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RESEARCH ARTICLE

IMPACT OF MONSOON ON WATERLOGGING AND GROUNDWATER QUALITY IN HISAR DISTRICT

Santosh Rani[1]*, Mukesh Kumar[1], Kapil Rohilla[2], Naveen Kumar[3], Rajkumar[1] and Baljeet Singh Gaat[1]

1- Department of Soil and Water Engineering, COAE&T, CCSHAU, Hisar – 125004
2- Haryana Space Application Centre, Hisar – 125004
3- Department of Agricultural Engineering, SKNCOA, SKNAU, Jobner - 303329

Email: snjangra94@gmail.com

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Abstract: The study was conducted to assess and map the extent of waterlogging and groundwater quality in Hisar district through Geo-spatial techniques. The maps of water table depth and groundwater quality for pre and post monsoon seasons were generated for the years 2013 to 2018. LANDSAT-8 satellite image was effectively used for determining surface waterlogged area which found to be 7.76 per cent in Hisar district. Analysis of water table depth maps for both pre and post monsoon of Hisar district generated in GIS environment for the years 2013 to 2018 reveals that in post monsoon area (average 0.80 %) under fully waterlogged (< 1.5 m) condition was increased as compared to pre monsoon (average 0.30 %).

Keywords: Geo-spatial techniques, Groundwater quality, Waterlogging, Water table

INTRODUCTION

Waterlogging and salinity are the dual problems which are mainly found in irrigated area of developing countries like India. In India, the area under waterlogging and salt affected land found to be 2.46 and 7.0 million hectares (mha) (Kanga and Singh, 2017). Generally waterlogging is followed by salinization in arid and semi-arid regions. Hence, it is considered as dual problem. Prolonged stagnation of water over the surface or saturation of root zone due to poor drainage and shallow water table causes restriction in air diffusion in the soil and reduced oxygen level leads to waterlogging condition. Waterlogging causes change in cropping pattern which ultimately leads to inefficient use of land. Land becomes partially unavailable for part of the year or fully unavailable throughout the year, leading to overall poor production and performance of agricultural sector. Due to excess of irrigation water in poorly drained areas, waterlogging and secondary salinization appeared and caused losses in productivity for rice (42%), wheat (38%) and sugarcane (61%) crops (Samra *et al.*, 2006).

Haryana state is situated in the middle of the flat, topographically featureless, Trans-Gangetic alluvial plain. In this plain, drainage systems to manage groundwater tables are almost absent. Thick calcareous layers irrigated by canal and tube well in these areas caused secondary soil salinization and waterlogging is caused by thick calcareous layers due to irrigation from canal and tube well (Mandal *et al.*, 2017). The waterlogging and salinity are becoming big problems due to over use of water in rice-wheat cropping system. Therefore, proper management strategies are urgently required to manage salinity and waterlogging. Waterlogging and salinity have adverse effect on the crop and land productivity which occurs mainly due to uprising of salts with water table in root zone (Datta *et al.*, 2002). It is the major factor in land degradation which occurs mainly due to blockage of natural drainage with the construction of transport network (e.g. roads, railway line and other structure) responsible for stagnating monsoon runoff (Goyal *et al.*, 2005). Hence, assessment of rigorousness and extent of the waterlogging and salinity is necessary. Extent of waterlogging is not only determined by field condition but also influenced by the situation of neighbouring area of the site. Thus, mapping of available features of waterlogged and saline area is required in planning and management of the problem. The common tactics of mapping waterlogged area such as ground survey has very limited scope due to high human power and time

*Corresponding Author

required, shortage of data available and costs involved. Further, the problem of waterlogging is dynamic which limits the usefulness of traditional methods for data collection. Remote sensing technology coupled with GIS tools is reliable tool in mapping and analysing different spatial descriptions of the study area. Field data used in conjunction with information derived from satellite images can overcome the limitations of traditional approach of survey due to less time, cost and high effectiveness.

MATERIALS AND METHODS

The study was conducted for Hisar district which is located in west central part of Haryana and lies in semi-arid region between latitude 28º 56'00"N to 29º 38'30" N and longitude 75º 21'12"E to 76º 18'12" E having mean maximum temperature 43˚C (May & June) and mean minimum temperature 5˚C (January). The area is mainly irrigated by shallow tubewells, network of Bhakhra and Western Yamuna Canal Systems. The net irrigated area in Hisar district is 272000 ha out of which 63000 ha is irrigated with tubewells/borewells (Anonymous 2013).

