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Impact of Land Irrigability Classes on Crop Productivity in Canal Command Area of Gujarat: An Economic Analysis

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Abstract

The impact of land irrigability classes on crop productivity has been reported based on the survey of Mahi right bank (MRB), Ukai-Kakrapar right bank (UKRB) and Kakrapar left bank (KLB) canal command areas of the Gujarat state. The multi-stage random sampling method was used to select the farmers. The MRB and UKRB areas have five different soils environment in terms of land irrigability classes, while the KLB area has only three soils environment. The major crops grown in the UKRB are sugarcane, rice, cotton and pigeon pea, while sugarcane and rice are the major crops in the KLB. Similarly, in the MRB, rice, pearl millet, groundnut, wheat and tobacco crops occupy 95 per cent of the total irrigated area. The study has revealed that farmers have violated the recommended cropping pattern and are growing high water-requiring crops, irrespective of their suitability to land. In the land irrigability classes III, IV and V, cultivation of sugarcane and rice has led to waterlogging and secondary salinization problems, and reduction in crop yields. Hence, the cultivation of lower irrigability classes with minimum use of major inputs is not an advisable proposition. It would be better if crops are selected according to land irrigability classes which might result in a higher production with lower unit cost of production in the command areas under the study.

Introduction

Development of irrigation network to feed the increasing human population is a worldwide concern. A substantial investment has been made in the country for creating assured irrigation-facilities through major and

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medium irrigation projects to increase agricultural production. The irrigated area of the country has increased from 21 Mha in 1950-51 to 57 Mha during 1999-2000 (www.agricoop.nic.in). Unfortunately, the introduction of canal irrigation has resulted in the development of soil salinity and shallow water-table in the arid and semi-arid regions, which have depicted serious negative impact on the agricultural environment in these areas.

Among the 8 land-capability classes, which are based on soil characteristics, soil depth, texture, slope, and water-holding capacity, the first four are considered suitable for crop production. The choice of crops and cropping patterns based on capabilities gives higher returns per unit area with adequate provision of conserving the natural resource (van Wambeke and Rossiter, 1987). Under the irrigated conditions, these land capabilities are called 'Land Irrigability Classes'. Of late, researchers and planners have laid much emphasis on 'Land Capability Classes' as such to achieve sustainability in agricultural production (Alagh, 1990). Therefore, what is urgently called for is an appropriate land-use policy so that optimal use of land resources based on land capability or sustainability is taken care of (Khoshoo and Deekshatulu, 1992). In the present paper, impact of natural resources like soil and other factors has been studied on crop production and profitability under different land irrigability classes in the semi-arid regions of Gujarat state.

Methodology

Ukai-Kakrapar and Mahi Right Bank canal command irrigation projects in Gujarat were selected for the study. The Ukai-Kakrapar irrigation project has four main canals, viz. Ukai Left, Ukai Right, Kakrapar Left and Kakrapar Right. Ukai Right and Kakrapar Right Bank Canal command areas are located between the Narmada and the Tapi rivers, whereas Mahi Canal Command area is located in parts of Kheda and Panchmahal districts in Gujarat. Thus, canal command areas represented by Ukai-Kakrapar Right Bank (UKRB), Kakrapar Left Bank (KLB) and Mahi Right Bank (MRB) were selected for investigation. The data were collected from 400, 180 and 500 farmers distributed over 40, 18 and 50 villages of UKRB, KL and MRB canal command areas, respectively during the years 1990-91 and 1991-92. Farmers were selected using the multistage stratified random sampling technique. The selected villages were classified into different land irrigability classes, as shown in Table 1.

The UKRB was covered predominately by four crops, viz. rice, sugarcane, cotton and pigeon pea, while the KLB was dominated by rice and sugarcane only. Rice, wheat, pearl millet (summer as well as *kharif*), groundnut (summer) and tobacco were the important crops in the MRB. All

Table 1. Classification of villages into different land irrigability classes

Land irrigability class	No. of villages selected			
	UKRB	KLB	MRB	Total
I	1	-	15	16
II	9	3	9	21
III	21	10	9	40
IV	7	5	5	17
V	2	-	12	14
Total	40	18	50	108

these crops occupied more than 90 per cent of the total cultivated area in the respective canal command areas. James (1994) has suggested the Productivity, Earnings, Labour and Land valuation approaches to estimate the impact of environment on economic performance. The Land valuation approach can't be used in general due to the fact that land value has increased in barren areas also because of scarcity of land in canal command areas due to industrialization (Gajja *et al.,* 1996). Hence, the three approaches, viz. Productivity, Earnings and Labour and the unit cost of production guided directly by environment were used in the present study.

