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IDENTIFYING THE IMPACT OF LANDUSE / LAND COVER ON GROUNDWATER USING GIS: CASE STUDY OF KANPUR CITY, UTTAR PRADESH

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ABSTRACT

Groundwater is the most essential resource on the planet Earth because water in other sources is not available everywhere and the groundwater is the only source of water that is present almost everywhere. Groundwater is very much affected by the land use land cover as wherever there is buildings or built-up land the groundwater level is declining very fast because in the built-up area there is very little or no space left for the groundwater recharge. Open space or the arable land provide spaces for groundwater recharge. The reason behind this declining water level is that the groundwater is not recharging at the rate it should be recharged to maintain the water table of an area. The study is made in the Kanpur city and it was found that the land use land cover pattern affects the groundwater level. So, groundwater level is greatly affected by the change in land use / land cover pattern. Near River Ganga where there is build-up area there is decline in water level whereas there is arable land that is cropland the groundwater level is more than 20 meters even when the rock type and soil type is same.

Keywords: *Groundwater, Land use/ land cover, GIS, Groundwater recharge, Groundwater potential zone.*

INTRODUCTION

Over the past 250 years more than half the global land that is free from ice has been directly or indirectly modified by activities of human, mainly by converting huge forest land to agricultural use as arable land which is about 70% and pasture land which is about 30%. These changes in land use pattern can ultimately be attributed to growth in population and increasing food demand. Up to about 1950 the rate of conversion was higher than the rate of population growth, and occurred mainly in Asia, Europe, and North America. In India also the Land use / Land cover pattern is greatly changing after the independence due to the increased rate in urbanization. This urbanization results in decline rate of groundwater in most of the city areas of India

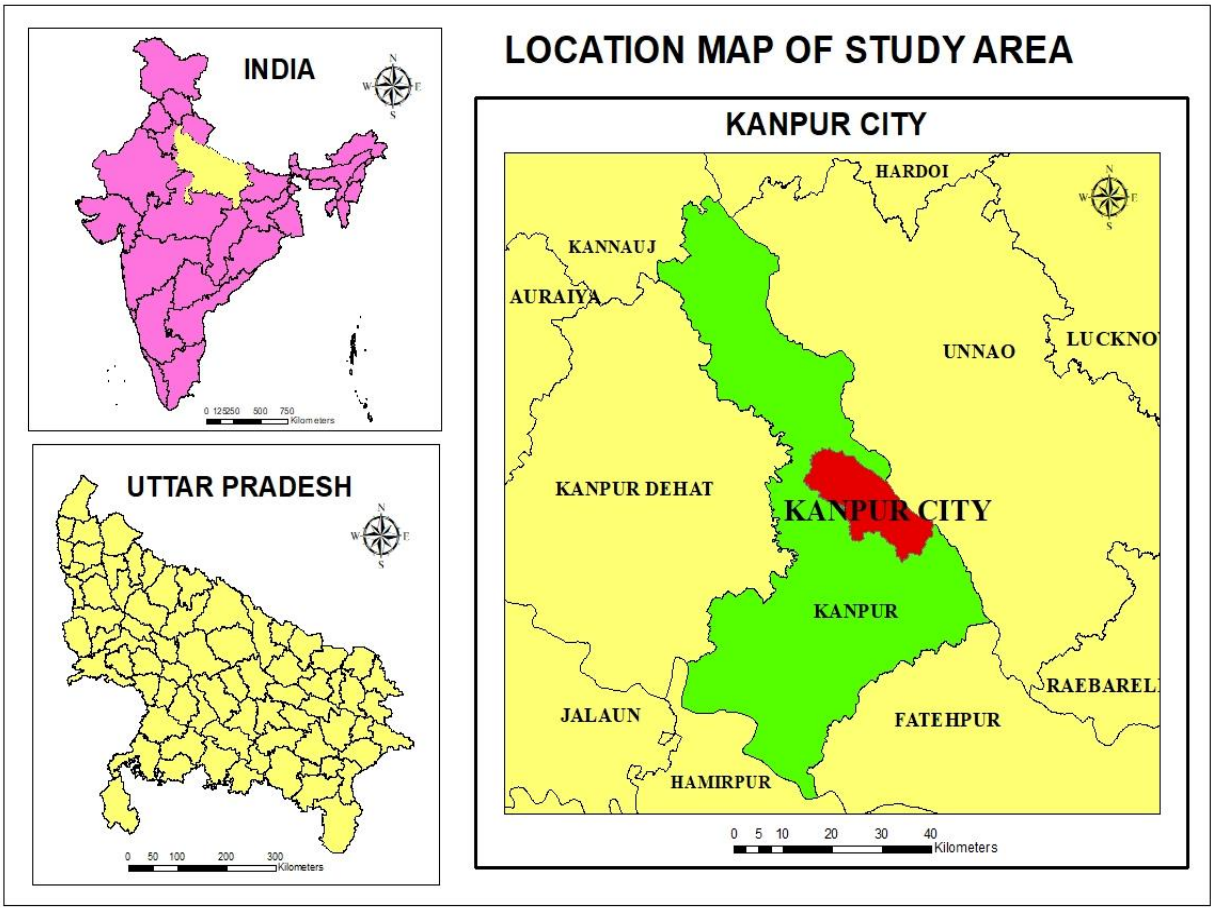
because most groundwater originates directly from excess rainfall infiltrating the earth surface. Thus, land use has a major influence on both groundwater quality and recharge rates. Different land-use practices leave distinctive signatures on the quality of groundwater recharge and, in some instances, result in diffuse groundwater pollution, irrespective of climatic conditions. Similarly, land-use practices influence groundwater recharge rates, especially under more arid conditions. Given the large storage capacity of most aquifer systems, groundwater response to land-use impacts will usually be gradual and often delayed. Moreover, groundwater quality degradation, once it has occurred, is likely to be long-lived and costly to remediate.

