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Productivity Variation and Land Irrigability Class in Kakrapar Canal Command Area in Gujarat State

INTRODUCTION

One of the major goals for Indian agriculture is to increase foodgrains production substantially in order to cope with the population growth. Of the various methods of intensive agriculture, adoption of high-yielding varieties (HYVs), application of timely and adequate quantities of fertilisers and irrigation play an important role in increasing production. Irrigation is expected to raise agricultural productivity, cropping intensity and provide stability in the long run without environmental degradation. Unfortunately, the introduction of irrigation has resulted in soil salinity and shallow water table in arid and semi-arid regions. Soil salinity and waterlogging problems are seriously affecting the agricultural production in the irrigated areas. In some of the major irrigation projects the objective of canal irrigation to raise production per unit area has not been realised but on the contrary, production and profitability have been adversely affected (Joshi and Agnihotri, 1984).

Studies on the heterogeneity of land in India have been few and far between. Consequently, economists in particular have treated land as a homogeneous factor of production or have misunderstood the nature of differentials in land quality in India. It is well-known that the production performance of any crop is directly guided by soil characteristics, viz., texture, soil depth, slope, water holding capacity and internal drainage. These parameters define the land capability or suitability to different crops. Generally, there are eight land capability classes. The first four classes are suitable for crop production and the next four are restricted to pasture development, recreation and wild life use only (Davidson, 1980). Recently more emphasis has been given to land capability for optimal agricultural production (Alagh, 1990; Khoshoo and Deekshatulu, 1992). Under irrigated conditions, land capability classes are represented by land irrigability classes.

The specific objectives of this paper are to examine (i) the variation in land productivity in terms of production per unit area under different irrigation classes and (ii) the influence of land irrigability class, fertilisers, human labour and other expenses on this variation.

Hypotheses

The study hypothesised that with the expansion in the area under assured irrigation, the farmers will substitute crops like jowar, bajra, cotton and wheat with sugarcane and paddy and often ignore the suggested cropping pattern based on soil-water relationship, because sugarcane and paddy have high profitability and low yield uncertainty as compared to jowar, bajra, wheat and cotton. Moreover, the incidence of diseases and pests on sugarcane and paddy is less as compared to cotton. Water requirements of sugarcane and paddy, especially the HYVs are much greater than for the other crops. Therefore, it is possible to expect that this would lead to the problem of soil salinity and waterlogging which will adversely affect the crop productivity and profitability.

The hypothesis pertaining to the role of land irrigability class and soil degradation level was that it would cause a reduction in the crop yields. Complementary inputs like fertilisers,

hired and family labour were expected to increase the crop yields. The variation in land irrigability classes and soil degradation levels will reduce the efficiency of the complementary inputs.

Study Area

Kakrapar is one of the biggest irrigation projects in the Gujarat State, which has 2.04 lakh hectares of irrigation capacity. This project has two main canals called Kakrapar Right Bank Canal (KRBC) and Kakrapar Left Bank Canal (KLBC). For the present study KRBC was selected because it has higher irrigation intensity (114 per cent) as compared to KLBC (94 per cent) and four irrigability classes exist in this project.

METHODOLOGY

Sampling Procedure

The study is based on data collected from 220 farmers distributed over 22 villages during the agricultural year 1989-90. Multi-stage stratified random sampling technique was used to select the ultimate unit of the sample, i.e., the farmer. A complete list of all the villages falling under different land irrigability classes (see Appendix) was prepared and the villages were selected on the basis of probability proportional to sample size technique. The number of villages selected under land irrigability classes I, II, III and IV was 1, 4, 13 and 4 respectively.

The selected farmers were classified according to the degree of soil degradation. The distribution of farmers according to soil degradation level and land irrigability class along with the total area under selected crops, viz., cotton, sugarcane, paddy and other crops is given in Table I. The study is based on three crops, namely, cotton, sugarcane and paddy. These crops are selected because they are important crops in the study area and occupy about 90 per cent of the total cultivated area in the command area.

