Journal for Re Attach Therapy and Developmental Diversities
eISSN: 2589-7799
2023 Nov; 6 (10s2): 2262-2267

Impact Of Climate Change On Rainfall And Ground Water Level In Kanpur City.

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Abstract:
Any location's rainfall directly and indirectly influences the local Environment, people's livelihood, food, and drinking water. Analysis of Rainfall helps to provide input for planning for renewable energy projects, agricultural practices, etc. It is also used to predict natural disasters like drought and flood, which creates Uncertainty in the water supply and its management. The present study explores the relationship between the long-term rainfall pattern (2010-2022) and the water level fluctuation in Kanpur Nagar. The district experienced an average annual rainfall in Kanpur Nagar is 821.09mm. Intergovernmental Panel on Climate Change predicted that 1861 the global mean surface temperature has increased by 0.6- 0.2℃ since 1861 and estimated an increase of 2 to 4℃ over the next 100 years. The rise in Temperature also affects the hydrological cycle by directly increasing evaporation and evapotranspiration. As a result, these changes affect the amount of precipitation, and intensity indirectly impacting the influx and storage of surface and underground water. The fluctuations in the water table also show a declining level compared to previous decades. The variations in rainfall and water level are related to the EL-Nino and La Nino effects. The change in climate variables, such as air temperature, precipitation, and evaporation, directly impacts surface water resources. Impact surface water resources. The intense cultivation of water-intensive crops is the major cause of fluctuation in water level. Create artificial water recharge and Replace water-intensive cropping patterns by cultivating less water-consuming crops with efficient water management technology, which may help to overcome future distress conditions. The greater changeability in rainfall could mean more continuous periods of high and low groundwater-level saline intrusion in coastal aquifers due to rising sea levels. levels. Groundwater resources in a straight line related to climate change through the direct interaction with surface water resources. Therefore, measuring the impact of climate change on groundwater resources provides not only authentic forecasting of change in the utmost climate variable but also accurate evaluation or prediction on groundwater recharge.

Keywords: climate change, underground water, water resource, water management, aquifer recharge.

1. Introduction

Water is important for every living life but climate change threatens the water availability and its sustainable quality and quantity. The Ecosystem faces serious faces threatening remarks by climate change. The Intergovernmental Panel on Climate Change defines climate as the average weather in terms of the mean and its variability over a certain period and a certain area is a statistically significant variation of the mean state of the climate or its variability lasting for decades or longer is referred to as climate change. Rainfall is considered the prime source of groundwater and rainfall irregularity has an impact on groundwater reservoirs (Acworth et al. 2016). High rainfall is more prone to enough water recharge, and lower rainfall is poor recharge. Relationship between rainfall variability and water table fluctuation. According to the IPCC Report 2014, increase in the intensity and frequency of extremely hot, heat waves and heavy precipitation along with an increase in the amount of Rainfall in high latitudes and a decline of the same in subtropical regions. The atmospheric concentration of greenhouse gases causes us to move towards the climate change period.

Since the 1950s the concentration level of carbon dioxide has increased. This phenomenon may significantly alter global and local climate attributes like temperature and precipitation. The hydrological cycle is affected by climate change through precipitation Rainfall patterns, evapotranspiration, and soil moisture change due to climate change.

According to the CGWB 2014 report, in India, 75% of rainfall occurs from June to September. The year-to-year Changeability in monsoon rainfall leads to extreme events like droughts and floods resulting in a decline in water level and agricultural output. Events like drought flood and desertification are directly connected with rainfall patterns, atmospheric circulation, soil moisture, and water availability (Mall and Anandha Kumar 2010; 2014; Bhatt and Mall 2015).

