PRODUCTIVITY AND RESOURCE STRUCTURE: A CASE STUDY OF AGRICULTURAL DEVELOPMENT OF GUJARAT*

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Hypothesis

Productivity, the output flow per unit of resource input, is an outcome of the interaction of the mutually reinforcing forces of agrarian structure, resource endowment and technology—the three resource structure dimensions. Of these three dimensions, the technology is likely to have the most direct impact on productivity. For, the output flow per unit of resource input is the sum total of the product-mix as well as input-mix—the two technology facets.

However, the availability and application of a technology is constrained by the structure and magnitude of resource endowment, which, in turn, is conditioned by the agrarian structure prevailing in the economy. This thought process assumes a situation of no change and simple nature on the part of each of these resource structure dimensions.

Indeed, each of these dimensions connote a complex phenomenon and we do not operate in a static world. For instance, the technology dimension tends to encompass that spectrum of techniques in its purview as will range between the most primitive and the latest. In the dynamic context, therefore, we find the relationship to be quite intricate.

Depending upon the resource structure, institutional, political and social milieu, development process releases such forces as may perpetuate, weaken or strengthen the resource structure that may retard or promote the growth of productivity. For instance, in Haryana, the increase in farm productivity due to the adoption and spread of seed-chemical technology has tended to strengthen the relative resource endowment position of the different farm size-groups, which has, in turn, led to the perpetuation of their respective techniques of production.[1]

Using a relatively comprehensive methodology, this study proposes to further examine the relationship between productivity and resource structure. To be more specific, the twin objectives of this study are: (*i*) to analyse the resource structure of agriculture, and changes therein, during the development process; and (*ii*) to relate these structural features, and changes therein, with agricultural productivity.

The study is organized into four sections: Section I gives a brief description

1. For empirical evidence, see Baldev Singh: Capital Formation in the Agricultural Sector in Haryana, Kurukshetra University, Kurukshetra, 1972 (unpublished Ph.D. Thesis).

of the methodology. Section II lists the variables and data sources. Section III presents the results and attempts their interpretation. Further reflections on the analysis are dealt in the concluding section.

I

METHODOLOGY

Macro growth situations, particularly those dealing with agricultural development, are known for their intricate mutual interdependence behaviour. The use of multivariate analysis for such situations of mutual interdependence, the pre-requisite of which is the absence of interdependence amongst the set of independent causal variables, has, therefore, to be taken with a pinch of salt. This probably explains the mushroom growth of sophisticated econometric models, on the one hand, and the extensive use of the technique of factor analysis, on the other. We propose to employ for this study the latter alternative.

The technique of factor analysis helps to delineate the basic structural features of a situation. These features are reflected by a set of indices. The four mathematical principles which help to form these indices, hereafter referred to as factors,[2] from the observable variables that depict the situation under examination are: (i) "Those variables that are most clearly intercorrelated are combined within a single factor; (ii) the variables allocated to a given factor are those that are most nearly independent of the variables allocated to the other factors; (iii) the factors are derived in a manner that maximizes the percentage of the total variance attributable to each successive factor (given the inclusion of the preceding factors); and (iv) the factors are independent (uncorrelated with each other)".[3] Using these principles, the factor indices may be obtained by a number of standard techniques: the principal factor technique and vari-max rotation procedure are most widely used to get a unique factor indices solution.

A few words about the interpretation of the final unique solution[4] invariably referred to in the literature as matrix A. Its constituent, the aijth coefficient, shows the net correlation (often called factor loading or connection coefficient) between the jth factor and the ith observed variable. The factor loading square, (aij),[5] represents the proportion of the total unit variance of the variable i which is explained by factor j, after allowing for contribution of other factors. The sum of the squared factor loadings, or the 'Communality', of each variable

2. These indices are also referred to in the literature as aspects, components or dimensions.

3. Irma Adelman and Cynthis Taft Morris: Society, Politics and Economic Development: A Quantitative Approach, Johns Hopkins Press, Baltimore, 1967, p. 132.

4. For details on the interpretation of factor analysis results with the help of an empiricial exercise, see B. Singh, "Structural Analysis of a Micro-Administrative Unit: An Application of Factor Analysis", Indian Journal of Regional Science, Vol. X, No. 2, 1978.

5. For details, see Harry H. Harman: Modern Factor Analysis, University of Chicago Press, Chicago, 1968, Chapters 8 and 14.

indicates the proportion of the total unit variance explained by all the factors taken together.[6] The sum total of the effect of all the variables belonging to a factor indicates the proportion of the total unit variance explained by that factor. The grouping of variables into common factors may reasonably be done by assigning each variable to that factor with which it shows the closest linear relationship, *i.e.*, that factor in which it has the highest loadings. In a borderline situation, where loadings of a variable in two factors are very close, the variable may be assigned to that factor with which it is, on *a priori* grounds, judged to have the closest affinity.