In the study area, to assess the extent of subsurface waterlogging and groundwater quality fluctuations, data on water table depth maps and groundwater quality for pre and post monsoon from 2013 to 2018 were attached into ArcMap to create point features and interpolated using Inverse Distance Weighted (IDW). This interpolation method follows the concepts of proximity to Thiessen polygons with gradual change of the trend surface. Maps of subsurface waterlogging were classified using reclassify tool in the ranges, fully waterlogged (depth < 1.5 m), waterlogged (1.5-3 m), potentially waterlogged (3-10 m) and safe (> 10 m) (Paliwal, 2017). Similarly, groundwater quality classified into four different regions i.e. good (0 - 2 dS/m), marginally saline (2 - 4 dS/m), saline (4 - 8 dS/m) and highly saline (>8 dS/m) (Paudyal *et al*., 2016).

LANDSAT-8 satellite data (Table 1) was used to delineate surface waterlogged area. Layer stacking and mosaicking of the collected images was performed and it was clipped to the district boundary in order to obtain the final False Colour Composite (FCC) (Red, Green and Near Infrared) image (spatial coordinate system World Geodetic System (WGS) 1984 UTM 43N projection was used). The image was visually analysed to identify surface waterlogged area according to shape, size, texture, tone and association in Hisar district. The dark blue to blackish red mixed tone with irregular shape and coarse with mottled texture were considered as surface waterlogged area and digitized manually on standard FCC image. Dark black tone within regular shape was considered as water bodies and not digitized as surface waterlogged area.

RESULTS AND DISCUSSION

Subsurface Waterlogging

The groundwater data reveals that the average water table depth in whole district during pre-monsoon was 7.73, 7.55, 7.81, 7.94, 7.67 and 7.74 m in June 2013, 2014, 2015, 2016, 2017 and 2018, respectively whereas during post-monsoon, it was 7.29, 7.56, 7.61, 7.65 and 7.64 m in October 2013, 2014, 2015, 2016 and 2017, respectively. The extent of subsurface waterlogged area for both pre and post monsoon seasons (2013-18) was assessed and mapped as critical areas in term of ground water level near to ground surface (< 1.5 m) as shown in figures 1 and 2, respectively. The maximum area covers under the water table depth 3.0 - 10.0 m. In the pre monsoon, area under fully waterlogged condition was estimated as 3.92, 18.03, 12.29, 5.56, 23.68 and 9.92 km^2 in June 2013, 2014, 2015, 2016, 2017 and 2018, respectively while in post monsoon, area under fully waterlogged condition was found to be 44.53, 25.31, 20.04, 24.04 and 47.83 km^2 in October 2013, 2014, 2015, 2016 and 2017, respectively. This reveals that in post monsoon season waterlogged area under shallow water table depth increases as compared to pre monsoon. The change in area under shallow water table depth is clearly visible in figure 1 and 2. Likewise the area under safe zone in pre monsoon estimated 809.23, 814.86, 881.18, 1010.36, 1011.85 and 1121.39 km^2 in June 2013, 2014, 2015, 2016, 2017 and 2018, respectively while in post monsoon area found to be 737.22, 840.79, 999.45, 958.76 and 966.57 km^2 in October 2013, 2014, 2015, 2016 and 2017, respectively. The area under different water table depth (0-1.5, 1.5-3.0, 3.0-10.0 and > 10.0 m) for pre and post monsoon is presented in table 2. The villages which mainly come under shallow water table depth (<1.5 m) are Sorkhi, Sisar, Mohla, Puthi, Kumba (South-East of Hisar), Mirka, Satrod Kalan, Satrod Kurd, Dhani Raipur, Kaimri (centre of Hisar district), Ghirai, Garhi, Dhani Mirdad, Matloda and Rajli (South of Hisar district).

