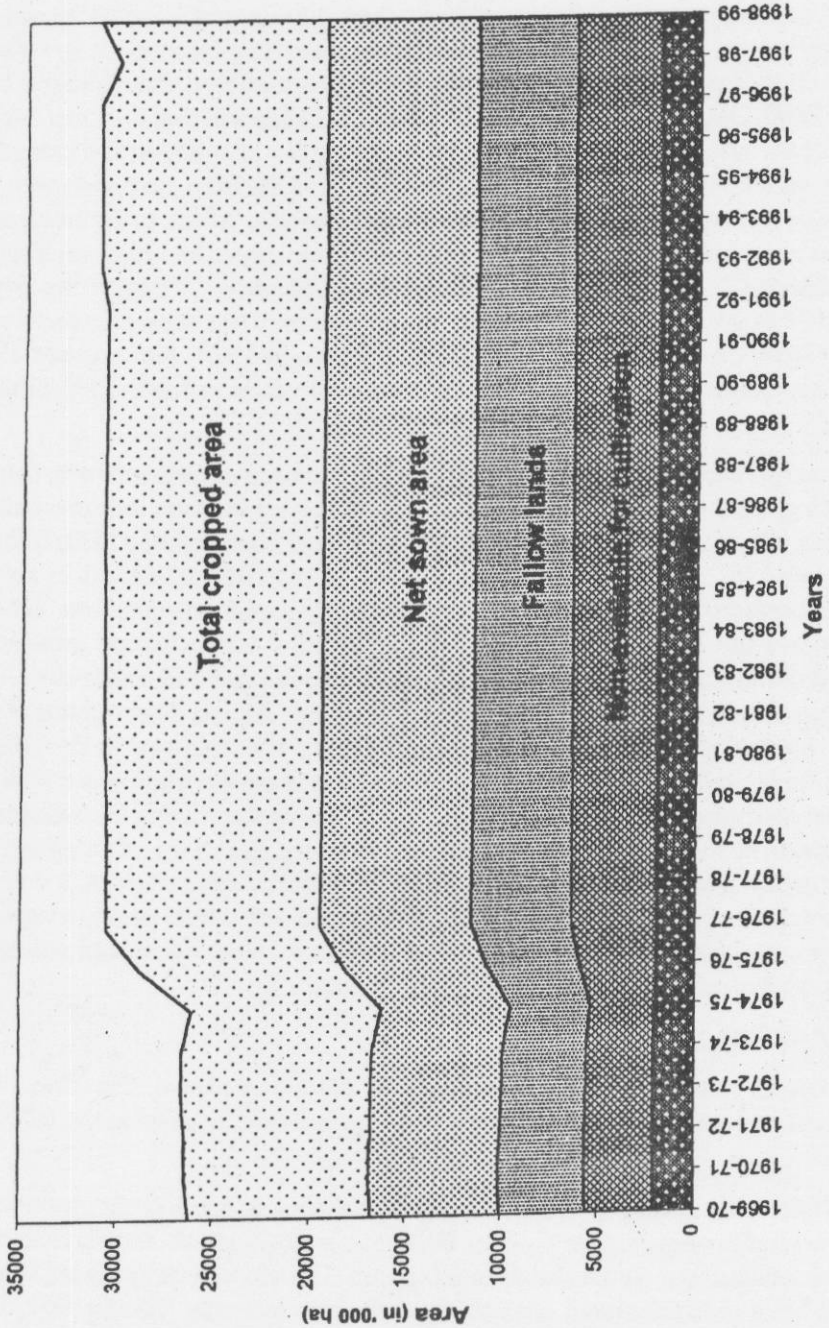
There are numerous studies on the regional variation in agricultural intensity. A group of agricultural scientists explains the variations of agricultural intensity in relation to the physiographic factors specially soils and meteorological conditions which generate land potential for cultivation and determine the agricultural yield (Stamp 1958, 1960, Vink 1975, Prasad et. al. 1987, Smith et.al. 1991, Gorski et. al. 1994). However, many economists and geographers challenge this deterministic approach of agricultural productivity conceiving that the technological progress and transport changes are the major causes of crop specialization and agricultural intensification (Binswanger 1978, Visser 1980, 1982, Learman & Conkling 1995). The increasing demand of food for every increasing population is also realised one of the demographic causes of agricultural intensification and changes in crop pattern as persuaded by Boserup (1965,1981). Since crop intensity is one of the main attributes of agricultural productivity because it is implicitly related to the expansion and intensification processes of agricultural landuse (Singh 1994). It is obvious to realise that crop intensity is determined by various factors as highlighted above and its regional pattern are likely to be the result of their direct or indirect effects. Infact, the effects of such factors are multi-dimensional. The physical properties of land that are related to its climatic conditions, soil fertility and relief features, directly control the expansion and intensification process of agricultural landuse practices. The economic and technological factors also intensify and alter the crop pattern. The socio-cultural dimensions of agricultural labour force provide the basis of consumption pattern and demand for the available food. However, the composition of such factors varies areally as well as temporally because of changing scenario of agricultural practices. These facts should be studied for the underdeveloped agricultural economy provailing in the Assam plains where the agricultureal landuse pattern seem to be stagnant in its nature and unchangeable over time inspite of available fertile soils and favourable agro-meteorological conditions with increasing significantly the population pressure as well as the urban growth Singh and Das 2000; Bhagabati 2000, Taher, 1975. For example, the general landuse pattern of the state show that there is almost equal share of land under major landuse categories as the cultivated land (Net Area Sown and Fallow land) 33 percent, the area under forest 33 percent and the other areas 33 percent, Surprisingly, There is no observation of much change in the landuse practices during the last 20 years (Fig 1). On the other hand, the population pressure on land has been increased 136 percent during the last 30 years from 150 persons per sq.km in 1971 to 416 persons per sq. km in 2001 because of demographic expansion by natiural growth and immigration. The crop patterns are also stable as paddy dominated monocropping. Therefore, the emerging reginal pattern of crop intensification may be the result of various combination of factors in the state. On the other hand, the population pressure on land has been increased 136 percent during the last 30 years from 150 persons per sq. km in 1971 to 416 persons per sq. km in 2001 because of demographic expansion by natural growth and immigration. The crop patterns are also stable as paddy dominated monocropping. Therefore, the emerging regional pattern of crop intensification may be the result of various combination of factors in the state.

