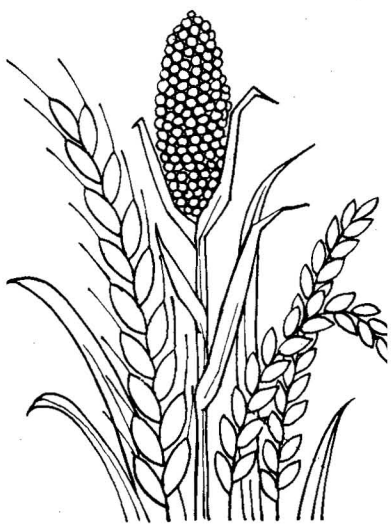
Vol XXXIX
No. 3

ISSN 0019-5014

CONFERENCE
NUMBER

JULY-
SEPTEMBER
1984

INDIAN JOURNAL OF AGRICULTURAL ECONOMICS



INDIAN SOCIETY OF
AGRICULTURAL ECONOMICS,
BOMBAY

AN ASSESSMENT OF THE ADVERSE EFFECTS OF CANAL IRRIGATION IN INDIA

P.K.Joshi and A.K.Agnihotri*

During the past few decades, intensive studies have been carried out highlighting the benefits of irrigation and its role in agricultural development. Recently, it has been observed that the economic gains from canal irrigation are not commensurate with the large public investments and subsidy given to the beneficiaries. Besides huge investment and scanty benefits, canal irrigation in various regions is seriously causing environmental imbalances leading to social disaster in the long run.

The major adverse effects of canal irrigation and its mis-management observed in many irrigation projects are the problems of soil salinity, waterlogging and canal seepage. These degradation processes have already converted a large fertile irrigated area into unproductive barren lands. The other problems that originated from canal irrigation are infestation of weeds; inception of water-borne diseases; growing income disparities, etc. These harmful environmental effects that resulted in canal irrigation at the micro level reflected the downward shift in the production function of an indvidual decision-maker and added to private costs. At the macro level, the emerging effects are unemployment, migration, diseases, regional disparities, decline in production, ecological imbalance, etc., which escalated the public investment and added to the social costs.

Until recently, little attention has been given to the diseconomies associated with canal irrigation. The present study is an attempt in this direction. The primary objective of the study is to examine the magnitude and socio-economic consequences of soil salinity and waterlogging due to canal irrigation. The secondary objective is to suggest appropriate strategies to overcome the problems of soil salinity and waterlogging.

For the purpose of the study, a few canal irrigation projects were selected, where the problems of salinity and waterlogging were found pervasive. Data on the extent of salinity and waterlogging were compiled from various secondary sources. Cropping pattern, yield and prices of important crops, infestation of weeds, diseases, etc., of all the selected irrigation projects were also collected from secondary sources.

MAGNITUDE OF WATERLOGGING AND SOIL SALINITY

Since the problems of waterlogging and soil salinity were identified and diagnosed in recent past, the exact magnitude of the problem due to canal

* Division of Agricultural Economics, Central Soil Salinity Research Institute , Karrnal (Haryana).

irrigation is yet to be quantified. However, a recent study carried out by the Administrative Staff College of India estimated that roughly ten million hectares of cultivated land are affected by waterlogging and another 25 million hectares by salinity problems, and they are no longer fit for cultivation.[1] These estimates revealed that 56 per cent of the land irrigated by all systems (ten million hectares more than the total land under canal irrigation) is in imminent danger of going out of cultivation.

In this study, the available information on waterlogging and soil salinity in a few irrigation projects is presented in Table I. The intention was to focus on the seriousness of the problem in areas where irrigation was made available through canal. The table reveals that the problems of salintiy and waterlogging have been developing at an alarming proportion in all the canal irrigation projects. However, the extent varied from one irrigation project to another due to several reasons, *viz.*, type of soil, nature and extent of salts in soil, water distribution system, cropping pattern, on-farm water management, drainage, etc. These factors, if managed unscientifically, further aggravate the problems of salinity and waterlogging.