Groundwater Quality

The ground water quality maps of Hisar district during pre and post monsoon season are shown in figure 3 and 4, respectively. It was found that the average groundwater quality in whole district was 2.96, 3.04, 3.17, 3.25, 3.35 and 3.34 dS/m in June 2013, 2014, 2015, 2016, 2017 and 2018, respectively whereas during post-monsoon, it was 2.86, 3.11, 3.17, 3.27, 3.18 and 3.34 dS/m in October 2013, 2014, 2015, 2016, 2017 and 2018, respectively. Analysing groundwater quality fluctuations in study area (electrical conductivity (EC)), it was observed that the maximum area of Hisar district covers groundwater quality 2.0-4.0 dS/m. In pre monsoon season, area under highly saline (> 8.0 dS/m) category was estimated to be 29.56, 26.16, 27.39, 29.41, 30.67 and 31.60 km^2 in June 2013, 2014, 2015, 2016, 2017 and 2018, respectively. While in post monsoon, area under highly saline (> 8.0 dS/m) category was observed to be 27.35, 26.62, 27.88, 29.70, 25.12 and 32.26 km^2 in October 2013, 2014, 2015, 2016 and 2017, respectively.

There is only small variation in area of highly saline category for both pre and post monsoon in the Hisar district. The patch of highly saline area is found in the same regions for pre and post monsoon of the district as shown in figures 3 and 4. From table 3, it is observed that area under saline category (4.0 - 8.0 dS/m) increased from 2013 to 2015 and afterward it is almost stabilized. Similarly, area under good quality (0 - 2.0 dS/m) was in decreasing trend for both pre and post monsoon but for the year 2017, there was sudden increase in area under this category. The villages in Hisar district mainly Dhani Raipur, Ludas, Kamari (centre of Hisar district), Durjanpur P/T, Landhari P/T (North of Hisar district) comes under highly saline categories.

Surface Waterlogged Area

This was revealed that Hisar district faces both surface and subsurface waterlogging problem. The surface waterlogged area was found maximum in central and south-eastern part comprising nearly 7.76 percent (315.30 km²) of the total area, indicates severe problem of waterlogging during *rabi* season as shown in figure 5. In FCC image, surface waterlogged area was easily identified as dark blue to blackish red mixed tone (higher absorption of electromagnetic radiation in visible and near infrared band), irregular in shape and coarse with mottled in texture. The standing surface waterlogged area reveals as dark blue to black in tone depending on the water depth that is in small proportion as compared to blackish red mixed tone which was identified as waterlogged area (also verified from water table depth maps of 2017) with supportive active growth of aquatic crops.

CONCLUSION

Analysis of water table depth maps for both pre and post monsoon of Hisar district generated in GIS environment for the years 2013 to 2018 reveals that in post monsoon area (average 0.80 %) under fully waterlogged (< 1.5 m) condition was increased as compared to pre monsoon (average 0.30 %). The area under highly saline ground water increased in the recent years. LANDSAT-8 satellite image was effectively used for determining surface waterlogged area which found to be 7.76 percent in Hisar district.

Table 1: Detail of specification of satellite data

Satellite	Sensor	Spectral Resolution (µm)	Spatial Resolution	Path No.	Row No.
LANDSAT-8	Operational Land Imager	Band 3: 0.533 - 0.590 Band 4: 0.636 – 0.673 Band 5: 0.851 – 0.879	30 m	147	40

Table 2: Area distribution under different water table depth categories in Hisar district during 2013-18

Year	Pre and Post monsoon	Area under different water table depth (km^2)			
		0-1.5 m	1.5-3.0 m	3.0-10.0 m	> 10.0 m
2013	June	3.92	123.57	3125.33	809.23
	October	44.53	338.73	2,941.21	737.22
2014	June	18.03	305.75	2922.85	814.86
	October	25.31	298.38	2,897.26	840.79
2015	June	12.29	227.81	2940.65	881.18
	October	20.04	266.64	2,775.26	999.45
2016	June	5.56	200.24	2845.61	1010.36
	October	24.04	294.85	2,784.16	958.76
2017	June	23.68	331.64	2694.82	1011.85
	October	47.83	376.98	2,670.55	966.57
2018	June	9.92	283.57	2646.75	1121.39

Table 3: Spatial distribution of groundwater quality in Hisar district during 2013-18

