

## CANAL IRRIGATION AND LAND DEGRADATION IN HARYANA

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**ABSTRACT :** The recent past has witnessed a growing concern among researchers, planners and policy makers regarding the adverse effects of excessive irrigation on the quality of land. It has been suggested that over irrigation in the absence of a proper drainage outlet, leads to land degradation through waterlogging and salinization. In the initial stages, there is a decline in land productivity, and if no measures are taken, the land ultimately becomes unfit and goes out of cultivation. Evidences indicate that though water logging and salinization appear as problems in almost all irrigation projects, they are found to be of a more serious nature in parts of Haryana due to its typical geohydrological characteristics. The present paper examines the extent and nature of land degradation in Haryana in the wake of rapid expansion of irrigation, mainly by canals, and suggests some remedial measures.

### INTRODUCTION

Indian agriculture has undergone significant transformation during the last few decades particularly after the onset of green revolution in the mid sixties. Irrigation has been an important input of the new technology. The other inputs are high yielding variety of seeds and chemical fertilizers. That is why, the technology is sometimes termed as seed-water-fertilizer technology. However, the recent past has witnessed a growing concern among researchers and planners regarding the adverse effects of the new technology on ecosystem. Irrigation is one such case which is viewed as a major cause of land degradation through water logging and salinity. In the absence of proper drainage outlet coupled with poor water management, excessive irrigation results in the rise of ground water table leading to water logging and salinity. In the water logged areas excessive moisture in the soil inhibits the growth of plants. Further, ground water starts rising, reaching the aeration zone, from where

it moves upwards in the soil by capillary action and is lost through evaporation from the land surface resulting in increasing accumulation of salts in the soil profile. As the process results from human activities, mainly irrigation, it is sometimes termed as secondary salinization (Szaboles, 1986 : 197). Salinity can also occur independent of water logging in part accentuated by overuse of chemical fertilizers and pesticides (Chopra, 1989 : 45). In the initial stages productivity levels of the affected lands decline sharply. In the absence of any corrective measures the land ultimately turns into waste land and goes out of cultivation. The resultant effects are loss of natural resources, ecological imbalances, unemployment, regional disparity, migration, etc. (Joshi, 1987 : 416).

Evidences reveal that though water logging and salinity appear as problems in all irrigation projects, the problem of land degradation is found to be of a more serious nature in parts of Haryana due to its typical geohydrological

conditions. Rising water table and consequent water logging have adversely affected large tract of agricultural lands in the canal irrigated areas of the state. This spells trouble for agriculture based economy of the state where crop productivity is already showing signs of stagnation (Hindustan Times, April 8, 1999). In the light of this, the present paper aims at examining the extent and nature of water logging and salinization in the state in the wake of rapid expansion of canal irrigation. The study also proposes some remedial measures to arrest the growing menace of waterlogging and salinization.

### DATA BASE

The study is based on secondary sources of data. While data relating to various aspects of irrigation in the state during the post green revolution period have been obtained from the Statistical Abstract of Haryana, 1995-96, statistics on quality and depth of underground water, magnitude and extent of salt affected area etc. were collected from 'Towards Improve Water Management in Haryana State', an Indo-Dutch Operational Research Project on Hydrological Studies (1996), funded jointly by the Ministry of Foreign Affairs of the Netherlands and the Indian Council of Agricultural Research (ICAR), and Activities and Development of Ground Water in Haryana', Ground Water Cell, Haryana Agriculture Department (1998).

