IDENTIFICATION AND PHASING OF AGRICULTURAL DEVELOPMENT IN ROHILKHAND, UTTAR PRADESH

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Introduction :

The mechanics of agricultural development in a particular region is highly associated with the processes of the diffusion of technological innovations. Therefore, an integrated approach for the regional davelopment is necessary for the proper and balanced regional planning. The main determinants of agricultural development relate to the agricultural potentiality and the basic regularities inherent in agricultural production. Therefore, the Chief Objective of this study is to measure the degree of regional imbalances based on the potentiality theory and to determine the stages of agricultural development for minimizing the 'gaps within and between the various agricultural areas.

The present analytical study is associated with a homogeneous meso-level areal unit (3095 Sq. Km. area, i. e. 10.04% of Uttar Pradesh), named Rohilkhand. Situated in the northern part of Upper-Ganga plains, an intensive but non-primitive subsistence type of agriculture is practiced here exemplifying a conflict between tradition and change. Although it lies on the northern border of tropical lands (27°25′ N to 30°7′ N and 78°0′ E to 80°35′ E), it carries the problems of low productivity despite enjoying more favourable physical conditions such as gentle topography, fertile alluvial soils of river-borne sediments deposited by the Upper part of Ganga, Ramganga and their tributaries and significant rainfall (annual mean 100 cm.) with less flooded areas, as compared to other parts of northern India. The developing agricultural economy of Rohilkhand is evidenced by its more than 3/4th share of total area under cultivation (76.32%) and in which 90.11% of total labour is engaged.

Previous Approaches and the Concept of Agricultural Development

Reviewing the concerned literature of agricultural production, it is obvious that the results of the previous approaches depend, considerably on the three modes of analysis, viz. aggregation, comparison and estimation. Aggregation techniques ate mainly concerned with the synthesis of production variables. The agricultural porduction and the variations within these production types are identified by combining them into a single index of productivity, e. g. component analysis by Kendall[1], ranking coefficient method by Stamp[2] and weighted aggregation by Bhatia[3]. Secondly, the comparison techniques include the relationship in the agricultural production with its consumption patterns adopted by Chakravarti[4],

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1. Kendall, M. G. 'The Geographical Distribution of Crop Productivity in England,' *Jour. of the Royal Stati. Soci.*, New Series, 102 (1939), pp. 21-48.
2. Stamp, L. D., *Our Developing World*, Fabber and Fabber, London (1960), pp. 104-10.
3. Bhatia, S. S. 'A New Measurement of Agricultural Efficiency in Uttar Pradesh', *Eco. Geog.*, 43, No. 3, (1967), pp. 244-60.
4. Chakravarti, A. K. 'Food Grain Sufficiency Patterns in India,' *Geog. Review*, 60 (1970) pp. 208-28.

with the population examined by Singh[5]. Lastly, the input-output relations and the estimation of Potential production which were, first, described by the British Geographers during second war period. Stamp analysed the land resources with the new measures of Potential Production Unit.[6] In the other branches of economic sciences, the inductive estimation techniques are generally used by production scientists to estimate the regular production features with the interpretation of various mathematical functions, viz. logarithmic estimation of production as determined by Douglas and Cobb[7], logistic law of economic development by Tintner[8] and the exponential growth equation for economic development, utilized by Casetti, et. al.[9]

From a review of the literature, it is noteciable that the agricultural production results may be assessed by employing the inductive—estimation technique for determining the phases of agricultural development. The whole process of development is associated with the concept of rate of change in the agricultural production. The lower rate of change depicts the slower process of development and viceversa. Therefore, the whole concept of agricultural development is based on the three fundamental components of potential theory, that are (1) average agricultural productivity which is the total agricultural production per unit of innovation intensity (Y/X), (2) marginal productivity ($\triangle Y/\triangle X$) considered as the absolute rate of change in agricultural production ($\triangle Y$) with respect to absolute rate of change in the index of technological innovations ($\triangle X$), and (3) the agricultural potentiality which is the relative rate of change and defined as proportionate change in the quantity of agricultural production ($\triangle Y/Y$) with respect to proportionate change in the innovation index ($\triangle X/X$). Thus, the term agricultural potentiality is related with the former two components and therefore, it is the ratio between marginal and average agricultural productivity as $\{(\triangle Y/\triangle X)/(Y/X)\}$.