<div align="center">II</div>

<div align="center">VARIABLES, COVERAGE AND DATA BASE</div>

From an empirical perspective, the four building blocks of agricultural resource structure are represented by four resource inputs: land, labour, capital and water. In an economy, these resource inputs may manifest themselves in the garb of a number of variables depending on the prevailing mix of natural conditions, man-made institutions and the development stage attained by the economy. Our selection of variables to proximate these resource inputs has, however, been further conditioned by the availability of data relating to each of the districts[7] of Gujarat around the triennial of 1960-61 and 1970-71, the two reference points (arbitrarily) chosen for the purposes of comparative-static inter-district analysis. In all, 20 variables are selected to represent the resource structure of Gujarat's agriculture.

The land resource input is represented by seven variables: (*i*) net sown area (NSA); (*ii*) cropping intensity; (*iii*) operational size of the holding; (*iv*) proportion of area owned and self-cultivated to total cultivated area; (*v*) number of holdings below four hectares to total number of holdings; (*vi*) concentration ratio of operational land holdings; and (*vii*) number of joint cultivating holdings as a proportion of total number of holdings (only for 1971). The labour resource input is proximated by three variables: (*i*) work-force engaged in the primary sector (activities) as a proportion of total labour force; (*ii*) male agricultural work-force per '1,000-hectare' unit of NSA; and (*iii*) literacy rate of rural male population. The water resource input is represented by four variables: (*i*) normal rainfall (mm.); (*ii*) irrigated area as a proportion of NSA; (*iii*) irrigated area by wells[8] to total irrigated area; and (*iv*) number of pumpsets per '100-hectare' unit of irrigated area.[9] The capital resource input is proximated by five variables: (*i*) animal

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6. Thus, the communality feature of factor analysis may be considered analogous to R^2 in the regretion analysis.

7. Except the district of Dangs, for which information on the number of variables for 1971 was not available. Also, in 1971, the district of Gandhinagar was merged with Ahmedabad, and Bulsar with Surat. Effectively, there are, therefore, 16 districts only.

8. Wells include pumpsets as well.

9. This variable can as well be included under the capital resource input category.

draught power[10] per '1,000-hectare' unit of NSA (No.); (ii) number of ploughs[11] per '1,000-hectare' unit of NSA; (iii) number of tractors per 'lakh-hectare' unit of NSA; (iv) fertilizer consumption[12] per '100-hectare' unit of gross cropped area (kg.); and (v) area under high-yielding varieties (HYVs) of food crops as a proportion of corresponding total cropped area (only for 1971).

The reference period of these variables varies with the nature of the variables flow or stock. Since annual information on flow variables, such as fertilizer consumption, irrigation, etc., is available, triennial annual average of years around 1960-61 and 1970-71 is estimated (to minimize the effect of random weather, climate and other exogenous factors). For stock variables, such as tractors, ploughs, land holdings, etc., it is the year in the vicinity of these periods for which information is available, say quinquennial livestock census of 1961 and 1972.

Having identified and estimated the variables representing the agricultural resource structure, a few words on the estimation of agricultural productivity are called for. Agricultural production is the sum total of production produced by the spectrum of agricultural activities varying from crop cultivation to fish cultivation. Traditionally, however, crop cultivation holds the dominant position and is often used as a proxy for agricultural production. Owing to districtwise data limitations, we had to content with the sum total value of production produced by the seven important crops. Four of these are food crops: wheat, bajra, jowar and rice; and three non-food crops: cotton, groundnut and tobacco. To account for the product quality variations, the location-specific triennial average prices are multiplied with the corresponding quantity figures. Estimates of agricultural productivity per hectare are obtained by dividing the sum total value of the set of seven selected crops by the corresponding cropped area.

Further these estimates are made temporarily comparable by using constant prices, i.e., triennial average of 1969-70, 1970-71, and 1971-72.

Finally, the districtwise information base: Information has been scanned through both published and unpublished, often mimeographed, documents.[13]

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10. It is obtained in bullock pairs by giving equal weights of 0.5 to each of bullocks and 'he-buffaloes' and of 1.0 (unity) to camels.

11. Ploughs include wooden and iron ploughs.

12. Fertilizer consumption is obtained by adding with equal weights assigned to equal physical weights of N, P_2O_5 and K_2O.