Year	Pre and Post monsoon	Area under different groundwater quality (km^2)			
		0-2.0 dS/m	2.0-4.0 dS/m	4.0-8.0 dS/m	> 8.0 dS/m
2013	June	753.28	2711.59	568.46	29.56
	October	806.52	2685.51	541.96	27.35
2014	June	439.57	3043.68	551.71	26.16
	October	334.37	3106.30	594.28	26.62
2015	June	258.32	3136.62	639.35	27.39
	October	207.89	3172.96	653.07	27.88
2016	June	188.92	3119.68	723.65	29.41
	October	186.93	3116.27	729.35	29.70
2017	June	193.11	3003.88	834.27	30.67
	October	328.45	3022.96	685.20	25.12
2018	June	201.54	2966.28	862.08	31.60
	October	201.76	2955.03	872.58	32.26

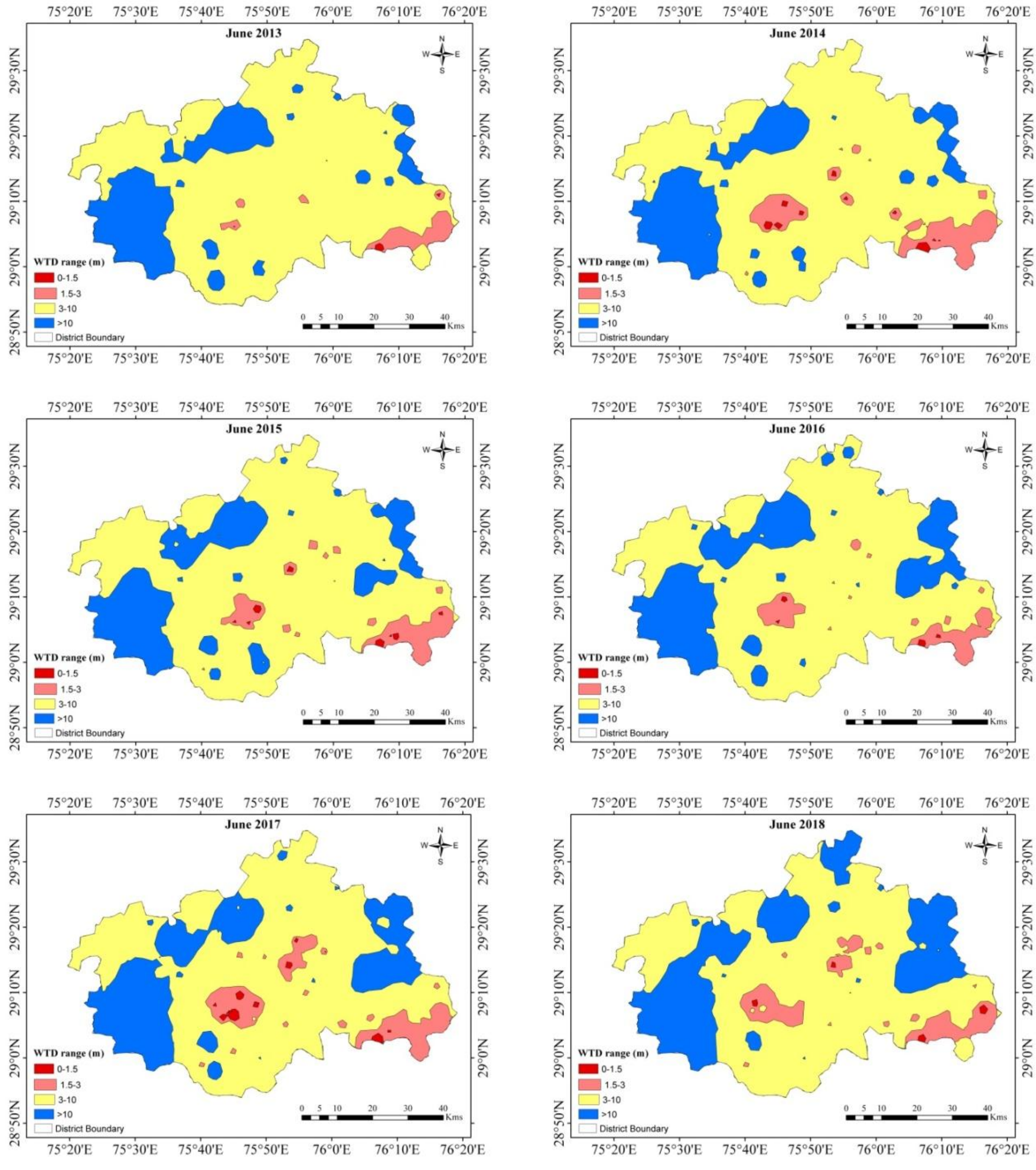


Figure 1: Water table depth maps of Hisar district for Pre-Monsoon (2013-2018)