The present research examines the regional variations of crop intensity and its determinants. A simple cartographic technique of showing the distributional pattern of crop intensity has been adopted by collecting district wise agricultural statsistics for the year 1998-1999. A step-wise multiple regression technique is used to carve out the effects of different intensity determinants.

What is Crop Intensity and its Determinants?

There is a variety of models developed by economists and geographers on the assessment of agricultural intensity, which include a broader view of agricultural production and its factors. A variety of agricultural production functions based on the law of diminishing marginal return to agricultural inputs have been applied. A logarithmic relationship of agricultural out put with respect to technology and labour variables is established by Douglas and Cobb (1928), while this relationship was specified as exponential by Spillman (1933) and Tintner (1961). The intensive use of technology

Fig 1 Land Use Trend in Assam.



that is based on the physical conditions of land, alters the curve of marginal products in agricultural practices. Most agricultural geographers view crop intensity in terms of the areal perspective of agricultural landuse rather than production pattern (Stamp 1950. 1958, Shafi 1960, Dayal 1978, Singh 1994). These studies reveal that the crop intensity is the result of the area cropped more than once during the year within the category of Net Sown Area (NSA) in general landuse. The NSA and the area cropped more than once change over time, which alter the pattern of crop intensity. Infact, in the crop pattern of plain areas of intensive cultivation, the crops are grown more than once on a specific piece of cultivated land, which views the crop intensification. It means the vertical expansion of NSA refers to the crop intensity, which can be or has been calculated easily multiplying Gross Cropped Area (GCA) by NSA (Hussain 1979, Mohammad 1981). Therefore, crop intensity is 'area-based' attribute of agriculture rather than 'production based'.

Increasing crop-yield may be a significant determinant of crop intensity because yield increasing technological factors would expand the agricultural landuse patterns and vice-versa (Binswanger & Ryan 1977). It means crop intensity may likely to be the positively related to crop yield. The second cause of crop intensification in an area may be the increasing food demand through increasing population pressure. Bouserp (1965) examines the effects of population on agricultural intensity and growth and confirms that demographic expansion in an area of developing and under-developed economies has the direct bearing on agricultural intensity. A third determinant of crop intensity especially for the state of Assam where paddy is dominated in its cropping pattern may be related to paddy crop. The paddy crop is grown three times in a year as in summer, autumn and winter seasons. Since the winter paddy dominates the cropping pattern, its share may influence the crop intensity. Autumn and summer crops of paddy are grown generally in many of the fields of winter paddy in Assam. It indicates that the higher ratios of autumn paddy and summer paddy with winter paddy area would determine the crop intensification. Keeping these aspects in mind, we should proceed to find the causes after quantifying the given determinants.

