Original Research Article

Spatio-temporal Analysis of Irrigation Development in Southwestern Haryana

ABSTRACT

Haryana is an agricultural developed state in India, and a. Agriculture here plays an important role in the economic development of the state. But the state is not homogenous with reference to physiography and such a difference in physiography clearly depart Southwestern Haryana from Rest of HaryanaHovewer, the state is heterogeneous in terms of physiography and such difference in physical geography clearly distinguishes South Western Haryana from the rest of it. Moreover, Southwestern Haryana is less developed than Rest of Haryana from agricultural point of view. There are various factors behind such a difference in the agricultural development of this region and irrigation is one of the most important one. In the Southwestern Haryana development of canals and,tubewells is different from Rest of Haryana. In this background, the present study aims to examine the development of irrigation in southwest Haryana from spatial and temporal prospectives using secondary data sources. In particular, the methodology was based on trend analysis, least squares and cartographic representation.In this background the present study based on secondary sources of data examine the irrigation development in Southwestern Haryana on the basis of spatial and temporal aspects with the help of trend line graph, least square method and cartographic representation. The finding of the study reveals that development of canals irrigation in Southwestern Haryana is in infancy stage. Out of all districts of this region Bhiwani &Charkhi Dadri district shows a measurable growth in canals irrigation with negative trends. Due to the unevenits rugged topography, Southwestern Haryana is mainly depends on tubewell irrigation. Such a dependency can be justified with the positive trends of tubewell irrigation in this region. The trends of tubewells irrigation in Southwestern Haryana is areahead of Rest of Haryana. The study also reveals that, except for Gurugram & Nuh district, irrigation intensity in the study area is increasingin the study area. Bhiwani has the highest per unit change in irrigation intensity with respect to time periodover a particular period of time, while Gurugram & Nuh shows negative change from 1990-91 to 2020-21.

Keywords: Irrigation Development, Trend Lines, Irrigation Intensity, Southwestern Haryana

1. INTRODUCTION

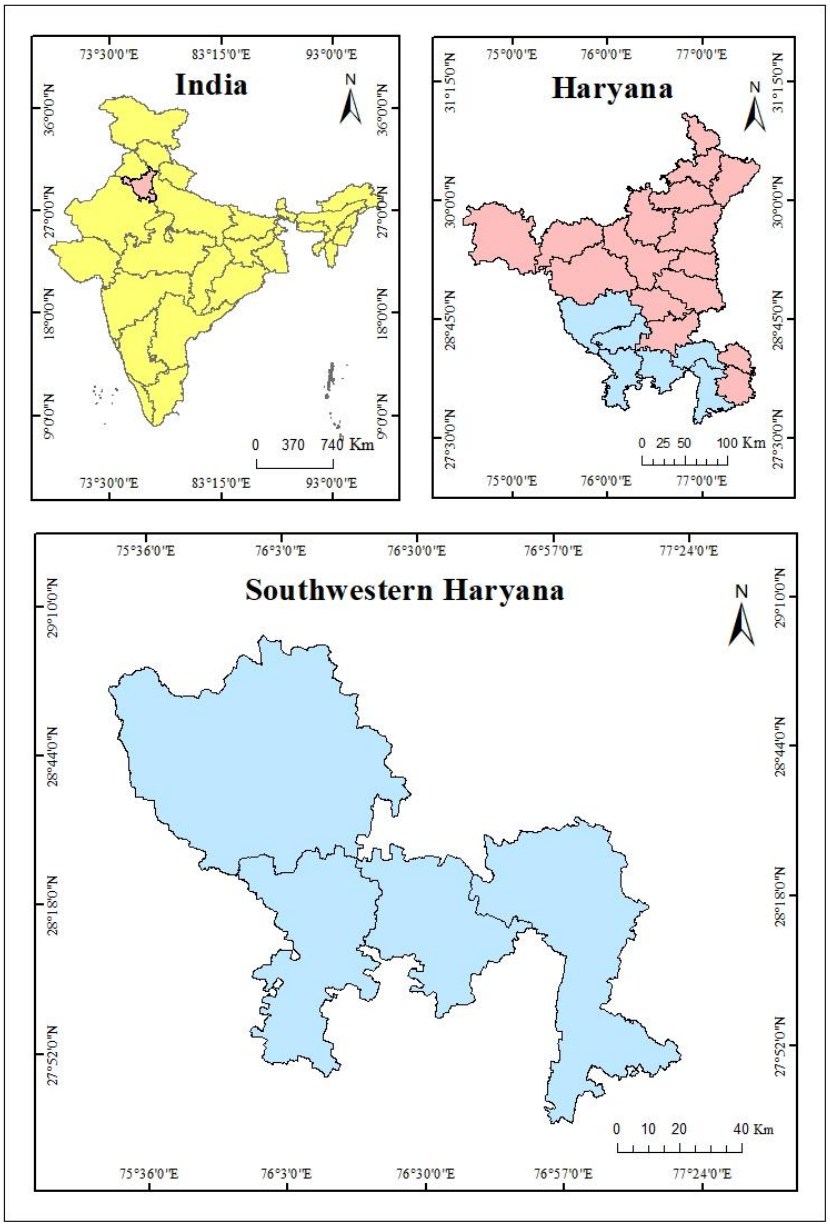
Agricultural development is one of the indicators of socio-economic development of a society. To grow crops and take healthy production fertile soil, seeds, micro and macro nutrients, machinery, irrigation etc. are the basic necessities. However,Neddless to say that all above discussed elements of crop production are important, but irrigation keeps its own importance and position in agricultural production. Irrigation is an artificial process of providing water to crops for their growth mainly to replace missing rainfall in periods of drought. It severs two main objectives i.e.,such as supplying essential water to plants to fulfil their biological needs and helpings soil in leaching its salts. Farming without irrigation is very limited and it is not possible to grow crops without artificial irrigation. It helps in growing

crops and maintaining landscapes in the dry areas especially when rainfall is below average from its required amount [1,2]. Irrigation helps in socio-economic development of mankind[3]. It is a tool which has direct positive correlation with net sown area, production, yield, agricultural productivity, cropping intensity etc.[4-6]. Irrigation helps in poverty alleviation[7-10]. Irrigation has more elasticity than any other factors in agricultural development. However, some studies reveals that there is no direct impact of irrigation development on economic development and poverty reduction[11]. Irrigation development leads to heterogenous impacts, it helps in increasing agricultural output and wealth of farmers [12]. Econometric and descriptive analysis confirm that irrigation has a positive impact on land productivity [13].

The irrigation development in Haryana has increased with currency rate after the introduction of Green Revolution in 1965-66[14]. However, adoption of Green Revolution (use of HYV seeds, chemical fertilizers, chemical pesticides & weedicides, mechanization etc.) has accelerated water requirement especially for wheat and rice crops[15]. At present, Haryana is a leading state in India from the view of irrigation development. The net area irrigated by different sources in the state has increased from 12.93 lakh ha to 33.60 lakh ha since 1966-67 to 2020-21 [16]. Tubewells and canals are the dominating source of irrigation in the state. However, due to limited availability of canal water especially during dry season, dependency on tubewells irrigation is higher than canal irrigation[17]. The share of percentage of net irrigated area by canals and tubewells in Haryana based on triennium average (2018-21) is 20.27 percent and 58.80 percent respectively[18]. However, uneven physiography, presence of sand dunes and patches of Aravalli hills in Southwestern Haryana restrict this region from the irrigation development. In the view of above econometric and descriptive discussion, the present study tries to explore the temporal and spatial dimensions of irrigation development in Southwestern Haryana viz-a-viz Rest of Haryana.

