Full Length Research Article

Research Journal of Agricultural Sciences
Volume 15; Issue 05 (Sept–Oct 2024); pp 1156–1160

ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

Appraisal of Waterlogging in Central Haryana Using Remote Sensing and GIS

Kiran Bala Bishnoi[1], Anurag Airon[2], Kapil Panwar*[3] and Randhir Kaswan[4]

[1-2,4] Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar - 125 004, Haryana, India
[3] Haryana Space Application Center (HARSAC), Hisar - 125 004, Haryana, India

Received: 01 Aug 2024; Revised accepted: 17 Sep 2024

Abstract

One-third of the agricultural land faces the problem of waterlogging. The water table has risen to variable depths in different regions of Haryana, including Hisar, Fatehabad, Sirsa, Rohtak, Jhajjar, and some villages of district Charkhi Dadri. It has transformed a large component of land barren, i.e., unfit for agricultural purposes. For this purpose, LANDSAT 4-5 TM data of different dates, and analyses were carried out on ERDAS IMAGINE 2014 software. We find the waterlogged affected area in central Haryana with the help of geo-informatics techniques like unsupervised classification and NDWI indices. Heavy rainfall can cause waterlogging in areas where the soil's root zone has inferior drainage ability. Waterlogging is not necessarily the result of the water table rising. For this, the heavy rainfall years were identified by rainfall record analysis, and two years (1995 and 2010) were selected. Satellite images of these years were analysed. The common waterlogged area in two years was termed highly vulnerable, whereas a single year was a vulnerable zone for waterlogging. This is beginning to affect our natural environment dramatically, reduce the viability of our agricultural sector, and damage private and public infrastructure.

***Key words*:** Waterlogging, Remote sensing, GIS, Haryana, LANDSAT

Many environmental issues, including soil salinity, waterlogging, air and water pollution, and air pollution, plague us today. Water logging may occur from extremely poor soil drainage in the rooted zone, rather than necessarily being caused by the water table rising. The condition of waterlogging can be managed in several ways. Agro-forestry is one of the more affordable models and seems to provide the solution to both of these problems [1]. The measurement and recording of electromagnetic radiation emitted or reflected by the earth's surface is the fundamental component of remote sensing. This may be helpful for waterlogging and soil salinity investigations in locations with high water tables, ponded water, saline water, salty soil, and flora impacted by salt that gives contrasting reflectance with other landscape elements so that they may be clearly identified [2-3]. At present, the identification and mapping of the waterlogged area is carried out using digital analysis of false colour composites (FCC).

Waterlogging is a significant agricultural issue, particularly in regions like Central Haryana, where excessive soil moisture can negatively impact crop productivity, degrade land quality, and alter hydrological patterns. Appraising waterlogging using remote sensing and GIS (Geographic Information Systems) offers an effective approach to monitor, map, and manage the affected areas [4-6]. Using remote sensing and GIS, continuous monitoring of waterlogged areas is possible, leading to the development of early warning systems that can help farmers take preventive actions before severe damage occurs.

Many studies have been conducted by research scholars regarding waterlogging at the district, state, national, and international levels. Pathak [7] studies "Agro forestry: A tool for arresting land degradation". Almost 2.8 million Hectares of salt-affected soils are present within the Indo-Gangetic alluvial plain occupying parts of Punjab, Haryana, Uttar Pradesh, Delhi, Bihar, and Rajasthan states. Delineation of salt-affected soils and waterlogged areas in the Indo-Gangetic plains using IRS-1C LISS-III data [8]. The application of remote sensing technology in mapping and monitoring degraded lands, especially salt-affected soils, has shown great promise of enhanced speed, accuracy, and cost-effectiveness. Mandal and Sharma [9] shaded the result visual interpretation of Indian Remote Sensing data (IRS LISS II) on a 1:50,000 scale followed by a ground survey identified waterlogged and salt infestation in IGNP, Rajasthan.

