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CONCENTRATION OF CANAL IRRIGATION IN HARYANA: A SPATIAL ANALYSIS

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Abstract

Canals are most important source of irrigation in plains where perennial rivers provide water to the canals throughout the year. Haryana is located in northern part of India and it has a semi-arid type of climate. The state has a canal network of 5016 kilometres and about one fourth area of the cultivable land is irrigated by canals. This study, therefore attempts to examine the canal irrigated area under different canal systems and regional variations in the concentration of canal irrigation in Haryana. The study is based on tehsil level data collected from District Statistical Abstracts of Haryana (2010-13). In the triennium of 1966-69, canals were the main source of irrigation in the state and accounted for 76.7 per cent of the net irrigated area but in 2010-13 triennium the area under canal irrigation declined to 41.7 per cent because of the expansion of tube-well irrigation. The tehsil-wise concentration of canal irrigation has been captured by using location quotient index. The study highlights notable regional variations in the concentration of canal irrigation ranging from 0.01 to 2.38 in Gurgaon and Bawani Khara tehsils, respectively during 2010-13.

Introduction

Irrigation is the most important factor in the development of agriculture. Water flowing in the rivers, is being used to meet the needs of human life and for cultivation of crops since the advent of human civilization. As the pressure of population increased and standard of living of human beings improved, necessity of water resources for agriculture has been felt to increase the agricultural production (Thakur and Tiwari, 1998; Sohal, 2008; Pawar and Bhise, 2011).

Canals can be an effective source of irrigation in areas of perennial rivers and gentle slope. Un-irrigated wastelands can be developed through canals and dependence on

rainfall can be minimized. Canal irrigation is helpful for the achievement of stabilized diversified commercial farming and high agricultural production efficiency. Canals are also useful for generation of hydro-electricity, navigation, drinking water supply and fisheries. Thus, investment in canal irrigation development has enhanced the productive capacity of land resources.

Haryana with 1.2 million hectare of area under canal irrigation ranks sixth among the states of India after Uttar Pradesh (2.6 million hectare), Rajasthan (1.9 million hectare), Madhya Pradesh (1.6 million hectare), Andhra Pradesh (1.4 million hectare) and Karnataka (1.3 million hectare) in 2012-13. Canals are

second important source of irrigation after tube-wells in the state, accounting nearly 41.7 per cent of the net irrigated area. In order to meet the staggering demand of water for agriculture, it is essential to utilize and harness the available surface water through canals before attempting to lift the ground-water. In the present paper, therefore, an attempt has been made to study the canal irrigated area under different canal systems and concentration of canal irrigation in Haryana.

Study Area

Haryana is located between 27° 39' 25" to 30° 55' 51" north latitudes and 74° 27' 80" to 77° 36' 05" east longitudes (Fig.1). It covers an area of about 44212 km². It constitutes 1.4 per cent of the total geographical area and accounts for 2.1 per cent population of the country. In terms of physical features, it is bordered in the north-east by the Siwalik Hills particularly in Panchkula district. Aravalli ranges pass through the dry semi-arid region in the south-west which find extension in parts of Gurgaon, Rewari, Mahendergarh, Bhiwani and Jhajjar districts. Leaving aside the Siwalik Hills in the north-east and Aravalli ranges in the south-west, Haryana is almost plain with elevation varying from 200 metres to 300 metres above the mean sea level and has general slope from north-east to south-west. The state is administratively divided into 22 districts and 74 tehsils. It has agriculture based economy as 45 per cent of total working population of the state is engaged in agricultural activities and agriculture sector contributes about 14.5 per cent of its gross domestic product. Nearly 88 per cent of net sown area is under irrigation of which 58.3 per cent is irrigated by tube-wells and 41.7 per cent by canals. Wheat and rice are the principal crops which require intensive irrigation and occupy about 66 per cent of the gross irrigated area.

Objectives

Major objective of this study is to examine the concentration pattern of canal irrigation in Haryana.