Regression Analysis

Multiple regression analysis using Cobb-Douglas production function was carried out to assess the magnitude of influence of various factors on land productivity. The specification of the economic model used is given by Eq. (1):

$$Y= f(X_1, X_2, X_3, X_4, X_5, X_6) \quad \ldots(1)$$

where

Y = Crop yield (q/ha)

X_1 = Land quality representing different irrigability classes (I to V)

X_2 = Soil quality representing extent of soil degradation level (1 = Normal, 2 = Marginal, 3= Moderate, 4 = Severely degraded)

X_3 = Expenditure on fertilizer and manure (Rs/ha)

X_4 = Hired labour (man-days/ha)

X_5 = Family labour (man-days/ha)

X_6 = Miscellaneous expenses including seeds, chemicals, ploughing, and irrigation charges, etc. (Rs/ ha).

In order to detect multicollinearity, zero order inter-correlation matrices were generated. The inter-correlations were then compared with multiple correlation coefficient following Klein (1962).

Results and Discussion

Cropping Pattern

The recommended cropping pattern in a canal command area is based on the classification of land into different categories. The recommended as well as the existing cropping patterns in both command areas indicated a high degree of divergence (Table 2). The area under high water-requiring crops was found to be more than the recommended cropping pattern. Sugarcane and rice dominated due to their ability to fetch higher economic returns (Nilkantha and Mitra, 1986). The high water-requiring crops like sugarcane and rice, were grown in all the classes of land, which was basically the violation of scientific norms, i.e. choice of crops and cropping intensity based on soil-water-crop relationship. Under the recommended cropping pattern, land was to be kept fallow for one to two seasons but such remedial measures were not being undertaken at any place in the study area. The land, which was not suitable for irrigation, had also been brought under irrigation, causing an adverse effect on the plant-soil-water relationship.

Land Irrigability Classes *vs* Crop Productivity

The productivity of various crops under different canal commands showed a declining trend with increase in the land irrigability class sequence

Table 2. Recommended and actual cropping pattern in canal command areas

('000 ha)

Crop	Area			
	Suggested		Actual	
	UKRB	MRB	UKRB	MRB
Sugarcane and Perennials*	46.8	7.7	162.4	13.3
Rice	79.8	45.8	45.7	75.1
Vegetable	25.2	-	5.6	-
Sorghum, Pearl millet and other *kharif* pulses	42.9	39.2	1.4	14.0
Wheat	49.2	52.2	7.3	10.7
Cotton	70.9	13.1	8.8	-
Tobacco	-	13.1	-	24.7
Oilseeds	25.9	-	7.3	3.7
Miscellaneous	30.0	41.6	19.8	9.9
Total	370.7	212.7	258.3	151.4

*Including banana
UKRB = Ukai-Kakrapar Right Bank
MRB = Mahi Right Bank

(Table 3). The maximum yield was obtained under the normal soil condition of land irrigability classes I and II, which was very close to the targeted yield of 4-5 t/ha under National Demonstrations, as fixed by the National Commission on Agriculture (Robert, 1992). The National Demonstration was held predominately on ideal soil conditions (i.e. land irrigability classes I and II). The minimum yield was obtained in the land irrigability class V. The required yields under land irrigability class II were obtained only through following of efficient management practices. The land irrigability classes III and IV indicated reduction in yield levels as well as increase in soil degradation levels. It was due to the cultivation of high water-requiring crops along with high cropping intensity (300%). The land irrigability classes III, IV and V were not suitable for high water-requiring crops because the high cropping intensity resulted into accumulation of water in sub-soil profile causing rise in water-table and if the groundwater was saline, it led to secondary salinisation. If the existing canal irrigation was used only for land irrigability classes I and II, the present level of crop production would have

Table 3. Production performance of crops under different land irrigability classes

(q/ ha)