1.1PROFILE OF STUDY AREA

Haryana is a landlocked state in north India. The state is located within latitude 27º39' N to 30º55'5" N and longitudes 74º27'8" E to 77º36'5" E. It occupies a total land mass of 4.42 million ha which is 1.4 percent area of the country. The rainfall pattern in the state shows a little variation and intensity of rainfall decreases as one moves from north to south. The mean rainfall of the state lies between 200 to 600 mm. Southwestern Haryana receive less rainfall in comparison to rest of Haryana. The mean temperature of the state varies from 23.5º to 25.0ºC [19]. On the basis of physiography, the state can be categorized into two main regions i.e., alluvial plain region which lies in the most of the state except southwestern Haryana, and sand dunes with patches of Aravalli hills in the southwestern Haryana. The region of southwestern Haryana has distinct topographical features than that of rest of Haryana. The southwestern Haryana cover six districts (Bhawani, CharkhiDadari, Mahendragarh, Rewari, Gurugram, and Nuh) (Pic.1). It is a semi-dry region. Irrigation in this region is mainly dominated by tubewells. Sahibi, Indori, Kasonti, and Dohan are the main seasonal rivers of the study area. Due to the scarcity of water and sandy nature of soil this region restricts the development of agriculture.The main plant species of this area belongs to xerophytes type of vegetations (*kair, ber, jal, kikar* etc.).



Pic. 1. Map of Southwestern Haryana, Showing the Study Area

1.2OBJECTIVES OF THE STUDY

- To study the trend and temporal patterns of irrigation development in Southwestern Haryana.
- To evaluate the inter-regional variation in irrigation development in the study area.
- To study the spatial patterns of irrigation development in Southwestern Haryana.

1.3RESEARCH QUESTIONS

- Is the trend and pattern of irrigation development in study area are distinct from rest of Haryana?

- Why Southwestern Haryana has less irrigation development in comparison to rest of Haryana?
- How Southwestern Haryana shows inter-regional variation in irrigation development?
- Is there any spatial variation in the irrigation development of study area?

2. DATA BASE AND RESEARCH METHODOLOGY

The study is based on secondary sources of data (from 1990-91 to 2020-21) which has been taken from statistical abstract of Haryana (various issues). To analyses data various statistical tools and cartographical techniques ~~has~~ have been used. To compute trends of irrigation development, time series analysis has been performed. To ~~know~~ assess the impact of time on irrigation development linear regression equation has been used [20].

Linear Regression Equation

$Y = aX + b$

Here, Y is the dependent variable (irrigation development)
X, is the independent variable (time period)
a, is regression coefficient
b, is intercept value

Index value has been calculated to monitor the spatial variation of different factors in the study area with respect to Haryana. To depicts the spatial development of proportion of irrigated area (on the basis of various sources of irrigation) and irrigation intensity, maps have been used on the basis of triennium average for 1990-93 and 2018-21.

2.1LIMITATION OF THE STUDY

Due to non-availability of separate data for few years Bhiwani and Charkhi Dadri, and Gurugram and Nuh districts has been assumed single unit as Bhiwani &Charkhi Dadri and Gurugram & Nuh during the study. The results of these two districts are based on the combined data of their parental district.

3. RESULTS AND DISCUSSION

3.1 DEVELOPMENT OF CANALS IRRIGATION

Fig 1(a) shows the district-wise trends of percentage of net sown area irrigated by canals in Southwestern Haryana. The findings of the study shows that there is no significant development in canal irrigation in all the districts of Southwestern Haryana. The regression coefficient value shows that all district of the study area depicts a decline growth in canal irrigation with respect to time during post liberalization period. However, within the region Bhiwani &Charkhi Dadri district shows highest decline in percentage of net sown area irrigated by canals followed by Gurugram & Nuh. The intercept value is highest for Bhiwani &Charkhi Dadri (35.78) and lowest for Rewari (2.56).

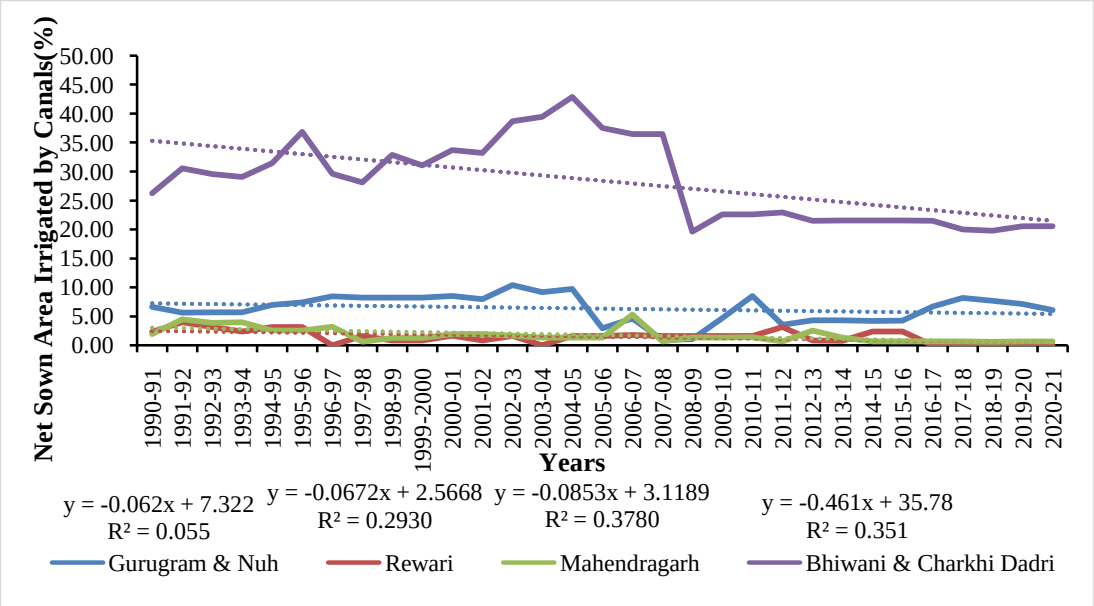


Fig. 1(a). District-wise Trends of Percentage of Net Sown Area Irrigated by Canals