MATERIALS AND METHODS

The study area covers the central part of Haryana consisting of 6 districts namely Bhiwani, Charkhi Dadri, Jhajjar, Rohtak, Panipat, and Sonipat with 1131689.275 hectares (25.59% of the state's geographical area) located from 28º21'23"N to 29º32'02" N latitudes and 75º28'25" E to 77º14'04" E longitudes. The state has a population of 25 million (2% of India's Population) as per census 2011. More than 70% of the population of Haryana is dependent on the agricultural sector for their livelihood. The average annual rainfall of the

***Correspondence to:** Kapil Panwar, E-mail: kapilgeography1@gmail.com

Citation: Bishnoi KB, Airon A, Panwar K, Kaswan R. 2024. Appraisal of waterlogging in central Haryana using remote sensing and GIS. *Res. Jr. Agril. Sci.* 15(5): 1156-1160.

state as a whole is 573 mm and below for arid and semi-arid regions. The net cropped area is 3.64 million hectares. About 86% of the area is arable, and of that, 96% is cultivated. About 75% of the area is irrigated through tube wells and an extensive system of canals.

In the present research, satellite data was analyzed in ERDAS Imagine 2014 and Arc. GIS 10.8 software. The unsupervised classification of LANDSAT 4-5 satellite images, (classified into 20 to 25) was done. Crop classification, crop health and viability assessments, and agricultural practice monitoring are all accomplished through the use of satellite and aerial imagery as mapping tools [10]. For identifying the classes, each class was highlighted at a time and then determined which of the land uses it belonged to by interpreting the original multispectral image.

(i) *Primary data*

The basic primary data used in this study was the USGS website (LANDSAT 4-5) with optimum spatial and temporal resolution. The bands in the images used were 4, 3, and 2 in LANDSAT 4-5.

(ii) *Secondary data*

Rainfall year was accessed from the records available in the Department of Meteorology, CCSHAU, and statistical abstract. Two years (1995 and 2010) were observed to have a high amount of rainfall in most of the districts.

Table 1 Details of satellite data used in the present work

S. No.	Satellite / Sensor	Path	Row	Date of Scene
1.	LANDSAT- 4&5	147	39,40	11/11/1995
	Band 2 (0.52-0.60 µm)*			03/10/2010
	3 (0.63-0.69 µm)			
	4 (0.76-0.90 µm)			

*Wavelength (micrometers)