Formation of Indices

In order to test the validity of the facts as described above, the district-wise quantitative strength of crop intensity and its determinants are indexed in the following manner.

(i) ***Crop-Intensity Index :*** Infact, Indian agriculture is food grain dominated. However, Indian Agriculture Census does not contain much details about the economic attributes of general landuse categories. Therefore, an aggregated landuse statistics have generally been used to measure crop intensity (Bhatia1967, Shafi

1960). The same measurement of crop intensity (I) is used here as :

I=[GCA/NSA)*100], subject to I > 100 because NSA < GCA.

(ii) ***Crop-Yield Index:*** Instead of caloric significance of crops, the crop-price is considered as one of the important parameters for crop-yield index. The weighted mean technique is applied by considering n principal crops of the state. The crop-yield, y_i, crop-area A_i, and the harvesting price of the ith crop, i.e., pi are taken as conversion factors for preparing composite yield index in its money term for the j th district.

$$Y_j = \sum_{i=1}^{n} y_i A_i P_i / \sum_{i=1}^{n} A_i$$

(iii) ***Population Pressure Index:*** The index of population pressure on agricultural land named here as 'population density' (Pd) has been constructed dividing total population by the total agricultural land of the district for showing its effect on crop intensity in the areas of Assam plain. It is mathematically notated as Pd = (total Rural Population/Total Agricultural land).

(iv) ***Crop-pattern Indices:*** The contribution of winter paddy crop in cropping patter is indexed by calculating its percentage share to the total GCA (i.e., called Share of Winter Paddy Area, Swp). It would show the strength of paddy crop in crop intensity. While the effects of summer and autumn paddy areas have been assessed by calculating their crop-area ratios with winter paddy crop (that are named as Summer Paddy Ratio, and Autumn Paddy Ratio, Spr and Apr respectively) because these subsidiaries paddy crops are generally grown almost on the same crop-fields of winter paddy in different seasons. Such indexes of cropping pattern may provide important clue for the variations in crop intensity and its factors prevailing in the Assam plains. They are quantified as

(i) Swp = [(Area under Paddy/GCA) * 100]

(ii) Spr = (Area under Summer Paddy/Winter Paddy Area)

(iii) Apr = (Autumn Paddy Area/Winter Paddy Area)

Results and Discussion

There are two major aspects of the results inferred from the present analysis: (a) the categorization of districts under various classes of given indexes which should provide the basis of their areal variations, and (b) the 'step-wise regression analysis' considering crop intensity index, (I), as dependent variable and remaining five indices (that are considered as intensity determinants) as independent/ explanatory variables (X_1, X_2, ..., X_n) to find out the degree of their contribution and rate of their effectiveness to the index of crop intensity in Assam[1]. Following are the salient features of the analysis which have been drawn through preparing distributional maps and tables for the interpretation of results.

(1) Inspite of the favourable agro-ecological conditions in Assam plains, the average value of crop intensity is recorded 145.44%, which is lower than the other plain areas of the country. It shows that the processes of agricultural intensification have not yet been accelerated in the Assam plains. As a result, crop-intensity is stable at its lower level.

(2) On account of significantly uniform distribution of crop intensity in Assam towards its low class (145-125%), its conefficient of areal variation is recorded very low (i.e., 12.4%) rather than the coefficients of areal variations persisting in the determinants of crop intensity (i.e., independent variables) (Table 1). It means that the areal variation pertaining to the crop-intensity index is influenced more by the physical factors of land rather than other factors. Since the physical land conditions are more or less homogeneous in Assam plains, the pattern of crop intensity seems more uniform. However, it is not true for the case of summer as well as Autumn Paddy Ratios for which the coefficients of variation lie more than 85%. It indicates that summer and autumn paddy areas have the obliterated patterns. In some areas of Assam plains summer paddy areas are important to contribute to the crop intensity but, in the other areas, autumn paddy areas obliterate in its pattern. It increases the range as well as coefficient of its areal distribution. The distribution of these ratios range from its minimum of .0046 to a maximum of 0.8888 for summer Paddy ratio and from .0163 to 1.4770 for Autumn Paddy ratio (Table 1). It shows that there is a usual practice about the use of winter paddy areas in summer and autumn seasons for second paddy crops. Consequently, it increases double cropping areas and thereby crop intensity in the state. Therefore, the correlation coefficients of crop intensity with summer as well as autumn paddy ratios have been noticed significantly positive and strong.