Crop	Land irrigability class					Average
	I	II	III	IV	V	
			UKRB			
Sugarcane*	106.00	72.73	55.28	34.05	-	56.94
Cotton	25.05	17.11	6.31	3.78	1.79	8.41
Rice	36.34	23.00	9.44	6.86	-	12.51
Pigeon pea	14.82	7.08	5.63	1.87	2.05	5.52
			KLB			
Sugarcane*	-	72.37	42.07	32.21	-	44.52
Rice	-	26.31	16.55	9.01	-	15.00
			MRB			
Rice	42.60	22.08	12.43	8.54	7.91	17.09
Wheat	21.70	11.25	8.56	4.28	3.21	5.34
Pearl millet (*kharif*)	17.91	11.86	17.84	6.25	4.12	13.99
Pearl millet (summer)	21.90	15.79	11.13	8.29	-	17.95
Tobacco	19.67	8.79	9.53	-	-	16.37
Groundnut (summer)	17.08	14.49	8.64	3.29	-	10.57

*Yield of sugarcane in t/ha
UKRB = Ukai-Kakrapar Right Bank
MRB = Mahi Right Bank
KLB = Kakrapar Left Bank

been much higher (nearer to double) without the degradation of environment and sustainability of production could have also been maintained.

Cost of Production

The sustainability and economic viability of agriculture in the long-term depends on the efficient utilization of natural resources like soil and water. The unit cost of production reflects how efficiently natural resources (soil and water) are used. The unit cost of production at cost C level increased with increase in the land irrigability class sequence (Table 4). The crop production under land irrigability classes I and II, with low unit cost of production compared to that in classes IV and V was the indicator of sustainability. The land irrigability classes IV and V were often subjected to economic and technical constraints for crop production (Donald, 1980). The land irrigability class III that was marginally economical had either soil-

Table 4. Unit cost of production (cost C) of crops under different land irrigability classes

(Rs/q)

Crop	Land irrigability class					Average
	I	II	III	IV	V	
			UKRB			
Sugarcane*	187.85	220.76	277.13	455.32	-	275.78
Cotton	398.06	484.85	860.63	1174.12	1910.51	715.78
Rice	158.37	203.98	362.05	422.93	-	311.40
Pigeon pea	311.67	395.81	511.19	950.93	960.50	466.59
			KLB			
Sugarcane*	-	275.25	363.30	438.94	-	352.89
Rice	-	211.93	249.14	265.61	-	246.17
			MRB			
Rice	171.01	236.97	302.84	376.96	394.31	399.48
Wheat	242.04	336.56	351.80	555.76	635.19	432.04
Pearl millet (*kharif*)	124.91	174.00	193.14	208.38	245.75	130.14
Pearl millet (summer)	144.19	168.85	188.67	230.68	-	162.49
Tobacco	578.43	793.52	792.95	-	-	613.52
Groundnut (summer)	427.27	532.50	544.31	873.73	-	500.27

* Cost of production Rs/tonne
UKRB = Ukai-Kakrapar Right Bank
MRB = Mahi Right Bank
KLB = Kakrapar Left Bank

depth or internal drainage or both constraints, which adversely affected the production performance. Therefore, the inclusion of land irrigability classes III, IV and V had led to an increase in the unit cost of production, which was much higher than the average cost of production. As mentioned earlier, if the canal irrigation potential could be limited to land irrigability classes I and II, the average unit cost of production would have been much lower than the observed level.

Measure of Profitability

The effect of land irrigability classes could further be visualized from the measurement of profitability, which tended to decline with increasing irrigability classes (classes IV and V). The maximum net income was generated by land irrigability class I and minimum by classes IV and V (Table 5). The reason for cultivation of such soils was that it generated some farm income.

Table 5. Net income from crops under different land irrigability classes

(Rs/ha)

Crop	Land irrigability class					Average
	I	II	III	IV	V	
			UKRB			
Sugarcane	22489.10	12308.65	6239.25	479.57	-	6503.47
Cotton	9718.10	6392.21	-508.76	-1633.17	-2077.81	540.29
Rice	4231.13	1923.52	-819.38	-920.33	-	-522.12
Pigeon pea	5590.42	1799.64	782.02	-564.63	-636.52	1012.42
			KLB			
Sugarcane	-	13439.51	4515.69	885.02	-	5089.03
Rice	-	1817.49	286.34	119.20	-	398.08
			MRB			
Rice	5674.80	1317.78	-286.88	-790.46	-956.18	679.25
Wheat	2714.09	425.86	-358.64	-789.76	-844.51	15.53
Pearl millet (*kharif*)	2240.28	946.42	445.77	220.14	-81.50	1549.05
Pearl millet (summer)	3194.62	1969.63	1128.74	532.57	-	2133.46
Tobacco	5596.87	1810.08	1256.40	-	-	3156.02
Groundnut (summer)	5512.75	1933.59	1629.45	-468.90	-	2550.59