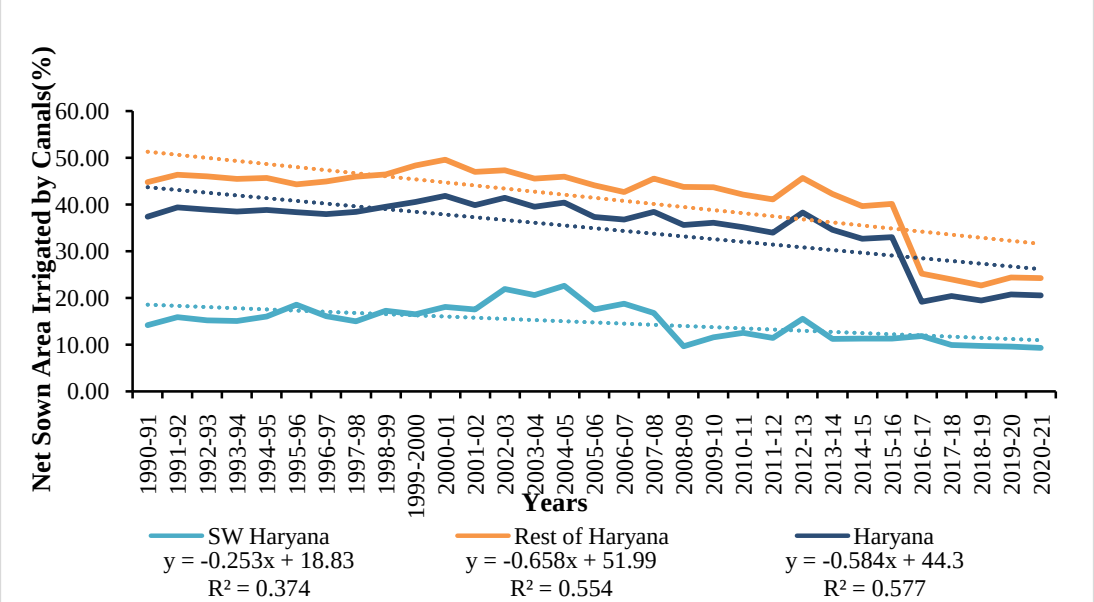


Fig. 1(b). Region-wise Trends of Percentage of Net Sown Area Irrigated by Canals

In case of regional variation (Fig (1(b) & Fig. (c)) reveals that both the regions i.e., Southwestern Haryana and Rest of Haryana depicts negative trends. However, it is important to note that coefficient value of rest of Haryana (-0.658) is more than Southwestern Haryana (-0.253). The intercept value of Rest of Haryana is highest in among all three regions which depicts that Rest of Haryana faces major changes in net sown area irritated by Canals as compared to Southwestern Haryana and Haryana. Such a decrease in the percentage of net sown area irrigated by canals in Haryana is mainly due to increase in the dependency on tubewells irrigation and increasing demand of canal water for non-

agricultural purposes. Fig. (c) also reveals that net area irrigated as percentage of net sown area in Southwestern Haryana has been decreased from 15.07 percent in 1990-93 to 9.53 percent in 2018-21.

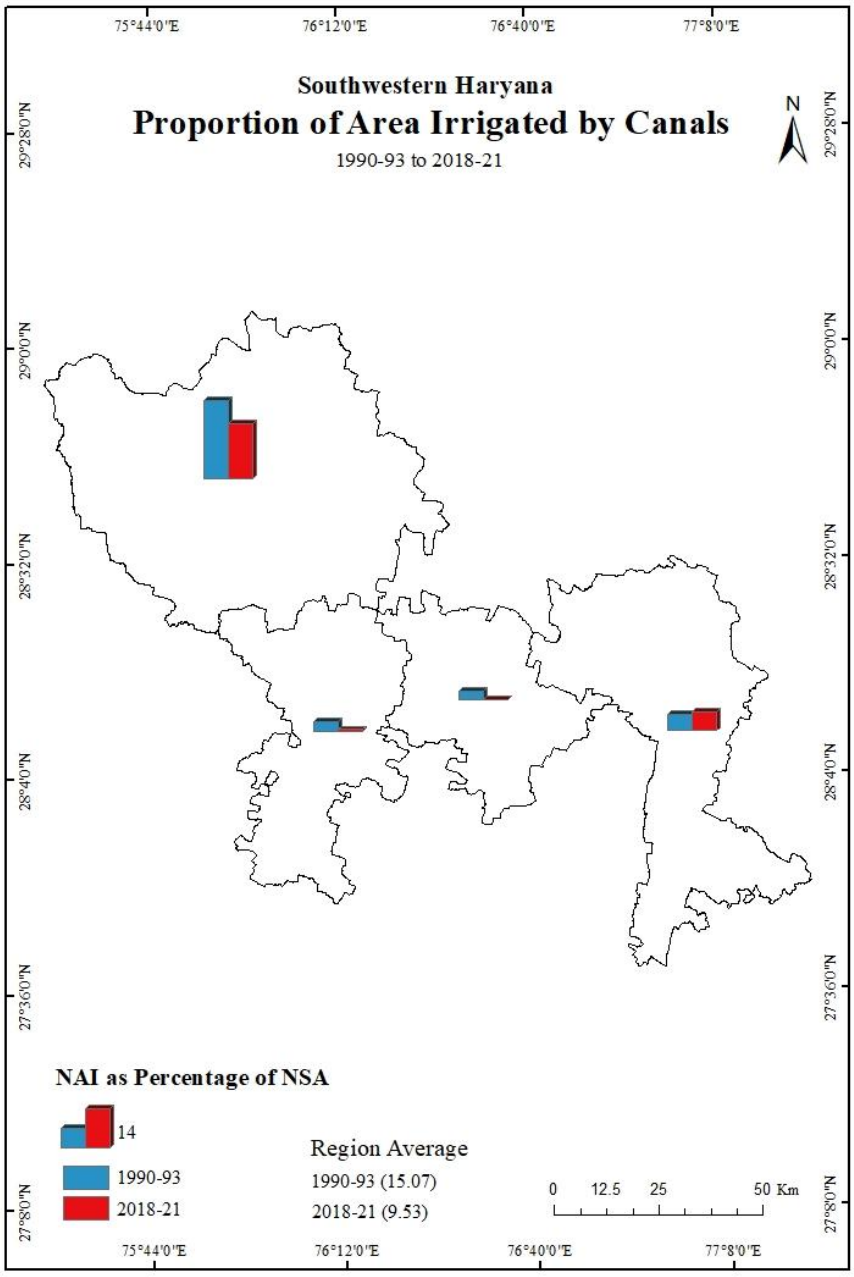


Fig. 1(c). Proportion of Area Irrigated by Canals

Table 1. Index Value of Area Irrigated by Canals

Districts/Regions	Index Value (1990-93)	Index Value (2018-21)
Gurugram & Nuh	0.16	0.34
Rewari	0.08	0.00
Mahendragarh	0.09	0.03
Bhiwani &Charkhi Dadri	0.75	1.00
SW Haryana	0.39	0.47
Rest of Haryana	1.19	1.17
Haryana	1.00	1.00

Source: Calculated by Authors

Table 1 show the relative position of districts of Southwestern Haryana, Southwestern Haryana and Rest of Haryana with respect to Haryana in terms of average net sown area irrigated by Canals for the triennium period of 1990-93 and 2018-21. The findings of the study show that index value of percentage of net sown area irrigated by canals during 1990-93 was highest Bhiwani &Charkhi Dadri (0.75) and lowest for Rewari (0.08). The index value of rest of Haryana (1.19) depicts a much better position of this region than Southwestern Haryana (0.39) during the same time period. However, during 2018-21 triennium period relative position of district of Southwestern, Southwestern Haryana and Rest of Haryana follow the pattern of 1990-93. It is important to note that index value of Southwestern Haryana show a positive growth while rest of Haryana show a decline in index value.

3.2 DEVELOPMENT OF TUBEWELLS IRRIGATION

District-wise trends of percentage of net sown area irrigated by tubewells has been shown by Fig 2(a). The findings of the study reveal that in the study area Rewari district has the highest intercept value (68.87) followed by Mahendragarh district (62.28). it shows that both two district mainly depends on tubewell irrigation. However, it is interesting to note that Bhiwani &Charkhi Dadri district has highest coefficient value (1.73) which indicate that one unit change in independent variable (time period) leads to 1.73 units change in net sown area irrigated by tubewells keeping other factors constant. R2 value for Bhiwani &Charkhi Dadri (74.57 percent) is highest among all districts of the study area, which further shows that 74.57 percent change in net sown area irrigated by tubewells is explained by single independent variable (time period).