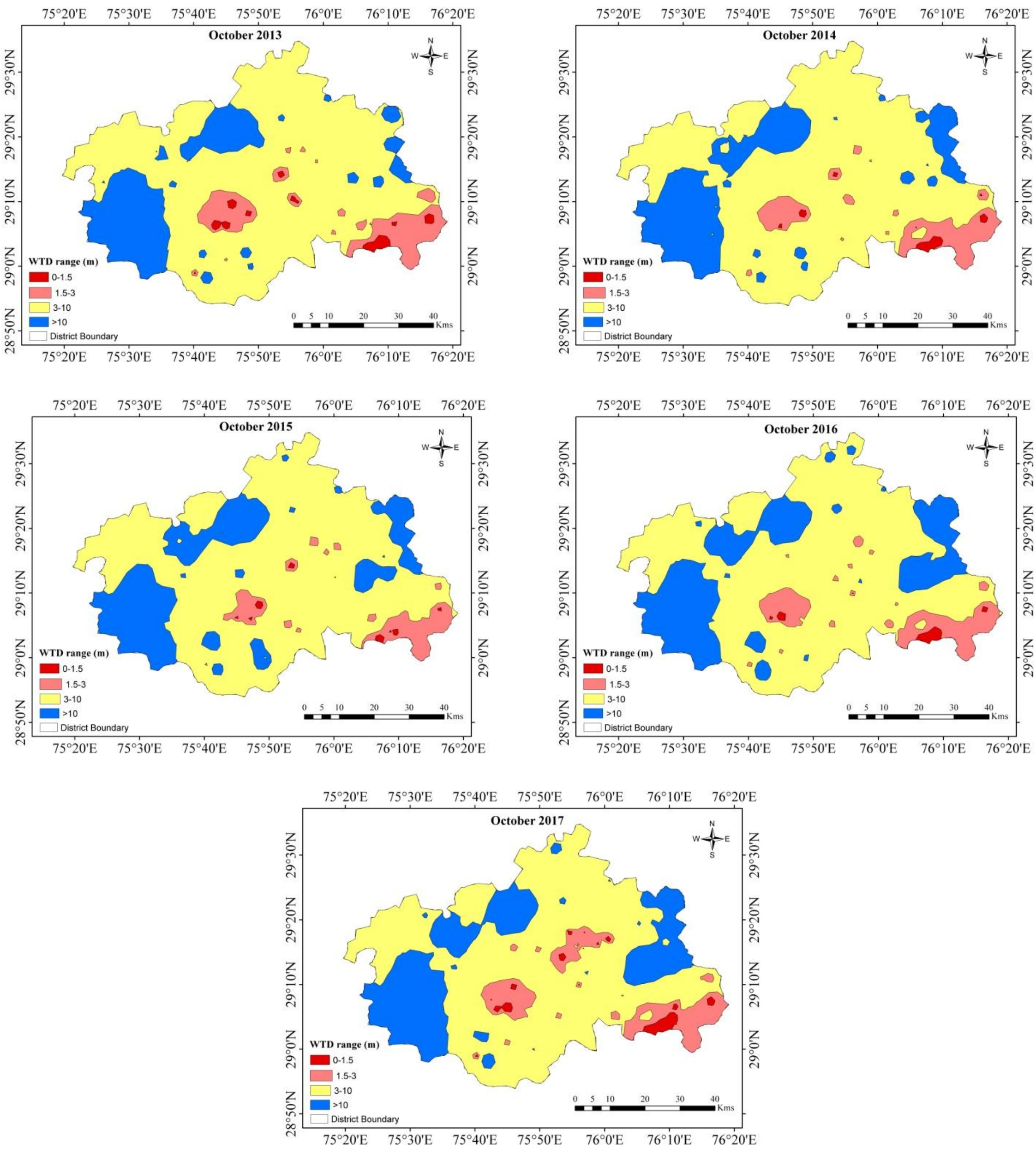
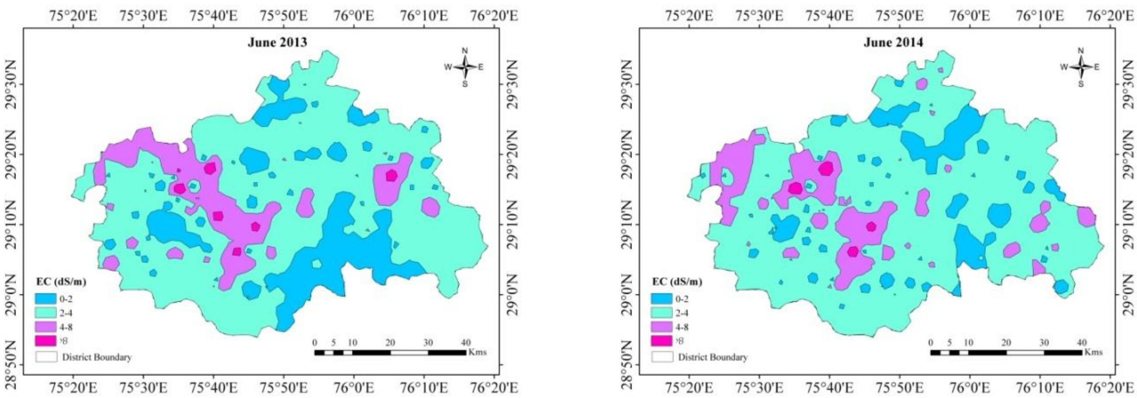


