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ECONOMICS OF IRRIGATION: A REGIONAL PERSPECTIVE* (A CASE STUDY OF A DPAP DISTRICT, SURENDRANAGAR)

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Two alternatives open to a policy-maker engaged in the process of rural development in the early stages of development are: (*i*) to ignore structural reforms and go straight for resource development and (*ii*) to go for structural reforms together with resource development.[1] The former alternative is the obvious preference; it being politically as well as administratively a soft option. And, amongst the resource development alternatives, land resource development through irrigation, which is known to be a watershed between traditional and modern agriculture,[2] appears to be the most rewarding and, hence the preferred child of policy-makers.

No wonder, the watershed planning forms the nebulous of rural development planning strategy of the arid regions in India.[3] Since no watershed is functioning at present in the region of study, it is not possible to study directly the economics of this rural development strategy. However, an indirect attempt is made in this paper.

To be more specific, we propose to assess, given the behavioural relations of the farmers of the region[4] the likely impact of the additional irrigation facilities on the regional economy, on the one hand, and on the various household classes constituting the rural economy, on the other. Besides this, an attempt is also be made to understand the mechanics of this impact.

METHODOLOGY

The 78 × 83 regional programming model of Surendranagar[5] forms the basis of this study. This model explicitly accounts for farm and non-farm rural households of the district. Indeed, farm households are represented by three relatively homogeneous farm size classes: small (upto 12.5 acres), medium (between 12.5 acres and 25 acres) and large farm households (above

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* This study borrows freely from the Indian Council of Social Science Research (ICSSR) sponsored research work carried out at the Sardar Patel Institute of Economic & Social Research during 1976-78. For details, see Baldev Singh: Integrated Local Level Planning: Some Empirical Explorations, Sardar Patel Institute of Economic & Social Research, Ahmedabad, 1978 (mimeo.).

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1. For a theoretical case in support of second alternative, see Karl A. Fox, Jati K. Sengupta and Erik Thorbecke: The Theory of Quantitative Economic Policy with Applications to Economic Growth and Stabilization, North-Holland Publishing Co., Amsterdam, 1966, pp. 447-482.
2. For empirics in support of this assertion, see Baldev Singh: Capital Formation in the Agricultural Sector in Haryana, Kurukshetra University, Kurukshetra, 1972 (unpublished Ph. D. Thesis), p. 134.
3. D. Aurora: A Note on the Drought Prone Area Programme, Ministry of Agriculture, Government of India, New Delhi, 1975 (mimeo.).
4. For a comprehensive analysis of this aspect, refer Singh: Integrated Local Level Planning: Some Empirical Explorations, *ibid*, Chapter Six on "Irrigation, Productivity and Employment".
5. For details of the model, refer Singh: *ibid*, Chapter Eleven on "Planning for Rural Sector: Resources and Technology Coefficients".

25 acres). On the resource front, 16 of the 78 regional resource constraints represent the macro resource position of the rural district, while the other 62 resource constraints represent the specific resource position of each of the four rural classes representing the primary sector of the district. Each of these four classes are free to draw upon the macro resources at either the market price or their shadow price. On the activity front, 58 of the 83 regional activities represent the productive activities, *i.e.*, crop and animal activities, engaged in by the four groups of households, and the remaining 25 cost activities represent the households' option to supplement their resources from the regional resource pool at the market price.

To assess the impact of irrigation on the regional economy, we make a bold assumption that additional land brought under irrigation does not differ from the existing irrigated land irrespective of its supply source: traditional schemes—major, medium or minor irrigation, or the scheme evolved under the development strategy of watershed planning In other words, we assume that the irrigation input will continue to be partially used as protective shield against draught situations and partially to act as a productivity booster.[6] Thus adequate timely irrigation supplies, a common feature of perennially irrigated regions, will continue to elude the region.