13. The published sources consulted are: (i) Handbook of Basic Statistics: Gujarat, Bureau of Economics and Statistics (yearly issues); (ii) Socio-Economic Review: Gujarat, Bureau of Economics and Statistics (various issues); (iii) Quarterly Bulletin of Economics and Statistics, Bureau of Economics and Statistics, Vol. III, No. 3, July-September 1963; and (iv) Gujarat Economic Association Conference Papers, Edited by V. S. Vyas et. al., Baroda, January 1971. A number of mimeographed documents referred are: (i) Livestock Quinquennial Census, Bureau of Economics and Statistics, 1972; (ii) Irrigation in Gujarat, Bureau of Economics and Statistics, 1974; (iii) Fact Book on Manpower: Gujarat, Bureau of Economics and Statistics, 1973; (iv) Districtwise Area, Production and Yield Per Hectare of Important Food and Non-food Crops: Gujarat, Directorate of Agriculture; (v) Agricultural Census 1970-71: Statistical Tables: Gujarat, Directorate of Agriculture, Vol. II; (vi) Fertilizer Consumption, Directorate of Agriculture; and (vii) Area under High-Yielding Varieties, Directorate of Agriculture. Besides, a number of other unpublished statistics are obtained through the courtesy of Directorate of Agriculture, and Bureau of Economics and Statistics, Gujarat.

III

FACTOR ANALYSIS: RESULTS AND INTERPRETATION

The results of factor analysis, computed[14] in standardised form with the help of principal factor technique and vari-max rotation procedure, are summarised in the matrix of common factor coefficients, the matrix A, presented, for 1961, in Table I and, for 1971, in Table II. The listing of the variables is according to their factor loadings (*i.e.*, factor coefficients), except in the case of agricultural productivity variable which is of prime interest and, therefore, gets the allocation in the first row. Accordingly, Tables I and II list, in the second row onwards, first the variables that have their highest loadings in factor I, then those with highest loadings in factor II, III, IV and V successively. Figures in brackets indicate the loadings in that factor to which each variable is assigned. These tables give, besides the factor loadings, two additional sets of information: in the last column, it is the 'communality' of each variable, and in the last row, it is the percentage variation explained by each factor.

Before we proceed to identify the individual factors specified in the results of our statistical analysis, a few general highlights of the result may be noted. The set of five factors explain more than 90 per cent of the variations in the agricultural productivity (per hectare), on the one hand, and in the resource structure of the agricultural sector as a whole, on the other. While factor compositions have remained, by and large, unaltered, changes are discernible in the relative importance of factor roles during the decade of the sixties.

Factor I: Technology Variant I—Traditional
Agricultural Technology

About two-fifths of the total variance of the set of variables selected to represent the resource structure of Gujarat's agriculture is explained by this factor alone. This factor is represented, as indicated by individual factor loadings, by five variables. Four of these variables which tend to stick together during the triennium of 1960-61 and 1970-71 are: (*i*) animal traction power: number of draught animals per 100-hectare unit of NSA; (*ii*) animal drawn implements: number of ploughs per 100-hectare unit of NSA; (*iii*) labour force: number of male agricultural workers per 1,000-hectare unit of NSA; and (*iv*) precipitation: normal rainfall (mm.). The fifth variable is associated with land input. In 1960-61, it is cropping intensity. In 1970-71, it is number of joint holdings to total number of holdings.

The under currents of this factor tends to highlight the salient characteris-

TABLE I—ROTATED FACTOR MATRIX FOR AGRICULTURAL PRODUCTIVITY PER HECTARE TOGETHER WITH 18 AGRICULTURAL RESOURCE INPUT VARIABLES: GUJARAT, 1950-61

Variable No.	Description	Factor loadings of factor					Commu-nality
		I	II	III	IV	V	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	Productivity per hectare (Rs.)	—0.072 (.00052)	0.847 (0.717)	—0.069 (0.005)	0.425 (0.181)	0.181 (0.033)	0.941
2.	Cropping intensity (per cent)	0.956	—0.123	0.053	0.146	0.006	0.953
3.	Animal draught power per 1,000 hectares of NSA (numbers)	0.873	—0.086	0.011	0.264	0.329	0.948
4.	Ploughs per 1,000 hectares of NSA (numbers)	0.837	0.284	0.163	0.177	0.326	0.945
5.	Male agricultural work-force per 1,000 hectares of NSA (numbers)	0.761	0.449	0.214	0.196	0.322	0.969
6.	Rainfall (mm.)	0.652	—0.234	0.339	0.531	0.022	0.876
7.	Tractors per lakh hectares of NSA (numbers)	0.143	0.889	0.113	0.041	0.158	0.850
8.	Fertilizer consumption per 100 hectares of GCA (kg.)	0.127	0.888	—0.152	0.162	0.016	0.854
9.	Literacy rate of rural male population (per cent)	0.136	0.693	0.509	0.002	0.229	0.810
10.	Concentration ratio of land holdings	0.343	0.047	—0.873	0.083	0.022	0.889
11.	Self-cultivated area to NSA (per cent)	0.031	0.111	0.852	0.204	0.131	0.800

(Contd.)

TABLE I (Concld.)

