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Delineation of ground water table zones in the Tarai belt of North - West Uttar Pradesh using remotely sensed data and their relationship with soils

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Abstract
The Tarai belt of North - West Uttar Pradesh is being intensively used for agriculture and is known for high water table conditions. The need of ground water table and soil information is of much importance in crop selection, field management and in providing an efficient drainage system. To harvest ground water judiciously, it is important to find out different ground water table zones for their utilization in a planned and scientific manner. Recently, remote sensing has emerged as a powerful modern technology for the survey, assessment and monitoring of the natural resources.

Keeping it in view, the present study was undertaken to identify different water table zones in the Tarai area of Udham Singh Nagar district using remote sensing data. By superimposing the soil map with ground water table depth information, a total of four soil cum ground water table associations were identified. These are (i). water table within 1.4 m from ground surface with poorly drained clay loam soils, (ii). water table depth between 1.4 m and 3.0 m with imperfectly drained silty clay loam soils, (iii). water table between 3.0 m and 3.5 m with moderately well drained loamy soils, and (iv). water table depth more than 3.5 m from ground surface with well drained sandy loam soils. It was found that ground water table remained shallow in heavy textured soils due to local physiography and poor profile drainage as compared to light textured soils. It reveals that IRS - LISS II F.C.C. data are quite useful in delineation of ground water table zones with thematic information. Shallow ground water table zones are found associated with heavy textured soils where as light textured soils are associated with deep water.

INTRODUCTION

The *Tarai* belt is intensively being used for agriculture. It has high water table zone. High water table is one of the main factors that restricts rooting depth of the plant and causes damage to the standing crops. The need of ground water table and soil information is of much importance in crop selection, field management and in provi-ding an efficient drainage system. To harvest ground water judiciously, it is important to find out different ground water table zones for their utilization in a planned and scientific manner. Recently, remote sensing has emerged as a powerful modern technology for the survey, assessment and monitoring of the natural resources. Data provided by remote sensing represents a new measuring technique in hydrology. Investigation units,the potential application of remotely sensed data to water -resources studies, was a phenomena of the 1960's, especially the latter half of the 1960's. A large proportion of the published data either fits into the qualitative observational category of data utilization or deals with the future possibilities for data use, rather than direct problems met and answered. On the other hand, each year brings increased knowledge of methods for applying remote sensing techniques to water resources studies, and the rate at which concrete results are being obtained seems to be accelerating.

At present there are atleast three broad categories for utilization of remotely sensed data in hydrologic studies. In the first category, simple qualitative observations are made. A visual observation that water from factory effluent into a stream has a different colour than the stream water, would be an example. In the second category, geometric form, dimensions, pattern, geographic location, and distribu-tion are the types of information sought. Area, shape, length, as well as man made features, such as the location of wells, respresent information recorded. The quantitative analysis of a drainage basin and channel network, and geographic locations of fractures, faults etc., would fall into this category. Remotely sensed data often can be used to detect and map such features for better and more quickly than through ground - based methods. In the third category, correlations are made between point measurements on the ground and some property of the remotely sensed data, such as the density level of some selected spectral band or the difference in the density level between two spectral bands. The distribution of this density level or difference in density levels then provides a means of extrapolating the ground data in space and (or) time. Remotely sensed data with ancillary / thematic information are found quite reliable in revealing hydrological condition of a region. For instance, the density difference between several spectral bands on multispectral data permits water depth to be mapped. Krischner *et al.* (1978) found that soils with high reflectance corresponded to the moderately well drained classes where as those with the low reflectance represented the poorly drained soils. According to Sinha (1987), the soil reflectance varies with particle size distribution in field conditions. Mathur (1992) reported that the water table was deep in light textured soils as compared to heavy textured soils.

Proper inventory of soil and water resources is must for their judicious utilization to meet the increased food requirement. Soil and land use classification provides basic information required in solving agronomic, economic and engineering problems for command area developement. The collection of information and thereby developement of an optimal planning strategy by conventional methods is a tedious and time consuming task.