For the purpose of this study, the regional programming model is solved to maximize regional income[7] by the simplex method for three alternative irrigation situations.[8] In the first situation, it is assumed that 5 per cent of the net sown area of the region will be brought under irrigation. This level is raised to 10 per cent and 15 per cent under the other two situations. This additional irrigated land is distributed amongst small, medium and large cultivators as per the distribution of unirrigated net sown area of the region amongst these groups. Apart from additional irrigated acreage, we assume that the region is insulated from changes in the rest of the society.

IRRIGATION AND REGIONAL INCOME

Since irrigation leads to increase in productivity of the land irrespective of the productive or protective nature of its use, investment in irrigation in a region should lead to increase in the income of the region. This proposition is corroborated by data in Table I. When unirrigated net sown area of the region is brought under irrigation by 5 per cent, 10 per cent and 15 per cent, it increases the income of the region from the existing income, proximated by optimum basic solution, of Rs. 82.84 crores to Rs. 85.19 crores, Rs. 87.15 crores and Rs. 88.75 crores respectively. In other words, when more and

6. For a comprehensive treatment of the role played by this phenomenon in agricultural development, see Baldev Singh, "Productivity and Resource Development: A Case Study of Agricultural Development of Gujarat", presented at the Seminar on Regional Patterns of Agricultural Development, The Giri Institute of Development Studies, Lucknow, August 5-6, 1977 (mimeo.).

7. For empirical evidence in support of income maximizing objective over that of employment maximizing objective, refer Singh: Integrated Local Level Planning: Some Empirical Explorations, *op. cit.*, Chapter Twelve on "Regional Planning Goal: Employment or Income".

8. Computations are done at IBM 360/44 system of Physical Research Laboratory, Ahmedabad. For this purpose, the standard L.P. package evolved by Shri C. S. R. Murty, Physical Research Laboratory, has been used.

TABLE I—IMPACT OF IRRIGATION INVESTMENT ON OPTIMUM LEVELS OF INCOME IN RURAL SURENDRANAGAR UNDER INCOME MAXIMIZATION OBJECTIVE: 1975-76

Sr. No.	Income recipient classes	Optimum solution of 78 × 83 programming model			
		Basic solution	When unirrigated net sown area is brought under irrigation by		
			5 per cent	10 per cent	15 per cent
1.	Income of rural Surendranagar (Rs. crores)	82·84 (8,129)	85·19 (8,359)	87·15 (8,552)	88·75 (8,709)
	(*i*) Farm household's income ..	78·69 (9,415)	81·18 (9,712)	83·18 (9,952)	84·73 (10,137)
	(*a*) Small farms	10·13 (3,724)	10·76 (3,956)	10·81 (3,974)	10·94 (4,022)
	(*b*) Medium farms	25·04 (8,421)	26·53 (8,922)	28·09 (9,446)	28·71 (9,654)
	(*c*) Large farms	43·52 (16,333)	43·89 (16,471)	44·28 (16,618)	45·08 (16,918)
	(*ii*) Non-farm household's income ..	4·15 (2,264)	4·01 (2,188)	3·97 (2,166)	4·02 (2,172)
2.	Composition of rural income (per cent)	100·00	100·00	100·00	100·00
	(*i*) Farm household's income ..	94·99	95·29	95·44	95·47
	(*a*) Small farms	12·23	12·63	12·40	12·33
	(*b*) Medium farms	30·23	31·14	32·23	32·35
	(*c*) Large farms	52·53	51·52	50·81	50·79
	(*ii*) Non-farm household's income ..	5·01	4·71	4·56	4·53
3.	Incremental income per irrigated acre (Rs.) to				
	(*i*) Rural district economy ..		302·17	277·10	253·31
	(*ii*) Farm household's economy ..		320·17	288·67	258·88
	(*a*) Small farm		976·74	527·13	418·60
	(*b*) Medium farm		691·09	707·32	567·41
	(*c*) Large farm		74·36	76·37	104·50

Figures in brackets denote per household income in rupees.

more land is brought under irrigation, the rate of increase in the income of the region declines. The decline in the rate of increase in the income of the region is, however, consistent with our *ceteris paribus* assumption.