Database and Methodology

The study is based on secondary sources of data. The data pertaining to the canal command areas and length of canals are obtained from Irrigation and Water Resources Department, Panchkula, Haryana. Data about area under canal irrigation (2010-13) have been collected from District Statistical Abstracts published by the Department of Economic and Statistical Analysis Haryana. Thereafter, the triennium averages were obtained to calculate tehsil-wise concentration of canal irrigated area. The concentration of canal irrigation is calculated by applying the location quotient index formula. It is a simple and most widely used index to measure the concentration of a spatial unit in the total of any distribution (Peters, 1987; Reddy and Reddy, 1992; Thakur and Jaglan, 2005; Sandhu, 2007; Guimaraes et al., 2009; Ramphul, 2012; Krishan and Singh, 2017) and mathematically represented as:

$$Q = X_i/X \div Y_i/Y$$

where, Q = location quotient; X_i is area under canal irrigation of the tehsil; X is net irrigated area of the tehsil; Y_i is area under canal irrigation of the state and Y is net irrigated area of the state. Higher the value of index, more is the concentration of canal irrigation and *vice-versa*. Tables and choropleth maps have been prepared by using Arc GIS 10.3 package to interpret the results.

Results and Discussion

The development of canal irrigation in Haryana started in the second half of the 14th century with the initiative of *Sultan Ferozshah Tughlaq* for the improvement of agriculture. No doubt, canal irrigation was started on a limited scale, but till the close of the 20th century



Source: Administrative Atlas of Haryana, 2011.

Fig. 1

canals were the major source of irrigation in Haryana. However, major development of canal irrigation began after construction of Western Yamuna Canal. Efforts were made to expand canal irrigation facilities to chronically drought affected areas by taking up several major and minor canal irrigation schemes. In addition, lift canal irrigation systems were introduced to take water to the semi-arid and arid uplands in the south and south-west parts of the state. In 1966-69, canal irrigation was the main source of irrigation in the state and accounted for 76.7 per cent of net irrigated area, while its share declined to 41.7 per cent in 2010-13. Leaving aside the area under Siwaliks and Aravalli hills, the plain topography of the state was helpful for construction of canals.

Area Irrigated under Different Canal Systems

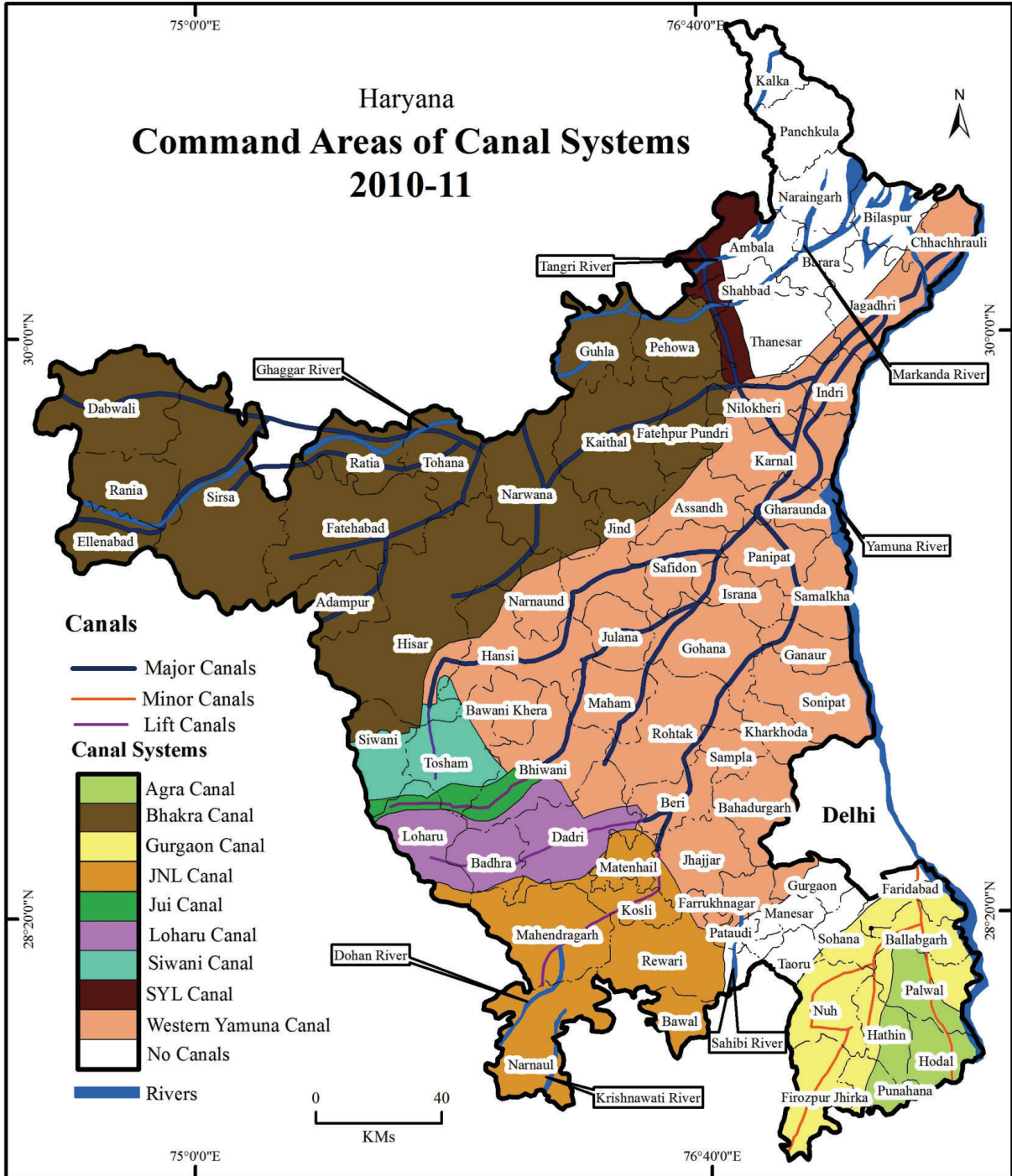
The state has well developed system of canals. Although the Western Yamuna Canal system is the oldest, yet it is the Bhakra Canal system that irrigates more area in the state. In fact, Bhakra Canal system with 736 km long