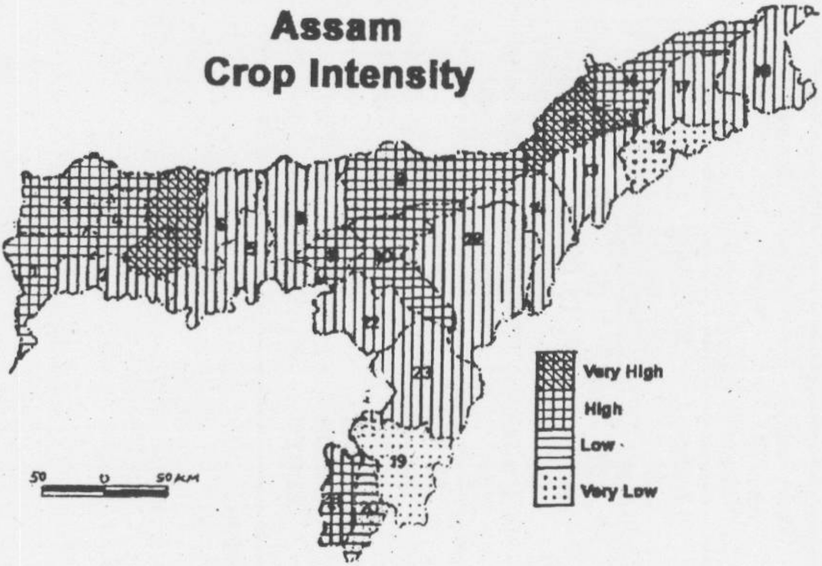
(3) More details about the distributional pattern of crop intensity shows an interesting feature that more than a half part of the state (11 districts out of total 23 which include about 53.65% area of the state) falls under the category of low crop intensity (145-125%). This category includes entire central part of Brahmaputra valley including North Cachar and Karbi Anglong Hill areas. On the other hand, Lakhimpur district of Upper Assam and Barpeta district of Lower Assam, which account for only 7% share of total area, are included in the category of Very High

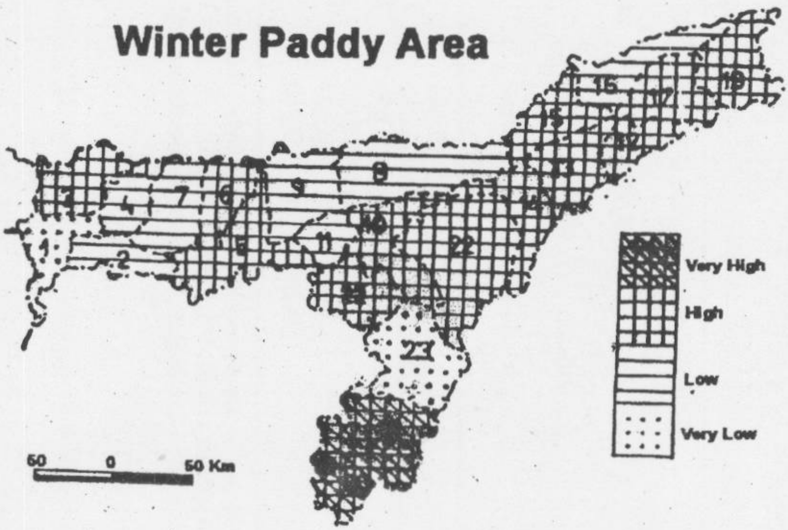
Table 1 Various Categories and Coefficient of Variations of Different Determinants of Crop-Intensity(1998-99).