### THE STUDY AREA

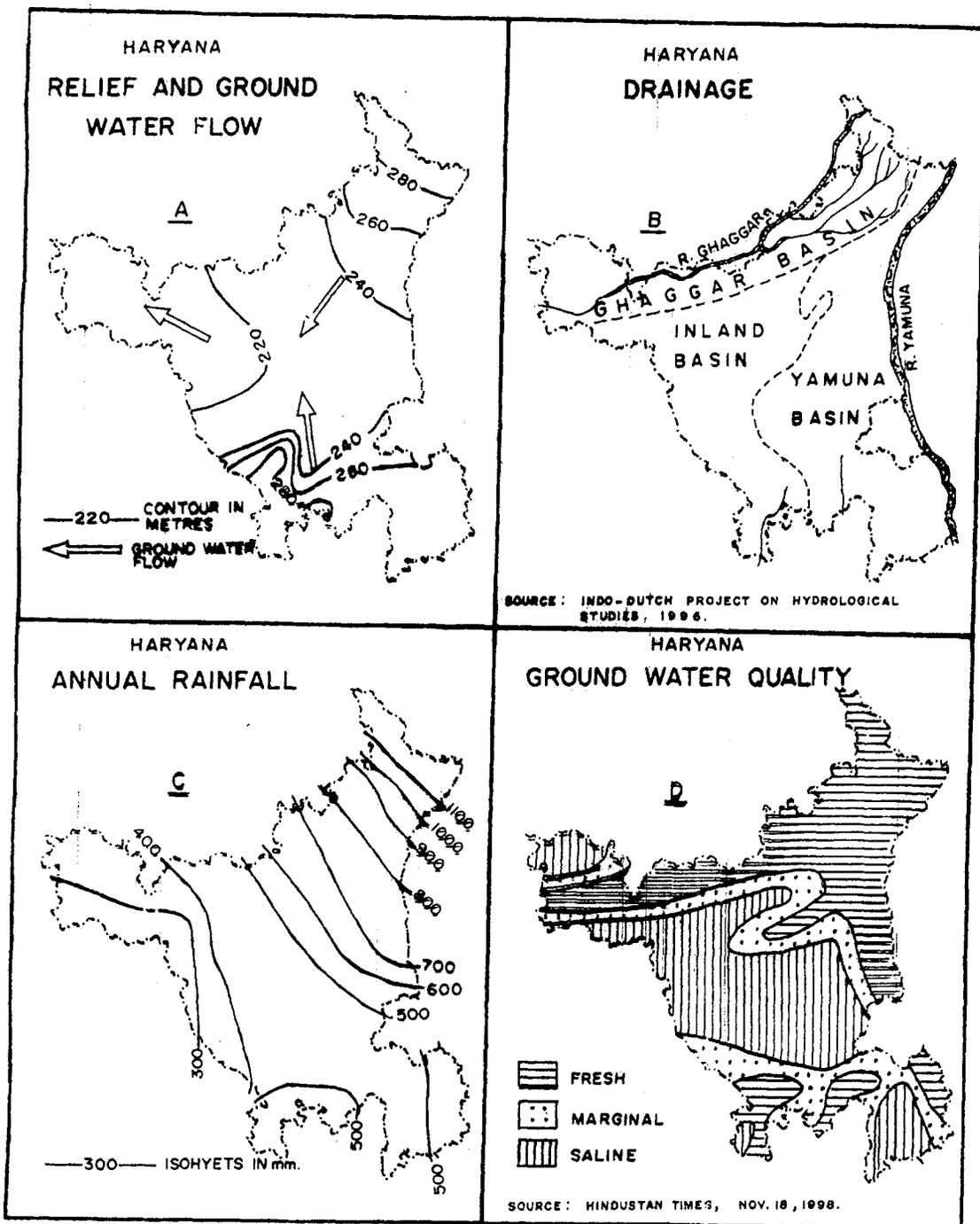
Haryana came into existence after the reorganisation of the erstwhile united Punjab in the year 1966. The state with a geographical area of nearly 44 lakh sq. km, i.e. 1.48 per cent of the Indian union, accommodates nearly 2 per cent of its population as per 1991 census [1]. Average density of population in the state is 372 persons to a sq. km as against the national

average of 273 persons sq. km. Of the total population, nearly three fourths still reside in the rural areas. With a little less than 60 per cent of the male workforce engaged in agriculture, the economy of the state overwhelmingly depends upon agricultural sector. Agriculture and its allied activities contribute more than 40 per cent of the NSDP, a share that is much higher than the nation's average (CMIE, 1994).

### Physical setting

**Physiography :** The northern part of the state is bounded by the Shiwaliks which provide slope towards south and south-west. Likewise the Aravalli outliers in the south and south-east provide slope towards the north. These topographical differences in the north and south result in the formation of a saucer type depression in the central part of the state. Both surface and ground water flow towards this depression (see Map 1 A). It is only in eastern Gurgaon that the land in general has a southerly and south-easterly slope. The western part is sandy characterised by shifting sand hills interrupted by places of firmer and, in parts loamy soils.