STUDY AREA

The Kanpur city lies in middle of Uttar Pradesh State. It lies between 25°55' and 27° North latitude and 79°30' and 80°35' East. Major part of the city falls into Toposheet No. 63B/07 and some small part of the city falls into 63B/02, 63B/03 and 63B/06 of survey of India topographical sheets on 1:50,000 scale. The total geographical area of the city is 260 km^2 (Metropolis area is 260 km^2 whereas metro area of the city is 403 km^2). This city is in Kalyanpur block. The major part of the area is almost a flat plain with some minor undulations. The Ganga and Yamuna River with their tributaries form the drainage system of the study area.

As per census of 2011 the total population of Kanpur city is 4,581,000. The literacy rate was 79.65 per cent and sex ratio was 862 in 2011.

The average annual rainfall in Kanpur city is 821.9 mm. The climate is sub humid and it is characterized by hot summer and general dryness except in the south west monsoon. May and early part of June constitute the hottest part of the year. The mean daily maximum temperature of the city in May is 41.70° C. About 90% of rainfall takes place from third week of June to September. Surplus water is available to deep percolation to ground water during monsoon season. 27.20° C is the mean daily minimum temperature is and maximum temperature rises up to 450° C or over. With the onset of the monsoon in June the day temperature drops down appreciably. The January is the coldest month with mean daily maximum temperature at 22.80° C and mean daily minimum temperature at 8.60° C. The mean monthly maximum temperature is 32.20° C and mean monthly minimum temperature is 19.50° C. During monsoon season the relative humidity is high and in summer season, humidity is less. The mean monthly morning relative humidity is 69% and mean monthly relative humidity is 50%. The winds are generally light with some strength in force during summer and early monsoon season.