Name of categories	Crop Intensity Classes	Crop Yield Index (Rs/ha)	Population Pressure Index (per/sq.km)	Winter Paddy Area(%)	Summer Paddy Ratio	Autumn Paddy Ratio
Very High	165 & above (2)	18,500 & above (6)	300 & above (5)	60 & above (3)	.25 & above (4)	.60 & above (4)
High	165-145 (8)	18,500-16,500 (5)	800-700 (7)	60-40 (11)	.25-.15 (3)	.60-.40 (6)
Low	145-125 (11)	16,500-14,500 (4)	700-600 (9)	40-20 (7)	.15-.05 (8)	.40-.20 (4)
Very Low	125 below (2)	14,500 & below (8)	600 & below (2)	20 & below (2)	.05 & below (8)	.20 & below (9)
Maximum value	182.720	21428.640	1020.000	65.340	0.889	1.470
Minimum value	113.210	11634.380	452.000	16.140	0.005	0.016
Mean value	145.441	15739.872	689.087	41.359	0.155	0.411
Standard Deviation	18.024	4408.2937	134.1495	13.443	0.233	0.366
CV (%)	12.393	28.007	19.468	32.502	150.453	89.126
R	1.000	-0.349	0.141	-0.411**	0.434*	0.443*

N.B. : The figures in parentheses show the number of districts in each category.
*Significant at 95%, **Significant at 99%

Abbreviations: CV = Coefficient of variation, r= coefficient of Correlation.


Assam
Crop Intensity
Very High
High
Low
Very Low
50 0 50 KM


Winter Paddy Area
Very High
High
Low
Very Low
0
50 Km

Crop intensity (above 165%) Fig. 2. Fertile soils and favourable climatic conditions are likely to be the factors behind high intensity in these districts. It is interesting to note here that the areal patterns of intensity-determinants do not match with these intensity pattern. As a result, coefficients of correlation between crop intensity and its determinants are found weak in may cases.

(4) Step-wise multiple regression analysis shows that, overall 39.6% areal variability is drawn by the five intensity determinants considered for the present analysis. It means a larger part of variation (that is more than 60%) depends on the variables which have not been included in the present case. It is an evidence that these five determinants are not enough to explain satisfactorily the causes of crop intensity. For more details, it can be said that out of these five determinants, the crop-yield index (X_1) and winter paddy area (X_3) are considered the main explanatory variables which contribute 12.18 and 9.74%'s respectively to the crop-intensity in Assam (Table-2). If the crop-yield is considered individually as an important explanatory variable for crop intensity in the present analysis, it is found that it contributes significantly (ΔR^2 = 12.18%) to crop intensity with its insignificant and negative rate (b = -.06142). Contrary to it, the contribution of population pressure is noticed lesser than crop-yield but its (population pressure) rate is recorded higher (b=0.0041). The interaction of these two explanatory variables improves the receptivity of crop-yield determinant. It is interesting to highlight that the crop-intensity is increased faster when the summer paddy ratio (X4) increases in the distribution. It sensitizes crop intensity at its highest rate of 28.24 times in Assam, though the contribution of this variable is recorded much lesser (R^2 = 7.95%). It shows an evidence that the summer paddy is generally grown on the crop-fields of winter paddy. If summer paddy is increased slightly in such areas, it raises the crop intensity very fast (Table 2)

The autumn paddy ratio (X_5) also have significant effects on crop intensity but negatively. Autumn paddy crop is generally grown in the low intensity areas. Therefore, it contributes ony 1.63% to it. Inversely, higher crop intensity areas infact do not have higher percentage share of autumn paddy. However, the areas other than winter paddy crop are used under autumn paddy in Assam valley. Thus, autumn paddy ratio accelerates expansion process of landuse and, therefore, does not contribute much to thecrop intensity index.

Conclusion

There are various crop intensity determinants influencing the agricultural practices of Assam, though the agriculture is still under the major influence of natural land conditions rather than modern technology. As a result, crop-yield becomes the major

Table 2 Step-wise Multiple Regression Analysis

Name of Independent Variables	*Intercept 'a'*	*Rate value 'b'*	R^2 *(%)*	ΔR^2 *Difference*
Step-1: Crop Yield Index (X_1)	167.90	-0.00143	12.180	12.180
Step-2: Crop Yield Index(X_1) Population Pressure(X_2)	146.68	-0.00187 0.04096	20.288	8.108
Step-3: Crop Yield Index (X_1) Population Pressure(X_2) Winter Paddy Area (X_3)	146.56	-0.00081 0.05155 -0.57812	30.025	9.737
Step-4: Crop Yield Index (X_1) Population Pressure(X_2) Winter Paddy Area (X_3) Summer Paddy Ratio (X_4)	141.55	-0.00152 0.04314 -0.15136 28.24032	37.975	7.950
Step-5: Crop Yield Index (X_1) Population Pressure(X_2) Winter Paddy Area (X_3) Summer Paddy Ratio (X_4) Autumn Paddy Ratio (X5)	156.61	-0.00210 0.04923 -0.28849 36.43536 -14.14916	39.603	1.628

