SUMMARY & CONCLUSION
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India, with a mainly agricultural economy, depends heavily on the availability of water for a good year. Rainfall, characterised by seasonal and annual variations, is not a very reliable source of irrigation in most parts of the country. Availability of groundwater is therefore a major asset that greatly influences the agriculture. While surface water potential has been used to the full in several states, the same cannot be said of groundwater. Nevertheless, the droughts that is periodical failures of rainfall, place a great strain on the groundwater resource. For evolving policies for the best use of water resources, a refined assessment of the groundwater resources become indispensable.

Hence, an attempt has been made to make a comprehensive study for the aquifer system and evaluate the groundwater resources of Aligarh district for the integrated regional development and the role of groundwater in the development of agriculture.

Aligarh district, spreads over an area of 5019 sq. km., forms a part of Ganga - Yamuna - Doab and lies in the Central Ganga basin. The district is mainly drained by numerous rivers and drainage lines. The Ganga and Yamuna are the two perennial rivers. However, Nim, Kali, Rind, Sengar and Karwan form important tributaries of the main two rivers.

The district has the shape of a quadrilateral with a gentle slope from north to south. Physiographically, from the Ganga right bank to Yamuna left bank, the district is divisible into the following five distinct physiographic units viz. Low valley of the Ganga and Kali, Eastern Upland, Central Depression, Western Upland and Yamuna Lowland. Six major soil types namely (i) Ganga Khadir, (ii) Eastern Upland, (iii) Central
Lowlands, (iv) Western Uplands, (v) Trans Yamuna Khadir and (vi) Yamuna Khadir are found. The district Aligarh falls under subtropical climatic zones of India and is characterised by hot summer and chilly winter. The average annual rainfall at Aligarh, the district headquarters is 678.73 mm. About 85% of the total rainfall occurs during the south-west monsoon in the months of July and August each year. The minimum and maximum temperatures recorded at 3.3 °C and 45.3 °C respectively.

As regards the origin of the Ganga basin, it was interpreted to be formed as a foredeep or a great rift valley which was later filled up with the alluvium of the thickness 4.5 km to 20 km. A third view regards it a sagging in the crust, while the fourth more accepted view presents it as a resultant of the buckling down of the northern fringe of the Peninsula. However, at present, Indo-Gangetic plain is considered as a peripheral foreland basin, formed as a result of continent-continent collision between Indian and Asian Plates.

Consequent to the oil and water drillings in the Ganga basin, the sub-surface topography beneath the Quaternary alluvium is found to consist alternate spurs and depressions. The study area lies on Aligarh-Kasganj-Tanakpur spur. The geological cross-sections reveal that on the eroded surface of the Archean basement (Bundelkhand granite), the Upper Vindhyan were deposited during the Upper Proterozoic era. Thereafter they underwent a Post-Vindhyan faulting and erosion since Cambrian to Lower Pliocene. During this span of time encompassing about 500 million years, the Vindhyan topography was reduced to almost peneplain and on these eroded surface of the Upper Vindhays, Neogene Siwaliks were deposited which was later on followed by the deposition of Quaternary sediments. The Quaternary sediments healed up earlier depressions through
rapid sedimentation giving thereby a broad monotonous level expanses which is the present Ganga basin. Further the thickness of the Vindhyans, Neogene Siwaliks and Quaternary sediments gradually increased due north which attains their maximum thickness close to Himalayan foothills.

Hydrogeologically, there occurs 2 - 3 tier aquifer system in the district. The 1st aquifer which occurs in the depth range of 0.9 - 66 m.b.g.l. is the most potential granular zone in both the quantitative and qualitative terms. The 2nd and 3rd aquifer which occur in the depth ranges of 99.69 and 144.00 m and 132.00 and 300.00 m respectively, have got great quantitative potential but unfortunately, in the area lying between Karwan and Yamuna, the quality of formation of water deteriorates below 100 metres and continuous so down to the bed rock. The quality deterioration is due to the thickest clay beds of the Ganga basin and the sub-surface Vindhyan ridges. Besides the above all other granular zones encountered in boreholes at different depths at various places have little spatial extension and are of lenticular nature. The quality of their water is not good. All the aquifer in the district have a pinching and swelling dispositions. They have a tendency to dilate at one place due to the coalescence of two or more granular zones and attenuate at other, due to splitting of one aquifer into several granular zones thus giving the deceptive look of the multiplicity of the aquifers in the district.