The incremental return per irrigated acre shows a similar behaviour. It registers a declining trend from Rs. 302.17 to Rs. 277.10 to Rs. 253.31 per irrigated acre as the unirrigated net sown area of the region is brought under irrigation by 5 per cent, 10 per cent and 15 per cent respectively.

A disquieting fact brought to light by Table I is that the additional irrigation input to the region results in absolute as well as relative decline in the incomes accruing to the non-farm group of households. In absolute terms, the income accruing to a non-farm household declines from the existing level of Rs. 2,264 to Rs. 2,188, Rs. 2,166 and Rs. 2,172 as the coverage of additional irrigation increases from 5 per cent to 10 per cent to 15 per cent of the unirrigated net sown area of the region respectively. In relative terms, its share in the regional income declines from the existing level of 5.01 per cent to 4.71 per cent, 4.56 per cent and 4.53 per cent in the corresponding irrigation situations.[9] We may recall that the main source of income of these non-farm households is their wage income; only 25 per cent of their income accrues from other activities proximated in the regional model by milk animal and sheep rearing activities. In other words, irrigation leads to a decline in the demand for hired labour input in the region.

Among the farm size categories, the additional incomes accruing to various farm size categories in response to additional irrigational input move in consonance with the observed inverse relation between productivity per acre and farm size. As a consequence, the small and medium farm household categories improve their relative share in regional income at the cost of large farm household category (Table I). The relative gains in income are, however, particularly marked in the case of medium farm households.

In other words, given the existing technology and resource base of the various farm categories of the region, the medium sized farms [10] are relatively better placed to absorb, assimilate and convert the additional supplies of irrigation input into production and income. Indeed, the incremental returns per irrigated acre achieved by various farm categories in the region are highest on medium farms, except in one situation, when only 5 per cent of the unirrigated net sown area is brought under irrigation, when small farms have the highest return of Rs. 976.64 per irrigated acre (Table I). In contrast, the level of incremental return per irrigated acre on large farms is, as would be expected, very low; it lies between Rs. 74 and Rs. 104 per irrigated acre. Interestingly, the incremental returns per irrigated acre on large farms show, in contrast to the other farm categories, positive, though slow, response to additional supplies of irrigation. However, the levels achieved by the large category of farms continue to be substantially lower than those of other corresponding farm categories.

To assess how far irrigation is economical in the district, we have tried to compute the cost per acre of investment with the help of 5 major and 12 minor irrigation schemes of the district. We find from Table II that, on an average, an irrigated acre of land depending upon major or minor irrigation schemes calls for an investment of Rs. 1,269 and Rs. 1,670 respectively. Assuming a life span of 20 years for major irrigation schemes and 10 years

9. An inkling of this expectation emerges from behavioural analysis of farmers. For details see Singh: Integrated Local Level Planning: Some Empirical Explorations, *op. cit.*, Chapter Six.

10. The medium sized farms are defined to have operational holdings between 12·5 acres and 25 acres.

TABLE II—PER ACRE COST AND BENEFIT OF IRRIGATION INVESTMENT, SURENDRANAGAR

Sr. No.	Selected economic characteristics	Irrigation schemes	
		Major*	Minor**
1.	Number of schemes in Surendranagar	5	12
2.	Investment expendtiure per scheme (Rs. lakhs)	57·62	16·55
3.	Benefits (acres)	4,540	991
4.	Investment expenditui e per acre (Rs.)	1,269	1,670
5.	Expected life (years)	20	10
6.	Per acre irrigation cost (Rs.) (including maintenance charges@ 1 per cent of the investment)	76	183
7.	Returns per irrigated acre as per the regional programming model when 5 per cent of the net sown area is brought under irrigation***		
	(*i*) For rural economy (Rs.)	302·17	
	(*ii*) For farm sector (Rs.)	320·17	
	(*a*) Small farms (Rs.)	976·74	
	(*b*) Medium farms (Rs.)	691·09	
	(*c*) Large farms (Rs.)	74·36	