N.B.: Number of observations (n) = 23,
The difference of R2, shows the effect of additional independent variable at each step of the multiple regression analysis.

determinant of crop intensity due to the direct control of natural land conditions on it. Population pressure on agricultural land is also a significant determinant which directly contribute to the crop-intensity. The summer paddy ratio which influences comparatively lesser than crop yield as well as population pressure, but it is the most sensitive determinant in altering the areal pattern of crop intensity in Assam plains. Even slow increases in this ratio shows a fast rate of its receptivity and significant contribution to the crop intensity. The determinants which have been considered here are not sufficient to explain the effects. The determinants related to market forces and locational advantages of available agricultural technological packages may be more important in this regard. These facts have been indicated by many geographers and economists. For example, the increase in crop-yield is noticed by intensification of modern package of yield technology (seed-fertilizer-irrigation) in green revolution areas, which explicitly influence the crop intensity index (Bhalla and Tyagi 1985). Technological innovations are diffused through the market centers in its surrounding agricultural areas as Von Thunen's theory of spatial structure of agriculture dictates. It analyses the influence of market forces on the land use intensity where the economic rent is altered by the transport cost (i.e., distance dependent) Hall1996, O'Kelly and Bryan 1996, Visser 1980, 1982, Singh 2002). As a result, regional patterns of crop intensity would have been emerging because of market forces and technological intensification in transport sectors of the economy. In the spatial structure of agriculture production, capital-labour ratio falls down as distance to market increases. Technological progress will extend spatial margin to profitability by a capital deepening processes. Technological intensification and technological changes may improve the trend of capital-labour ratio for the intensity enhancement in its spatial margins (Visser 1980, 1982, Singh 1994, 2002). In the end, it can be said that in the case of Assam plains, the effects of market forces may be visualized now on crop-intensity pattern and, therefore, the determinants present are contributing only 40% areal variability of crop intensity.

Note :

1. Infact, step-wise multiple regression analysis provides the basis of measuring the degree of constitution of the independent variables(s) to the dependent ones in terms of R^2 value. The analysis is based on its areal variability. Secondly, it also provides the rate of effect of the independent variables(s) separately as well as together (if one should consider them as an interaction factor) in terms of linear gradients as denoted by 'b' coefficients. The intercept point as shown by 'a' is the value of dependent variable when the value(s) of independent variable(s) are considered as zero in multiple regression equation as:

$Y_0 = a + b_1X_1 + b_2X_2 + b_3 + X_3 + ... + bnX_n$, where Y_0 = dependent and

X_n = independent variables.

Reference

Bhagabati, A.K., A.K. Bora & B.K. Kar (eds 2001): Geography of Assam, Rajesh Publications, New Delhi.

Bhagabati, Dinamani (2000) : Population Pressure on Land and Associated problems in Selected Areas of Nalbari District, Submitted to the Department of Geography, Gauhati University, pp. 50-87.

Bhalla, G.S. and Tyagi, D.S. (1985): Patterns in Indian Agricultural Development- a

District Level Study, Institute for Studies in Industrial Development, New Delhi.

Bhatia, S.S. (1967) : A New Measurement of Agricultural Efficiency in Uttar Pradesh, India, Economic Geography, Vo. 43 (3), pp. 244-60.

Binswanger, H.P. & J.G.Ryan (1977): Efficiency and Equity Issues in Exante Allocation of Research Resources, Indian Journal of Agriculture Economics, Vol. 32 (3).

Binswanger, H.P. (1978): Induced Technological Change-Evolution of Thought, in H.P. Binswanger & V.W. Ruttan (eds): Induced Innovation, John Hopkins University Press, Baltimore.

Boserup, E. (1965) : The Conditions of Agricultural Growth, George Allen & Unwin, London.

Boserup, E. (1981): Population and Technology, Basil Blackwell, Oxford.

Chauhan, V.S. and Singh, S. (1977): Measurement of Agricultural productivity in U.P., The Geographical Review of India, Vol. 39(3), pp. 222-31.

Douglas, P.H. and C.W. Cobb (1928): A Theory of Production, American Economic Review (Supplement), Vol. 18, c.f., G. Tintner (1952) : Econometric, John Willey & sons, Inc, New York, pp.51-52.