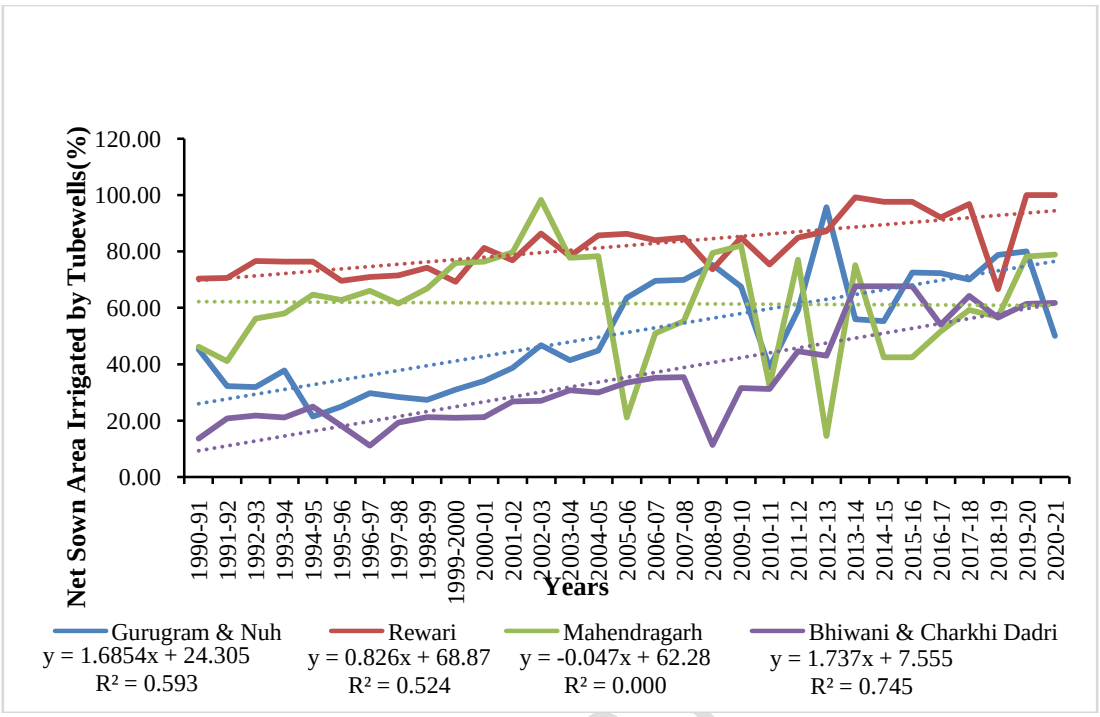


Fig. 2(a). District-wise Trends of Percentage of Net Sown Area Irrigated by Tubewells

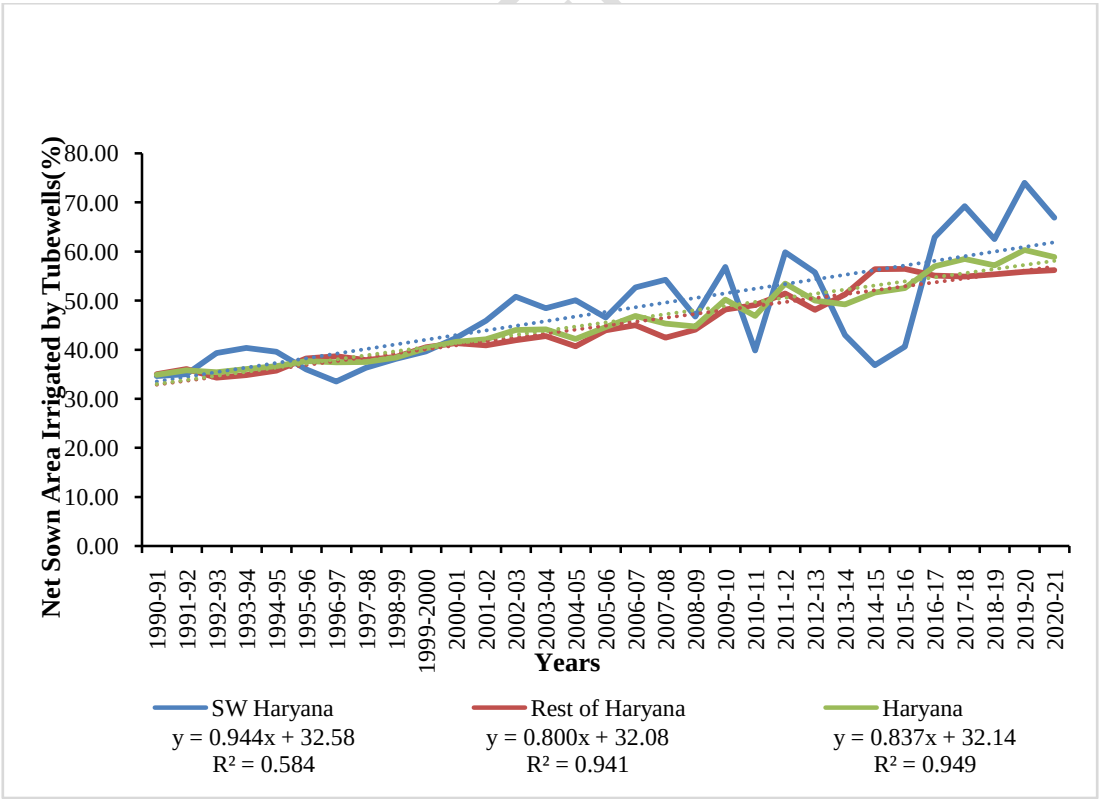


Fig. 2(b). Region-wise Trends of Percentage of Net Sown Area Irrigated by Tubewells

However, region-wise analysis shows that Southwestern Haryana as well as Rest of Haryana follow positive tends with intercept value 32.58 and 32.08 respectively (Fig. 2(b)). Further regression coefficient values of Southwestern Haryana and Rest of Haryana indicate that one unit change in independent variable (time period) leads to 0.94 and 0.80 unit change in net sown area irrigated by tubewells (percentage) respectively. The study further indicates that net area irrigated as percentage of net sown area in the study region has increased from 36.30 percent to 67.80 percent during 1990-93 to 2018-21 (Fig 2(c)).