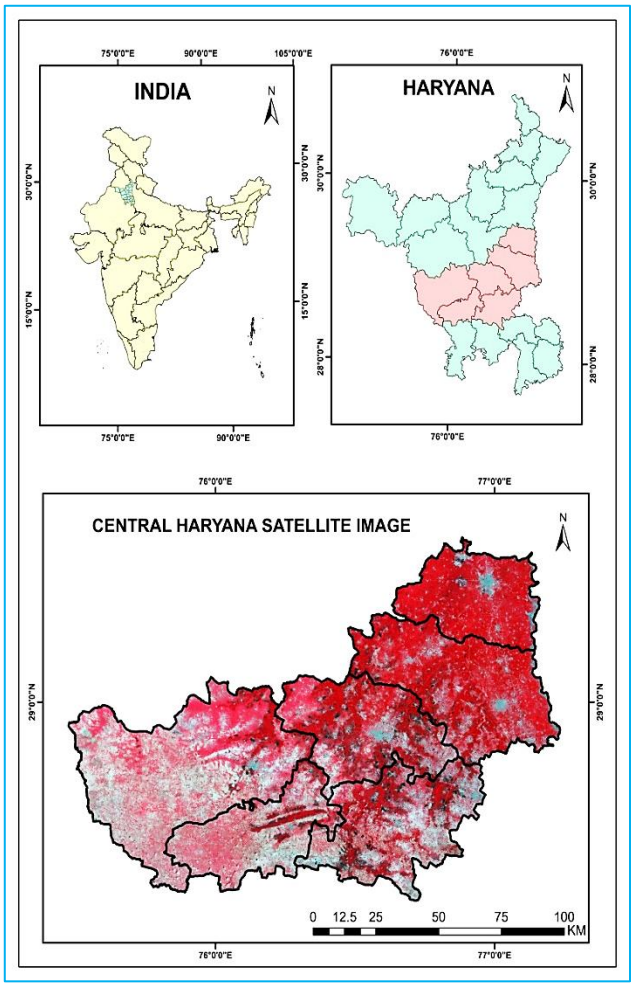

Fig 1 Location map of study area

Unsupervised classification

Unsupervised classification is a method in which the computer searches for natural groupings of similar pixels called clusters [11]. In ERDAS, the Iterative Self-Organizing Data Analysis Technique (ISODATA) algorithm is used to conduct unsupervised categorization. The analyst enters a confidence threshold and the desired number of clusters using this technique. Then, the computer or software creates clusters iteratively, which means that the clusters get better and better with each subsequent iteration.

Multispectral classification is an information extraction process that analyzes the spectral signatures and then assigns pixels to classes based on similar signatures [12]. For example, all of the pixels that represent an area of forested land on a TM image should have roughly the same spectral signature. Classification procedures attempt to group such similar pixels.

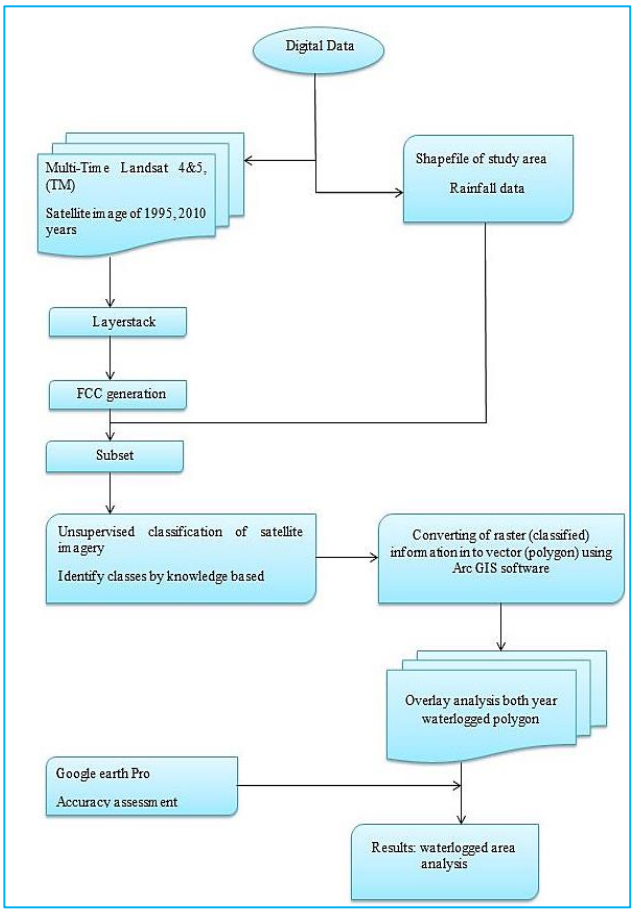

Fig 2 Methodology flow chart

RESULTS AND DISCUSSION

Rainfall year was accessed from the records available in the Department of Meteorology, CCSHAU, and statistical abstract. Two years (1995 and 2010) were observed to have a

high amount of rainfall in most of the districts. Therefore, these two years were selected for analyzing the water logging area in central Haryana.