TABLE I — EXTENT OF WATERLOGGING AND SOIL SALINITY IN SELECTED IRRIGATION PROJECTS IN INDIA

(thousand hectares)

Irrigation projects	State	Extent of Waterlogging	Extent of Soil salinity
Sriramsagar	Andhra Pradesh	60.00 (47.62)	1.00 0.79
Tungabhadra	Andhra Pradesh and Karnataka	4.65 (1.27)	24.48 (6.69)
Gandak	Bihar and Uttar Pradesh	211.01 (21.11)	400.00 (40.03)
Ukai-Kakrapar	Gujarat	16.25 (4.32)	8.29 (2.20)
Mahi-Kadana	Gujarat and Rajasthan	82.00* (16.81)	35.76 (7.33)
Malaprabha	Karnataka	1.05* (0.99)	– –
Chambal	Madhya Pradesh and Rajasthan	98.70 (20.31)	40.00 (8.23)
Tawa	Madhya Pradesh	– –	6.64 (3.79)
Rajasthan Canal	Rajasthan	43.10 (7.98)	29.11 (5.39)
Sarda Sahayak	Uttar Pradesh	303.00* (28.34)	50.00 (4.68)
Ramganga	Uttar Pradesh	195.00 (32.99)	352.42 (59.62)
	Total	1,014.76	947.70

Data have been compiled from: Report on the Status of Irrigation Development in India, Central Water Commission, New Delhi, 1981; Resource Analysis and Plan for Efficient Water Management: A Case Study of Mahi RBC Area (Gujarat), Water Technology Centre, Indian Agricultural Research Institute, New Delhi, 1983; B.D. Bithu, "Environmental Impact of Irrigation in Arid Area", in Seminar on Irrigation in Arid Lands, Central Board of Irrigation and Power, New Delhi, 1983; Problems of Water and Soil Management in Irrigation Commands, 9th Combined Workshop of Co-ordinated Projects for "Research on Water Management and Management of Salt — Affected Soils and Use of Saline Water in Agriculture", Indian Council of Agricultural Research, New Delhi, 1982; Reports of Irrigation Commission, Volumes II and III, Ministry of Irrigation, Government of India, New Delhi, 1972; P.S. Rao and A. Sundar, "Tungabhadra Projects", *WAMANA*, Vol. 4, No. 1, January 1984, pp. 1-19 and A.N. Chaturvedi, "Canal Irrigation: A Cause for Ecological Imbalance With Special Reference to Sarda Canal System", *WAMANA*, Vol. 3, No. 1, July 1983. p. 2.

Note:— * Figures included waterlogging and soil salinity.

Figures in parentheses are the percentages of the irrigation potential created in the respective command areas.

1. B. Bowonder and C. Ravi: Waterlogging from Irrigation Projects: An Environmental Management Problem, Centre for Energy and Technology, Administrative Staff College of India, Hyderabad, 1984.

The annual increase in soil salinity and waterlogging in selected irrigation projects was also estimated and shown in Table II. It reflected that every year, a large part of good and fertile land was rendered unproductive and barren in almost all the irrigation projects. The annual increase in soil salinity and waterlogging was as high as 50 thousand hectares and 27 thousand hectares respectively in Ramganga project area in Uttar Pradesh. It revealed that the problems are severe in nature and their repercussions would seriously affect the agricultural development.

TABLE II — ANNUAL INCREASE IN WATERLOGGING AND SOIL SALINITY IN SELECTED IRRIGATION PROJECTS

(*thousand hectares*)

Irrigation projects	Waterlogging	Soil salinity
Sriramsagar	10.00	0.17
Tungabhadra	0.17	1.91
Gandak	3.50	36.36
Ukai-Kakrapar	0.63	0.32
Mahi-Kadana	3.90*	1.70
Malaprabha	0.52*	–
Chambal	7.59	3.08
Tawa	–	1.11
Rajasthan Canal	3.92	2.65
Sarda Sahayak	5.72*	0.94
Ramganga	27.86	50.35

*Figures included waterlogging and soil salinity.