network of canals irrigates 52.6 per cent of canal irrigated area spreading over 14 tehsils and 1257 villages, while Western Yamuna Canal system with 3200 km long network of distributaries in 28 tehsils and 2041 villages accounts for only 39.5 per cent of canal irrigated area (Table 1). Thus, about 92 per cent of total canal irrigated area of the state is irrigated by these two canal systems. The western Yamuna Canal command area comprises of Kurukshetra, Karnal, Panipat, Sonapat, and Rohtak districts and parts of Yamuna Nagar, Kaithal, Jhajjar, Hisar, Bhiwani and Jind districts, while Bhakra Canal system irrigates larger parts of Kaithal, Hisar, Fatehabad and Sirsa districts. Rest of the canal irrigated area in Haryana is irrigated by minor canals and lift canals (Fig. 2). Minor canal system comprising Agra Canal and Gurgaon Canal, respectively irrigates 2.4 per cent and 0.7 per cent of canal irrigated area in the south-western parts of the state. Similarly, lift canal systems comprising Jawaharlal Nehru, Jui, Loharu and Siwani Canals irrigate parts of Bhiwani, Mahendergarh and Rewari districts

Table 1
Haryana: Canal Systems (2010-13)

Canals Systems	Command Area (000 ha)	Length (km)	Canal Irrigated Area (000 ha)	Canal Irrigated Area (Per cent)	No. of Tehsils	No. of Villages
Bhakra Canal	1403.1	735.8	662.5	52.6	14	1257
Western Yamuna Canal	1406.9	3200.0	498.1	39.5	28	2041
Agra Canal	111.7	72.0	29.6	2.4	4	170
Jawaharlal Nehru Canal	387.7	193.0	19.4	1.5	6	787
Jui and Loharu Lift Canals	211.8	551.9	17.3	1.4	3	262
Siwani Lift Canal	99.5	36.0	13.7	1.1	2	81
Sutlej Yamuna Link Canal	63.3	92.0	9.5	0.8	3	188
Gurgaon Canal	242.4	135.0	9.2	0.7	5	640
No Canals	494.8	0.0	0.0	0.0	9	1415
Haryana	4421.2	5015.7	1259.3	100.0	74	6841

Source: Irrigation and Water Resources Department, Panchkula, 2010-11 and District Statistical Abstracts, Haryana, 2010-11, 2011-12 and 2012-13.



Source: Irrigation and Water Resources Department, Panchkula, Haryana.

Fig. 2

and jointly account for about 4 per cent of canal irrigated area of 11 tehsils and 1130 villages (Table 1; Fig. 2). The Sutlej Yamuna Link Canal sharing only 0.8 per cent of canal irrigated provides water for irrigation to 3 tehsils and 188 villages of Ambala and Kurukshetra districts.