Figure 2: Water table depth maps of Hisar district for Post-Monsoon (2013-2017)



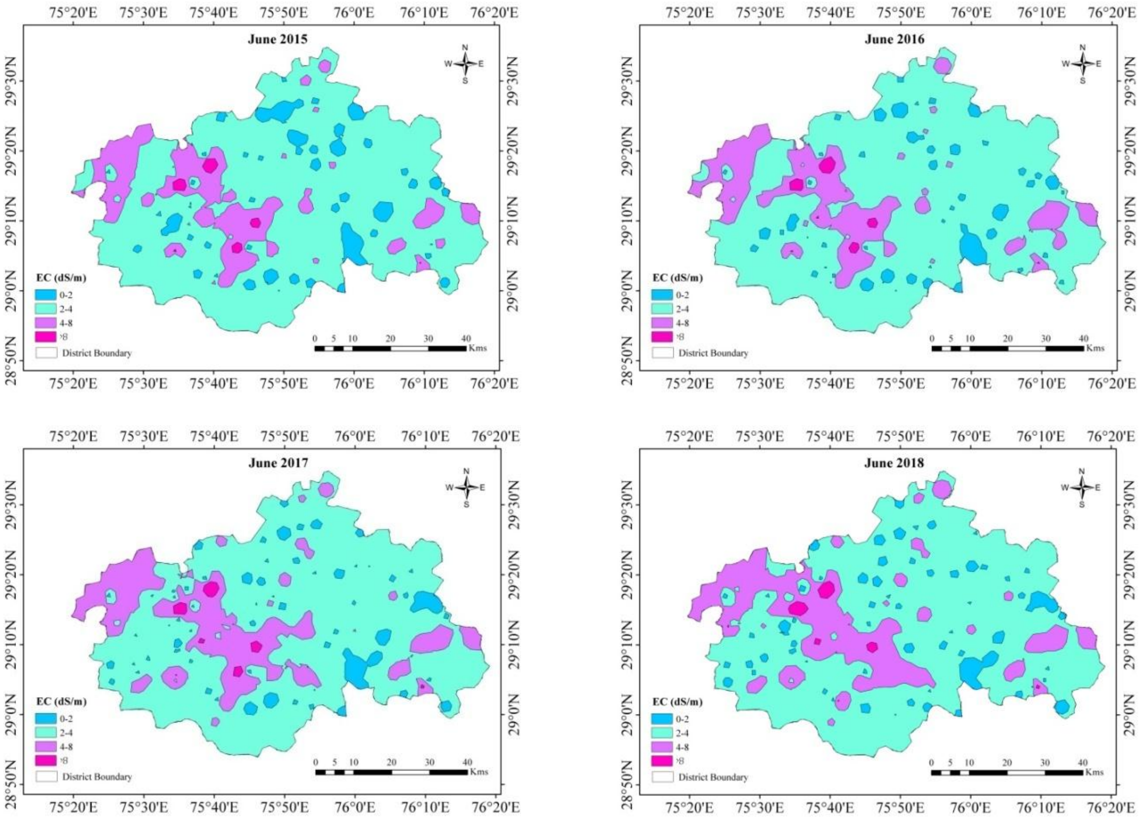