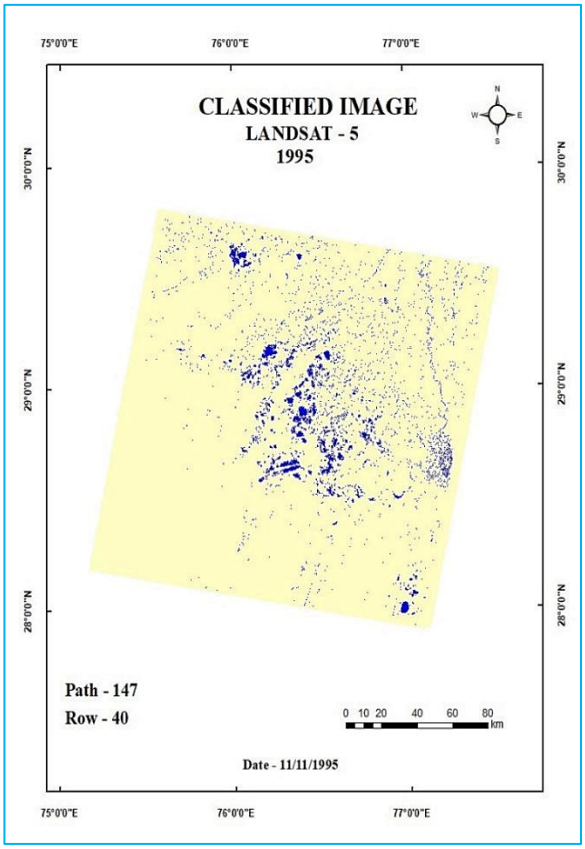

Fig 3 Water bodies in satellite image 1995

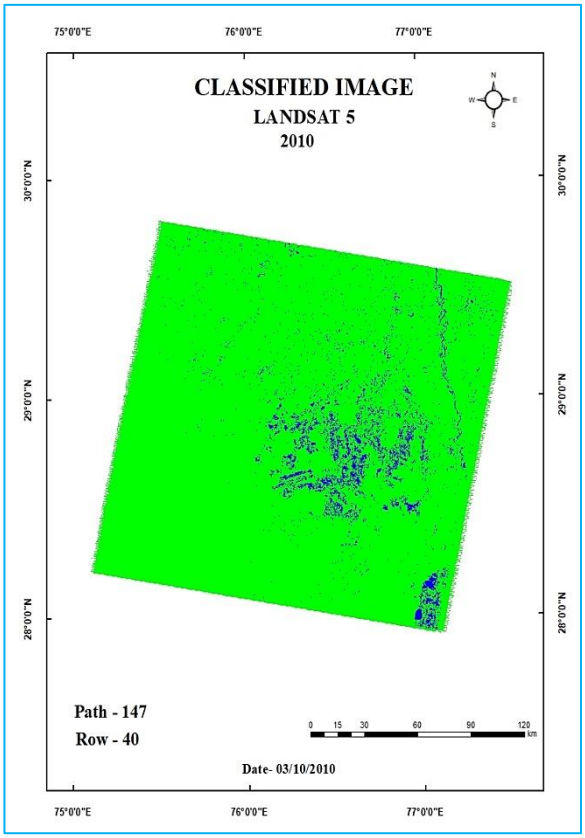

Fig 4 Water bodies in satellite image 2010

Landsat 4-5 TM satellite images taken on 11 November 1995 and 03 October 2010. Water logging was analyzed in the satellite image of November 1995, in which waterlogged area was seen in dark form (Fig 3) and then they were classified. For identifying the classes, each class was highlighted at a time and then determined which of the land uses it belonged to by interpreting the original multispectral image**.** Then each class was given a color such as water blue and all other land use features were displayed in the same color such as cream color in the November 1995 image and grouped other classes [13-14].

The area was seen in dark form (Fig 4) and the same method was applied in 2nd satellite image of October 2010, in which the waterlogged then they was classified waterlogged area as blue, and other features were in green color. November 1995 and October 2010 images are shown in (Fig 5-6) respectively. The area was seen in dark form (Fig 4) and the same method was applied in 2nd satellite image of October 2010, in which the waterlogged then they was classified waterlogged area as blue, and other features were in green color [15]. November 1995 and October 2010 images are shown in (Fig 5-6) respectively.