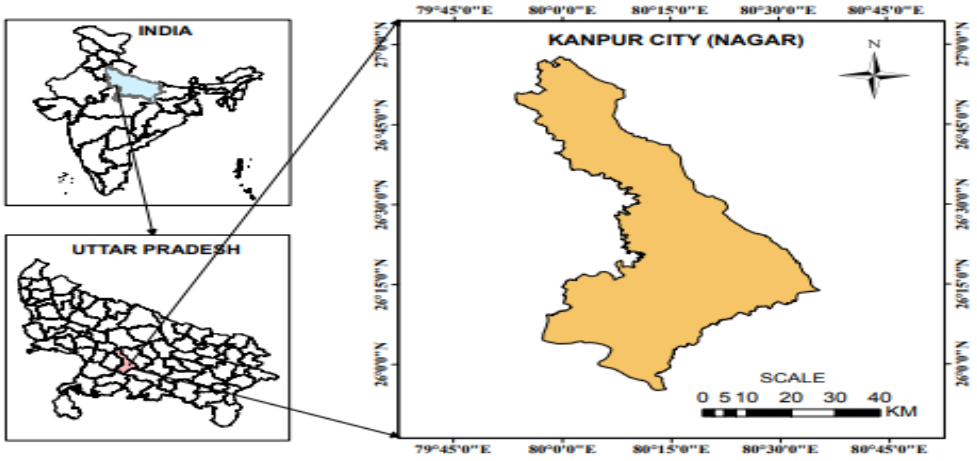
An increase in extreme events trends and a decline in monsoonal rainfall through frequent and temporal variation increase food shortage conditions. In India, 68% Faces drought conditions, and 12% are flooded. Agricultural productivity is greatly affected by the extreme climate change. The spatial and temporal variation in rainfall affect the surface water storage. the shortage leads to the development of groundwater activity for agricultural, industrial, and domestic purposes. the prolific aquifers have large amounts of groundwater storage all are replenishable natural resources (Chatterjee and

Purohit 2009; 2009). Spatial and temporal change decline in groundwater lead to a serious threat to groundwater resources. The hydrological cycle intensifies with the more precipitation or the more evaporation. Excess precipitation will be Unequal distribution of rainfall around the globe. In some parts of the world, we see a significant reduction in precipitation and a seasonal change in the timing of wet and dry. Precipitation is an important component in understanding the relationship between rainfall- and runoff which influences the drought and rainfall assessment and mitigation.
The study area is part of the Ganga Yamuna Doab region, which is densely populated and cultivated. The main aim of this study is to understand the Changing pattern of rainfall that affects the groundwater level in the Kanpur Nagar district. we find the solution to the water scarcity problem and spread general awareness among the people to conserve water resources for future generations.

2. Study Area

The study area consists of the Kanpur Nagar district located on the right bank of the Ganga River in the central part of Ganga Yamuna Doab. The area covers 3155km. Its longitudinal extension is from 25˚55'Nto 27˚N Latitude from 79˚ 30'E to 80˚35'E longitude. About 90% of the rural area, 10% of urban, 2% is forest cover. It is divided administratively it has 3 Tehsils, Kanpur Sadar, Ghatampur, and Bilhaur and it consists of 10 community development blocks. According to the 2011 census, The Total population of Kanpur Nagar district is 4,581,268 people, 64.3% female and 53.7% male. The density of the population is 1452 person/km2.
The study area comes under the subtropical types of climates the Average annual temperature of this region is 25℃. The Average Annual Rainfall of the region is 872.10mm occurred in monsoon months. The Average Annual Rainfall is 872.10mm which occurs in monsoon months. The total cropped area under Kanpur Nagar in 2021 was 3,33943 hectares. Kanpur hinterland is Fertile and the city has benefited from its upper Ganga valley and Bundelkhand. The major crops included Wheat, Rice, Maize, and Bajra.

Fig 1: - Map of Kanpur Nagar



Objective
•To discuss the Impact of climate change Rainfall on groundwater resources
•To show the Changing Pattern of Rainfall in Kanpur Nagar.
•To evaluate the fluctuation in the relationship between rainfall and groundwater level in Kanpur Nagar

3. METHODOLOGY

This paper is based on the secondary data collected from different sources like journals, Articles, books, Newspapers, socioeconomic, and government sites, and their published data. Rainfall data was collected from the National Water Informatics Center, water level data was collected from the Department of Drinking Water and Sanitation, and the period-wise average depth of groundwater was collected from Jal Jeevan Mission Uttar Pradesh. Different statistical methods like Charts and Graphs etc. can describe data.

4. REVIEW OF LITERATURE

Groundwater is majorly influenced by rainfall which is considered the major source of recharge groundwater. According to the International Panel on Climate Change 2014 report, they predicted the acceleration temperature trend of 2 to 4℃ over the 21st century. This work explains the relationship between the long-term rainfall (1992-2014) and the water table

fluctuation over the Varanasi district. (**Mall kumar Raiesh, Haq saidul, Bhatt diva, dev Sangita 2020**). This paper explains the relationship between climate change and hydrology in Kanpur Nagar district UP (**Maity sukamal 2021**). This article focuses on the impact of climate change on groundwater resources, and the climate change scenario in India (**Kumar C.P.2012**). This study provides results about groundwater management and unplanned urban expansion of the city (**Gupta Rachana and Singh Deepesh 2023**).