Assumptions and Methodology

Before considering the calculations of significant solutions, a few assumption and limitations are imposed in the present study. Owing, no doubt, to the large number of innovational elements, it is immposible to search out the laws and regularities in the agricultural development by any mathematical theory. Therefore, the following factors are considered as common to all the solutions dealt within this paper.

Rohilkhand, a meso-level areal unit, has

5. Singh, Jasbir, '*An Agricultural Atlas of India : A Geographical Analysis*', Vishal Publications, Kurukshetra (Haryana), (1974), pp. 251-62.
6. Stamp, L. D., *The Under-developed Land of Britain*, London (1954), p. 12.
7. Douglas, P. H. & C. W. Cobb, 'A Theory of production', *American Eco. Rev.*, Supplement, 18 (1928); Quoted from G. Tintner, *Econometrices*, John Willey & Sons, Inc. New York (1952), pp. 51-2.
8. Tintner, G., 'The Logistic Law of Economic Development', *Arthaniti*, IV, No. 1 (1961), pp. 75-8.
9. Casetti, E., et. al., 'Concerning the Spatial Spread of Economic Development,' paper No. p. 1203, *International Geography* (Abstract of the papers submitted to 22nd I. G. C. Canada), 2 (1972), pp. 897-99.

been assumed to be homogeneous with respect to physical factors, viz., soil fertility, climatic conditions, ground water table, etc. as there are little or no variations except for the minor range of nutritive indices of soil fertility varying from 1.63 to 2.33 and general decrease of annual rainfall from the North-East to South—West direction.

In spite of all these common physical factors, the three restrictions have also been imposed.

(1) Adoption of innovations of different magnitude influences the variations in the agricultural development. Thus, the index of innovations' elements (X) has the physical relationship with agricultural production (Y), is written as $Y=f(X)$.

(2) Standing assumption for the behaviour of this production curve is that it starts from the origin $(0, 0)$.

(3) It is hypothesized in the present study that increase in the total agricultural production and decrease in its rate of change always occur with the increasing intensity and spread of innovation waves in the developing areas of which the Rohilkhand is an example. Therefore, the elasticity of innovations and the level of agricultural potentiality follow the law of diminishing returns. Figure—1 presents the hypothesis graphically in which the curve is asymptotic having a convex nature.

Allowing to these limitations and assumptions in the study, the general mathematical model which is based on the reciprocity law of agrarian economic development has been employed. It is expressed as :

$$Y=A(1+BX^{-1})^{-1}$$

(Where A & B are the positive parameters of the model that are calculated by least square method of estimation and X, Y are the strictly positive quantities of innovations and agricultural production respectively).

The model is defined with the four specified conditions that satisfy the nature of present assumptions and hypothesis, as :

(1) The positive increase in average agricultural productivity because $Y/X > 0$.

(2) The law of diminishing returns is applicable because marginal productivity is positive with the declining rate of change, as : $(\Delta Y/\Delta X)=B/A(Y/X)^2 > 0$ and $\Delta y^2/\Delta X^2 < 0$.

(3) The potentiality which is positive and declining, will always vary within the range of zero to one, because $(\Delta Y/\Delta X)/(Y/X)=B/A(Y/X) > 0$.

(4) The nature of reciprocity model is asymptotic, in which :

When, $X \to 0$, so that $BX^{-1} \to 0$.
then, $Y=A$.

Determination of Development Stages in the Agriculture of Rohilkhand

The study relates to the data of gross agricultural production and the adoption of innovations in the agriculture for three years' average (1968-69 to 1970-71) pertaining to total 32 *tehsils* of Rohilkhand. The data are collected from the various District Agriculture, Statistics and Planning Offices. The aggregation of various dependent production variables has been made with the gross values of agricultural production of principal crops by considering the relative weightages in terms of money value, caloric significance and grain—equivalents of crops by the application of

'Geometric Mean Technique'[10]. On the other hand, the index of innovations intensity has been prepared by taking into consideration the six infra—structural variables of agricultural innovations. Table 1 shows the distribution and variabilities of these variables. The average irrigated area in Rohilkhand is only 34.9% but it has the lowest variability (39.74%) indicating the uniformity in its distribution while the highest variability (63.65%) is found in the mechanical aids with the very low average intensity of adoption. It is due to the slower diffusion to modernization techniques and the general backwardness in the agricultural societies.