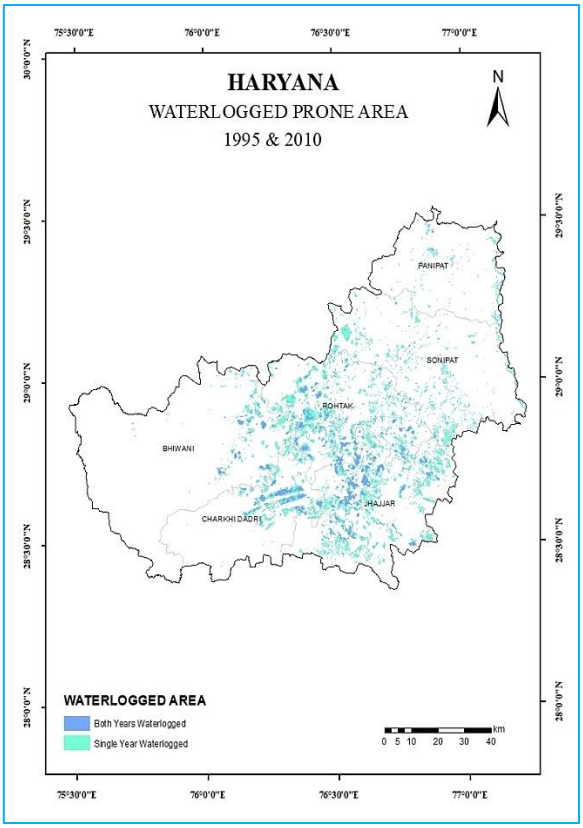

Fig 5 Waterlogged prone area in central Haryana

The two-year classified images were converted into vector format for GIS analysis. By using ArcGIS software both images were overlaid and the common area selected which was waterlogged in both years was coded as one, Single year waterlogged was coded as 2, and the rest of the area was coded as 3. The results are shown in (Fig 5).

Table 2 Waterlogged area of central Haryana in percentage (%)

Districts	Waterlogged area (%)
Bhiwani	3.23
Charkhi Dadri	10.70
Rohtak	21.02
Jhajjar	19.17
Sonipat	6.43
Panipat	3.15

In Bhiwani district, 10,300 hectares area was waterlogged area, which was about 3.23%. Due to sandy soils, there is no waterlogging in the western part but waterlogging was more observed in North Eastern part of Bhiwani. The common area of waterlogged in both years (1995 and 2010) was 2,478 hectares, while the single year (1995/2010) waterlogged was 7,821 hectares in Bhiwani. Charkhi Dadri has 14,333 hectares area was waterlogged, which was about 10.7%. There was no waterlogging in the western part of Charkhi Dadri as is sandy soils, but waterlogging was more in its eastern part [16].

The geographical area of Rohtak district is 1, 61,622 hectares out of these 33,983 hectares of area was waterlogged which is 21.02% of the area of this district. Data showed that Rohtak had the highest waterlogged area in central Haryana. Waterlogged had been observed in the western and southwestern parts of Rohtak. The common area of waterlogged in both years (1995 and 2010) was 8,603 hectares, whenever there is heavy rainfall, this area will be waterlogged first. Single year (1995/2010) waterlogged was 25,380 hectares in Rohtak [17].