Variable No.	Description	Factor loadings of factor					Commu- nality
		I	II	III	IV	V	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
12.	Irrigated area by wells to total irrigated area (per cent)	0.137	0.184	0.805	0.055	0.225	0.704
13.	Number of holdings less than four hectares to total number of holdings (per cent)	—0.653	0.354	—0.589	0.025	0.284	0.954
14.	Pumpsets per 100 hectares of gross irrigated area (numbers)	—0.119	—0.284	0.555	0.575	0.130	0.750
15.	Size of holding (hectare)	—0.666	—0.390	0.516	0.042	0.318	0.965
16.	Irrigated area to NSA (per cent)	0.014	0.007	0.048	—0.936	0.047	0.881
17.	Proportion of area under non-food crops (per cent)	—0.519	0.424	0.270	0.478	0.274	0.826
18.	Net sown area (hectare)	0.017	0.098	—0.016	0.034	—0.963	0.939
19.	Work-force in the primary sector to total work-force (per cent)	0.588	0.053	0.244	0.277	0.534	0.770
	Per cent variation explained	42.5	18.6	13.0	8.0	5.7	

Note:— (1) Figures in brackets indicate the factor to which each variable is assigned. Variables omitted because of (i) insignificant correlation: none; (ii) low high loading: none.

(2) A variable having loading on two factors which are not significantly different is assigned to that factor to which it is judged to have closest affinity.

(3) The percentage of overall variance explained by factors is 87.9. The percentage of variance explained by the last factor is 5.7.

(4) Figures in parentheses of first row are respective square values.

TABLE II—ROTATED FACTOR MATRIX FOR AGRICULTURAL PRODUCTIVITY PER HECTARE TOGETHER WITH 26 AGRICULTURAL RESOURCE INPUT VARIABLES: GUJARAT, 1970-71

Variable No.	Description	Factor loadings of factor					Communality
		I	II	III	IV	V	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	Productivity per hectare (Rs.)	0.350 (0.123)	0.047 (0.002)	0.795 (0.632)	0.268 (0.072)	0.310 (0.096)	0.932
2.	Joint holdings (numbers) to total number of holdings (per cent)	0.899	0.025	0.021	0.142	0.145	0.850
3.	Rainfall (mm.)	0.881	0.308	0.156	0.006	0.056	0.899
4.	Ploughs per lakh hectares of NSA (numbers)	0.881	0.089	0.003	0.164	0.372	0.949
5.	Animal draught power per 1,000 hectares of NSA (numbers)	0.780	0.094	0.185	0.038	0.515	0.918
6.	Male agricultural work-force per 1,000 hectares of NSA (numbers)	0.753	0.236	0.374	0.200	0.359	0.931
7.	Owned and self-cultivated area to NSA (per cent)	0.097	0.880	0.281	0.265	0.004	0.933
8.	Irrigated area by wells to total irrigated area (per cent)	0.059	0.860	0.012	0.313	0.207	0.884
9.	Concentration ratio of land holdings	0.345	—0.827	0.221	0.229	0.072	0.909
10.	Pumpsets per 100 hectares of gross irrigated area (numbers)	0.218	0.824	0.043	0.416	0.116	0.915
11.	Number of holdings below four hectares to total number of holdings (per cent)	0.591	—0.554	0.402	0.276	0.279	0.969
12.	Size of holding (hectare)	0.624	0.500	0.445	0.236	0.280	0.971

(Contd.)

TABLE II (*Concld.*)

Variable No.	Description	Factor loadings of factor					Communality
		I	II	III	IV	V	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
13.	Literacy rate of rural male population (per cent)	0.021	0.327	0.850	0.132	0.167	0.875
14.	Tractors per lakh hectares of NSA (numbers)	0.013	0.383	0.824	0.142	0.000	0.846
15.	Fertilizer consumption per 100 hectares of GCA (kg.)	0.050	0.307	0.802	0.358	0.077	0.874
16.	Area under HYV to total area (per cent)	0.150	0.130	0.604	0.158	0.565	0.748
17.	Proportion of area under non-food crops (per cent)	0.067	0.241	0.245	−0.877	0.103	0.902
18.	Cropping intensity (per cent)	0.458	0.074	0.003	0.829	0.069	0.907
19.	Irrigated area to NSA (per cent)	0.099	0.291	0.645	0.532	0.193	0.831
20.	Net sown area (hectare)	0.038	0.056	0.054	0.289	−0.894	0.890
21.	Work-force in the primary sector to total work-force (per cent)	0.192	0.426	0.082	0.421	0.640	0.812
	Per cent variation explained	39.3	19.0	15.9	8.9	6.0	

Note.— (1) Figures in brackets indicate the factor to which each variable is assigned. Variables omitted because of (*i*) insignificant correlation: none; (*ii*) low high loading: none.

(2) A variable having loading on two factors which are not significantly different is assigned to that factor to which it is judged to have closest affinity.

(3) The percentage of overall variance explained by factors is 89.3. The percentage of variance explained by the last factor included 6.0.