For finding out the composite intensity of such innovation variables by putting them into the same Umbrella, the regional average of each variable is taken as 100 and the relative performance of each *tehsil* is obtained in relation to the regional average. The composite intensity of all six relative indices for each *tehsil* is also prepared by applying the same 'Geometric Mean Technique'. Now, for further interpretation, employing the reciprocity model in the given set of agricultural production and innovation data, the constant values of the theoretical curve are calculated.* It is graphically portrayed in Figure—1.

On the other hand, by employing the potentiality theory the nature of and gaps between two curves, marginal productivity and potentiality coefficients, are calculated (Figure—2). The whole process of development is distinguished into four stages by imposing two important conditions that are related with the tendency of both curves.

(1) The equilibrium coefficient which indicates the level of optimum rate of change in the agricultural production must be equalized

Table—1

Means, Standard Deviations and the Degree of Variabilities in the intensity of Agricultural Innovations in Rohilkhand.

Sl. No.	Name of the Innovations	Units of Values	Mean	S.D.	C. V. (in %)
1.	Extent of Irrigation	% of GIA to GCA	34.90	13.87	39.74
2.	Chemical Fertilizers	NPK Kg/ha.	50.00	26.00	52.00
3.	Mechancial aids	No. of ag.implements per 1000 ha. of NAS	11.83	7.53	63.65
4.	Intensity of Improved Seeds	% area under HYVs to GCA	35.58	14.88	41.82
5.	Electric Consumption	per ha. of NAS (Kw/hrs)	172.19	85.03	49.32
6.	Transportation Intensity	Roads in Km. per 1000 Sq. Km.	290.16	179.10	61.73

N. B.—GIA = Gross Irrigated Area, GCA = Gross Cultivated Area, and NAS = Net Area Sown.

10. Singh, Surendra & V. S. Chauhan, 'Measurement of Agricultural Productivity—A case study of Uttar Pradesh, India', *Geog. Rev. of India*, 39, No. 3 (1977), pp. 222-31.