Analytical Approach

The production function of the Cobb-Douglas form was used to estimate the magnitude of influence of various factors on the productivity of the selected crops. The production functions were estimated by using Ordinary Least Squares (OLS) method.

The variables included in the production function are:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6)$$

where Y = yield of the crop measured in quintals per hectare for cotton and paddy and in tonnes per hectare for sugarcane,

X_1 = land irrigability index representing different irrigation classes (1=class I; 2=class II; 3=class III and 4=class IV),

X_2 = soil quality index representing the extent of soil degradation due to salinity problem (1 = normal soil; 2 = marginal; 3 = moderate and 4 = strongly affected),

X_3 = expenditure on fertiliser and manure (rupees per hectare),
X_4 = hired labour in man-days per hectare,
X_5 = family labour in man-days per hectare,
X_6 = other expenses including seed, irrigation, chemicals and tractor charges, etc., in rupees per hectare.

TABLE I. CROPPING PATTERN ADOPTED BY THE FARMERS AS PER LAND AND SOIL QUALITY

(area in ha)

Type of soil degradation level (1)	Crop				
	Cotton (2)	Sugarcane (3)	Paddy (4)	Other crops (5)	Total (6)
			Land irrigability class I		
Normal	12.9	9.7	8.5	7.7	38.8
	(8)	(5)	(8)	(6)	(27)
			Land irrigability class II		
Normal	17.4	30.4	10.3	12.2	70.3
	(10)	(10)	(6)	(7)	(33)
Marginal	4.0	10.9	6.5	5.2	26.6
	(3)	(3)	(3)	(2)	(11)
Moderate	9.7	5.3	5.3	-	20.3
	(5)	(3)	(4)		(12)
Strong	-	-	2.4	0.4	2.8
			(3)	(1)	(4)
			Land irrigability class III		
Normal	5.3	41.8	4.6	7.7	59.4
	(3)	(16)	(2)	(5)	(26)
Marginal	-	7.9	3.8	0.9	12.6
		(5)	(3)	(1)	(9)
Moderate	41.3	83.3	60.0	24.5	209.1
	(26)	(28)	(38)	(21)	(113)
Strong	20.5	11.5	32.1	5.4	69.5
	(7)	(4)	(20)	(6)	(37)
			Land irrigability class IV		
Moderate	7.7	44.9	24.1	3.8	80.5
	(6)	(17)	(16)	(4)	(43)
Strong	6.1	10.9	8.9	0.4	26.3
	(8)	(6)	(4)	(1)	(19)
Total	124.9	256.6	166.5	68.2	616.2
	(76)	(97)	(107)	(54)	(334)

Figures in parentheses indicate the number of farmers.

RESULTS AND DISCUSSION

Consequences of Changes in Cropping Pattern

The existing and suggested cropping patterns in the Kakrapar canal command area is given in Table II. The suggested cropping pattern is based on soil-water relationship. The existing cropping pattern is dominated by sugarcane accounting for about 60 per cent of the total culturable command area as compared to 14.3 per cent in the suggested cropping pattern.

Wheat occupies only 2 per cent of the area as against 12.5 per cent in the suggested cropping pattern. Farmers in the command area allocate large acreage to high water requirement crops like sugarcane and paddy as compared to low water requirement crops like jowar, bajra, cotton, wheat, etc. Sugarcane is even cultivated on land irrigability classes III and IV which are suitable only to two and one season crops respectively. This breaks the soil-water relationship resulting in salinity and waterlogging. Any diversion from the suggested cropping pattern leads to salinity and waterlogging which ultimately lead to a decline in farm production. Therefore, the suggested cropping pattern should be strictly followed either by price mechanism along with HYV or through check on the supply of irrigation water.