II

DISECONOMIES RELATED TO CANAL IRRIGATION

As stated earlier, the adverse consequences of canal irrigation are technical, biological, economic, social and environmental in nature. In this section, the adverse effects (diseconomies) are broadly discussed in a multi-dimensional framework as follows:

(i) Cost to Society

In the process of irrigation development, huge public investments were made in construction and design (CD), and operation and maintenance (OM).[2] Projectwise per hectare expenditure on CD and OM is presented in Table III. The per hectare expenditure on CD and OM varied from one irrigation project to another due to many factors. It ranged from Rs.2,200/ha. in Ramganga irrigation project to Rs.15,480/ha. in Sriramsagar irrigation project. The past evidences revealed that such investments on irrigation development caused hazards to the society with the development of harmful environmental effects related to canal irrigation.

2. Since Independence, the country has invested Rs.7,510 crores to create an irrigation potential of 16.9 million hectares upto1979 80through major and medium irrigation projects. Report on the Status of Irrigation Development in India, Central Water Commission, New Delhi, 1981, p. 4.

TABLE III – PROJECTWISE EXPENDITURE ON CANAL IRRIGATION DEVELOPMENT AND COSTS DUE TO WATERLOGGING AND SALINITY

Irrigation projects	Expenditure per hectare (thousand Rs.)	Waterlogging and salinity cost to society (million Rs.)
Sriramsagar	15.48	944.04
Tungabhadra	2.72	79.34
Gandak	2.95	1,804.00
Ukai-Kakrapar	3.87	95.05
Mahi-Kadana	4.02	473.80
Malaprabha	9.84	10.29
Chambal	2.62	362.70
Tawa	4.70	31.20
Rajasthan Canal	4.66	336.70
Sarda Sahayak	2.84	1,002.00
Ramganga	2.20	1,215.00

As mentioned earlier, the canal irrigation network in the command areas has generated the problems of soil salinity and waterlogging and rendered chunk of fertile areas out of cultivation. Consequently, the investment made on the development of canal irrigation in these areas became uneconomic to the society. Since the canal irrigation projects were introduced in different regions, a huge public outlay could not add to the social benefits but only incurred costs. The table reflected that such social costs resulting from the problems of soil salinity and waterlogging accounted for more than Rs.6,000 million in the eleven selected irrigation projects. The cost to society was observed to be as high as Rs.1,804 million in Gandak irrigation project. The latest Malaprabha irrigation project in a short span of four years has added roughly Rs.10.29 million to the social cost. Had this huge investment been utilized for taking precautionary measures, the situation would be totally different. Suitable measures therefore may be taken to overcome these environmental problems at the earliest.

(ii) Changes in Productivity

Productivity is the main criterion to judge the efficiency of irrigation water. In the past, several studies have shown that there is a positive relationship between irrigation and crop productivity. These studies were confined to the firm (micro) level only and ignored the externalities related to canal irrigation. In reality, it has been observed that canal seepage and mismanagement of irrigation water adversely affected both the irrigated and unirrigated areas by raising the water table and creating the problems of waterlogging and soil salinity. These factors adversely affected the crop growth and decreased the production per unit area.

To examine the impact of irrigation on rice productivity at the macro level in a few irrigation project areas, three periods were compared. These periods were: *(i)* three years' average yield of rice[3] before irrigation, *(ii)* the

3. Districtwise yield of rice for different periods was compiled from various issues of *Agricultural Situation in India*.

period immediately after irrigation and *(iii)* the existing yield (1978-81) and they are presented in Table IV. It can be seen from the table that except for Sriramsagar and Malaprabha irrigation projects, all the other irrigation projects displayed very poor performance. The existing rice yields in Chambal and Tawa irrigation projects were far below the pre-irrigation period yields, while the Gandak and Kosi projects showed stagnated rice yield during the latter two periods.