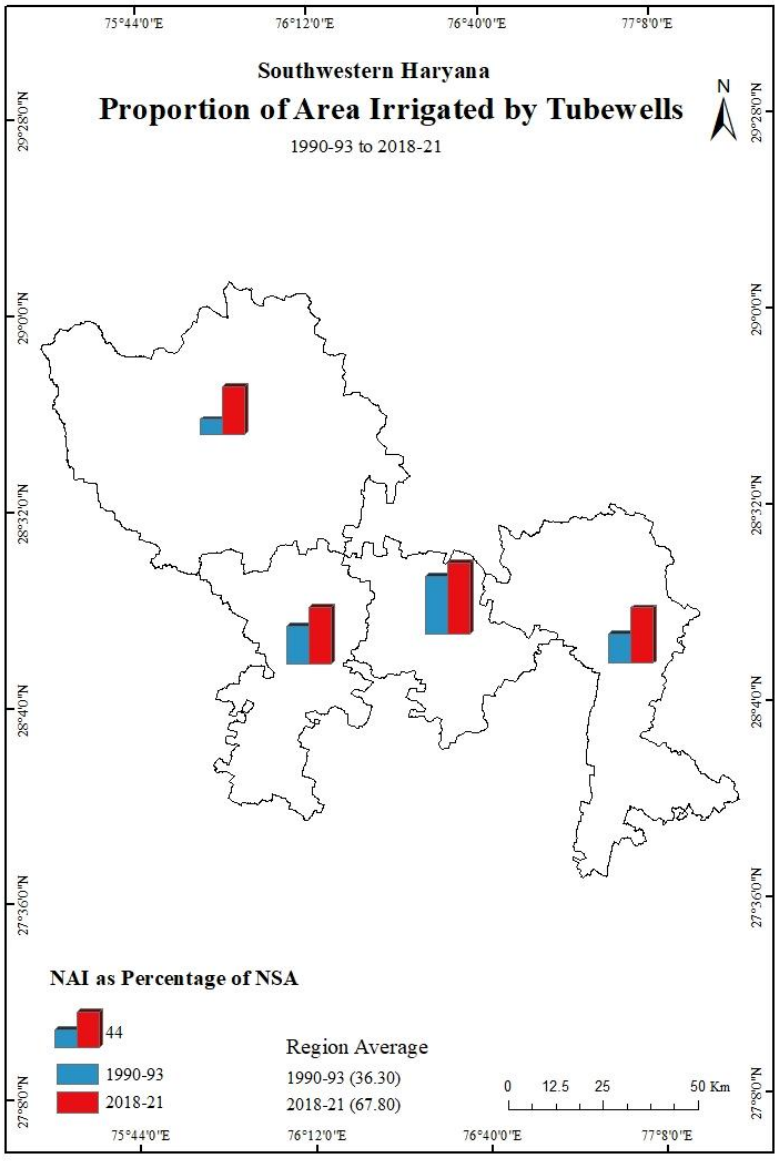


Fig. 2(c). Proportion of Area Irrigated by Tubewells

Table 2 delineates the relative position of different districts and regions with respect to Haryana average net sown area irrigated by Tubewells. In 1990- 93, Bhiwani &Charkhi Dadri

(0.53) had the lowest index value with respect to Haryana. Among the districts of study area Rewari had the highest index value (2.05) which indicates that it was more than double of the state average.

Table 2. Index Value of Irrigated by Tubewells

Districts/Regions	Index Value (1990-93)	Index Value (2018-21)
Gurugram & Nuh	1.03	1.18
Rewari	2.05	1.51
Mahendragarh	1.35	1.21
Bhiwani &Charkhi Dadri	0.53	1.02
SW Haryana	1.03	1.15
Rest of Haryana	0.99	0.95
Haryana	1.00	1.00

Source: Calculated by Authors

In 2018-21, all district shows highest value of index as compared to the state average. The values are 1.18, 1.57, 1.21and 1.03 respectively for the districts Gurugram & Nuh, Rewari, Mahendragarh and Bhiwani &Charkhi Dadri. However, Rewari shows a decline in index value as compared to 1990-93 but still it is above from the state average. When we compare the regions data Southwestern Haryana had the highest index value of 1.03 and 1.15 during 1990-93 and 2018-21 respectively, whereas Rest of Haryana had an index value almost equal to the state average during both time period.

3.3 DEVELOPMENT OF CANALS & TUBEWELLS IRRIGATION

District-wise trends of both canal and tubewell irrigation has been shown by fig. 3(a). The study shows an upward trend line of all districts in the study area except Mahendragarh which shows a decline trend with regression coefficient value -0.04. However, Gurugram & Nuh shows a highest value of regression coefficient of 1.49 among all districts. The intercept value is highest for Rewari (71.41) and lowest for Gurugram & Nuh (32.79) which indicate that percentage of net sown area irrigated by canals &tubewells both is highest in Rewari and lowest in Gurugram & Nuh district. Mahendragarh and Bhiwani &Charkhi Dadri districts have lowest R^2 value of 0.0005 and 0.08 respectively whereas Rewari and Gurugram & Nuh has a high R^2 value of 0.46 and 0.59 respectively.

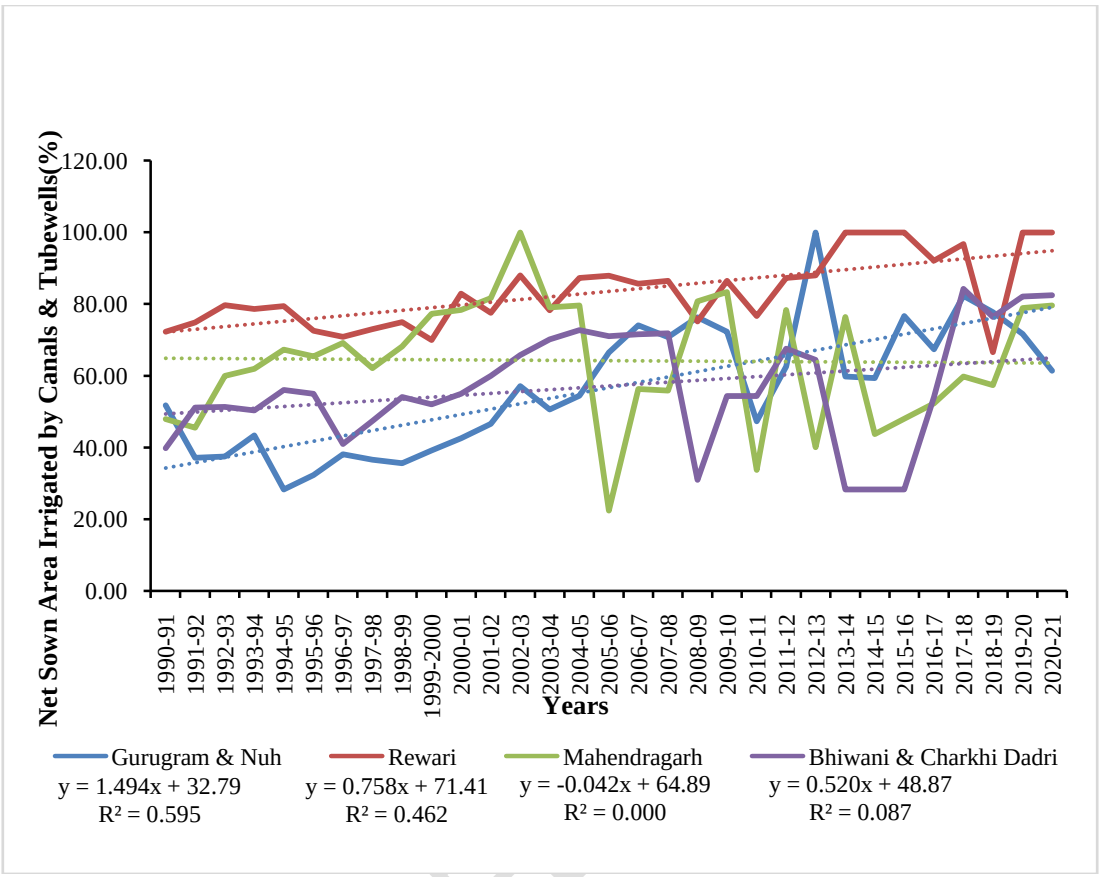


Fig. 3(a). District-wise Trends of Percentage of Net Sown Area Irrigated by Canals &Tubewells