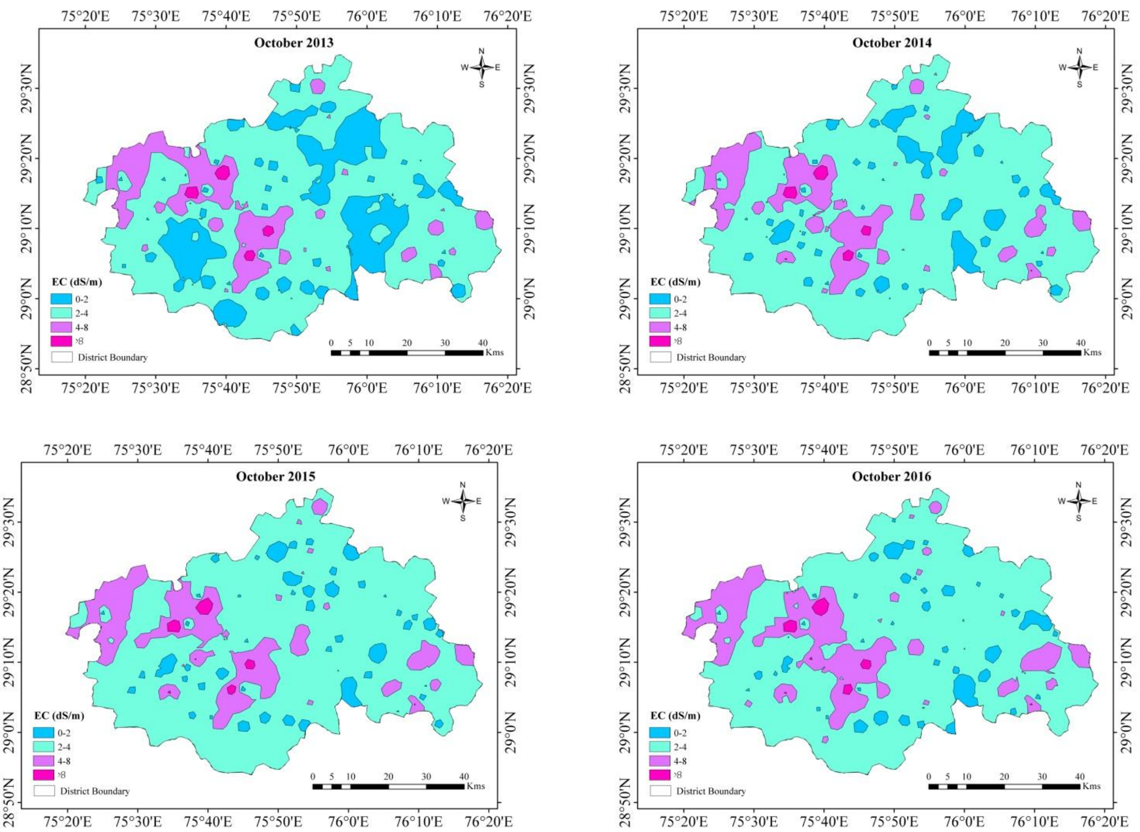


Figure 3: Groundwater quality maps of Hisar district for Pre-Monsoon (2013-18)