TABLE IV — AVERAGE YIELD OF RICE COVERED UNDER SELECTED IRRIGATION PROJECTS

(kg./ha.)

Irrigation projects	Year of first irrigation	Period		
		I	II	III
Sriramsagar	1974	1,280.0	1,758.0	2,116.0
Gandak	1969	567.0	883.0	810.0
Kosi	1961	598.0	791.0	796.0
Malaprabha	1978	1,094.0	1,197.0	1,279.0
Chambal	1967	408.0	467.0	333.0
Tawa	1974	912.0	879.0	671.0

Note: I = Yield before irrigation; II = Yield immediately after irrigation; and III = Present yield.

These facts revealed that the objective of canal irrigation to raise the per unit production was not realised. On the contrary, it adversely affected productivity. It is most likely that in the years to come the productivity may further decelerate with far-reaching consequences.

(iii) Loss in Production

It has been shown in the earlier section that average rice productivity in both the irrigated and unirrigated areas did not reflect any rising trend. The situation has been worse in canal irrigated areas, where problems of water-logging and salinity have cropped up. Consequently, the production has

TABLE V — PRODUCTION LOSSES OF RICE DUE TO WATERLOGGING AND SOIL SALINITY IN SELECTED IRRIGATION PROJECTS

Irrigation projects	Production loss	
	Quantity (thousand tons)	Value (million Rs.)
Sriramsagar	26.26	49.61
Tungabhadra	27.65	53.77
Gandak	296.75	532.61
Ukai-Kakrapar	13.07	26.69
Mahi-Kadana	60.97	149.77
Malaprabha	0.75	1.50
Chambal	41.53	97.35
Tawa	3.45	6.27
Rajasthan Canal	18.54	53.22
Sarda Sahayak	182.97	317.09
Ramganga	297.77	516.04
Total	969.71	1,803.91

started declining in these irrigated and problem affected areas. Expected production losses of rice in waterlogged and saline areas have been estimated and the estimates are presented in Table V.

A substantial rice production was lost due to the salinity and waterlogging problems in all the selected irrigation projects. It is estimated that rice production in the eleven selected irrigation projects declined by 9,69,710 tonnes during 1980-81, amounting roughly to Rs.1,803.91 million. The production in the coming years is expected to decline further due to an increase in the magnitude of the problem. The production of other crops would have also declined considerably in these affected areas. The ultimate result would, therefore, be changes in the cropping pattern, and possibly decrease in the profit.

(iv) Problem of Aquatic Weeds

Aquatic weeds are posing a serious threat to most of the canal irrigation projects throughout the country. Their magnitudes, however, vary from one project to another due to several factors, *viz.,* technological, climatic conditions, socio-economic use of project water, etc. Recently, the National Committee on Environmental Planning and Co-ordination conducted a survey to assess the magnitude of weed problems in different parts of the country arising from canal irrigation and its results are compiled in Table VI. The survey reported that water hyacinth, cattails, water lettuce and water fern appeared to be most threatening weeds, especially in the States of West Bengal, Bihar, Orissa and Assam.[4] These weeds have infested roughly 40 per cent of the total cultivable area (8,00,000 hectares) of these States. Among these weeds, water hyacinth was most severe, covering an area of about 150 thousand hectares in West Bengal and 50 thousand hectares elsewhere in the country. Similarly, *salvinia sp.* has already spread in 60 per cent of the total water surface of the Kakki reservoir in Kerala within a short period of four years.