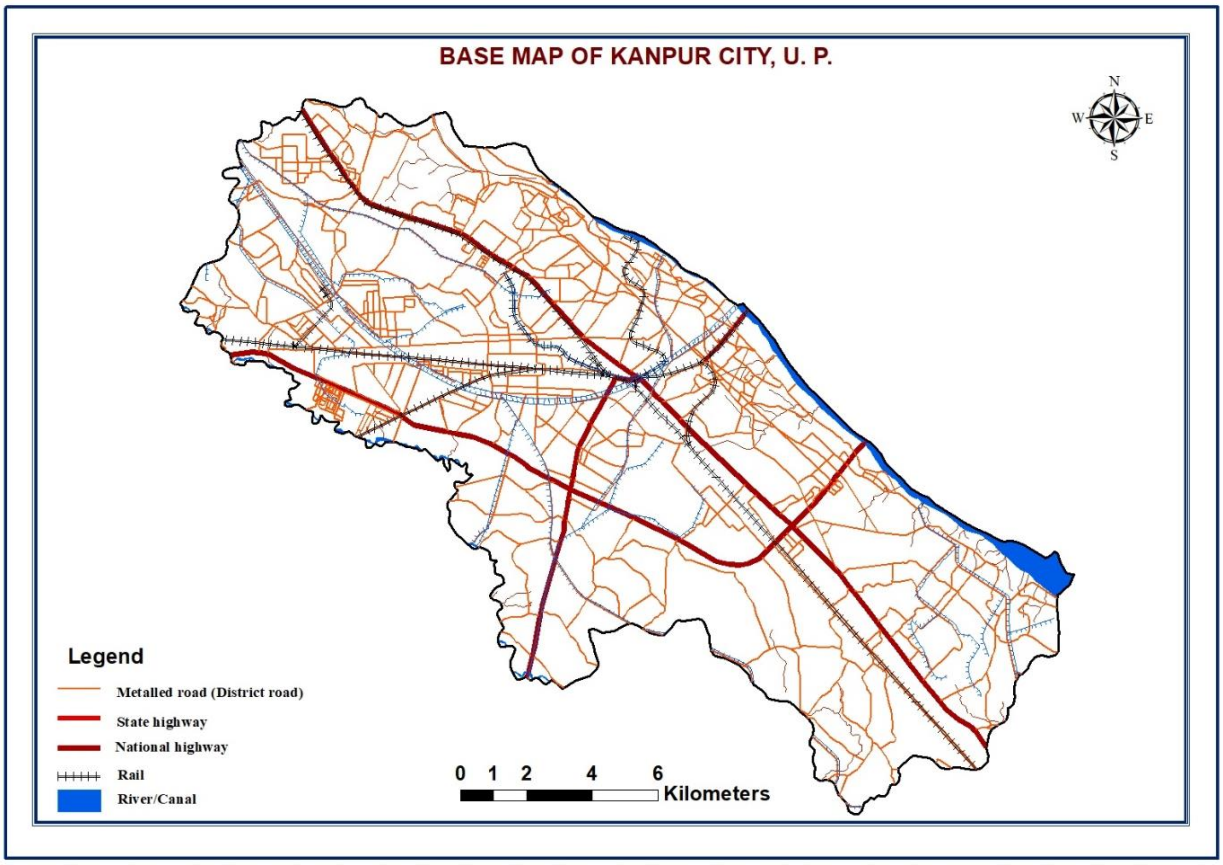


METHODOLOGY

DATA USED:

In the following study listed data are used

- Topographical sheets of Survey of India to prepare Base map and drainage map of the study area.
- Remote sensing data (IRS 1C, LISS III) to prepare the Land use/ land cover map and Geomorphology map.
- Geological maps of Geological Survey of India are used to prepare Lithology, lineament and Soil maps.
- Status of groundwater development and stressed blocks and water table data is collected from State Groundwater department, U.P. and Central Groundwater department.



Various thematic maps like Lithology, Geomorphology, Land use/cover (LULC), Drainage and water level map were prepared in the GIS environment. The groundwater potential zones were obtained by overlaying all these thematic maps using the spatial analysis tool in ArcGIS 10.5 software. It was validated through ground verification.

PREPARATION OF THEMATIC LAYERS

Thematic maps like Land use/cover (LULC), Lithology, Geomorphology and groundwater level map were prepared in the GIS environment using the various types of data like Remote sensing data (IRS 1C, LISS III) used to prepare the Land use/ land cover map and Geomorphology map, Geological maps of Geological Survey of India are used to prepare Lithology and Soil maps whereas groundwater level maps are prepared from the data collected from State Groundwater department, U.P. and Central Groundwater department like the status of groundwater development and stressed blocks and water table.

RESULT AND DISCUSSION

Various layers are prepared for the analysis. The outcome of the layers prepared are discussed below. Prepared layers are as follows:

1. Lithology & Soil Types
2. Geomorphology
3. Land Use / Land cover
4. Pre-Monsoon Water Level and Post-Monsoon Water Level Map

LITHOLOGY & SOIL TYPES

The Kanpur city is part of Indo-Gangetic Plain. The clay, silt, gravel and sands of different grades are main sedimentary constituents in the study area. The generalized geological succession varies from Upper Pleistocene to Recent and from Lower Pleistocene to Upper Pleistocene having Alluvium Fine Sand and Clays and Older Alluvium Sand of different grades and clay mixed with Kankar respectively as shown in the table. Bundelkhand Granite (Archean), Vindhyan Sandstone (Proterozoic) The older alluvium, alluvial deposit mostly occurring in the central part were deposited during lower to Upper Pleistocene period. The newer alluvium was deposited during Upper Pleistocene to Recent period mostly occurring along the course of rivers. The soil of the district exhibits a great variety of composition and appearance. The major part of the district consists of ordinary soils known locally as Bhur and Sand on ridges, clay or Matiyar in depressions and Loam or Domat in the Plains. The 'Reh' prevails in the clay dominant areas.