Remote sensing enables faster and accurate land use mapping of basin or a region. The remote sensing has proved to be the most efficient economical and reliable technique to prepare a comprehensive inventory of the natural soil resources and land use pattern of an area. Sahai (1983) has used the remote sensing technique for the study of soils and land use in semi arid areas. Shanware *et al.* (1985) and Natrajan *et al.* (1986) studied land use pattern in Sikar district of Rajasthan and Mewat area of Gurgaon district in Haryana. Sharma *et al.* (1992) delineated the soils in Bhabar and Tarai zones of western Uttar Pradesh using IRS data. Varma *et al.* (1995) used remote sensing data for soil survey and agricultural land evaluation in a part of Behgul river catchment.

THE STUDY AREA

University Farm of G.B.Pant University of Agriculture and Technology, Pantnagar, which lies in *Tarai* belt of Udham Singh Nagar district, has been selected for the present study. The farm area extends almost rectangularly measuring about 12 km East - West and almost 5 km North - South. The total University Farm is spread over an area of 57.5 km^2 and is located between 28^{0}59' to 29^0 03' N latitude and 79^0 23' to79^0 30' E longitude in the Tarai belt as shown in Fig. 1.The climate of the area is subtropical humid marked by extreme winter and very hot summer. The maximum temperature reaches occasionally beyond 46^{0}C. The annual rainfall ranges from 1140 mm to 1900 mm.

MATERIALS AND METHODS

IRS -LISS II FCC of bands 2, 3 and 4 combination on 1:50000 scale geocoded data of premonsoon period were acquired for detection of ground water table zones in association with soils. The imageries were visually interpreted on light table. Detailed soil map was superimposed with information of ground water table depth to find out the relationship. The boundaries delineated from imagery interpretation were superimposed with the ground water table - soil map to identify ground water table zones. Ground water table zones along with soil information were delineated on the basis of tone and texture of the image. The interpretation key along with soil characteristics is given in Table 1.

Table 1. Image characteristics and associated soil properties.

Characteristics	Water Table Depths (cm)	
	Less than 3 m	More than 3 m
1. Image characteristics	Light to moderate bluish gray tone, smooth	Pink to brownish yellow tone, smooth
2. Surface texture	SCL-CL	SL-L
3. Subsurface texture	SCL-SiL	SL-SiL
4. $CaCO_{v3}$3 layer	Present	Absent
5. Drainage	Imperfect to poor	Moderately well to well
6. Infiltration rate	Moderately slow to slow	Moderately high
7. C-horizon (cm)	96 - 100+	127 - 177+
8. Series	Phoolbagh and Beni	Haldi and Patharchatta

CL - Clay Loam, L - Loam, SCL - Sandy Clay Loam, SL - Sandy Loam, SiL - Silty Loam.

RESULTS AND DISCUSSION

By visual interpretation two distinct colours/ tones with texture were delineated on the imageries of university farm. Superimposing these boundaries with the information of ground water table (Fig.2), two zones were identified, viz. (i). area with ground water table less than 3 m from the surface and (ii). ground water table more than 3 m from the surface.

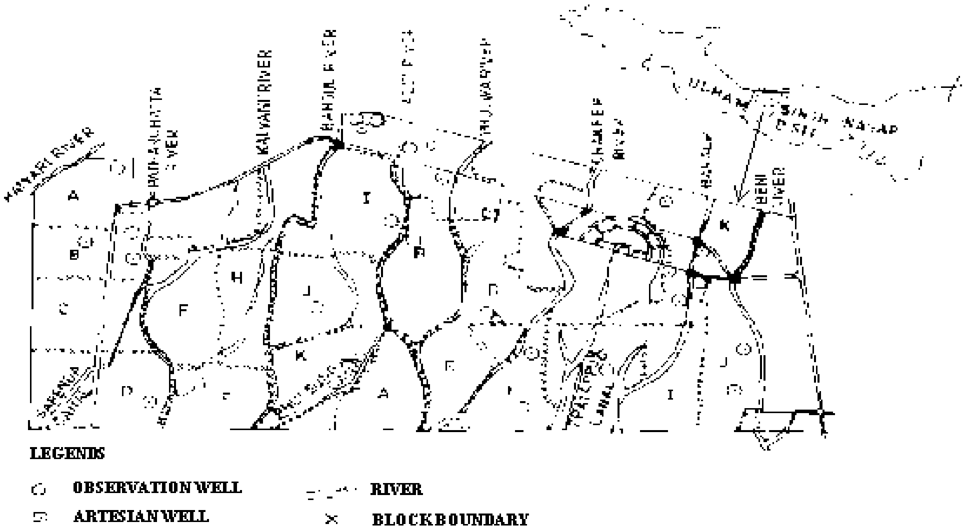

Figure 1. Index map of the study area.