Concentration of Canal Irrigation

During 1966-69, 76.7 per cent of net irrigated area in the state was irrigated by canals, while the share of canal irrigated area declined to 69.3 per cent in 1980-83 and further reduced to 41.7 per cent in 2010-13. Thus, canal irrigated area showed a decline of 35 per cent points during this period of 1966-69 to 2010-13. To understand the concentration of canal irrigation in Haryana, tehsil-wise location quotient index has been calculated and presented in Table 2. The index values are grouped into three categories and discussed as under:

(i) Areas of High Concentration of Canal Irrigation (more than 1.20)

A continuous patch of 25 tehsils of Sirsa, Hisar, Fatehabad, Jind, Rohtak, Jhajjar, Sonipat, Panipat and Bhiwani districts starting from western to central-eastern part of the state is distinguished as areas of high concentration of canal irrigation (Fig. 3). The tehsils recording index of more than 1.20 are included in this category (Table 2). This belt is mainly served by Bhakra and Western Yamuna Canal systems. The high canal irrigated areas occupied about 73 per cent of the net irrigated area of the region. In general, it has been observed that within this belt the concentration of canal irrigation declines from west towards east. The region forms a part of the extensive Ghaggar-Yamuna Plain which slopes very gently from north-east to the south-west. In these tehsils plain topography and waters from Bhakra Canal and western Yamuna Canal favoured the development of canal irrigation. The introduction of canal irrigation has brought

large amount of barren and parched land under cultivation in these tehsils. Tube-well irrigation in this part of the state is limited due to high depth of ground water table and poor quality of water; therefore canals are the most important source of irrigation. Thus, high concentration of canal irrigated area in these tehsils is attributed to an increase in the utilization of available surface water resources, adequate timing of canal water supply from main canals to their distributaries and affordable charges of canal water. These tehsils are located near the head and along the branches of canal; therefore the use of canal water tends to be very intensive.

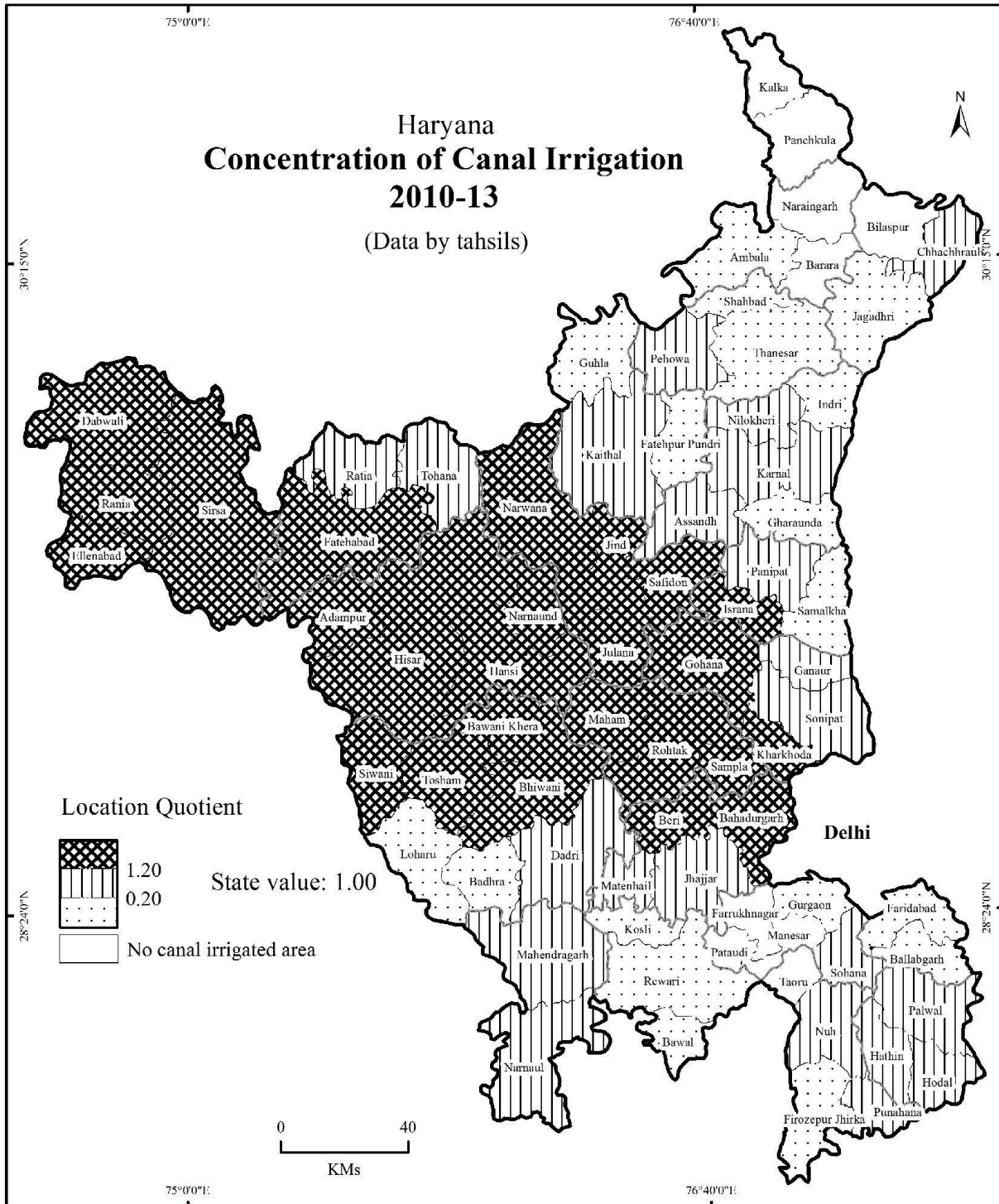
(ii) Areas of Moderate Concentration of Canal Irrigation (0.20 to 1.20)