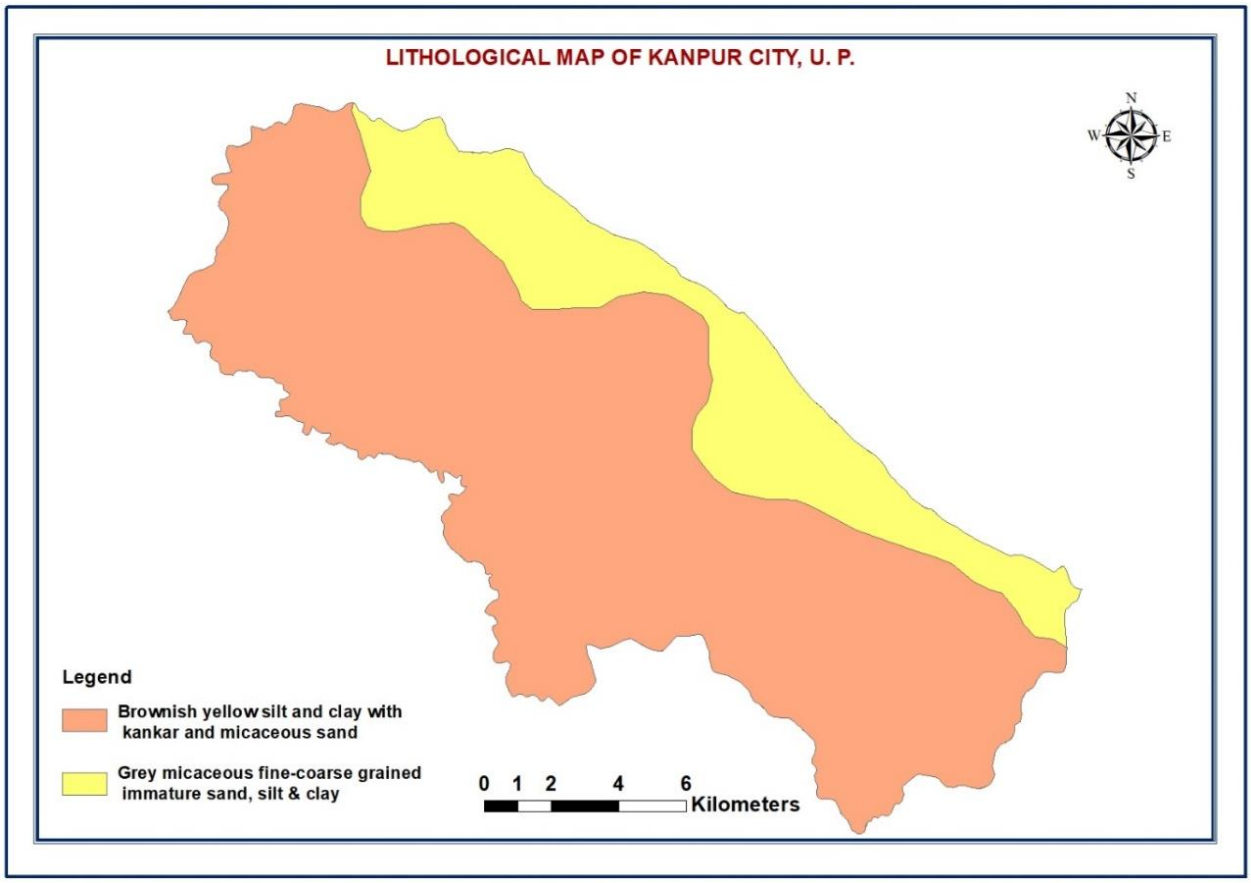


TABLE 2

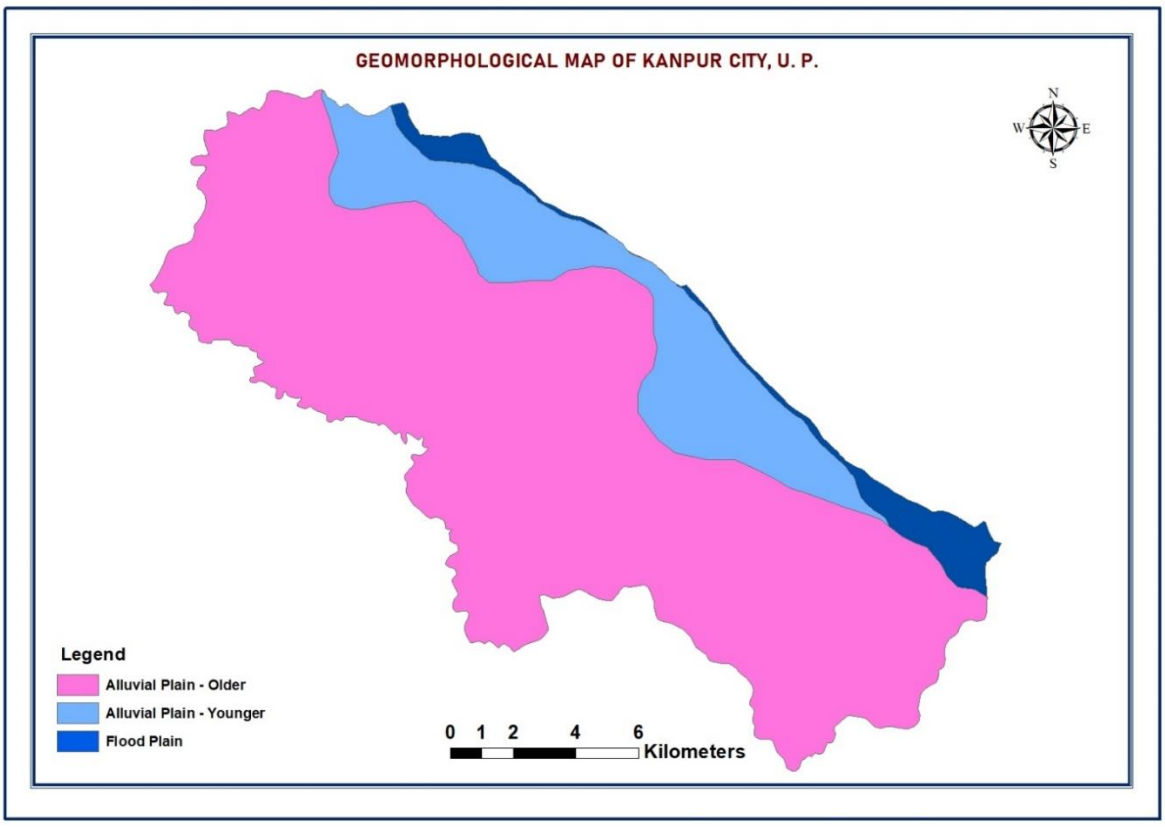
S. NO.	ROCK TYPE	AREA (KM^2)
1.	Brownish yellow silt and clay with kankar and micaceous sand	202.1
2.	Grey micaceous fine-coarse grained immature sand, silt & clay	57.9
	Total	260

GEOMORPHOLOGY

The Kanpur city is part of Indo Gangetic Plain. The silt, gravel, and sands of different grades are main water bearing formations. The ground water occurs 8 under unconfined condition in phreatic zones and under confined condition in deeper zones. The sedimentological constitution of the subsurface granular zones shows remarkable variation in the depth and the nature of occurrence in north and southern part of the district. In southern part specially along Yamuna River, feldspar-quartz, Jaspar sands and gravel (Mourum) are the main constituents of the granular zones that occurs comparatively at shallow levels i.e., 24 to 57 mbgl whereas in the northern parts along the Ganga River, these reworked sedimentary formations are existing at deeper levels i.e., 265 to 310 mbgl. The provenance of these sedimentary formations is mainly Bundelkhand Granite Complex of Archean age and Vindhyan Sandstone of Puranas. In the northern part the silt and clay sediments forming thin lensoid beds are frequently occurring in depth. This decline in water level is due to stress in shallow aquifer. In the city water level has gone down to 36.0 mbgl. The depth to water level at some places like Defence Colony, Jajmau, General Ganj & Civil Lines are more than 20.0 mbgl.