(4) Figures in parentheses of first row are respective square values.

tics of an agricultural situation, in which the agricultural economy, operating at or around low productivity equilibrium level, depends on (a) the vagaries of nature and (b) traditional cultivating technology, i.e., labour intensive bullock technology.[15] Further, additions to agricultural production are made primarily by additions to land input. Accordingly, we find that in spite of intensive land use, indicated by cropping intensity, yield per hectare remained unaffected by this factor in 1961.[16]

With proper disbursement of agricultural know-how, it may, however, be possible to raise the low productivity equilibrium level. During the decade of the sixties, Gujarat's agriculture got activated through two different, but complementary, channels: (i) the agricultural extension service disbursed the latest know-how of crop production,[17] and, probably more important, (ii) the stewardship towards co-operation provided by the intellectual and political leadership of Gujarat.[18] As a consequence, in 1971, we find there is a tendency on the part of farmers to increase the size of cultivating unit through co-operative effort.[19] (Note the positive association between the variable representing the number of joint holdings as a proportion of total number of holdings—a proxy variable for co-operation—and other variables belonging to this factor.) Also that this factor has a significant association with agricultural productivity. However, only 12.3 per cent of the variation in agricultural productivity is explained by this factor. Considering the structural importance of the factor, this limited achievement, although a feat in itself, tends to corroborate the belief that the potential to increase agricultural productivity with the traditional cultivating practices, given the institutional milieu, is either negligible or limited.

Factor II: Technology Variant II—
Modern Agricultural Technology

The most important determinant of agricultural productivity, explaining as much as 60 to 70 per cent of its variations, is endowed in modern agricultural technology—a concomitant of dynamic agriculture—represented, in 1961, by factor II and, in 1971, by factor III. Its constituent variables, as would be expected,

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15. Note the positive association amongst the variables of labour-land ratio, animal power, and ploughs.

16. Note that less than one per cent of the variation in agricultural productivity is explained by this factor.

17. The spectacular success of high-yielding bajra crop in Gujarat is a pointer of the phenomenon. For details, see C. H. Hanumantha Rao: Technological Change and Distribution of Gains in Indian Agriculture, The Macmillan Company of India Ltd., Delhi, 1975.

18. The success story of Gujarat's co-operative ventures is highlighted by the cooperative dairy projects, particularly the one located at Kaira.

19. Part of the explanation for co-operation may be to circumvent the legislations on agrarian reforms. Non-availability of relevant information in 1961 led to the exclusion of the variable from the set.

are as under:[20] (i) human capital: literacy rate of rural male population; (ii) land augmenting capital: fertilizer consumption per 100-hectare unit of gross cropped area (GCA); and (iii) land-labour augmenting capital: (a) number of tractors per lakh-hectare unit of NSA and (b) area under HYVs of food crops to total area under these crops.

The production potential of modern technology is reasonably independent of the spatial bondages. The same is, however, not true of its adoption. It is for this reason that the structural importance of this factor varies among nations; increasing with advancement in developmental process. Gujarat's agriculture, a state of developing Indian economy, subscribes a limited role to this factor. It explains less than one-fifth of the variations in resources structure of its agricultural sector.

During the sixties, Indian agricultural policy aimed at the spread of modern technology. As a consequence of its spread, we find that inter-district variations in Gujarat in the variables depicting the modern technology have registered considerable decline.[21] For instance, the coefficient of variation registers a decline from 105 per cent in 1961 to 60 per cent in 1971 in the case of land augmenting capital: fertilizer consumption per 100-hectare unit of gross cropped area, and from 25 per cent in 1961 to 16 per cent in 1971 in the case of human capital: literacy rate of rural male population. On the contrary, inter-district variations in productivity per hectare have increased from 37 per cent in 1961 to 54 per cent in 1971.

Since modern technology is the prime determinant of productivity, its spread across the districts is bound to lower its share in explaining the inter-district productivity variations, more so, when variations in productivity (per hectare) register an increase. The other likely consequence of the spread of modern technology is that its weight in explaining the resource base variations shall fall.

Indeed, it is so. Due to the spread of modern technology, its role in explaining variations both in resource structure and productivity has dwindled to a lower level: from 71.7 per cent in 1961 to 63.2 per cent in 1971 in the case of productivity and from 18.6 per cent in 1961 to 15.9 per cent in 1971 in the case of resource base.

Factor III: Institutional Variable 1—
Agrarian Structure

Structurally, the next important factor is identifiable with the cultivation

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20. The role of these modern technology embodying capital assets in agricultural production, individually as well as collectively, is well established in growth literature relating to developing as well as developed nations. See, for example, Rao: *op. cit..* Yujiro Hayami and Vernon W. Ruttan: *Agricultural Development: An International Perspective,* Johns Hopkins Press, Baltimore, 1971; Singh: *Capital Formation in the Agricultural Sector in Haryana, op. cit.;* and B. Singh, "Impact of Education on Farm Production", *Economic and Political Weekly,* Vol. IX, No. 39, September 28, 1974, pp. A-92-A-96.