Gorski, T.,et.al. (1994) : Agro-meteorological Quantification of Agriculture Year in Poland, Zeszyty Problemowe Postepw Nauk Rolniczych, Vol. 405, pp. 81-87.

Hall, P. (ed, 1966): Von Thunen's Isolated State: An English Edition of Der Isolierte Staat, Pergamon Press, London.

Hussain, M. (1979): Agricultural Geography, Inter-India Publications, New Delhi.

Learman, S. H. & E. C. Conkling (1995): Transport Change and Agricultural Specialization, Annals of Association of American Geographers, 65 (3), pp. 425-432.

Mohamad, Noor (1981): Perspective in Agricultural Geography, Vol. IV, Concept Publications Co., New Delhi.

O' Kelly, M.E. and D. Bryan (1996): Agricultural Location Theory: Von Thunen's Contribution to Economic Geography, Progress in Human Geography, Vol. 20 (4), pp. 457-75.

Prasad, C. et. al. (1987): First-line Transfer of Technology Projects, Publication and Information Division, ICAR, New Delhi.

Shafi, M.(1960): Measurement of Agricultural Efficiency in Uttar Pradesh, Economic Geography, Vol. 36(1).

Singh, S. (1994): Agricultural Development in India-A Regional Analysis, Kaushal Publications, Shillong, pp. 20-42.

Singh, S. (2002); Optimizing the Spatial Structure of Agricultural Production function, Geographical Analysis,s Vol. 34 (No.3), pp. 229-224.

Singh, S. and D.C. Das (2000): Pattern of Agricultural Labour Productivity in Lower Brahmaputra Valley, North-Eastern Geographer, Vol. 31 (1 & 2), pp. 35-43

Smith, B.et. al. (1991) : Evaluating Ontario's Potential for Food Production, Canadian Journal of Regional Science, Vol. 14 (1), pp. 1-22.

Spillman, W. J. (1993): Exponential Yield Function; c.f., R. Abler, S.S. Adam & P Gould (1971) : Spatial Organisation, Prentice-Hall, Inc. England and Cliff, New Jersey, p. 143.

Stamp, L.D. (1958): The Measurement of Land Resources, The Geographical Review, Vol. 48, pp. 1-15.

Stamp, L.D. (1960): Our Developing World, Faber & Faber, London, pp. 104-10.

Taher, M. (1975): Regional Basis of Agricultural Planning in the Brahmaputra Valley, North-Eastern Geographer, Vol. 8 (1 & 2).

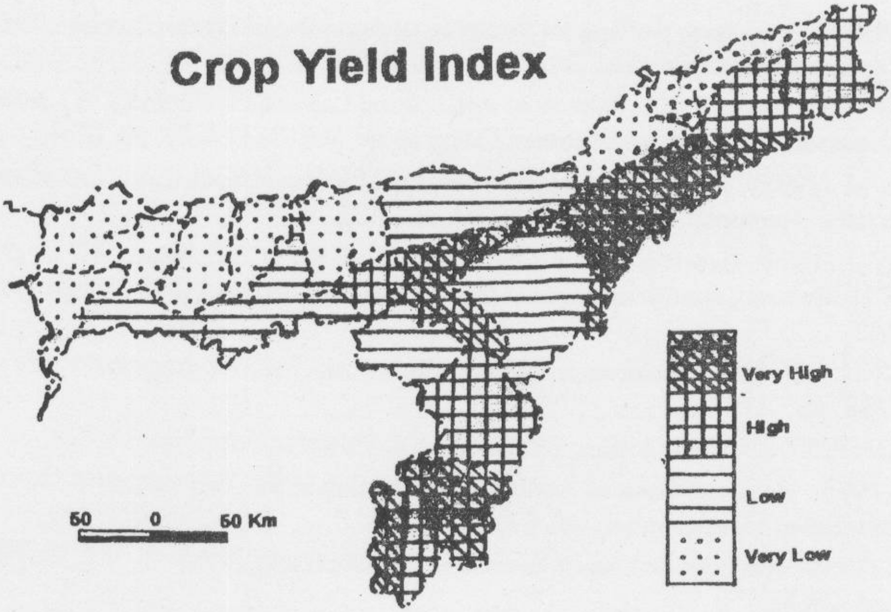
Tintner, G. (1961) The Logistic Law of Economic Development, Arthaniti, Vol. IV (No. 1), pp. 75-78.