* $Yc = 383.69997\ (1+226.44227\ X^{-1})^{-1}$

N. B.—The predicted values are significant at the level of 1.0%.

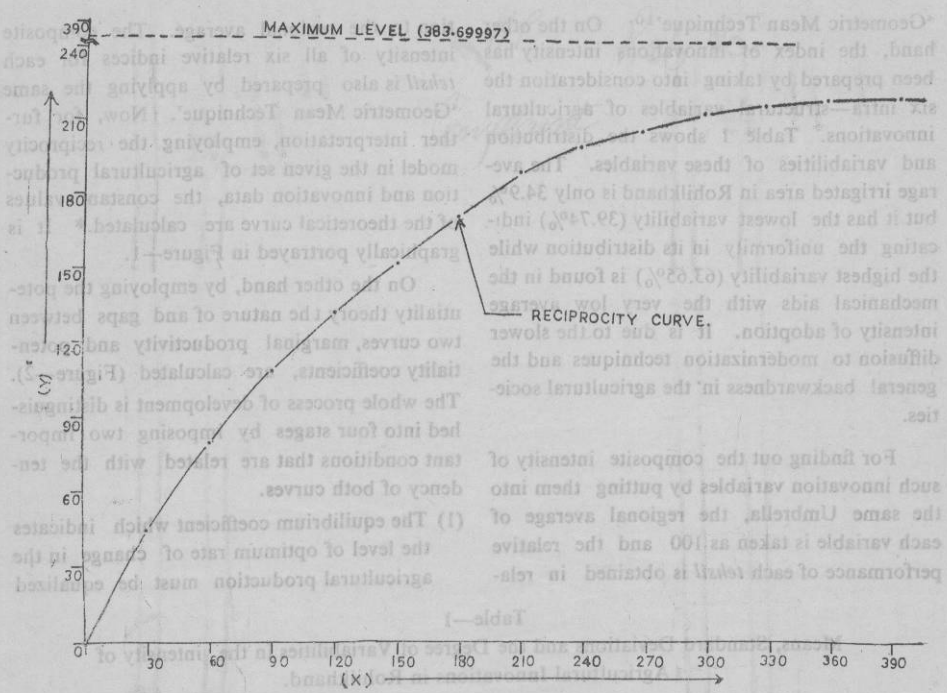

FIGURE-1: THE BASIC TYPE OF RELATIONSHIP BETWEEN PRODUCTION INDEX (VERTICAL AXIS) AND AGRICULTURAL INNOVATIONS' INDEX (HORIZONTAL AXIS).

at the point of intersection between marginal productivity and potentiality coefficients where the level of average productivity will be equal to 1.0 i. e. if, $B/A\ (Y/X)^2 = B/A\ (Y/X)$ then, $(Y/X) = 1.0$ and B/A will be equilibrium coefficient.

(2) The determinants of agricultural development that denote the ratio of average gap between both the curves, are the differences between both constants of the model, i. e. if, $B/A\ (Y/X)^2 = (A-B)\ B/A\ (Y/X)$ then $(Y/X) = (A-B)$ or, on the other hand, if $(A-B)\ B/A\ (Y/X)^2 = B/A\ (Y/X)$, then $(Y/X) = 1.0/(A-B)$ indicating the limits of development stages for the 'very high' and 'very low' rate of changes in the development curves respectively.

It is obvious from the above discussion that the first stage of development which includes high potentiality and marginal productivity is still higher than (A-B) times of potentiality values, with the resultant very high rate of change and the maximum gap between both the curves where the faster diffusion processes of technological innovations and the suitable agricultural infra-structure should be suggested for the immediate future. The second stage of development also incorporates the similar

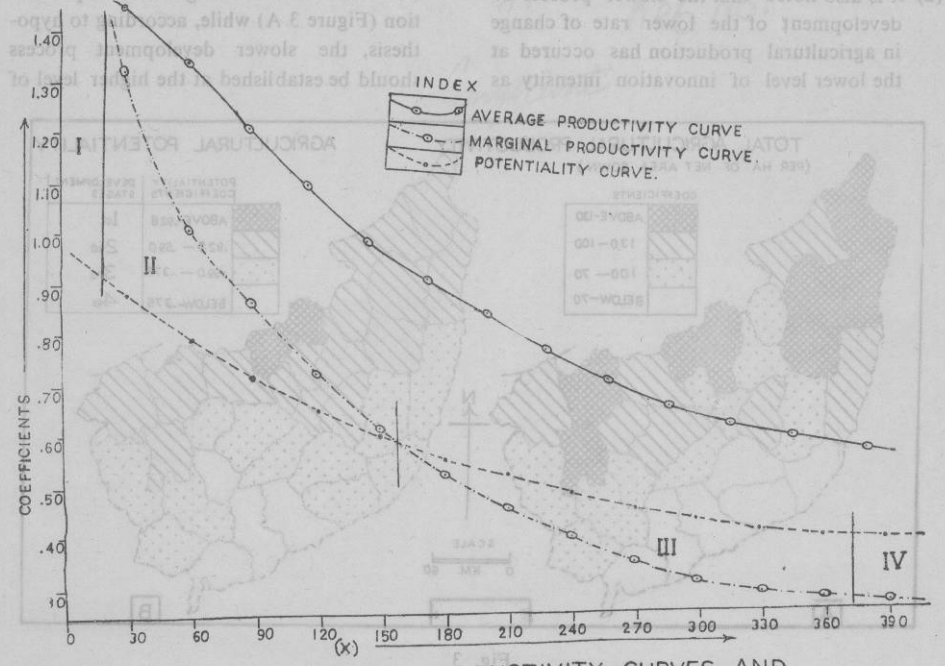

FIGURE-2: NATURE OF VARIOUS PRODUCTIVITY CURVES AND DEVELOPMENT STAGES.

nature of development curves with the medium gap and, therefore, such areas that come under the same category are potentially strong and may be developed in future. The third stage where marginal productivity is lower than potentiality resulting in an increasing gaps between the curves, is considered as the developed conditions in the agriculture while the fourth stage in indicating of the more developed conditions where the gap between both the curves is maximum, with very low rate of change.