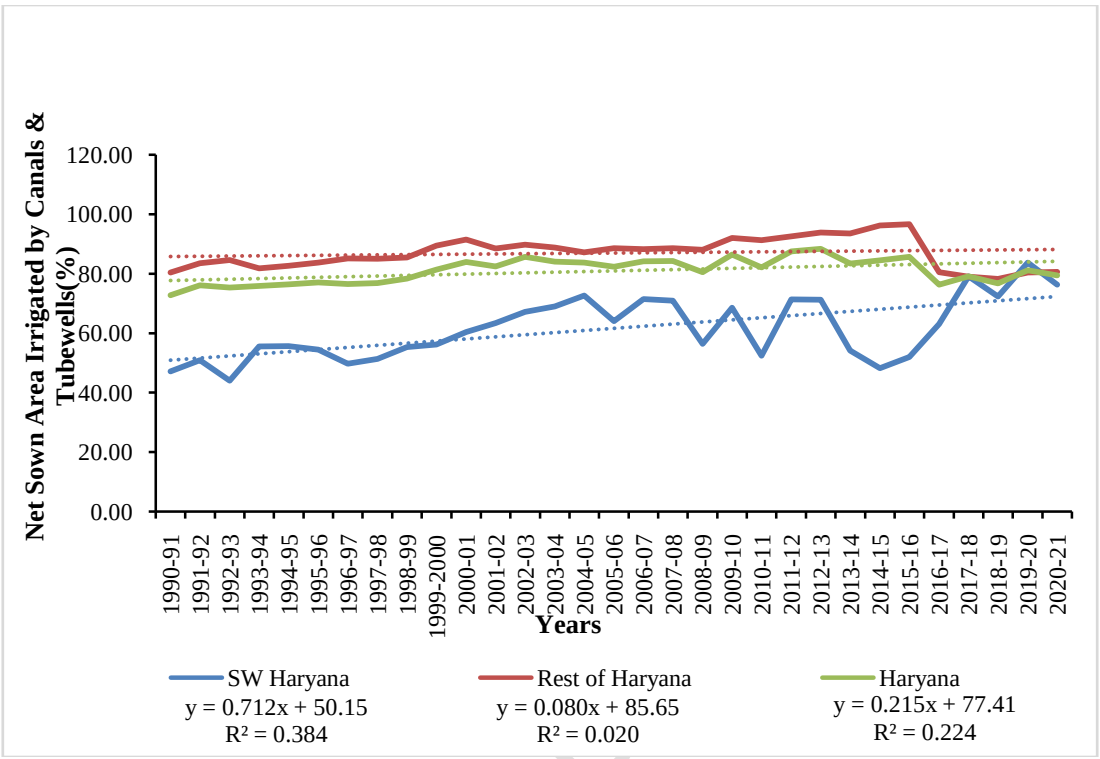


Fig. 3(b). Region-wise Trends of Percentage of Net Sown Area Irrigated by Canals &Tubewells

Figure 3(b) shows an upward region-wise trend of percentage of net sown area irrigated by both canals and tubewells. There is a high value of regression coefficient i.e., 0.71 for Southwestern Haryana followed by 0.21 and 0.08 for Haryana and Rest of Haryana respectively. The figure shows that per unit change in independent variable (time period) there is a 0.7126, 0.2157 and 0.0807 unit change in net sown area irrigated by both Canals and Tubewells. The intercept value lies between 50.15 to 83.65. The highest variance value is 0.3847 for Southwestern Haryana and lowest is 0.0205 for Rest of Haryana. The net area irrigated as percentage of net sown area in the study region has increased from 47.34 percent to 77.44 percent during 1990-93 to 2018-21 (Fig. 3(c)).

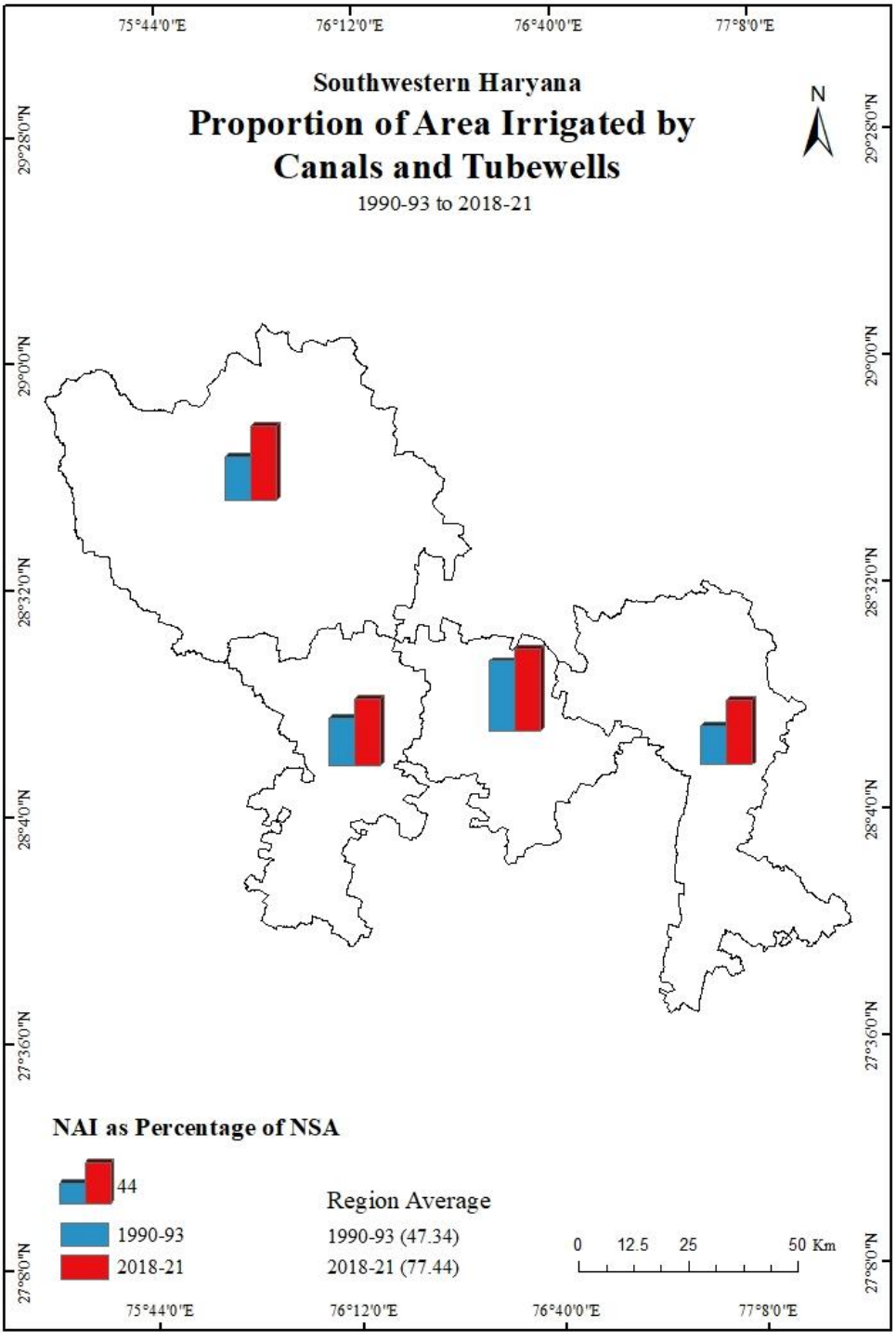


Fig. 3(c). Proportion of Area Irrigated by Canals &Tubewells

Table 3 depicts the relative position of different districts and regions with respect to Haryana average percentage of net sown area irrigated by both Canals and Tubewells. During 1990-93, Rewari shows a little higher index value of 1.01 as compared to Haryana while all other districts show a lesser index value. However, during the triennium period 2018-21 Rewari and Bhiwani &Charkhi Dadri shows an index value of 1.12 and 1.02 respectively which is higher than the state average while, Gurugram & Nuh and Mahendragarh shows a value of about 0.9 which lies very close to Haryana. Rest of Haryana shows a higher index value of 1.1 and Southwestern Haryana had a lesser value of 0.63 during 1990-93. Whereas, during 2018-21 both regions i.e., Rest of Haryana and Southwestern Haryana represent a value similar to Haryana.