**Drainage :** The Yamuna originating in the snowy regions of the Himalayas and flowing along the eastern border, is the only perennial river in the state. The Ghaggar also rises on the slopes of Himalayas but is perennial only in its upper course. The river contains more water in the rainy season. It flows in south-western direction alternately passing through Haryana and Punjab. The Ghaggar enters into Rajasthan before ultimately disappearing in Hanumangarh area of Bikaner in Rajasthan. A number of small streams drain the watershed of these two rivers on either side. Among the westward flowing streams are Tangri, Markanda, and Saraswati which join the Ghaggar on its left bank after passing through



MAP. 1

Fig. 1:

kurukshetra district. Likewise, in the south several short streams marked with fluctuating regime, originate in the Aravallis and flow towards the north. They are the Dohan, the Kasanti, the Sahibi and the Indori. The state can be divided into three river basins - the Yamuna basin, the Ghaggar basin and the inland basin (see Map 1 B).

**Climate :** The state is characterised by arid and semi arid type of climatic conditions. The year can be divided into four distinct seasons - a dry and hot summer from March to June, a hot rainy season from July to September, a post monsoon warm season from October to November and a cold season from December to February.

The state is normally deficient in rainfall over its greater part. It is located in the transition zone between the deserts of Rajasthan and the moderately humid upper Ganga plain. On an average, the state receives a rainfall of 545 mm annually. The amount of rainfall declines from north-east to south-west (see Map 1 C). Rainfall conditions are dominated by monsoon and nearly 80-85% of the annual rainfall occurs during the monsoon season. The remaining comes in the winter season due to western disturbances. As elsewhere in India, the rain is very erratic both temporally and spatially. Short rainy season followed by a long dry season is a typical climatic feature of Haryana. A long dry spell, spread over a couple of weeks, is not uncommon even in the rainy season.

The state can be broadly divided into two agro-climatic zones - the western zone and the eastern zone (Indo-Dutch operational Reasearch project on Hydrological Studies, 1996 : 23). The western zone spread over an area of 2.26 m hectares, covering the districts of Sirsa, Hisar, Bhiwani, Mahendragarh and parts of Rohtak and Gurgaon, represents the arid zone. The remaining parts of the state covering an area of 2.14 m hectares fall under

the eastern zone which represents the semi-arid zone.

**Water resources :** In terms of water resources - rainfall, surface runoff and ground water quality - the state is placed in a very disadvantageous position. As noted above rainfall is normally deficient and restricted in seasons, and its distribution over space is highly irregular. Further, the flow in the Yamuna, the only perennial river in the state, is very aberrant from year to year, season to season and month to month, and therefore, the mean discharge in the canals is highly variable (Singh, 1976 : 121). Similarly, though the state has vast resources of ground water, more than two thirds of the state has brackish ground water (see Map 1D).

The entire inland basin is underlain by marginal to saline water. Table 1 presents districtwise percentage share of geographical area with respect to quality of ground water.

**Table 1**  
**Ground water quality in Haryana.**

Districts	% geographical area under		
	Good	Marginal	Poor
Ambala	100	-	-
Yamunanagar	100	-	-
Kurukshetra	96	-	-
Kaithal	56	-	4
Kaithal	56	8	36
Karnal	60	5	35
Panipat	50	6	44
Sonipat	32	11	57
Rohtak	5	15	80
Faridabad	35	10	55
Gurgaon	24	13	63
Rewari	14	12	74
Mahendragarh	24	8	68
Bhiwani	10	15	75
Jind	14	7	79
Hisar	20	10	70
Sirsa	23	12	65

Source : M. C. Agarwal, 1997.

The worst affected districts are Rohtak, Bhiwani, Jind and Hisar, lying mostly in the inland basin. In more than 70 per cent of the geographical area of the basin ground water is of poor quality. In the saline water zone, ground water can not be used for irrigating the land.

## DISCUSSION

Soon after the state came into existence in 1966, the government gave top priority to improving the agricultural production. The period also coincided with the onset of green revolution in the country. From largely a food deficit area, Haryana has now become agriculturally one of the most developed states of India. This was possible mainly due to rise in the productivity levels. Thus, at present merely on 2.5 per cent of the total cropped area in the country, the state produces 5.6 per cent of India's food (CMIE, 1998). Expansion of irrigation has been an important input of the tremendous growth in agricultural output.