UKRB = Ukai-Kakrapar Right Bank
MRB = Mahi Right Bank
KLB = Kakrapar Left Bank

Table 6. Labour utilization under different land irrigability classes

(man-days/ha)

Crop	Land irrigability class					Average
	I	II	III	IV	V	
			UKRB			
Sugarcane	94.6(79.2)	74.1(60.1)	58.3(45.7)	45.8(30.1)	-	61.2(42.7)
Cotton	77.5(63.3)	60.5(44.9)	44.1(32.7)	24.5(12.3)	18.9(8.1)	42.9(28.3)
Rice	57.4(44.8)	43.3(31.6)	28.3(23.1)	16.7(8.1)	-	38.5(26.7)
Pigeon pea	44.5(30.4)	30.4(20.1)	22.9(12.1)	16.3(8.1)	17.5(5.2)	26.9(17.3)
			KLB			
Sugarcane	-	76.1(54.6)	62.9(39.1)	49.4(34.0)	-	58.8(40.4)
Rice	-	51.7(33.1)	40.7(23.0)	28.4(13.6)	-	41.4(21.4)
			MRB			
Rice	56.1(40.9)	46.7(27.3)	35.4(17.7)	29.1(16.6)	29.0(13.3)	37.8(19.5)
Wheat	42.1(29.1)	39.3(19.6)	28.9(15.1)	26.3(10.9)	23.7(6.9)	30.7(13.8)
Pearl millet (*kharif*)	20.0(10.4)	17.3(9.0)	12.3(6.0)	13.2(4.3)	10.1(3.1)	16.8(8.1)
Pearl millet (summer)	25.2(11.6)	21.2(8.6)	17.7(5.8)	19.4(3.1)	-	22.6(9.0)
Tobacco	69.3(51.2)	57.9(33.3)	44.9(26.6)	-	-	62.7(44.3)
Groundnut (summer)	36.6(23.6)	25.6(16.8)	20.9(13.1)	17.2(8.9)	-	24.9(12.7)

Note: Figures within the parentheses indicate number of hired labour
UKRB = Ukai-Kakrapar Right Bank
MRB = Mahi Right Bank
KLB = Kakrapar Left Bank

Employment

Besides impact on yield, unit cost of production and profitability, land irrigability classes also determine the extent of farm labour-use. The labour-use decreased with increase in land irrigability classes (Table 6). The use of hired labour in land irrigability classes III and IV was due to the fact that certain operations, e.g. transplanting of rice seedlings and removal of weeds were to be performed within a time frame. The agricultural sector is already facing a serious threat of unemployment and under-employment. Therefore, it should be of a serious concern for planners to devise strategies so that a favourable production environment could be maintained. Vaidynathan (1978) had explained that inter-regional variations in human labour demand depended on the crop yields and relative prices of different inputs. This confirmed that reduction in the yield level reduced the requirement of human labour also. The reduction in labour was therefore, directly related to crop yields and the

Table 7. Coefficient of parameters of production function of different crops grown in Ukai- Kakrapar Right Bank (UKRB) and Kakrapar Left Bank (KLB) canal command areas

Parameters	Crops in UKRB				Crops in KLB	
	Cotton	Rice	Pigeon pea	Sugarcane	Sugarcane	Rice
Land quality	-0.3648***	-0.2548***	-0.1954***	-0.1125***	-0.1592***	-0.1820***
	(0.0344)	(0.0605)	(0.0418)	(0.0257)	(0.0252)	(0.0390)
Soil quality	-0.3977***	-0.4235***	-0.2872***	-0.1926***	-0.1258***	-0.2762***
	(0.2870)	(0.0551)	(0.0350)	(0.0190)	(0.0236)	(0.0218)
Fertilizers & manure	0.0588**	0.0658***	0.0222**	0.0469*	-0.0625***	0.0104***
	(0.0127)	(0.0203)	(0.0103)	(0.0284)	(0.0140)	(0.0233)
Hired labour	0.0618**	0.0867*	0.01191**	0.1018**	0.2114***	0.1307***
	(0.0279)	(0.0510)	(0.0525)	(0.0349)	(0.0249)	(0.0233)
Family labour	0.0739**	0.0969*	0.2378**	0.2516**	0.1020*	0.2260***
	(0.0318)	(0.0510)	(0.0605)	(0.770)	(0.0580)	(0.0532)
Miscellaneous	0.0204	0.1198*	0.0325	-0.0336**	0.1032	0.2418**
	(0.0597)	(0.0603)	(0.0645)	(0.0439)	(0.2075)	(0.0896)
Constant	3.5336	2.6726	0.1010	0.1283	-2.3180	0.6509
R^2	0.8885***	0.7603***	0.8679***	0.8308***	0.9388***	0.8786***
No. of observations	146	120	99	125	101	135