The moderate concentration of canal irrigated areas cover 22 tehsils in 13 districts of Yamunanagar, Kurukshetra, Kaithal, Karnal, Panipat, Fatehabad, Sonipat, Jhajjar, Bhiwani Mahendergarh, Gurgaon, Mewat and Palwal. This category of areas includes tehsils having an index value ranging between 0.20 and 1.20. This moderate category of concentration of canal irrigation constitutes six clusters located in different parts of the state (Fig. 3). In the areas of moderate concentration of canal irrigation about 25 per cent of net area irrigated is irrigated by canals. These areas are mostly confined to the command areas of minor canals and lift irrigation canals. However, some tehsils recording moderate concentration of canal irrigation are also found in the command areas of Western Yamuna Canal and Bhakra Canal systems. These are the areas where adequate supply of canal water is not available; therefore farmers are gradually shifting to tube-well irrigation. Farmers of these areas are also shifting towards high-yielding hybrid varieties of crops which demand more and timely irrigation. This can be possible only through tube-wells. Hence, concentration of canal irrigation is moderate.

Table 2
Haryana: Concentration of Canal Irrigated Area (2010-13)

Tehsils	Districts	Location Quotient	Tehsils	Districts	Location Quotient
Bawani Khera	Bhiwani	2.38	Mahendergarh	Mahendergarh	0.45
Dabwali	Sirsa	2.38	Narnaul	Mahendergarh	0.44
Adampur	Hisar	2.25	Matanhail	Jhajjar	0.36
Beri	Jhajjar	2.17	Nilokheri	Karnal	0.36
Narnaund	Hisar	2.03	Karnal	Karnal	0.34
Meham	Rohtak	1.99	Punhana	Mewat	0.29
Bhiwani	Bhiwani	1.98	Kaithal	Kaithal	0.28
Gohana	Sonipat	1.93	Chhachhrauli	Yamunanagar	0.26
Julana	Jind	1.90	Sohna	Gurgaon	0.23
Hisar	Hisar	1.89	Ambala	Ambala	0.19
Fatehabad	Fatehabad	1.88	Samalkha	Panipat	0.18
Narwana	Jind	1.85	Shahabad	Kurukshetra	0.14
Sirsa	Sirsa	1.79	Thanesar	Kurukshetra	0.13
Siwani	Bhiwani	1.77	Loharu	Bhiwani	0.11
Ellenabad	Sirsa	1.72	Ferozpur Jhirka	Mewat	0.11
Rania	Sirsa	1.66	Bawal	Rewari	0.11
Safidon	Jind	1.60	Gharaunda	Karnal	0.10
Jind	Jind	1.53	Badhra	Bhiwani	0.09
Hansi	Hisar	1.51	Fatehpur Pundri	Kaithal	0.09
Israna	Panipat	1.50	Jagadhari	Yamunanagar	0.09
Sampla	Rohtak	1.45	Ballabgarh	Faridabad	0.08
Bahadurgarh	Jhajjar	1.44	Kosli	Rewari	0.04
Rohtak	Rohtak	1.42	Guhla	Kaithal	0.03
Kharkhoda	Sonipat	1.42	Rewari	Rewari	0.03
Tosham	Bhiwani	1.36	Faridabad	Faridabad	0.02
Assandh	Karnal	1.19	Indri	Karnal	0.02
Ratia	Fatehabad	1.04	Gurgaon	Gurgaon	0.01
Jhajjar	Jhajjar	1.04	Naraingarh	Ambala	0.00
Tohana	Fatehabad	1.00	Barara	Ambala	0.00
Panipat	Panipat	0.98	Pataudi	Gurgaon	0.00
Hodal	Palwal	0.92	Farukhnagar	Gurgaon	0.00
Sonipat	Sonipat	0.90	Manesar	Gurgaon	0.00
Nuh	Mewat	0.88	Taoru	Mewat	0.00
Hathin	Palwal	0.77	Panchkula	Panchkula	0.00
Pehowa	Kurukshetra	0.71	Kalka	Panchkula	0.00
Ganaur	Sonipat	0.68	Bilaspur	Yamunanagar	0.00
Dadri	Bhiwani	0.67	Haryana		1.00
Palwal	Palwal	0.47			