Findings and Significant Solutions

To examine the average, marginal and potentiality coefficients through reciprocity model, the potentiality levels and the development stages have been determined in the agriculture of Rohilkhand. (Table—2).

While explaining the stages and the regional inequalities in the agricultural development of Rohilkhand, the following conclusions and significant solutions may be discerned easily from the present research.

(1) The theoretical curve of agricultural production follows lesser degree of convexity indicating the slower process of agricultural development throughout the region (Figure-1). It confirms that the diffusion processes of technological innovations are limited in the region.

(2) It is also noted that the slower process of development of the lower rate of change in agricultural production has occured at the lower level of innovation intensity as well as lower level of agricultural production (Figure 3 A) while, according to hypothesis, the slower development process should be established at the higher level of

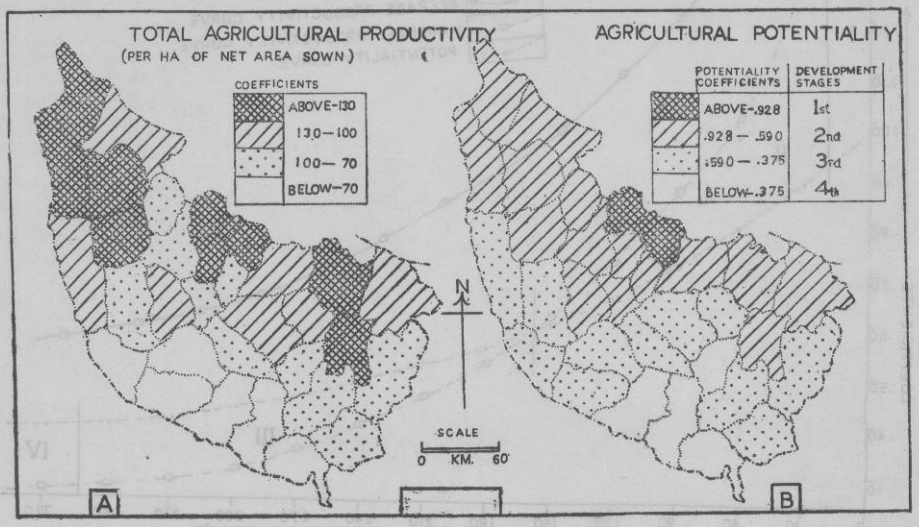

Fig. 3

Table—2 : Development Stages and Significant Change in the Agricultural Production of Rohilkhand.

Stages/changes in Production	X	Y	A. P. (Y/X)	M. P. B/A $(Y/X)^2$	P. C. B/A (Y/X).
First Stage					
1. Very high Rate of change	17.552	27.6022	1.572577	1.459451	.928063
Second Stage					
2. Optimum Rate of change	157.2577	157.2577	1.000000	.590154	.590154
Third Stage					
3. Very Low Rate of Change	376.9556	239.7056	.635899	.238639	.375278

N. B.—1. Equilibrium coefficient (B/A)=.590154 and the value of determinant of development (A - B)=1.572577.

2. A. P.=Average Productivity, M. P.=Marginal Productivity, and P. C. = Potentiality coefficients.

Table 3

Average & Marginal Productivity & Potentiality Coefficients in the various tehsils of Rohilkhand.