TABLE II. EXISTING AND SUGGESTED CROPPING PATTERN IN THE KAKRAPAR IRRIGATION PROJECT

(thousand hectares)

Crops	Cropping pattern	
	Existing (1988-89)	Suggested
(1)	(2)	(3)
Paddy	42.0 (21.9)	44.4 (19.9)
Sugarcane	114.4 (59.8)	31.8* (14.3)
Banana	2.6 (1.4)	-
Vegetables	4.4 (2.3)	14.5 (6.5)
Other perennials	3.8 (2.0)	-
Jowar/Bajra	1.1 (0.6)	28.5 (12.8)
Cotton	6.1 (3.2)	43.9 (19.7)
Oilseed	1.6 (0.8)	11.9 (5.3)
Wheat	4.0 (2.1)	27.7 (12.5)
Miscellaneous**	11.3 (5.9)	20.0 (9.0)
Total	191.3 (100.0)	222.7 (100.0)

Source: Government of Gujarat (1988), *Report on Modernisation of Ukai-Kakrapar Irrigation Project*, Superintending Engineer, Kakrapar Circle, Surat (Gujarat).

* Includes banana and other perennial crops in the suggested cropping pattern.

** Miscellaneous includes area under maize, pulses and fodder crops.

Figures in parentheses are percentages to the total.

Productivity Variation due to Irrigability Classes and Soil Quality

Productivity in terms of output and income per hectare for the selected crops is presented in Table III. It is evident from the table that the highest crop yields were observed on normal soils and the lowest on strongly degraded soils. Under moderate soil degradation level the yield is about 70 per cent lower in the case of cotton and paddy and about 50 per cent in the case of sugarcane as compared to normal soil. Similarly, under strongly degraded soil conditions, the yield is 85 per cent lower in the case of cotton and paddy whereas sugarcane witnessed 60 per cent reduction in the yield in comparison to normal soil.

TABLE III. PRODUCTIVITY AND INCOME OF CROPS UNDER DIFFERENT LAND IRRIGABILITY CLASSES AND SOIL DEGRADATION LEVELS

Land irrigability class (1)	Productivity of crops (qtl./ha)			Net income of crops (Rs./ha)		
	Cotton (2)	Sugarcane* (3)	Paddy (4)	Cotton (5)	Sugarcane (6)	Paddy (7)
			Land irrigability classes			
I	25.05	106.00	35.64	9,718.10	22,489.10	4,231.13
II	18.88	90.96	21.40	6,930.35	17,423.20	965.55
III	5.67	58.30	10.06	-489.89	6,654.20	-422.85
IV	3.53	34.67	7.15	-1,700.03	526.54	-1,415.31
Average	10.36	59.03	13.02	2,009.93	7,452.55	-121.81
			Soil degradation level			
Normal	22.38	88.63	29.27	8,133.86	16,498.50	2,683.38
Marginal	18.94	67.26	22.02	7,317.51	8,098.54	938.11
Moderate	6.33	43.10	11.36	-222.41	2,786.49	-356.36
Severe	3.03	33.16	4.45	-1,408.60	-88.32	-1,149.30
Average	10.36	59.03	13.02	2,009.93	7,452.55	-121.81

* Productivity in tonnes/ha.

In the case of land irrigability classes, the highest yield was observed on land irrigability class I and the lowest under class IV. The yield differential increases with the increase in the land irrigability class. The present yield levels of crops like cotton, sugarcane and paddy are far below than the target fixed (4 tonnes per hectare) under irrigation conditions by the National Commission on Agriculture (Government of India, 1976). In the case of land irrigability classes I and II, the yield level of these crops (equivalent to grain level) is nearly equivalent to the targeted yield of 4 tonnes per hectare. This indicates that the inclusion of land irrigability classes III and IV drastically reduced the overall yield levels. These classes have limited choice of crops to be grown. The continuous use of irrigation coupled with high water requirement crops under these land irrigability classes started showing yield reduction.