Source: District statistical abstracts of Haryana, 2010-11, 2011-12 and 2012-13.



Source: Table 2.

Fig. 3

(iii) Areas of Low Concentration of Canal Irrigation (below 0.20)

The tehsils recording index value of less than 0.20 are categorised as areas of low concentration of canal irrigation. Thus, 18 tehsils scattered over the north-eastern, southern and south-western parts of the state recorded low concentration of canal irrigation. These are the tehsils which have less than 18 per cent of net irrigated area through canals. The undulating and dissected topography of Siwalik Hills in the north-east and Aravalli hills in the south is detrimental to canal irrigation; hence concentration of canal irrigation is low in these areas. Similarly, in old alluvium tract of the Yamuna River, concentration of canal irrigation is low mainly due to the greater extent of tube-well irrigation. Apart from the soft rocks and plain surface where digging of tube-wells is comparatively easy, government's policy of providing cheaper loans and electric power has encouraged the development of tube-well irrigation in this part of the state. Moreover, in the flood plains of Yamuna River the average annual rainfall is more than 600 mm which is helpful to recharge the ground water table. Tube-well irrigation is also preferred by farmers than canal irrigation due to its timely availability. Likewise, the farmers of the tehsils located at the tail-ends of the canals, particularly in south-western parts of the state receive less supply of canal water; because in canal command area, the quantity of water available for irrigation to any field is a function of the distance of the field from the water outlet. Therefore, these farmers are gradually shifting towards tube-well irrigation; thereby leading to low concentration of canal irrigation in these tehsils. It must be mentioned that due to topographical constraints or dominance of tube-well irrigation, canal irrigation could not be developed in Kalka, Panchkula, Naraingarh, Barara, Bilaspur, Pataudi, Farrukhnagar, Manesar and Taoru tehsils (Fig. 3).

Conclusions

The study reveals that in 1966-69, canals were the main source of irrigation in Haryana and accounted for 76.6 per cent of the net irrigated area, while the share of canal irrigated area declined to 41.7 per cent in 2010-13. The distribution of canal irrigated area in the state is uneven. Areas of high concentration of canal irrigation is a continuous belt comprising 25 tehsils of Sirsa, Hisar, Fatehabad, Jind, Rohtak, Jhajjar, Sonapat, Panipat and Bhiwani districts located in the western and central-eastern part of the state. This belt is mainly served by Bhakra and Western Yamuna canal systems. The high canal irrigated areas account for about 73 per cent of the net irrigated area in these tehsils. On the other hand, the low concentration of canal irrigation is found in 18 tehsils of the state scattered in Ambala, Yamunanagar, Kurukshetra, Karnal, Kaithal, Panipat, Bhiwani, Gurgaon, Mewat, Faridabad and Rewari districts. In these tehsils only 18 per cent of net irrigated area is irrigated by canals. These are the tehsils where, either due to topographical constraints or less availability of canal water being located at the tail-end, the farmers are mostly dependent on tube-well irrigation; hence concentration of canal irrigation is low in these areas.

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