Table 3. Index Value of Area Irrigated by Canals &Tubewells

Districts/Regions	Index Value (1990-93)	Index Value (2018-21)
Gurugram & Nuh	0.56	0.89
Rewari	1.01	1.12
Mahendragarh	0.68	0.91
Bhiwani &Charkhi Dadri	0.64	1.02
SW Haryana	0.63	0.98
Rest of Haryana	1.11	1.01
Haryana	1.00	1.00

Source: Calculated by Authors

3.4 IRRIGATION INTENSITY

Irrigation intensity is the ratio of net irrigated area to gross irrigated area in percentage**.** Figure 4(a) depicts that all the districts of study area show an upward slope. The regression coefficient of irrigation intensity equation varies from 1.11 to 4.67 except Gurugram & Nuh (-1.0287) which depicts a negative slope. Bhiwani has the highest per unit change in irrigation intensity with respect to time period, while Gurugram & Nuh shows negative change from 1990-91 to 2020-21. The intercept value is highest for Gurugram & Nuh (207.59) and lowest for Mahendragarh (105.44) which portrays that Gurugram & Nuh had the highest irrigation intensity at the beginning of study period and Mahendragarh had the lowest one.

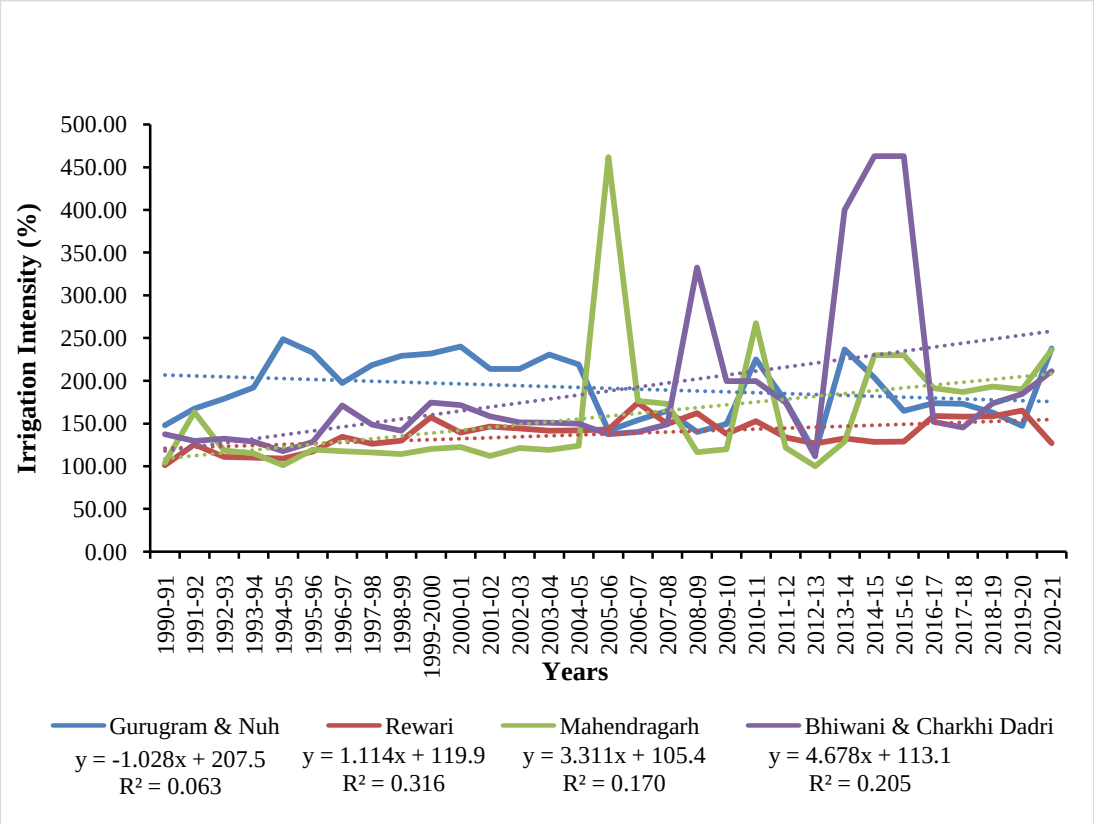


Fig. 4(a). District-wise Trends of Irrigation Intensity

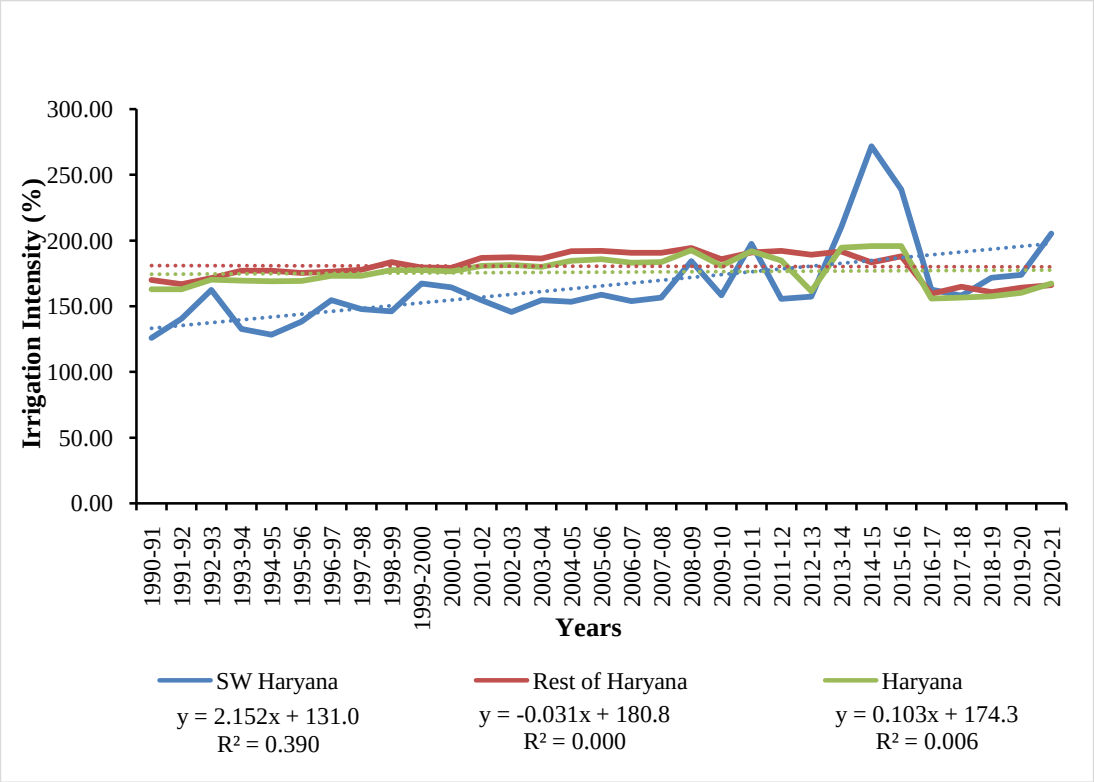


Fig. 4(b). Region-wise Trends of Irrigation Intensity

Southwestern Haryana has a steep slope with a regression coefficient of 2.15, while Rest of Haryana shows a negative trend with a regression coefficient of -0.03 during the study period (fig. 4(b)). The study further reveals that per unit change in independent variable (time period) leads to 2.15 unit change in irrigation intensity in Southwestern Haryana, while on the other hand irrigation intensity of rest of Haryana has attained saturation point and it shows a decline with respect to time period. The irrigation intensity in the study region has increased from 142.90 percent to 183.57 percent during 1990-93 to 2018-21 (Fig. 4(c)).