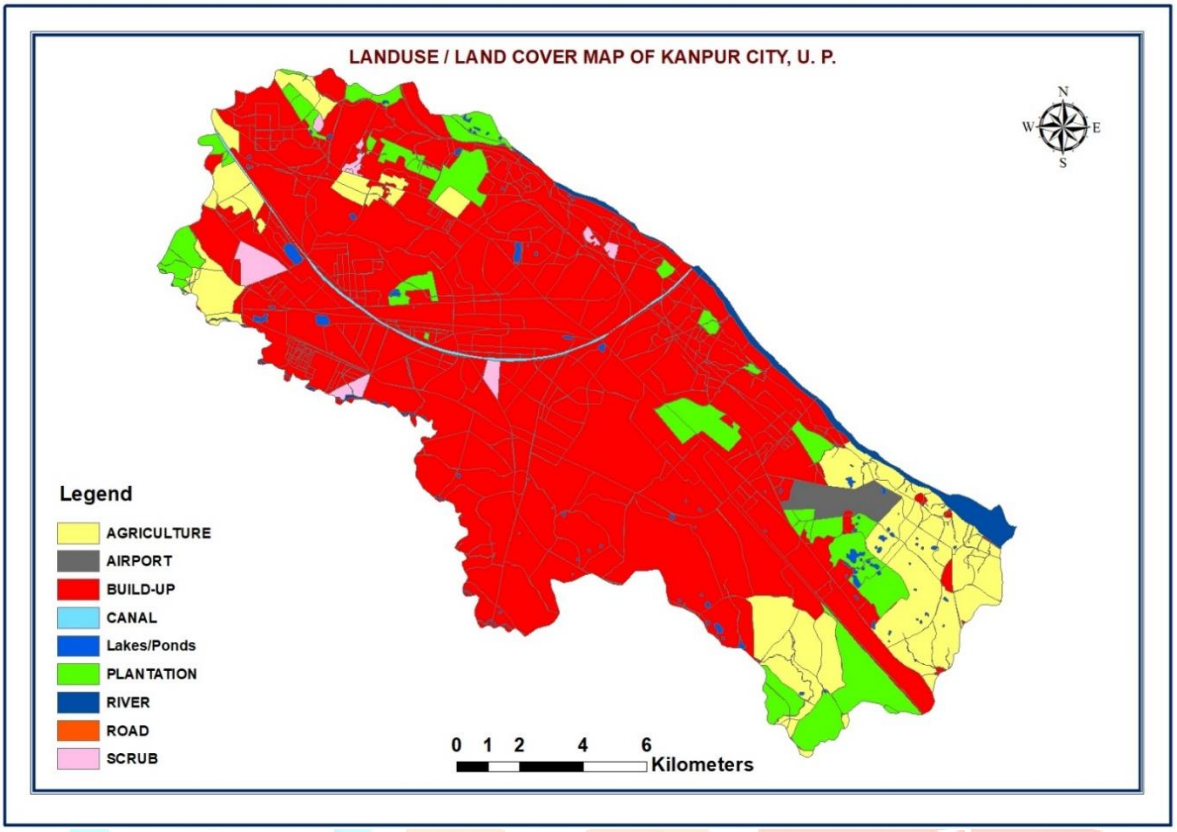
TABLE 3

S. NO.	GEOMORPHOLOGY	AREA (KM^2)
1.	Alluvial Plain - Older / Upper	202.7
2.	Alluvial Plain Younger / Lower	46.2
3.	Flood Plain	11.1
	Total	260



LAND USE PATTERN IN KANPUR CITY

Land use / land cover pattern is greatly changed during the last twenty years in the study area.



Today the settlement area in Kanpur city is 185.85 sq. km, whereas area under arable land that is to say agriculture is 34.1 sq. km and plantation 23.17 sq. km. Land use land cover pattern shows that more than 75 percent of land is under build-up and only 22.02 percent of land is under arable land which include both cropland and plantation, water bodies accounts for 3.17 percent only which include river/ streams, lakes/ ponds and canals. After analysing the land use / land cover pattern of the study area it is concluded that most of the land is under build-up so there is very little space left for natural recharge.