**Table 2**

### Net Irrigated Area - Haryana. (in thousand hectares)

Year	Area	% to NSA
1966-67	1293	37.8
1970-71	1532	43.0
1975-76	1754	48.4
1980-81	2134	59.2
1985-86	2248	62.2
1990-91	2600	72.7
1994-95	2719	76.4

*Source* : Statistical Abstract of Haryana, 1995-96.

Table 2 presents growth in net irrigated area in the state since its inception. In the year 1966-67, irrigation facilities were available to only 1.29 m. hectares which accounted for less than 38 per cent of the net sown area. The government, therefore, accorded the highest

priority to expand irrigation. Efforts were made to extend irrigation facilities to the chronically drought affected areas. Several major and medium irrigation schemes were initiated. In addition, the programmes of lift irrigation system were expedited to take water to the arid and semi arid uplands in the south and the southwest. At the same time steps were taken to modernize the old irrigation systems. Impetus was also given to the utilization of ground water through tubewells. The net irrigated area, thus, recorded an appreciable increase from 1.29 m ha in 1966-67 to 2.72 m ha in 1994-95. This accounts for more than 75% of the net area sown in the state. Thus, in a short span of nearly three decades, the state has made commendable progress in irrigation sector. In some of the districts like kurukshetra, kaithal, Panipat and Sonipat, almost cent percent NSA is under irrigation (Table 3).

**Table 3**

### Districtwise net irrigated area as percentage to NSA (1994-95)

Districts	% net irrigated area
1. Ambala	65.5
2. Yamunanagar	81.5
3. Kurukshetra	100.0
4. Kaithal	99.0
5. Karnal	97.4
6. Panipat	98.9
7. Sonipat	96.5
8. Rohtak	69.8
9. Faridabad	65.0
10. Gurgaon	28.3
11. Rewari	79.5
12. Mahendragarh	67.3
13. Bhiwani	56.1
14. Jind	88.6
15. Hisar	75.2
16. Sirsa	82.1

*Source* : As in Table 2.