21. For a different treatment, though similar in many respects, see B. Singh, "Changing Structure of Agriculture in Gujarat", *Gujarat Economic Association Conference Papers,* 1977, pp. 73-93.

base of agrarian structure, namely, land and, underlying beneath it, water. As an agricultural productivity determinant, its role is, however, insignificant. Further, the behaviour of this factor during the decade of sixties reveals disquieting features. While as a structural determinant it has improved its position (from 13 per cent in 1961 to 19 per cent in 1971), as a productivity determinant it retains its insignificant role.

In other words, the spate of agrarian legislations passed during the decade of the sixties has failed to improve the objective conditions, conditioning agricultural production, underlying the existing agrarian structure. On the other hand, the hold of the existing agrarian structure appears to have been strengthened.

An in-depth analysis of the constituent variables of the factor is likely to uncover the undercurrents of the disquieting phenomenal features. The man-made institutional conditions, conditioning the supply of land services, are proximated by the following variables: (i) land distribution pattern: concentration ratio; (ii) extent of small holdings: number of holdings below four hectares to total number of holdings; (iii) extent of tenancy: proportion of area owned and self-cultivated to total cultivated area; and (iv) scale of operation: the size of cultivating unit. The supply of underground water is approximated by the following two variables: (i) degree of dependence on underground water: irrigated area by wells[22] to total irrigated area; and (ii) extent of mechanization of water lifting: number of pumpsets per 100-hectare unit of gross irrigated area.

Interesting agrarian relations—the building blocks of objective conditions—are discernible (Table III). An increase in the scale of a farm-firm, i.e., the size of cultivating unit, is accompanied, more so, when ownership of land lies with the cultivating unit, by investment in capital intensive irrigation structures, namely, pumpsets. The obvious outcome being assured, timely and adequate irrigation supplies,[23] i.e., an increase in the degree of dependence on underground water supplies. Interesting, and probably more revealing, is the fact that these relationships get strengthened in a situation where land is relatively evenly distributed among the cultivating units; also, where there is less preponderance of small holdings.[24] It is, thus, the amalgamation of a set of conditions which form the building blocks of favourable objective conditions for agricultural production. This set of conditions are represented by a framework of relatively even land distribution, with land ownership rights bestowed in the cultivating units which are of such operational scale as is economically as well technically viable and socially desirable.

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22. The term well is used in a broad sense to include all the means of lifting or pumping out water from underground sources. For example, it covers man-muscle operated open wells; animal power operated Persian wells; and mechanical power operated pumpset, tubewells, etc.

23. Note the positive association of the above-mentioned two variables with this variable, proximated by irrigated area by wells to total irrigated area.

24. Note the inverse association between the above set of variables with the set of variables representing concentration ratios and the number of holdings below four hectares to total number of holdings.

TABLE III—SELECTED SET OF VARIABLES RELATING TO AGRARIAN
STRUCTURE OF GUJARAT : 1960-61 AND 1970-71

Sr. No.	Description	Mean values		t-test for mean value
		1961	1971	
A.	Land resource			
	(i) Size of the cultivating unit (hectares)	5.61	4.88	—0.79
		(5.24)	(4.20)	
	(ii) Concentration ratio cultivating units	0.48	0.46	—1.09
		(13.0)	(12.6)	
	(iii) Number of holdings below four hectares	56.0	58.50	0.32
	to total number of holdings (per cent)	(41.2)	(34.3)	
	'(iv) Owned and self-cultivated area to net sown	86.88	96.52	3.0*
	area (per cent)	(13.7)	(6.9)	
B.	Water resource: Underground			
	(i) Number of pumpsets per 100 hectare unit	6.77	39.23	4.26*
	of gross irrigated area	(80.30)	(73.9)	
	(ii) Irrigated area by wells to total irrigated	74.90	72.21	0.43
	area (per cent)	(22.43)	(24.25)	

Sources:
A. For land resource:
  (i) Statistical Tables Relating to Agriculture Census 1970-71, Gujarat, Vol. II, Directorate of Agriculture, Ahmedabad, 1973 (mimeo.).
  (ii) Handbook of Basic Statistics: Gujarat, Bureau of Economics and Statistics, Ahmedabad, 1963.
  (iii) M. M. Dadi, "Occupational Structure and Productivity", *Gujarat Economic Association Conference Papers*, Edited by V. S. Vyas et al., 1971, p. 84.
B. For water resource: (i) Irrigation in Gujarat: Bureau of Economics and Statistics, Gujarat, 1974 (mimeo.).
Note:— (i) Figures are mean values of 16 districts of Gujarat, excluding Dangs, and after merging Gandhinagar in Ahmedabad and Bulsar in Surat.
  (ii) Figures in brackets are corresponding values of coefficients of variation
  (iii) Figures with * mark are significant at 5 per cent level of significance.