Note: Figures within the parentheses are standard errors.
***, **, * denote significance at 1, 5 and 10 per cent levels, respectively.

Table 8. Coefficient of parameters of production function of different crops grown in Mahi Right Bank (MRB) canal command area

Variable	Crops in MRB					
	Rice	Wheat	Pearl millet (*kharif*)	Pearl millet (summer)	Tobacco	Groundnut
Land quality	-0.0987***	-0.1226***	-0.2223***	-0.1720***	-0.1169**	-0.1884***
	(0.0211)	(0.0315)	(0.0471)	(0.0470)	(0.0433)	(0.0665)
Soil quality	-0.1568	-0.2227***	-0.2889***	-0.2007***	-0.1788***	-0.2104**
	(0.0256)	(0.0338)	(0.0508)	(0.0454)	(.0232)	(0.0782)
Fertilizers & manure	0.4106***	0.1424***	0.1433*	0.1686***	0.2439***	0.0412**
	(0.0446)	(0.0253)	(0.0789)	(0.0235)	(0.0751)	(0.0201)
Hired labour	0.2172***	0.1888***	0.1683***	0.1960***	.01801***	0.1680***
	(0.0211)	(0.0264)	(0.0689)	(0.0297)	(0.0381)	(0.0375)
Family labour	0.4137***	0.4993***	0.1556***	0.2967***	0.1485***	0.1407***
	(0.0463)	(0.0730)	(0.0633)	(0.1363)	(0.0634)	(0.0423)
Miscellaneous	-0.0403	0.4269***	-0.2278*	0.0367	0.0265	0.1607
	(0.0812)	(0.1157)	(0.1145)	(0.1368)	(0.0779)	(0.1400)
Constant	-0.0073	-0.3481	2.8445	11.1791	-1.2290	-1.3085
R^2	0.8328***	0.8544***	0.8584***	0.5958**	0.7029***	0.8529***
No. of observations	250	168	46	88	77	36

Note: Figures within the parentheses are standard errors.
***, **, * denote significance at 1, 5 and 10 per cent levels, respectively

yield of crops could be maintained by adopting the suggested cropping pattern that was scientific and based on soil-water-crop relationship.

Impact of Resource Allocation on Crop Productivity

The test of multicollinearity indicated that it was not a problem in any pair of explanatory variables included in the study. The input variables included in the analysis explained adequate variation in productivity of all the crops (Tables 7 and 8). The negative and significant regression coefficients of land quality and soil degradation level implied that as the land quality and soil degradation levels increased, the crop yield declined. The other input variables like fertilizers and manure, hired and family labour had a positive relationship, indicating that with increase/decrease in the crop productivity, the use of these inputs also varied in the same way. This further indicated that the use of fertilizers and manure, and hired labour and family labour were guided by the land irrigability classes and soil degradation levels. The high crop productivity was clearly associated with good quality of land (land irrigability classes I and II), higher amount of fertilizer and manure application, and intensive use of hired and family labour.

Conclusions

The study has revealed that cultivation of high water-requiring crops, irrespective of their suitability to land by farmers has violated the suggested cropping pattern. In the land irrigability classes III, IV and V, sugarcane and rice are being cultivated. This is leading to waterlogging and secondary salinization, and reduction in crop yields in these land irrigability classes. Hence, high cost of production and reduction in profitability have forced the farmers cultivating the land of lower irrigability classes to minimize the use of major inputs. If suitable crops were taken according to land irrigability classes, much higher production could be achieved with the lower unit cost of production in the command areas under the study. Moreover, higher crop production coupled with low per unit production cost and eco-friendly environment canal irrigation under land irrigability classes I and II would also prevent secondary salinization.

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