A significant difference in net income per hectare was observed under normal soil and land irrigability class I as compared to severely degraded soils and irrigability class IV. The highest net income per hectare was observed under normal soil and land irrigability class I. Sugarcane being a commercial crop generated maximum net income per hectare, followed by cotton and paddy. Crop production is not a profitable proposition under moderate and strongly degraded soils and land irrigability classes III and IV.

The productivity is observed to be negatively associated with the degree of soil degradation and land irrigability class. The higher the degree of soil degradation and land irrigability class, the lower the levels of productivity.

Influence of Resource Factors on Land Productivity

The land productivity has significantly negative correlation with land irrigability class and soil degradation level for all the crops under study. Further, the yields of selected crops are found to be significantly positively correlated with other variables like fertiliser, hired

labour and family labour. The land irrigability class and soil degradation level are negatively correlated with fertiliser use, indicating that the use of fertiliser depends on either irrigation class or soil degradation level or both. A significant positive association is found between land irrigability classes and soil degradation levels. It indicates that as the land irrigability classes increases, soil degradation levels also increase.

The estimated results of log linear regression equations showing the effects of the selected factors on land productivity are presented in Table IV. The table reveals that the input variables included in the production function explained 73 to 85 per cent of the variation in land productivity, being maximum in sugarcane and minimum in paddy.

TABLE IV. COEFFICIENTS OF PARAMETERS OF PRODUCTION FUNCTION, STANDARD ERRORS AND COEFFICIENT OF DETERMINATION (R^2) OF COTTON, SUGARCANE AND PADDY CROPS

Variable	Cotton (N=76)		Sugarcane (N=96)		Paddy (N=107)	
	Regression coefficient	Standard error	Regression coefficient	Standard error	Regression coefficient	Standard error
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Land quality	-0.1458***	0.0309	-0.0962***	0.0132	-0.2597***	0.0726
Soil quality	-0.1749***	0.0244	-0.0973***	0.0100	-0.3541***	0.0737
Fertiliser	0.0676***	0.0211	0.0575*	0.0313	0.0450**	0.0224
Hired labour	0.2391***	0.0810	0.1366**	0.0659	0.1919***	0.0568
Family labour	0.2942***	0.1287	0.1363**	0.0300	0.3657***	0.0915
Other expenses	-0.0675	0.0890	-0.1940***	0.0782	-0.3329***	0.0915
Constant	1.1268		2.4996		4.4294	
R^2	0.8324		0.8555		0.7259	

***, ** and * significant at 1, 5 and 10 per cent levels respectively.

Among different inputs, land irrigability class and soil degradation level are negatively related with crop yield and are significant at 1 per cent level. Further, fertiliser, hired labour and family labour have statistically significant positive impact on yield. The regression coefficient of other expenses was significantly negative in the case of sugarcane and paddy only. It may be due to increased use of seed (more than recommended) and more number of ploughing in the degraded soils to maintain the germination and required plant population.

Resource Use Efficiency

Resource use efficiency of a particular crop is usually tested by comparing the marginal value productivities (MVPs) of inputs with their prices. The MVPs of fertiliser, hired labour and family labour in different land irrigability and soil degradation classes are presented in Table V. The results indicated that as the land irrigability class and soil degradation level deteriorate, the MVP and allocative efficiency of all the inputs declined. There is scope for increasing the fertiliser use in land irrigability classes I and II and also in marginally degraded soil, whereas in the remaining cases the farmers are applying higher doses of fertiliser, hence some quantity of fertiliser may be withdrawn.