Source: * Government of Gujarat: Perspective Plan of Gujarat, 1974-1984, Vol. II, State Planning Board, Gandhinagar, 1972, pp. 144-145.
** By courtesy of Executive Engineer, Irrigation, Panchayat Division, Surendranagar.
*** From Table I.

for minor irrigation schemes and a maintenance cost of irrigation schemes equivalent of 1 per cent of the investment, the per acre per annum cost of irrigation comes to Rs. 76 and Rs. 183 each under major and minor irrigation schemes. Our regional model yields a return of Rs. 302, Rs. 277 and Rs. 253 per irrigated acre per annum under each of the three experiments performed, *viz.*, when 5 per cent, 10 per cent, and 15 per cent of the net sown area is brought under irrigation.

Accordingly, irrigation turns out to be a paying proposition for the region. It carries around 100 per cent return per annum. However, amongst the farm size categories, irrigation investment fails to generate enough returns on large farms to meet even its cost (Table II). The policy implication of this is that services of public irrigation schemes should primarily be extended to small and medium farms to maximize the social welfare of the region.

IRRIGATION AND REGIONAL EMPLOYMENT

Since irrigation operations involve additional labour input, we would expect the regional employment to increase in response to irrigation investment in the region. The data in Table III belies these hopes. Not only

regional employment fails to increase in response to irrigation investment, it registers marginal decline as well. However, the rate of decline in the regional labour use tends to slow down as more and more land is brought under irrigation. Indeed, each additional irrigated acre reduces the regional demand for labour by 4.91 man-days, 1.08 man-day, and 0.59 man-day as we bring under irrigation 5 per cent, 10 per cent and 15 per cent of the net sown area of the region (Table III).

TABLE III—IMPACT OF IRRIGATION INVESTMENT ON OPTIMUM LEVELS OF LABOUR USE IN RURAL SURENDRANAGAR UNDER INCOME MAXIMIZATION OBJECTIVE: 1975-76

Sr. No.	Aspects of labour use	Optimum solution of 78 × 83 programming model			
		Basic solution	When unirrigated net sown area (NSA) is brought under irrigation by		
			5 per cent	10 per cent	15 per cent
1.	Labour use in rural Surendranagar (lakh man-days)	380·94	377·12	379·26	379·56
	(*a*) Self	277·26	277·97	281·61	280·16
	(*b*) Hired	103·68	99·15	97·65	99·40
2.	Labour use by farm households (lakh man-days)	359·87	355·85	357·98	358·29
	(*a*) Self	255·99	256·70	260·34	258·89
	(*b*) Hired	103·68	99·15	97·65	99·40
3.	Labour use by small farm households (lakh man-days)	66·10	65·21	62·17	58·70
	(*a*) Self	66·10	65·21	62·17	58·70
	(*b*) Hired	—	—	—	—
4.	Labour use by medium farm households (lakh man-days)	106·57	109·71	117·44	121·09
	(*a*) Self	81·80	83·40	90·08	92·10
	(*b*) Hired	24·77	26·31	27·36	28·99
5.	Labour use by large farm households (lakh man-days)	187·00	180·93	178·36	178·50
	(*a*) Self	108·09	108·09	108·09	108·09
	(*b*) Hired	78·91	72·84	70·27	70·41
6.	Labour use by non-farm households (lakh man-days)	21·27	21·27	21·27	21·27
	(*a*) Self	21·27	21·27	21·27	21·27
	(*b*) Hired	—	—	—	—
7.	Labour use per worker per annum (man-days)				
	(*a*) Rural Surendranagar	222	220	221	222
	(*b*) Farm households	251	252	255	254
	(*i*) Small farm households	239	236	225	213
	(*ii*) Medium farm households	220	224	242	248
	(*iii*) Large farm households	290	290	290	290
	(*c*) Non-farm households	180	174	172	174
8.	Seasonal pattern of labour use in rural Surendranagar (lakh man-days)				
	(*a*) January-April	139·48	144·74	153·98	159·40
	(*b*) May-August	136·53	135·63	136·16	137·86
	(*c*) September-December	104·94	96·75	89·13	82·30