Vink, A. P. A. (1975): Landuse in Advancing Agriculture, Srinagar-Valley, New York, pp. 15-16.

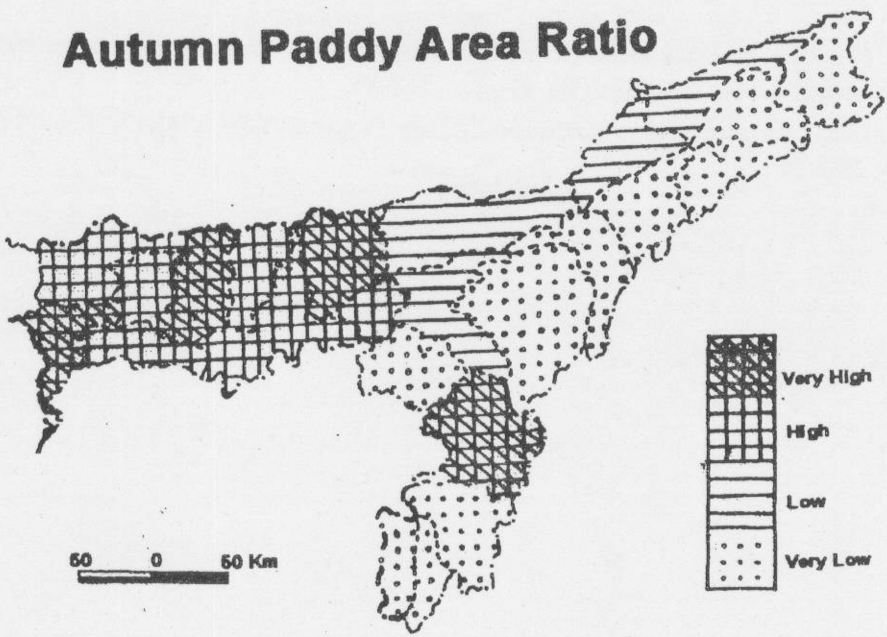
Visser, S. (1980) : Technological change and the Spatial Structure of Agriculture, Economic Geography, Vol. 56. (4), pp. 311-19.

Visser, S. (1982): On Agricultural Location Theory, Geographical Analysis, Vol. 14 (2), pp. 167-76.

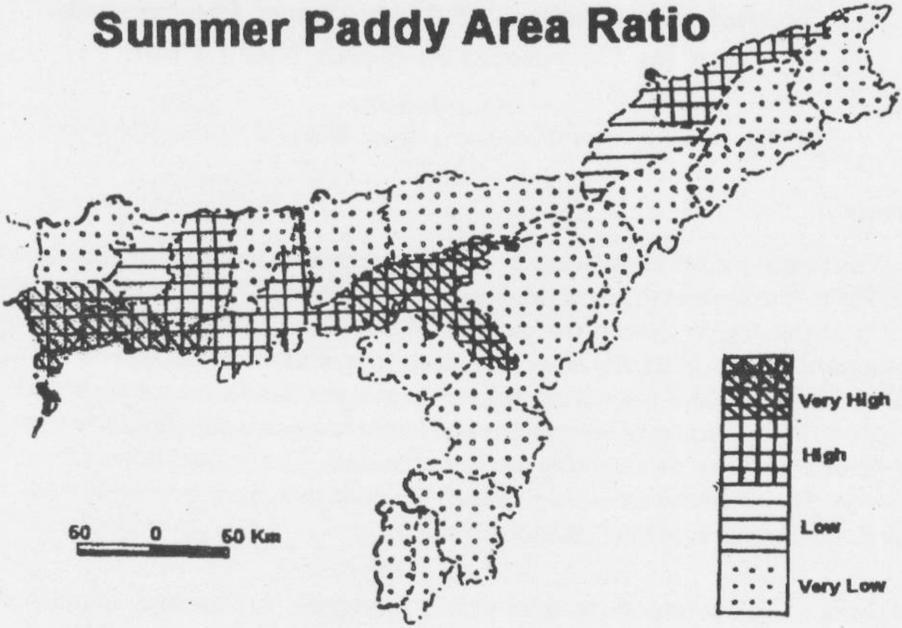
Crop Yield Index



Autumn Paddy Area Ratio



Summer Paddy Area Ratio



Population Pressure on Agricultural Land