TABLE VI — ABNOXIOUS AQUATIC WEEDS AND THEIR INFESTATION STATUS IN INDIA

Common name	Botanical name	Percentage showing		
		Increased infestation	Decreased infestation	Constant infestation
Water hyacinth	*Eichhornia Carssipes*	66.27	7.41	25.92
Water lily	*Nyphaes Stellata*	29.63	11.17	59.26
Florida elodea	*Hydrilla Verticillata*	37.84	13.51	48.65
Cattails	*Typha sp.*	63.64	2.27	34.09
Duck weeds	*Lemnoids sp.*	57.14	4.76	38.10
Tape grass	*Vellisneria sp.*	38.09	19.05	42.86
Water lettuce	*Pistia stratictes*	60.61	6.06	33.33
Water fern	*Salvinia sp.*	62.50	6.25	31.25

Source: Biswas, *op.cit.,*

4. D.K. Biswas, "Integrated Measures for Control and Utilization of Aquatic Weeds", *Bhagirath,* Vol. 25, No. 3, 1978, pp. 138-142.

The infestation of aquatic weeds in the reservoir or canal surface adversely affects the efficiency of canal irrigation. It has been estimated that the water saved from the evapo-transpiration loss caused by aquatic weeds may irrigate roughly 117 thousand hectares of wheat and 47 thousand hectares of paddy in Gandak command area itself. Besides affecting the crop growth, the aquatic weeds pose a threat to irrigation and drainage systems, fisheries, navigation, etc. Further, these weeds also create a favourable environment for the growth of pests and vectors of several epiderminological diseases.

(v) Infestation of Water-borne Diseases

Infestation of diseases is another adverse impact of canal irrigation witnessed in rural India since the planning era of the country. The major water-borne diseases observed to be very severe in the rural areas are dysentery, cholera, malaria and filariasis. The annual trends of these diseases in different States of India are shown in Table VII. It reflected that despite a huge investment on various disease eradication and health improvement programmes[5] in the rural areas, these water-borne diseases in different regions of India increased over the years unabated. However, there may be several reasons for infestation of these diseases. But unhygienic conditions and stagnation of water create a congenial environment for the growth of the dreaded pathogens of water-borne diseases. There are evidences from the Raichur district of Karnataka that after the construction of Tungabhadra dam and canal network, malaria became highly endemic.[6] In this direction, necessary measures are needed to check the extent of the water-borne diseases.

TABLE VII — COMPOUND GROWTH RATES OF WATER-BORNE DISEASES IN SELECTED STATES OF INDIA

State	Cholera	Dysentery	Malaria	Filariasis
Andhra Pradesh	–15.63	5.13	–2.96	12.75
Karnataka	4.08	12.75	–5.82	–2.96
Madhya Pradesh	11.63	2.02	7.25	–1.98
Orissa	–2.96	23.37	13.88	11.63
Rajasthan	1.01	4.27	17.35	1.01
Uttar Pradesh	3.05	6.18	–23.66	9.42

Note: — The growth estimates were based upon the data compiled from various issues of Statistical Abstract of India, Central Statistical Organisation, Department of Statistics, Ministry of Planning, Government of India, New Delhi

III

STRATEGIES FOR WATERLOGGING AND SALINITY CONTROL

The issue invariably raised is whether the problems of waterlogging and soil salinity are avoidable. Recent investigations in India and abroad have shown that such problems can be checked at the initial stage of the irrigation projects. Moreover, the areas which have been affected by salinity and waterlogging because of canal irrigation could also be reclaimed for agricultural

5. The health expenditure increased at an annual rate of 10.46 per cent. Sixth Five Year Plan 1980-85, Planning Commission, Government of India, New Delhi, 1981, p. 385.

6. D. Rai, "Environmental Impact from Development Activity", *Bhagirath*, Vol. 30, No. 3, 1983, pp. 115-122.

purposes. This section briefly discusses the possible strategies to control salinity and waterlogging arising from canal irrigation.