What does this decline in the regional demand for labour input denote? Does it denote that farmers want to have more leisure to enjoy the fruits of additional income accruing to them due to irrigation investment? Or, alternatively, does it indicate that farmers shirk to hire additional hands or even sack part of existing hired hands to avoid labour management problems when they are assured of a regularly higher stream of incomes? Or, both? Farmers as a class do not lend support to the first proposition. Indeed, there is an increase in the cultivators' labour input from the existing level of 255.99 lakh man-days to 256.70 lakh man-days, 260.34 lakh man-days and 258.89 lakh man-days as the coverage of additional irrigation increases respectively by 5 per cent, 10 per cent and 15 per cent of the unirrigated net sown area of the region. The only exception to this general behaviour is the category of small farmers. They tend to support this proposition. In fact, they tend to work for less and less number of days per annum (Table III).

The second proposition also gets only partial support from the farmers. However, the support does not come from the major hired labour employer category—the large farms. Notwithstanding the fact that irrigation induces demand for hired labour on medium farms, the net consequence of curtailment of demand for hired labour by the large farms is a decline in their regional demand, which, in turn, leads to a fall in the income levels of non-farm households—the poorest section of the society.

How shall these irrigation supplies influence the seasonal demand pattern of labour market? Table III, which also gives the seasonal labour demand pattern, reveals that the additional irrigation supplies to the region tend to build up pressures on the regional labour market. On the one hand, it tends to build up pressures on the labour demand during the triannum of January-April—the peak period of agro-based industrial activities in the region, particularly cotton ginning and pressing activities. And, on the other, it tends to increase the intensity of slack season of labour demand during the months of September-December.

IRRIGATION AND LAND USE PATTERN

Depending upon the relative strength of the productive or protective role of irrigation input, irrigation may or may not lead to a marked improvement in the land use intensity *i.e.*, cropping intensity. To the extent irrigational investment can generate adequate perennial supplies of irrigation input, it is likely to be primarily used in its productive rather than protective role and is expected to markedly improve the cropping intensity of land. Alternatively, when irrigational investment generates only seasonal supplies of irrigation input, it is likely to be primarily used in its protective rather than productive role and is not expected to bring any marked improvement in the land use intensity. Therefore, we would not expect irrigational investment in a dry region with very low and erratic precipitation, irrespective of its form: watershed or otherwise, to yield perennial flow of irrigation. Accordingly, we would not expect it to be primarily used for productive

rather than protective role and yield a markedly high cropping intensity. The data in Table IV tends to corroborate this proposition. The cropping intensity of the region shows positive, although very slow, response to irrigational investment in the region. It increases from the existing level of 99.64 per cent to 99.76 per cent, 100 per cent and 101.08 per cent as the additional irrigation increases respectively by 5 per cent, 10 per cent and 15 per cent of the unirrigated net sown area of the region.