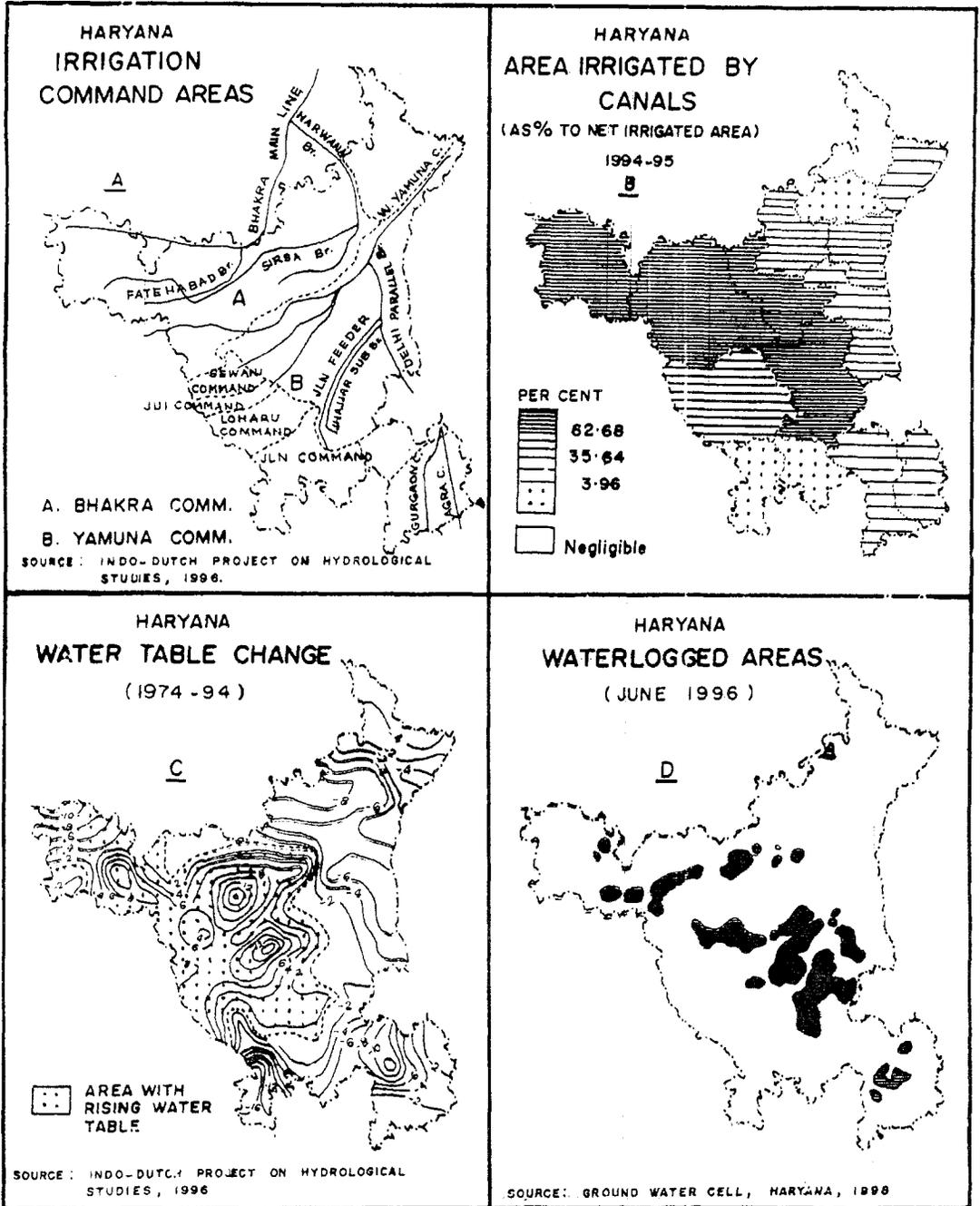


Fig. 2

### Canal irrigation

As far as canal irrigation is concerned the state receives water from two distinct sources - from the Bhakhra canal system and from western Yamuna canal system (see Map 2A). These two taken together supply water by gravity to about 88 per cent of the canal irrigated area. In the remaining area higher elevations, due to sand dunes and Aravallis, do not permit gravity irrigation. In these areas lift irrigation schemes have been developed. The schemes are Siwani, Jui, Loharu, Indira Gandhi and Jawaharlal Nehru lift irrigation schemes.

Table 4 presents growth in length of operative canals in Haryana. The state has recorded tremendous growth in the length of operative canals since the onset of green revolution in the country. The rates of growth in the length of main canals and distributories during 1966-67 and 1994-95 have been of the order of 70 per cent and 50 per cent respectively. The area irrigated by canals has recorded a growth of over 50 per cent during the period.

**Table 4**

#### Length of operative canals (in miles) and irrigated area (in thousand ha).

Year	Main canals	Distributories	Area irrigated
1966-67	910	4708	1311
1970-71	988	4769	1437
1975-76	1236	5569	1694
1980-81	1452	6124	1818
1985-86	1490	6377	1945
1990-91	1494	6570	1981
1994-95	1545	7045	1988

Source : As in Table 2

Nevertheless, as could be seen in Table 5, there has been a secular decline in the share of canals in the net irrigated area in the state. Canal irrigation accounted for more than three

**Table 5**

#### Percentage net irrigated area by canals in Haryana.

Years	% area
1966-67	76.64
1970-71	62.14
1975-76	59.06
1980-81	54.40
1985-86	52.98
1990-91	51.42
1994-95	50.82

Source : As in Table 2.

fourths of the net irrigated area when the state came into existence. However, this share has gradually declined to a little over 50 per cent by the year 1994-95. The decline has occurred mainly due to a more rapid expansion in area

**Table 6**

#### Districtwise percentage net irrigated area by government canals (1994-95).

Districts	% irrigated area
1. Ambala	N
2. Yamunanagar	3.96
3. Kurukshetra	2.72
4. Kaithal	58.46
5. Karnal	35.64
6. Panipat	27.96
7. Sonipat	61.44
8. Rohtak	68.57
9. Faridabad	32.27
10. Gurgaon	24.53
11. Rewari	3.96
12. Mahendragarh	3.81
13. Bhiwani	55.78
14. Jind	62.68
15. Hisar	85.33
16. Sirsa	76.90

N = negligible

Source : As in Table 2.

irrigated by tube wells. Since 1966 the number of deep tubewells in the state increased five fold to 3100 and private shallow tubewells increased 20 fold to touch the number of 550,000 in 1995 (Indo-Dutch Operational Project on Hydrological Studies, 1996 : 28). Notwithstanding a secular decline, it is important to note that canal irrigation occupies an important position in the central inland basin comprising the districts of Hisar, Sirsa, Rohtak, Jind and Sonipat (Table 6). On the whole canal irrigation is the mainstay of agriculture in the arid and semi arid parts of the state (see Map 2B).