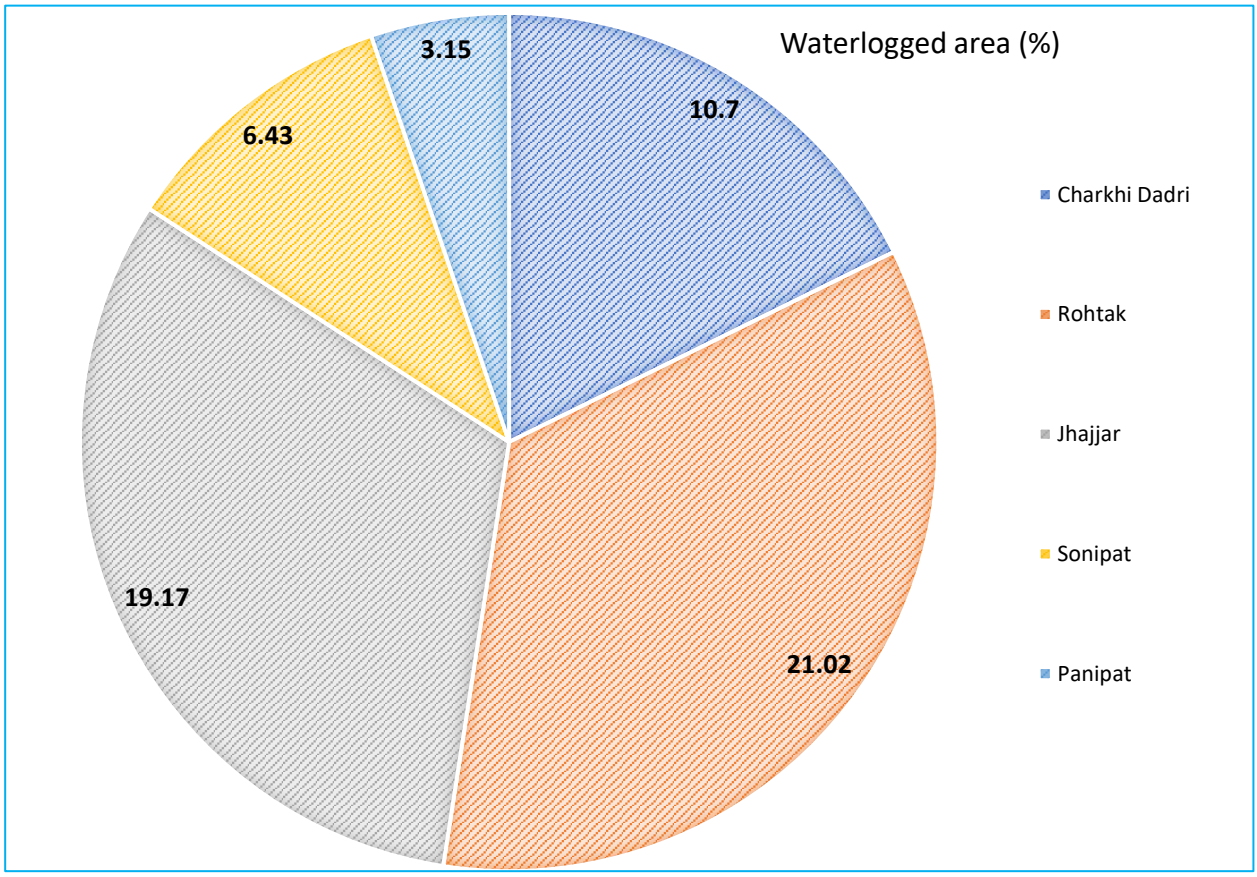

Fig 6 Comparison of waterlogged area in districts

Jhajjar was the second-highest waterlogged area in the north and northwestern parts. Jhajjar district has 1, 79,882 hectares geographical area out of which 34,486 hectares area was waterlogged area, which was about 19.17%. The common area of waterlogged in both years (1995 and 2010) was 9,043 hectares while single year (1995/2010) waterlogged was 25,442 hectares in Jhajjar. Waterlogged areas were more concentrated in the western part of Sonipat this was about 6.43%. The common area waterlogged in both years (1995 and 2010) was 1,344 hectares while the single year (1995/2010) waterlogged was 12,253 hectares in Sonipat.

The common area of waterlogged in both years (1995 and 2010) was 815 hectares, while the single year (1995/2010) waterlogged was 3,166 hectares in Panipat. Water logging was less in Panipat as compared to other districts. Some areas in the central part of Panipat were waterlogged 3.15%.