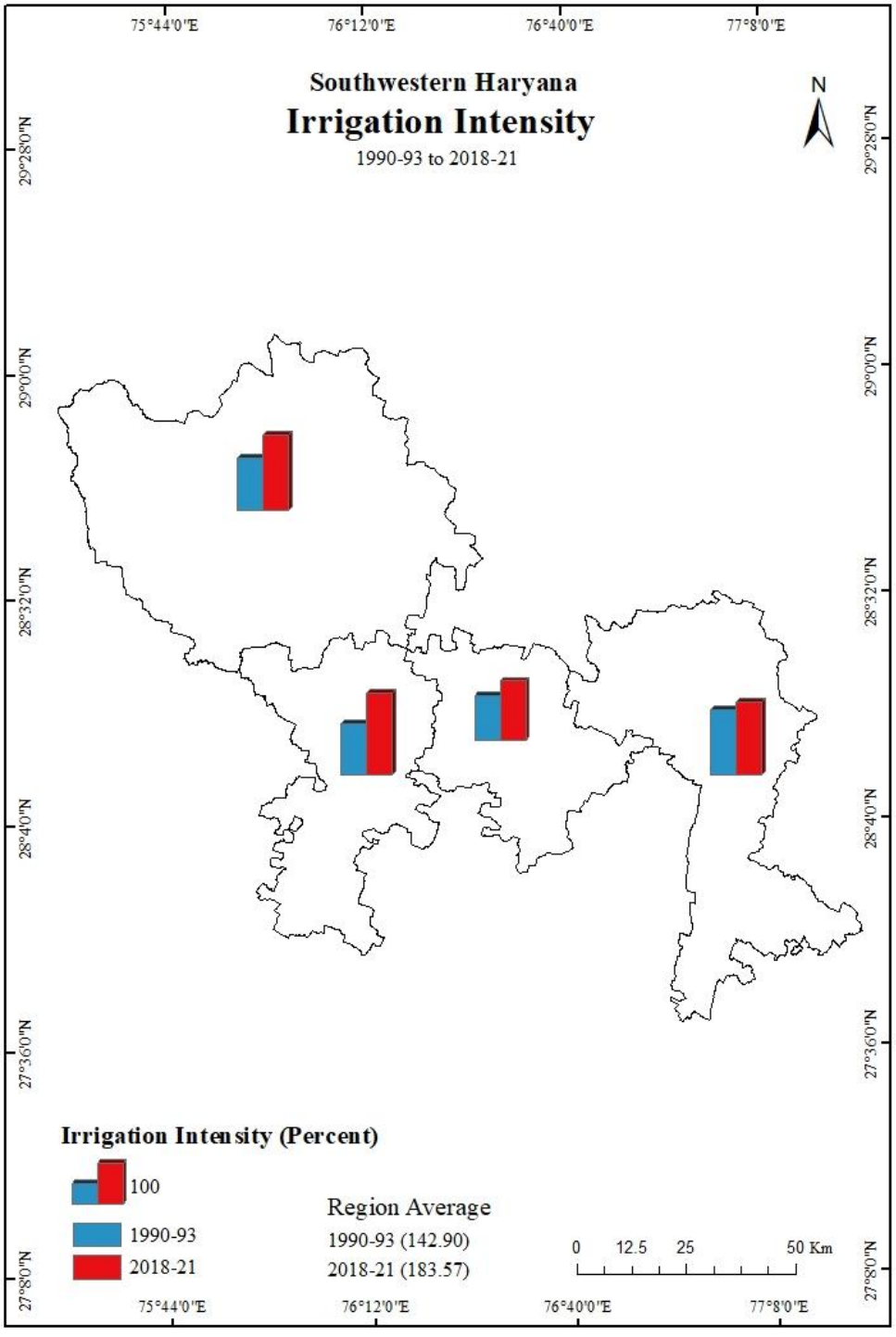


Fig. 4(C). Irrigation Intensity

Table 4 delineate the index value of irrigation intensity which shows the relative position of different districts and regions with respect to Haryana. In 1990-93, Gurugram & Nuh had the highest index value of irrigation intensity i.e., almost equal to the state average while Rewari had the lowest one (0.68). When we compare region-wise index value, Southwestern Haryana lags behind the state average as well as from Rest of Haryana with an index value of 0.86. During the 2018-21 triennium period all districts of study areas show a notable growth. The districts Gurugram & Nuh, Mahendragarh and Bhiwani &Charkhi Dadri shows an index value of 1.13, 1.28 and 1.17 respectively which is higher than the state average. Even Rewari shows a remarkable growth of 0.93 index value which is little behind the Haryana average. The study further states that during 1990-93 Southwestern Haryana was lagging behind from Rest of Haryana and Haryana as well but after liberalization period there is more increment in irrigation intensity of Southwestern Haryana as compared to both Rest of Haryana as well as Haryana.

Table 4. Index Value of Irrigation Intensity

Districts/Regions	Index Value (1990-93)	Index Value (2018-21)
Gurugram & Nuh	1.00	1.13
Rewari	0.68	0.93
Mahendragarh	0.78	1.28
Bhiwani &Charkhi Dadri	0.80	1.17
SW Haryana	0.86	1.14
Rest of Haryana	1.03	1.01
Haryana	1.00	1.00

Source: Calculated by authors

4. CONCLUSION

Irrigation is a basic necessity for agricultural development especially in the dry regions like Southwestern Haryana of India. Due to the uneven surface of this region canals development is a challenging and difficult process. However, measurable and significant net sown area especially in Bhiwani &Charkhi Dadri district receive canals irrigation. But the role and dependency on tubewells irrigation in Southwestern Haryana is dominating. Due to the economical irrigation source, tubewells irrigation in Southwestern Haryana is increasing with respect to time period. Among the districts of Southwestern Haryana, percentage of net sown area irrigated by tubewell irrigation is highest in Rewari and Mahendragarh district. However, it is important to note that overall tubewell irrigation in Southwestern Haryana is ahead of rest of Haryana and Haryana. On the other hand, development in canals irrigation is in better position in rest of Haryana than Southwestern Haryana. The regression coefficient of irrigation intensity equation is positive for all districts of Southwestern Haryana, except Gurugram & Nuh which depicts a negative slope. It shows that except Gurugram & Nuh district, irrigation intensity in the study area is increasing. Bhiwani has the highest per unit change in irrigation intensity with respect to time period, while Gurugram & Nuh shows negative change from 1990-91 to 2020-21. The region-wise analysis shows that Southwestern Haryana has a steep slope, while Rest of Haryana shows a negative trend.

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