### Land Degradation

Rapid expansion of irrigation mainly by canals in the state has resulted in serious amount of ecological destruction through water-logging and accumulation of salts in the soil profile. The problem is even more acute in the central inland basin due to poor water management. The problems of waterlogging and salinity in the state have been augmented by the topographic depression in the central part to which ground water flow from the rest of the areas. The ground water quality in this area is poor and unfit for irrigation. A continuous recharge to the ground water from the canals has resulted in sharp rise in the water table. Lack of proper drainage outlet further aggravates the crisis. Thus, while there is a rise in water table in this part, the peripheral areas mainly in north, east and south are experiencing increase in the depth of water table (see Map 2C) due to excessive use of ground water for irrigation purpose. In the inland basin with a continuous rise in water table, a considerable part of fertile land is turning into wasteland. The problem of waterlogging was further aggravated in the mid nineties due to floods which seriously affected the low lying areas

of Rohtak, Jind, Hisar, Bhiwani and parts of Sonipat and Jhajjar districts.

On the whole in more than one tenth of the total geographical area the depth of water table in pre-monsoon period (June) in 1996 was less than 3 meters from the surface (Ground Water Cell, Haryana Agriculture Department, 1998). It is remarkable to note that in Rohtak district nearly half of the total area is marked with water table with a depth of less than 3 meters. This is followed by Sonipat where nearly one-third of the total area is already in this category (Table 7).

**Table 7**

**Districtwise percentage area with water table depth of 3 meters or less - June, 1996.**

Districts	% area
1. Ambala	3.64
2. Yamunanagar	4.53
3. Kurukshetra	—
4. Kaithal	5.81
5. Karnal	—
6. Panipat	0.49
7. Sonipat	32.51
8. Rohtak	48.24
9. Faridabad	5.01
10. Gurgaon	8.37
11. Rewari	0.17
12. Mahendragarh	—
13. Bhiwani	2.39
14. Jind	19.06
15. Hisar	12.76
16. Sirsa	3.42

*Source* : Ground Water Cell, Haryana Agriculture Department, Chandigarh, 1998.

The spatial distribution of waterlogged areas is shown in Map 2D. It may be noted that above normal rainfall during the last few years has led to further rise in the ground water table. In Rohtak district alone as per agriculture department records, about 2000 hectares of

land has been out of cultivation due to rise in water table beyond critical level (Hindustan Times, Feb 28, 1999). Some of the prominently affected villages in the districts are Madina, Bahu Akbar Pur, Nidana, Girawar, Mokhra, Bhsava, Kanhi, Bohar, Rithal, Bhalaut, Kalanaur, Behrana and Balad.

That there exists a positive association between canal irrigation and the incidence of waterlogging in the state is revealed in a positive and significant correlation coefficient ( $r$ ) between the two. The value of ' $r$ ' in this case is 0.5331 which is significant at 5 per cent level of significance. When regression line, taking canal irrigation as independent variable and proportion of waterlogged area as dependent variable, is attempted, the values of regression coefficient and coefficient of determination work out to be 0.2445 and 0.2842 respectively. The ' $F$ ' is significant at 5 per cent level of significance. Though, the regression coefficient is not significant, a positive association between the two and some amount of causality are evident from the equation [2]. Thus, one unit of change in the independent variable causes an increase of 0.2845 in the dependent variable.

The incidence of rising water table often leads to the problem of accumulation of soluble salts in the soil profile. Soils become saline as a result of concentration of salts due to evaporation of ground water moving upwards. As already noted earlier, salinity can also result independent of waterlogging in part accentuated by excessive use of chemical fertilizers.