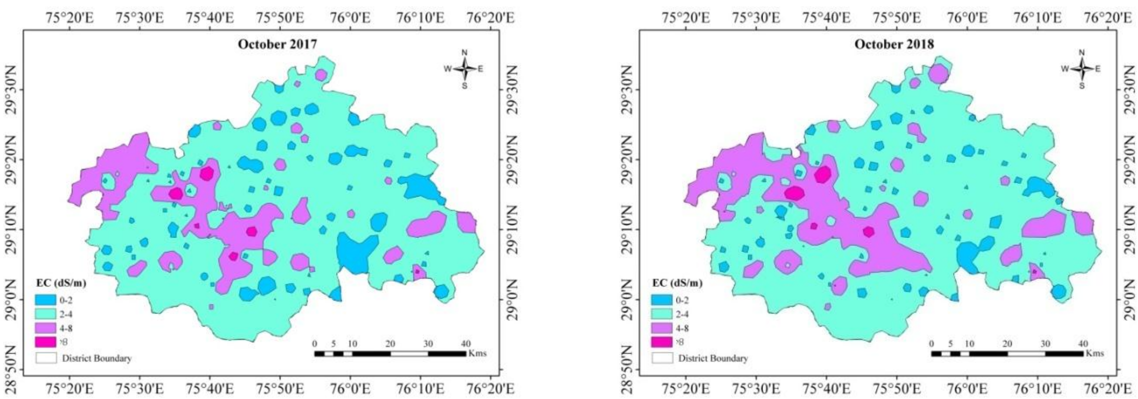


Figure 4: Groundwater quality maps of Hisar district for Post-Monsoon (2013-18)

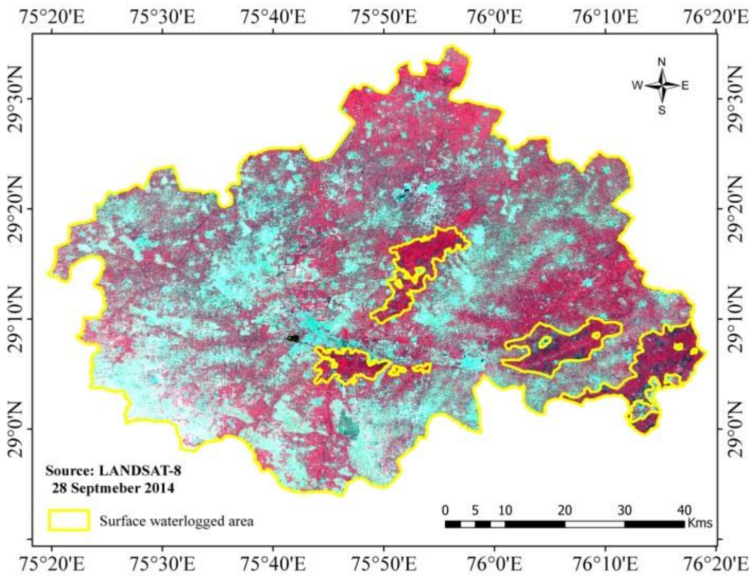


Figure 5: Surface waterlogged area in Hisar district delineated using LANDSAT-8 satellite data of 28th September 2014

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REFERENCES

Anonymous (2013). Ground water information booklet**,** Hisar district, Haryana. Central Ground Water Board, North-western region, Ministry of Water Resources, Government of India.

Google Scholar

Datta, K. K. and De Jong, C. (2002). Adverse effect of waterlogging and soil salinity on crop and land productivity in northwest region of Haryana, India. *Agricultural Water Management*, **57**(3), 223-238.

Google Scholar

Goyal, V. C., Jain, S. K. and Pareek, N. (2005). Water logging and drainage assessment in Ravi-Tawi irrigation command (J&K) using remote sensing approach. *Journal of the Indian society of remote sensing*, **33**(1), 7.

Google Scholar

Kanga, S. and Singh, S. K. (2017). Mapping of salt affected and waterlogged areas using geospatial technique. *Int. J. Recent Innov. Trends Comput. Commun*, **5**, 1298-1305.

Google Scholar

Mandal, A. K., Singh, R. and d K, S. (2017). Mapping and characterization of salt affected soils for reclamation and management: A Case Study from the Trans-Gangetic plains of India. In *Sustainable*

Management of Land Resources (pp. 145-173). Apple Academic Press.

Google Scholar

Paliwal, B. S. (2017). Global ground water resource and management. Scientific Publishers, 520.

Google Scholar

Paudyal, K., Jhorar, R. K. and Kumar, K. M. (2016). An approach for mapping and management strategies of waterlogged areas using Geo-spatial technique. *International Journal on Intelligent Electronic Systems*, **10**(2).

Google Scholar

Samra, J.S., Singh, G. and Ramakrishna, Y.S. (2006). Drought management strategies in India. ICAR, New Delhi, p. 277.

Google Scholar