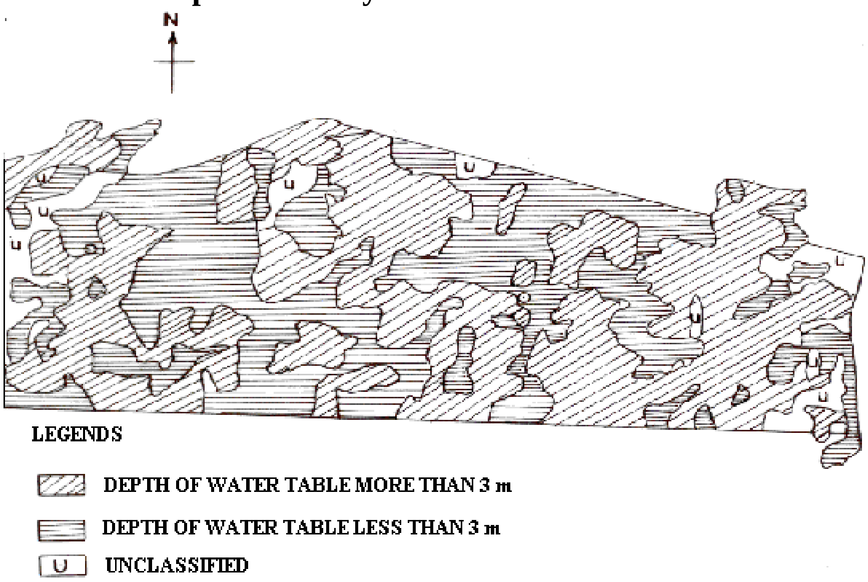

Figure 2. Ground water table map of University Farm based on visual interpretation.

By relating these zones with soil information, it was found that area of ground water table with less than 3 m depth from surface were associated with heavy textured and imperfectly to poorly drained soils whereas the areas with the ground water table depth of more than 3 m from surface were associated with the light textured moderately well to well drained soils. The image characteristics and associated soil information are given in Table 1.

By superimposing the soil map with ground water table depth information, a total of four soil cum ground water table associations were identified (Table 2). These were (i). water table with in 1.4 m from ground surfce with poorly drained clay loam soils, (ii). water table depth between 1.4 m and 3.0 m with imperfectly drained sility clay loam soils, (iii). water table between 3.0 and 3.5 m with moderately well drained loamy soils and (iv). water table depth more than 3.5 m from ground surface with well drained sandy loam soils. It was found that ground water table remained shallow in heavy textured soils due to local physiography and poor profile drainage as compared to light textured soils. Sharma and Sharma (1993) reported that in Tarai belt of Nainital district where water table remained less than 1 meter below the surface, the soils were poor and imperfect in drainage and heavier in texture. In comparison, the areas with water table more than 1 meter deep from the surface, had moderately well to well drained soils with relatively lighter textures. Similar results were reported by Krischner (1978) and Mathur and Tripath (1992).

Table 2. Water table depth and associated soil characteristics.

Soil Characsteristics	Water table depths			
	< 1.4 m	1.4-3.0 m	3.0-3.5m	> 3.5 m
1. Drainage	Poor	Imperfect	Moderately well	Well
2. Infiltration rate	Slow	Moderately slow	Moderately high	Moderately high
3. Slope (%)	0-1	0-1	0-1	1-3
4. $CaCO_3$ layer at soil depth	48-96	75-100+	nil	nil
5. Surface texture	CL	SCL	L	SL
6. Subsurface texture	SiL	SCL	SiL	SL
7. Soil Depth (cm)	96+	100+	177+	127+
8. pH (surface)	7.8	7.4	7.4	6.9
9. % O.C.(surface)	3.15	2.31	2.25	2.05
10. Soil Colour (surface)	10 YR 4/2	10 YR 3/3	10 YR 3/3	10 YR 3/3
11. Series	Phoolbagh	Beni	Haldi	Patharchatta
12. Taxonomic class (sub group)	Typic Haplaquoll	Aquic Hapludoll	Typic Hapludoll	Typic Hapludoll

Cl - Clay Loam, L - Loam, SCL - Sandy Clay Loam, SL - Sandy Loam, SiL - Silty Loam

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