TABLE IV—IMPACT OF IRRIGATION INVESTMENT ON REGIONAL LAND USE PATTERN UNDER INCOME MAXIMIZATION OBJECTIVE, SURENDRANAGAR: 1975-76

Sr. No.	Aspects of land use		Optimum solution of 78 × 83 regional programming model			
			Basic solution	When unirrigated NSA is brought under irrigation by		
				5 per cent	10 per cent	15 per cent
1.	Cropping pattern (per cent)		100·00	100·00	100·00	100·00
	(*i*) Bajri:	Unirrigated	20·42	15·10	12·14	9·66
		Irrigated	1·10	2·69	2·90	2·82
	(*ii*) Cotton:	Unirrigated ..	42·74	42·70	42·59	42·15
		Irrigated	3·37	6·32	9·34	11·13
	(*iii*) Jowar:	Unirrigated ..	0·58	—	—	—
		Irrigated : *Kharif* ..	1·75	1·03	0·88	0·75
		Rabi ..	0·92	1·00	0·73	0·79
	(*iv*) Wheat:	Unirrigated ..	1·24	1·24	1·24	1·23
		Irrigated	3·42	3·85	3·94	4·01
	(*v*) Groundnut:	Unirrigated ..	13·12	11·40	8·23	4·60
		Irrigated	—	0·99	2·74	5·69
	(*vi*) *Til*:	Unirrigated ..	10·68	13·21	15·02	17·13
	(*vii*) Pulses:	Unirrigated ..	—	—	—	—
	(*viii*) Green fodder:	Irrigated	0·09	0·06	0·04	0·04
	(*ix*) Vegetables:	Irrigated : *Kharif* ..	0·57	0·41	0·21	—
		Rabi ..	0	—	—	—
2.	Gross cropped area (lakh acres)		16·63	16·65	16·69	16·87
3.	Net sown area (lakh acres)		16·69	16·69	16·69	16·69
4.	Cropping intensity (per cent)		99·64	99·76	100·00	101·08

An increase in the income of the region in response to additional irrigated acreage can, in the absence of corresponding improvements in the land use intensity and labour input, arise from a change in the product-mix, *i.e.*, by substituting 'low valued' crops by 'high valued' crops. Bajra and jowar, the two inferior 'low valued' cereals tend to yield ground to cotton—a relatively 'high valued' crop (Table IV). Among the irrigated crops, cotton and groundnut, the two relatively 'high valued' commercial crops, jointly

corner almost all the additional irrigated acreage of the region, the two exceptions being the cereal crops of wheat and bajra—the two relatively 'high valued' cereal crops. The brunt of the additional land for irrigation appears to be borne by the unirrigated bajra, jowar and groundnut crops.

Among farm sizes, irrigation tends to strengthen the tendencies of crop specialisation. For instance, small and large farms tend to strengthen the production of their specialised crop, cotton. Medium farms, however, tend to substitute *til* for groundnut.

CONCLUSIONS

In an arid region, the injection of irrigation input, particularly when developed from low erratic precipitation base, fails to make any major dent into the use intensity of its land and labour resources. However, by crop-mix manipulations it helps to raise the income of the region, particularly of the farmers, more so, medium sized farmers. The net consequence of these crop-mix manipulations is that investment in irrigation in the region is a profitable proposition, except on large farms where the returns per acre per annum fail to meet the cost of irrigation supplies.

The failure of irrigation investment to expand employment opportunities in the region suggests that this investment cannot serve the interest of landless labourers and, hence, special policies need to be envisaged to protect their interests.

FORMULATION AND APPRAISAL OF AGRICULTURAL PROJECTS: A CASE STUDY

A. K. Sinha*

Soon after the formation of the State of Haryana in late 1966, an increasing awareness of the necessity and desirability of augmenting irrigation facilities for agriculture, especially in the chronically drought affected areas of the State, was visible in public policy. The result of the enhanced emphasis and the reassigned priorities was the formulation and implementation of three sizeable lift irrigation projects in the district of Bhiwani. It is proposed to study the formulation and implementation of these projects, to examine the problems of their appraisal and evaluation and to raise therefrom issues as are relevant to agricultural economists.

PROJECT FORMULATION

The three projects of Jui, Loharu and Sewani canal systems were formulated by the State Department of Irrigation and also implemented by it. The basic objectives were socio-economic: to prevent frequent occurrence of

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