TABLE V. MARGINAL VALUE PRODUCTIVITIES OF SELECTED INPUTS FOR DIFFERENT CROPS UNDER DIFFERENT LAND IRRIGABILITY CLASSES AND SOIL DEGRADATION LEVEL

Land irrigability classes/Soil degradation level	Cotton			Sugarcane			Paddy		
	Ferti-liser	Hired labour	Family labour	Ferti-liser	Hired labour	Family labour	Ferti-liser	Hired labour	Family labour
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Land irrigability classes									
I	1.37	121.64 (3.5)	280.88 (8.1)	1.4	93.6 (2.7)	296.3 (8.5)	1.1	44.6 (1.3)	186.1 (5.3)
II	1.13	109.62 (3.1)	245.74 (7.0)	1.2	90.0 (2.6)	347.4 (9.9)	0.6	31.1 (0.9)	124.1 (3.6)
III	1.00	43.55 (1.2)	74.76 (2.1)	0.7	61.1 (1.7)	226.3 (6.5)	0.6	33.2 (0.9)	49.5 (1.4)
IV	0.20	26.60 (0.8)	51.70 (1.5)	0.6	43.5 (1.3)	139.0 (4.0)	0.2	12.6 (0.4)	58.6 (1.7)
Average	1.10	56.30 (1.6)	114.65 (3.3)	0.8	60.5 (1.7)	221.4 (6.3)	0.5	27.9 (0.8)	65.5 (1.8)
Soil degradation level									
Normal	1.03	106.60 (3.1)	320.53 (9.2)	1.0	80.3 (2.3)	250.2 (7.1)	0.8	38.5 (1.1)	149.1 (4.3)
Marginal	1.20	118.07 (3.9)	303.43 (8.8)	8.0	71.0 (2.0)	241.6 (6.9)	0.3	37.1 (1.1)	120.5 (3.4)
Moderate	1.02	46.30 (1.3)	93.72 (2.7)	0.7	50.5 (1.4)	180.1 (5.1)	0.4	24.9 (0.7)	73.2 (2.1)
Severe	6.25	30.70 (0.9)	44.30 (1.3)	0.6	43.5 (1.3)	134.5 (3.8)	0.9	27.7 (0.8)	25.5 (0.7)
Average	1.10	56.30 (1.6)	114.65 (3.3)	0.8	60.5 (1.7)	221.4 (6.3)	0.5	27.9 (0.8)	65.52 (1.8)

Note: The MVP of fertiliser is in Rs. per rupee and the MVP of hired and family labour is in Rs. per man-day. Figures in parentheses indicate the allocative efficiency.

CONCLUSION

The results of the study showed that the farmers in the command area allocated large acreage to high water requirement crops like sugarcane and paddy and often ignored the suggested cropping pattern which is based on soil-water relationship. Sugarcane is even cultivated on irrigability classes III and IV, which are suitable only for seasonal crops, and this breaks the soil-water relationship. This has led to the problem of salinity and water-logging. The adverse effects of land degradation in terms of productivity and profitability of crops are also substantial. The crop productivity was found to be negatively associated with land irrigability class and soil degradation levels. The land irrigability class and soil degradation have negative effect on crop productivity. The coefficients of fertiliser, family labour and hired labour were significantly negative in all the equations. The MVPs and allocative efficiencies of complementary inputs like fertiliser, family and hired labour decreased with the increase in land irrigability class and soil degradation level. Hence this confirms the hypothesis formulated.

The study suggests that the suggested cropping pattern should be strictly implemented

in the command area to avoid the problem of salinity and waterlogging. The farmers should be encouraged to adopt improved water management practices like sprinklers, drips, conjunctive use of groundwater and canal water and to grow salt tolerant crops/varieties.

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APPENDIX

IRRIGATION SUITABILITY UNDER DIFFERENT LAND IRRIGABILITY CLASSES

Land irrigability class (1)	Irrigation suitability (2)	Limitation (3)	Choice of crop (4)
I	Highly suitable	None	Heavy water requirement crops
II	Suitable with slight obstacles	Moderately well drained, moderate soil depth	Light high water requirement crops
III	Moderately suitable with moderate obstacles	Imperfect or somewhat excessively drained soil and shallow soil	Only seasonal crops
IV	Marginally suitable with severe obstacles	Poorly excessively drained soil, very shallow soil	Only seasonal crops
V	Not suitable	Drained and shallow soil	Nil

Source: Davidson (1980).

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