(i) Drainage

To overcome the problems of waterlogging and soil salinity, drainage has been recommended as the most effective measure. In waterlogged areas, drainage removes excess water and creates favourable conditions for crop cultivation. Similarly, drainage followed by leaching with good quality water removes excess salts from the root zone.[7] At present drainage in the major irrigation projects in India is not receiving the due priority, resulting in a considerable loss to the society. It is therefore necessary that in all the canal irrigation projects, suitable drainage system should be provided in the initial stage. In the case of existing irrigation projects where waterlogging and salinity have already appeared, an appropriate type of drainage should be constructed at the earliest to check their further expansion. It is, therefore, necessary that while planning new canal irrigation projects, drainage should be made a pre-requisite not only to avoid huge social costs due to waterlogging and salinity but to realise the objective of increasing the efficiency of irrigation water both in the short and the long run.

(ii) Canal Lining

The basic aim of lining of watercourses is the conservation of water by reducing seepage losses in the vast network of field channels in use for the on-farm application of water. By lining the watercourses of about 15.2 thousand km. in length in Punjab, it is estimated that roughly 20 per cent of water is saved.[8] Similarly, lining of Karnal minor and Gudha distributary in Haryana saved considerable seepage losses.[9] Hence, canal lining is a preventive measure to avoid the waterlogging conditions along the canal. Besides reducing canal seepage and avoiding waterlogging conditions, lining of watercourses increases the intensity of irrigation, extends irrigation to new areas, increases crop yields, minimizes inequalities in the distribution of water among farmers, etc. It is, therefore, necessary that lining of watercourses should occupy a prominent place while formulating any canal irrigation project. However, the initial cost of lining is considerably high but the social gains will more than offset the costs.

(iii) On-farm Water Management

Under the existing water distribution system in India, the on-farm water management remained neglected, resulting in the problems of waterlogging and soil salinity. This adverse state of affairs could be checked with proper planning and scheduling of irrigation. Drip irrigation is recommended to increase

7. O.P. Singh, "Studies on Hydrological Aspects of Saline Soil Reclamation in Gohana Region of Haryana", Central Soil Salinity Research Institute, Annual Reports 1979 to 1982, Karnal.

8. H.S. Ahluwalia, "Utility and the Gains of the Lining of Watercourses of the Canal System in Arid Areas of the State of Punjab," in Seminar on Irrigation in Arid Lands, Central Board of Irrigation and Power, New Delhi, 24-25 November, 1983, pp. 67-76.

9. D.K. Gupta, "Impact of Lining of Watercourses on Agricultural Output — A Case Study", *WAMANA*, Vol. 2, No. 4, October 1982, pp. 1 and 8-16.

the water efficiency in highly saline areas.[10] Similarly, use of sprinkler irrigation is stated to be best in moderately saline areas.[11] Besides appropriate on-farm water management, suitable cultural practices, *e.g.,* proper selection of salt tolerant crops, varieties and crop sequences, application of slow releasing and granulated fertilizers[12] are essential to increase the crop yields in saline areas.

The on-farm development, including water management, requires substantial skill which depends upon the technical knowledge of the farmer and extension workers involved in irrigation. It is, therefore, necessary that before introducing canal irrigation in any region, the extension workers and farmers are given in-depth training in the utilization of irrigation water to attain the objective of increasing agricultural productivity and income.

10. M.C. Agarwal, "Comparative Performance, Feasibility and Economics of Different Irrigation Methods," in Seminar on Water Management at the Central Soil Salinity Research Institute, Karnal, February 13-15, 1984, pp. 23-24.

11. E. Bresler, "Trickle-Drip Irrigation: Principles and Application to Soil-Water Management," in N.C. Brady (Ed.): Advances in Agronomy, Vol. 29, Academic Press, New York, 1977, pp. 344-391.

12. R.P. Dhir, "Future Technological Needs of the Rajasthan Canal Command Area with particular reference to Stage II", in Seminar on Irrigation in Arid Lands, Central Board of Power and Irrigation, New Delhi, 24-25 November, 1983, pp. 47-60.