The agrarian legislations passed during the decade of the sixties, however, have failed to improve these conditions in any significant way. In fact, the status quo seems to have been maintained, except (i) that more area is reported to be under self-cultivation, (ii) that inter-district variations in these conditions have declined; and (iii) that the dependence on mechanically lifted underground water has increased (Table III). The outcome of a set of conditions represented by unequal land distribution coupled with unequal control over the limited underground water resources is obvious for agricultural production.[25] No wonder, the factor has no role to play vis-a-vis overall agricultural productivity.

25. For details, see B. D. Dhawan, "Utilisation of Ground Water Resources: Public versus Private Tubewells", *Economic and Political Weekly*, Vol. IX, No. 39, September 28. 1974.

Factor IV: Institutional Variable II—Land Use Pattern

The next factor in the declining order of structural importance is identifiable with the land use pattern. Since land use is heavily dependent on land augmenting investments, it is likely to be accompanied by investment in irrigation, which, in turn, is known for its role as a watershed between the age of livestock technology and that of tractor technology.[26] Accordingly, this factor is likely to have a favourable influence on agricultural productivity.

A detailed analysis of the constituent variables of the factor is likely to highlight the additional salient structural characteristics of Gujarat's agricultural economy. These variables, representing each irrigation and land use pattern, are as under: (*i*) extent of irrigation: irrigated area as a proportion of NSA; and (*ii*) land use pattern: (*a*) proportion of cropped area under non-food crops and (*b*) cropping intensity. The relationnhips amongst these variables are revealing, more so, in 1961. For, and that is apparently surprising, two of the constituent variables, namely, extent of irrigation and preponderance of non-food crops, are inversely related. However, an examination of the crop-mix grown in the region highlights the rationale behind this, apparently spurious, relationship.

The important non-food crops of Gujarat are cotton, groundnut and tobacco. The food crops are bajra, jowar, rice and wheat. With the exception of wheat crop, which is grown in the *rabi* season, all other crops are grown in the *kharif* season. And, the *kharif* season coincides with the rainfall months of monsoon season. Further, irrigation availability also coincides with these months. In fact, in many parts of Gujarat, it has been noted that wells as well as canals and tanks go dry in the *rabi* season.[27] And, drought situation prevails, even in the *kharif* season.[28] Given the scarce nature of water supply, its allocation, on rational grounds, is likely to favour such crop activities (*a*) that have less water requirements, (*b*) that are grown in those months when water availability is reasonably dependable, and (*c*) that are more productive. On all the three counts, it is the non-food crops, particularly cotton and groundnut, that command a position of top ranking (Table IV). Obviously, these stake the first claim on the scarce water supply. As and when additional water supplies become available, these are allocated to other crop activities according to, other things being equal, the declining order of their productivity levels.

Economic rationality of the farmers, thus, provides the explanation for the complex relationship between land use pattern and agricultural productivity, on the one hand, and among the variables representing the land use factor, on the other.

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26. For details, see Singh: Capital Formation in the Agricultural Sector in Haryana, *op. cit.*, Chapters 5 and 6.

27. For details, see B. Singh and Usha Sharma, "Agriculture and Animal Husbandry in Gujarat Economy in 2001 A.D.: A Study in Perspective", Sardar Patel Institute of Economic and Social Research, Ahmedabad, 1975 (mimeo.).

28. Gujarat is a drought-prone State. Indeed, 10 of the 19 districts are covered under the Drought-Prone Area Programme (DPAP).

TABLE IV—PRODUCTION PER HECTARE AND WATER REQUIREMENTS OF SELECTED SET OF IMPORTANT AGRICULTURAL CROPS, GUJARAT: 1961 AND 1971

(values in Rs. at 1969-71 prices)

Sr. No.	Name of crop	Mean values** 1961	Mean values** 1971	t-test value	Season	Growth period Sowing	Growth period Harvesting	Water requirements (mm.)
	Food crops							
(1)	Bajra	201 (33)	543 (26)	+8.37	(i) *Kharif* (ii) Hot weather	June-July February-March	September* May	515 N.A.
(2)	Wheat	624 (38)	1390 (16)	+9.10		October	February	489
(3)	Jowar	202 (80)	268 (59)	1.13	(i) *Kharif* (ii) *Rabi*	July-August September	Oct.-Nov.** January	252
(4)	Rice	647 (30)	912 (16)	+4.22		June-July	Oct.-Nov.	N.A.
	Non-food crops							
(5)	Tobacco	2133 (46)	3747 (39)	+3.11		August	Jan.-Feb.	N.A.
(6)	Groundnut	899 (21)	1166 (20)	+3.45		June-July	October	185
(7)	Cotton	821 (22)	1282 (66)	2.07		June-July	Feb.-March	390

Figures in brackets are respective values of coefficients of variation. N.A. = Not available.