There are various estimates relating to the magnitude of area affected by salinity in Haryana. According to one estimate as much as 450 thousand ha was suffering from salinity alkalinity and waterlogging (Singh, 1984). Basing their estimates on the interpretation of

LANDSAT imageries, Sharma and Bhargava (1993) suggested that nearly 164 thousand ha of land in the state is suffering from salinity (Sharma et al, 1997 : 357). According to another estimate about 190,000 ha of land area in the state is presently affected by the problems of salinity (Indo-Dutch Operational Research Project On Hydrological Studies, (1996 : 31). This constitutes nearly 4.3 per cent of the total area of the state. Of this 65,000 ha, accounting for more than one third of the total, is very severely affected by salinity. On such lands crop production is virtually impossible. In addition to this, another 3.30 lakh ha of land in the state is suffering from sodicity or alkalinity, two third of which are seriously affected. The problem of sodicity is mainly concentrated in areas with mean annual rainfall varying between 550 mm and 1000 mm. The districts of Karnal, Kurukshetra, Ambala, Gurgaon, Faridabad, Jind and Sonipat are badly affected by sodicity.

**Table 8**

**Districtwise estimates on salt affected areas in Haryana (in thousand hectares)**

Districts	Area
1. Ambala	9.23
2. Kurukshetra	29.03
3. Karnal	44.64
4. Sonipat	27.26
5. Rohtak	10.80
6. Faridabad	7.20
7. Gurgaon	10.70
8. Mahendergarh	6.70
9. Bhiwani	1.20
10. Jind	14.60
11. Hisar	8.50
12. Sirsa	-
<b>State average</b>	<b>163.77</b>

Source : Sharma, R. C. and Bhargava, G. P., 1993. (Borrowed from Sharma et al, 1997, pp. 357-58.)

Districtwise estimates on area affected by salinity based on Sharma and Bhargava is presented in Table 8. As could be seen, more severely affected districts are Karnal, Kurukshetra, Jind, Hisar, Sonipat and Rohtak.

### Remedial Measures

Due to the problems of waterlogging and salinity, considerable amount of agricultural land in the state is turning waste. The remedial measures will therefore have to aim at both reclamation of already affected area and prevention of further rise in the water table. The strategies can, therefore, be grouped under two headings - curative and preventive.

Among the curative measures horizontal tile drainage system [3] has been found to be very effective in controlling the water table and in reclamation of waterlogged and salt affected area. Under this system, drains could be laid at a given spacing at a depth of 2 meters from the surface. In an experiment conducted at HAU, Hisar, under the Indo-Dutch Operational Research Project on Hydrological Studies, it was discovered that within 3-4 years of installation of the drainage system the soil salinity in the root zone could be reduced to a tolerable limit. It also showed that the water table could be lowered within one week to 1 m below soil surface after heavy rainfall of about 200 mm occurring in 1-2 days. In addition to this horizontal drainage of surplus water, vertical drainage can also be applied to control rising water table. However, this technique has not proved very cost effective due to several factors.

Poor quality drainage effluent can be either pumped into canals or storage reservoirs. In the canals it can be mixed with fresh water keeping the salinity under tolerable limit and can be used for irrigation purposes. Similarly

water from storage reservoirs can be used for supplementing irrigation, fish culture and salt harvesting.

Among other curative measures are controlling water supply in the canals in the inland basin districts like Sirsa, Hisar, Rohtak and Jind during specific period in the year and encouraging conjunctive use of saline ground water with fresh canal water. Saline ground water can also be used alternately depending upon soil types and other geo-hydrological conditions.

Along with the curative measures discussed above, certain strategies should be adopted to prevent the problems of waterlogging and salinity. The important ones are listed below:

- i) Propagating efficient on-farm water management practices including modern methods of irrigation e.g. sprinkler, drip, furrows etc. The users should be given proper training for an efficient on-farm management of water and use of the modern methods of irrigation.
- ii) For an effective and efficient management of water resources users' association or societies should be formed.
- iii) Water pricing strategy should be changed so as to minimize water wastage through reduction in percolation losses.
- iv) Effort should be taken for the lining of remaining unlined canals and water courses in order to reduce the seepage losses in brackish ground water zone.
- v) And finally, constructing balancing / storage reservoir at appropriate sites in canal command areas for storage of surplus canal and flood water for its subsequent use.

## NOTES :

1. Excluding the states of Assam and Jamu & Kashmir.
2. The resultant regression equation is :  $Y = - 0.08 + 0.2445 X$   
where X is the share of canals in the net irrigated area, and Y is the share of waterlogged area in the total geographic area.  
And,  $R^2 = 0.2845$ , and 'F' = 5.96
3. A horizontal drainage system consists of a network of pipes installed horizontally below the ground surface for interception and discharge of excess water from soil.

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