TABLE 1

S. NO.	LANDUSE / LAND COVER	AREA (KM^2)
1.	Agriculture	34.1
2.	Plantation	23.17
3.	Settlement	185.85
4.	Road	2.65
5.	Stream	0.68
6.	River	4.31
7.	Lakes/Ponds	1.94
8.	Canal	1.31
9.	Scrub	2.89
10.	Airport	3.1
	Total	260

PRE-MONSOON WATER LEVEL AND POST-MONSOON WATER LEVEL MAP

Pre-monsoon water level and post-monsoon water level mapping of Kanpur city has been done using the groundwater level data collected from the State Groundwater board, Uttar Pradesh. In the prepared map of Pre-monsoon water level and post-monsoon water level map it is shown that groundwater level is more than 20 meters near the Ganga River in the northern part of the Kanpur city whereas less than 5 meters groundwater level is found near the Ganga River in the Southern part of the city. In Pre-monsoon the 45.18 km^2 area had water level more than 20 meters whereas the area increases to 57.9 km^2 in post monsoon period. The area which is having water level more than 20 meters is the old city area which is covered with buildings and roads with very little area available for recharge whereas the area that is having water level less than 5 meters is the arable land. Details of the groundwater level in the study area in Pre-monsoon season and post-monsoon season in meters is given below in the table 4 and table 5.

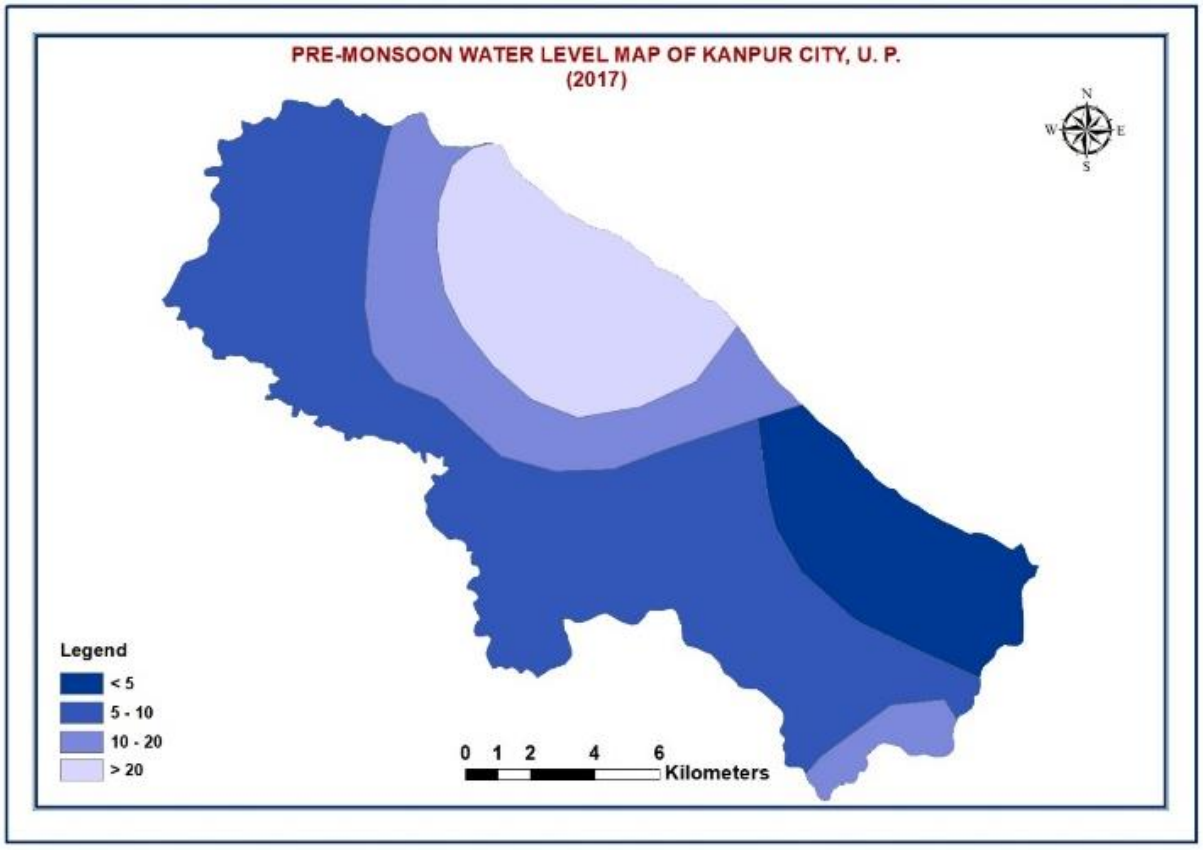
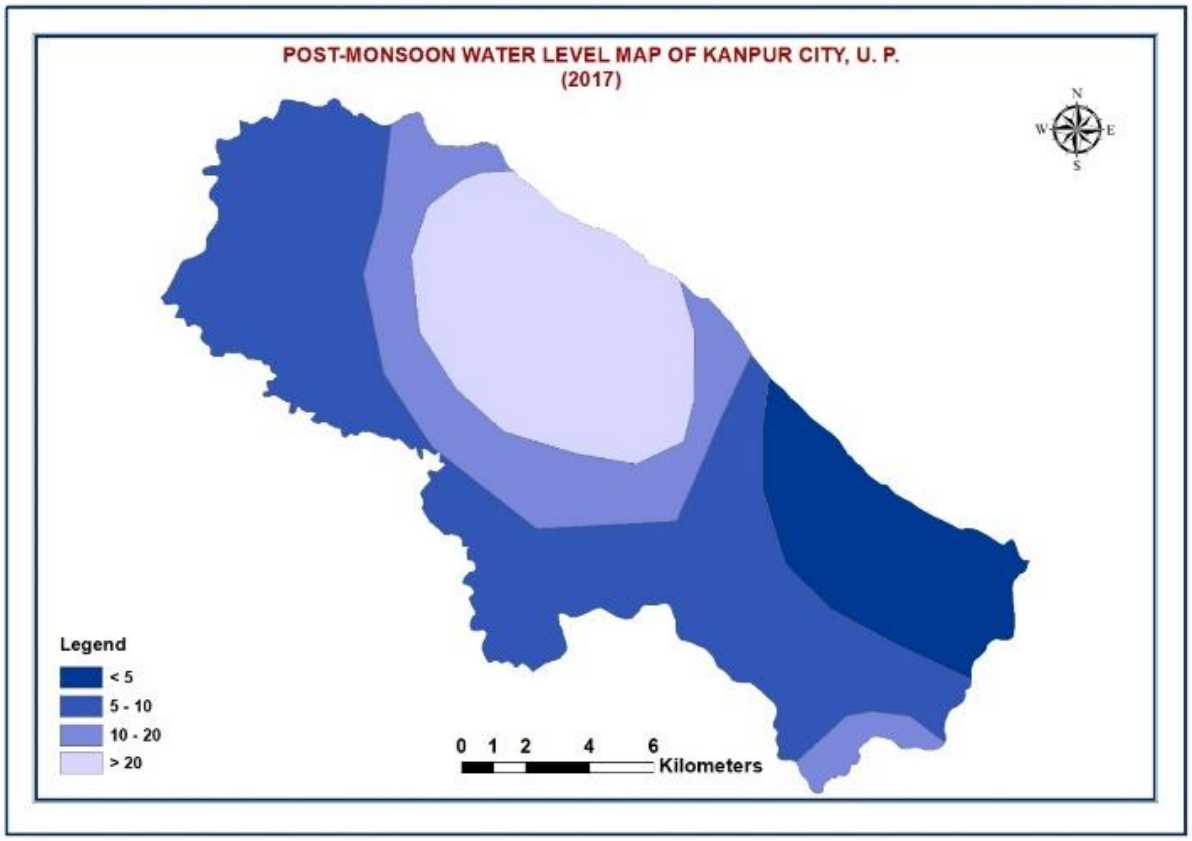