The granular zones comprising fine to medium, grey micaceous sands, occasionally intermixed with coarse sand and gravels forms about 60 per cent of total formation. In the district groundwater occurs under the water table condition in shallow aquifers and confined to semi-confined conditions in deeper aquifers.

The pre-monsoon depth to water level varies between 3.23 to 16.20 metres b.g.l. and post-monsoon depth to water level ranges between
2.05 to 16.48 m.b.g.l. The range of fluctuation (rise) between pre and post-monsoon periods between 0.03 and 2.73 m. In addition at places decline (negative fluctuation) of 0.03 m and 1.30 m has also observed in the district. The altitude of water table in the district ranges between 164 and 190 m.a.m.s.l. The general slope of water table in the district is from north-west to south-east which corresponds to the general groundwater in the basin. The general gradient of the water table is about 0.35 m per kilometre. By and large, the water table contours are moderately spaced thus, representing good to moderate permeability. Kali river which is a tributary of Ganga and flows through the interfluvial track of Ganga and Yamuna rivers in the district exhibits an effluent nature.

Three prominent groundwater divides are identified in the district. These occur along the courses of the Lower and Upper Ganga Canals and the main branches are found in the extreme north-eastern part of the district along the Lower Ganga Canal in Atrauli tehsil, and along the Upper Ganga Canal (Etawah and Kanpur Branches) extending from the north-central part to the south-eastern part of the district in a north-west to south-east direction in Koil and Sikandra Rao tehsils, and in the western part of the district along the Upper Ganga Canal (Hathras branch) covering Khair, Iglas and Hathras tehsils. In between the above three ridges, two groundwater depression are discernible.

Further, study of hydrographs of the key observation wells show by and large, a declining trend. The areas which are under the influence of canal network exhibits a rising trend. The intensity of decline is more in comparison to that of rise. The cause of the declining trend of groundwater is in fact that the groundwater is only source of irrigation in the western part of the district as example of Aligarh city with its 7 lakhs population where the groundwater is the only source of water supply. The trend may
aggravate in future due to increase in population, upcoming of new colonies, extensive agricultural activities and escalating industrialisation in the western part of the district.

An attempt has been made to evaluate the groundwater resources of the district (blockwise) through water level fluctuation method except in three blocks where ad-hoc norms have been taken. The net recharge of the district has been computed as 116399.51 ha. m. The net annual draft is 68681.99 ha. m., leaving the balance of 47717.52 ha. m. as a utilisable groundwater resource for future development. As per the NABARD’S norms the district falls under the ‘while’ (safe) category, vis-a-vis status of the ground water development. In view of 59.01% groundwater development, there is a wide scope for the large scale groundwater development through shallow and deep tubewells. Irrigation is mainly done through the shallow farmer’s tubewells. The assured irrigation through groundwater has revolutionised the food production in the district, which very well testifies the role of groundwater in the development of agriculture in transferring the rural landscape and the economy of the people of the district.

Water samples collected from observation wells, shallow and deep tubewells and also surface water bodies analysed for various constituents affecting the quality of water and its suitability for drinking and irrigational purposes was studied. The chemical analysis results show that the groundwater in the district is moderately to highly alkaline in reaction, fresh to saline and hard to very hard in nature. Further, the values of cations and anions are also found well within the prescribed limits. Shallow aquifers are highly polluted with the heavy toxic metals like Cu, Pb, Cr, Zn, Mn etc., which may entail various health hazards to its users. The value of E.C., S.A.R. and Na % of the groundwater samples of
Deeper aquifers are generally within the permissible limits for irrigation water. Thus, by the above standards, it has been concluded that the groundwater from deeper aquifers is good to moderately good, free from salinity and alkalinity, hazards and is fit for all types of irrigation. Analytical results reveal that the concentration of micro nutrients (trace elements) in the groundwater of Aligarh district are within the recommended limit of *Federal Water Pollution Control Federation (1968)* and *Ayers and Branson (1975)*, and have no toxic effects on plants if water are used continuously for irrigation purposes. The water from surface sources is fresh, potable and suitable for irrigation purposes.

The study of the irrigation pattern of Aligarh district shows that the groundwater is contributing in a big way and about 80 per cent of irrigation requirements are being made by it in the district. Further, the increasing trend of irrigated area under groundwater resource clearly indicates the role of groundwater in the development of agriculture in Aligarh district.