CONCLUSION

Central Haryana covers 6 districts which are Bhiwani, Charkhi Dadri, Rohtak, Jhajjar, Sonipat, and Panipat. The geographical area of these 6 districts is 11, 77,111 hectares, out of which 1,10,751 hectares were affected by waterlogging, which was 9.78 % of the total area. Due to increased irrigation facilities, there occurs a water logging problem in central parts of the state. The problem is exaggerated in high rainfall events. The middle area of Central Haryana was more waterlogged, which includes Jhajjar and Rohtak districts, Rohtak had the maximum waterlogged area, which was 21.05%. The waterlogged area was minimal in Panipat (3%). In both years (1995 and 2010) the common waterlogged area was 26,650 hectares and single year (1995/2010) waterlogged area was 84,101 hectares.

LITERATURE CITED

1. Dunin FX. 2002. Integrating agroforestry and perennial pastures to mitigate water logging and secondary salinity. *Agricultural Water Management* 53(1/3): 259-270.
2. Kılıc OM, Budak M, Gunal E, Acır N, Halbac-Cotoara-Zamfir R, Alfarraj S, Ansari MJ. 2022. Soil salinity assessment of a natural pasture using remote sensing techniques in central Anatolia, Turkey. *PLoS One* 17(4): e0266915.

3. Shammi M, Rahman M, Bondad S, Bodrud-Doza M. 2019. Impacts of salinity intrusion in community health: A review of experiences on drinking water sodium from coastal areas of Bangladesh. *Healthcare* 7: 50.
4. den Besten N, Steele-Dunne S, de Jeu R, van der Zaag P. 2021. Towards monitoring waterlogging with remote sensing for sustainable irrigated agriculture. *Remote Sensing* 13(15): 2929.
5. Houk E, Frasier M, Schuck E. 2006. The agricultural impacts of irrigation induced waterlogging and soil salinity in the Arkansas Basin. *Agric. Water Management* 85: 175-183.
6. Valipour M. 2014. Drainage, waterlogging, and salinity. *Arch. Agron. Soil Science* 60: 1625-1640.
7. Pathak PS. 2000. Agro forestry: A tool for arresting land degradation. *Indian Farming* 49(11): 15-19.
8. Dwivedi RS, Sreenivas K. 1998. Delineation of salt-affected soils and waterlogged areas in the Indo-Gangetic plains using IRS-1C LISS-III data. *Int. Jr. Remote Sensing* 19(14): 2739-2751.
9. Mandal AK, Sharma. 2011. Delineation and characterization of waterlogged salt affected soils in IGNP using remote sensing and GIS. *Jr. Indian Soc. Remote Sensing* 39(1): 39-50.
10. Panwar K, Airon A, Kaswan R, Bishnoi KB. 2024. Changing crop pattern in western agroclimatic zone (South Western Parts) of Haryana using geospatial techniques. *Res. Jr. Agril. Sciences* 15(2): 352-356.
11. Jensen JR. 2009. Remote sensing of the environment: An earth resource perspective, 2nd Edition, Pearson education, Inc. Lake Ave, Glenview, IL 60025, U.S.A. 583.
12. Sabins, Floyd F. 2007. *Remote Sensing: Principles and Interpretation*. 3rd Edition, Waveland Press.
13. Kumar S, Kumar G. 2019. Role of geospatial application in waterlogging and salinity assessment: a review. *Our Heritage* 67(1): 1-10.
14. Prajapati GS, Rai PK, Mishra VN, Singh P, Shahi. 2021 AP. Remote sensing-based assessment of waterlogging and soil salinity: A case study from Kerala, India. *Results in Geophysical Sciences* 7: 100024.
15. Kumar S. 2018. Remote sensing and GIS based groundwater prospects and quality assessments in Fatehabad district Haryana. *i-Manager Journal on Future Engineering and Technology* 14(1): 48.
16. Mandal AK, Paron P. 2016. Mapping and characterization of salt-affected and waterlogged soils in the Gangetic plain of central Haryana (India) for reclamation and management. *Cogent Geoscience* 2(1): 1213689.
17. Sushila, Sharma PK. 2021. Waterlogging problem in Central Haryana. *International Journal of Advances in Engineering and Management* 3(3): 910-914.