Sl. No.	Name of the tehsils/ districts.	Innovation Index (X)	Agricultural Productivity (Y)	Average agricultural Productivity (Y/X)	Marginal Productivity B/A $(Y/X)^2$	Potentiality coefficient B/A (Y/X)
Bijnor						
1.	Najibabad	93.72	143.09	1.5267818	1.3756870	.9010372
2.	Nagina	91.50	114.50	1.2513661	.9241328	.7384993
3.	Bijnor	168 21	173.17	1.0312704	.6276400	.6086088
4.	Dhampur	152.59	166.71	1.0925355	.7044282	.6447647
Moradabad						
5.	Amroha	113.07	143.65	1.2704519	.9525375	.7497629
6.	Hasanpur	113.65	108.02	.9504619	.5331322	.5609193
7.	Sambhal	100.36	91.48	.9115185	.4903391	.5379367
8.	Bilari	96.63	123.55	1.2785884	.9647773	.7545646
9.	Moradabad	98.26	98.43	1.0017301	.5921981	.5911755
10.	Thakurdwara	68.31	73.06	1.0695359	.6750817	.6311914
Rampur						
11.	Suwar	79.85	134.27	1.6815278	1.6686825	.9923611
12.	Bilaspur	87.43	137.65	1.5744023	1.4628408	.9291406
13.	Rampur	97.22	137.13	1.4105122	1.1741385	.8324201
14.	Shahabad	82.30	93.78	1.1394896	.7662780	.6724749
15.	Milak	60.26	77.88	1.2923996	.9857329	.7627154
Bareilly						
16.	Baheri	90.93	111.90	1.2306169	.8937404	.7262541
17.	Nawabganj	108.06	102.06	.9444752	.5264372	.5573862
18.	Bareilly	127.17	123.12	.9681528	.5531633	.5713597
19.	Aonla	106 55	70.77	.6641952	.2603495	.3919777
20.	Faridpur	111.79	70.75	.6328830	.2363808	.3734987
Pilibhit						
21.	Puranpur	103.05	112.91	1.0956817	.7084910	.6466214
22.	Pilibhit	114.87	159.18	1.3857404	1.1332595	.8178009
23.	Bisalpur	136.62	161.21	1.1799882	.8217145	.6963753
Shahjahanpur						
24.	Puwayan	99.90	80.03	.8011011	.3787392	.4727734
25.	Tilhar	104.33	71.83	.6884884	.2797427	.4063145
26.	Shahjahanpur	103.75	94.00	.9060240	.4844456	.5346941
27.	Jalalabad	105.61	65.05	.6159454	.2238978	.3635029
Badaun						
28.	Gunnaur	72.85	54.40	.7467398	.3290820	.4406918
29.	Bisauli	85.21	59.71	.7007393	.2897867	.4135444
30.	Sahaswan	77.87	52.78	.6777963	.2711214	.4000045
31.	Badaun	76.00	35.41	.4659210	.1281119	.2749653
32.	Dataganj	74.37	41.97	.5643404	.1879523	.3330480

agricultural innovations. It is due to the very low average agricultural productivity in such lower innovations intensity areas and, therefore, such areas are put under the list of fourth stage of development. The first stage of development is marked in the medium innovation intensity areas of Rohilkhand (Figure 3 B).

(3) The general trend of development process in Rohilkhand is quite clear from central-north down to south-east, from humid and fertile land of *Shivalik* foot hills to dry and lowlands of sandy loam of lower Ramganga basin, from reclamation and modernization in agriculture to traditional, less-intensive and poor-farming system, and from paudy and suger-cane cultivation to wheat and millets farming.

(4) The first and second stages of development, where the high potentiality levels and rapid development process are marked, cover more than half the area of Rohilkhand (53.18%) that incorporates generally the entire northern *terai* parts from *Chandi* hills (Bijnor district) to marshy lands of Sarda river (Pilibhit) in which the areas of central *terai* zone (northern half part of Rampur district) accommodates the first stage of development where the new agricultural innovations should be introduced in the near future. The areas of low potentiality and slower development are marked in the lower Ganga-Ramganga tract. (Figure 3 B and table 3).

Summary

The prime purpose of the present paper is to portray, through a quantitatively constructed model, some of the basic regularities inherent in agricultural production vis-a-vis on innovation index which has been rendered to an amalgam of irrigation, seeds, transport, mechanization, and fertilizers. The discussion, through confined to a meso-regional unit—Rohilkhand, claims wider applications to other countries of the tropics and their northern border lands, where an intensive but non-primitive subsistence type of agriculture is practiced. The scope of the investigation is confined to the optimum solution for agricultural development with the help of 'Reciprocity Model' which, resting heavily on the Mathematical derivation of the potential theory, identifies the laws governing agricultural potentiality and Marginal productivity. The generalized study concludes with a plea for optimum allocation of infra-structural inputs and the maximum utility of innovations according to the regional potentiality for maximized production.

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