Note:— * However bajra is also grown in the month of June-July by some farmers.

    ** Jowar is a *kharif* crop but some farmers have got success in growing it in the *rabi* season.

    *** Mean values are three-yearly averages around the year mentioned. + 't' values are significant at 5 per cent level of significance (at 15 degrees of freedom).

Sources: (1) R. S. Joshi, "Water Requirement of Crops in Gujarat", *Magazine of M. M. College of Agriculture*, Navsari, Vol. VI, No. 1, 1971-72.

    (2) Through the courtesy of Agronomist, Gujarat State.

    (3) For productivity estimates, see the relevant discussion and data sources in the text.

Factor V: Institutional Variant III—
Primary Sector Predominance

Structurally, the least important factor included in the analysis, accounting for about 6 per cent of the total variance and represented by net sown area and proportion of work-force engaged in the primary sector to total work-force, is identifiable with the predominance of the primary sector. On the one hand, the weight of the primary sector influences the size of the market, and on the other, the quantum of the service supplies of the endowed primary sector resources. These variables, individually as well as collectively, are likely to have a favourable effect on (the value of) agricultural productivity; the former affecting the unit value of agricultural output and the latter affecting the yield per unit of land. The intensity of positive effect on agricultural productivity is, however, subject to the overall developmental level of the sector (as well as the economy); which, in turn, depends on the technological horizon of its farm community. The positive, though nominal, influence of this factor on agricultural productivity in Gujarat, is, therefore, in line with our expectations (Tables I and II). Recall the ominous presence of unfavourable objective conditions faced by the dominant section of traditional conservative farm community of Gujarat.

Further, historically, the settlements of men-folk have been governed by natural conditions; favourable condition for production, say in the agricultural sector, encouraging settlement of more men in the sector. To cope up with population pressures with passage of time, however, additional, obviously, inferior lands are brought under cultivation. Being of inferior quality, these lands command low productivity levels and can stand, in turn, low population pressure. The obvious outcome being the prevalence of inverse relation between land under cultivation and labour force, on the one hand, and land under cultivation and agricultural productivity, on the other. Gujarat's experience corroborates this (Tables I and II).

IV

CONCLUDING REMARKS

Agricultural development experience of the sixties of Gujarat, when cast in factor analysis and static comparative framework with reference points revolving around 1961 and 1971, reveals five salient structural characteristics. Two of these are technology variants: traditional and modern; and the other three institutional variants: agrarian structure, land use pattern and primary sector predominance. It is the set of technology variants which command a dominant position in the explanation of structural variations, more so, in agricultural productivity. Within the technology set, it is, however, the modern technology variant which in primarily responsible for changes in agricultural productivity; and it is the traditional technology variant which is mainly associated with changes in resource structure. Accordingly, we find that Indian agricultural strategy of the sixties has primarily revolved around the modern technology variant; a preserve of progressive, usually

large capitalist farmers. Notwithstanding the marginal tilt in emphasis in the agricultural strategy around the late sixties in favour of small farmers, the increase in agricultural productivity is still primarily attributable to modern technology adopting farms. This may as well be due to the failure on the part of the Government to improve the agrarian structure: a pre-requisite for the absorption of modern technology by the group of farmers practising traditional and intermediate technology.[29]

The long run agricultural development strategy ought, therefore, to concentrate more at, besides developing the indigenous agricultural technology to suit the local climate and resource endowment structure, improving the objective conditions which determine whether, what and how much to produce and, in turn, invest. For, only this will help in the smooth reception, absorption and implementation of indigenously developed improved agricultural technology by the cultivating community.[30]

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29. For an interesting empirical exercise showing how unfavourable agrarian structure can retard the flow of benefits drawn from such crucial investment as irrigation, see B. Singh, "Economics of Irrigation: A Regional Perspective", *Indian Journal of Agricultural Economics*, Vol. XXXIII, No. 4, October-December 1978.

30. For empiricial explorations aimed at deciphering the salient features of an agricultural technology under alternative development strategies, see B. Singh: Regional Planning: Explorations in Agriculture and Industry, Oxford and IBH Publishing Co., New Delhi, 1980, Chapter 15. See also P. S. Appu, "Agrarian Structure and Rural Development", *Economic and Political Weekly*, Vol. IX, No. 39, September 28, 1974, pp. A-70-A-75; Jagdish N. Bhagwati and Sukhamoy Chakravarty: Contributions to Indian Economic Analysis: A Survey, Lalvani Publishing House, Bombay, 1971, pp. 50-94; Ragnar Nurkse: Problems of Capital Formation in Underdeveloped Countries, Oxford University Press, New York, 1957; and V. S. Vyas, "Structural Change in Agriculture and the Small Farm Sector", Presidential Address to the Gujarat Economic Association, Bulsar, 1975.