TABLE 4

S. NO.	WATER LEVEL (PRE-MONSOON)	AREA (KM^2)
1.	< 5 meters	35.68
2.	5 meters – 10 meters	131.19
3.	10 meters – 20 meters	47.95
4.	> 20 meters	45.18
	Total	260

TABLE 5

S. NO.	WATER LEVEL (POST-MONSOON)	AREA (KM^2)
1.	< 5 meters	36.9
2.	5 meters – 10 meters	118.86
3.	10 meters – 20 meters	46.34
4.	> 20 meters	57.9
	Total	260



CONCLUSION

The land use and land cover pattern play a very important role in groundwater recharging. In the study area settlement area is 185.85 sq. km, whereas area under arable land that is to say agriculture is 34.1 sq. km and plantation 23.17 sq. km. Land use land cover pattern shows that more than 75 percent of land is under build-up and only 22.02 percent of land is under arable land which include both cropland and plantation, water bodies accounts for only 3.17 percent only which include river/ streams, lakes/ ponds and canals. After analysing the land use / land cover pattern of the study area it is concluded that most of the land is under build-up so there is very little space left for natural recharge. Resulting in groundwater level decline in the build-up part of the Kanpur city which is more than 20 meters near the Ganga River in the northern part of the Kanpur city whereas less than 5 meters groundwater level is found near the Ganga River in the Southern

part of the city which is mostly under arable land. It is concluded that the GIS techniques are very useful for the identification of groundwater and land use / landcover pattern relationship.

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