Impact of climate change on Rainfall and groundwater resources

Surface water levels and their quality are impacted due to the fluctuation of climate change It is a great concern of government authorities and there is a decrease in the potential and the quality of groundwater, it is the main source of usable water supply source of human consumption and irrigation of agricultural produce worldwide. Groundwater aquifer recharge by rainfall through surface water bodies, the direct impact of climate change on precipitation, and surface water impact of underground water. The consequences of climate and non-climate change on groundwater levels and the regional hydrological cycle are important elements in understanding the influence that these factors exert on recharge and runoff.

The amount of water stored in the soil is important for agriculture and influences the rate of evaporation groundwater recharge, and generation runoff. water holding capacity of soil will affect the change in soil moisture deficit the lower the capacity the greater the sensitivity of climate change. Climate change also affects the soil characteristics through the change in waterlogging and cracking which may affect the soil moisture storage properties.

Groundwater is an important source of water all over the globe, especially in arid and semiarid regions. Groundwater is an important Freshwater source of water all over the globe, especially in arid and semiarid regions. The aquifer is recharged by the rainfall, rivers, and lakes. Change in the amount of rainfall will decline the recharge but winter in mid-latitude regions increases ground water level. Various types of aquifers recharge differently, basically two types of aquifers unconfined and confined. Unconfined aquifer is recharged directly by local rainfall, rivers, and lakes. The rate of recharge aquifer is influenced by the overlying rocks and soils. A confined aquifer generally recharges from lakes and rivers, rainfall that may occur in distances ranging from a few km to thousands of km. they are characterized by lying beds that are imperishable, and local rainfall is not much affected. In coastal zones, coastal aquifers are important sources of fresh water. Salinity intrusion can be a major problem in these zones. salinity intrusion refers to the replacement of freshwater in coastal aquifers by saltwater. This led to a reduction in the availability of fresh groundwater. Climate change variables can significantly change groundwater recharge rates for major aquifer systems and thus affect the availability of fresh groundwater. salinization of coastal aquifers is a function of the reduction of groundwater recharge and results in the decline of fresh groundwater resources. Sea level rise will be one of the causes of saline intrusion into the coastal aquifer. Shallow aquifers are at greater risk. Groundwater in low-lying islands is sensitive to change.

Climate Change Scenario in Kanpur Nagar Analysis of the relationship between Rainfall and Groundwater level

In rural areas, Groundwater is the major source of drinking water. Approximately 85% of the rural water supply in India is dependent on underground water. Due to the continued drawing of groundwater, the water table in many regions of the country has dropped significantly in recent years resulting in a threat to groundwater sustainability. States Like Gujrat, Punjab, Haryana, Tamil Nadu, and Rajasthan are registered groundwater development above the National Level Average. The Gujrat is in a critical situation. The water level of Ahmadabad is reported to be declining at a rate of 4 to 5 meters every year. In some areas of Delhi, the water level has fallen by over 10m. Even in Kerala where the intensity of monsoon rainfall is heavy, but water table is very low in all parts of the state.

An average decline in groundwater level by one meter would increase India's total carbon emission by over 1% because the time withdrawal time of the same amount of water will increase fuel consumption. The area projected to be irrigated by groundwater suggests that the increase in carbon emission could be 4.8% for each meter drop in groundwater level (Mall et al.,2006).

Climate change has affected groundwater due to changes in precipitation and evapotranspiration. Rise in Sea levels may cause an increase in saline intrusion in coastal and island aquifers. Frequent floods may affect groundwater quality in alluvial aquifers. Sea level rise leads to intrusion of saline water into fresh water in coastal aquifers and thus adversely affects groundwater resources.

Global warming will affect the water supply through changes in the hydrological cycle and the level of underground water recharges. Increase water demand in agriculture, particularly for irrigation purposes. Increasing drought conditions lead to increased water demand. It is predicted that the irrigated areas in India will require more water demand around 2025. Approximately 52% of irrigation consumption in India is drawn out from underground water. This alarming situation arises with the continuing decline of underground water reservoirs and the face-to-face increase of water demand for irrigation due to climate changes. Climate change will affect the groundwater level, soil moisture, and frequent flood and drought conditions. Various studies projected that an increase in temperature resulted in Precipitation decline causing a decline in groundwater level.

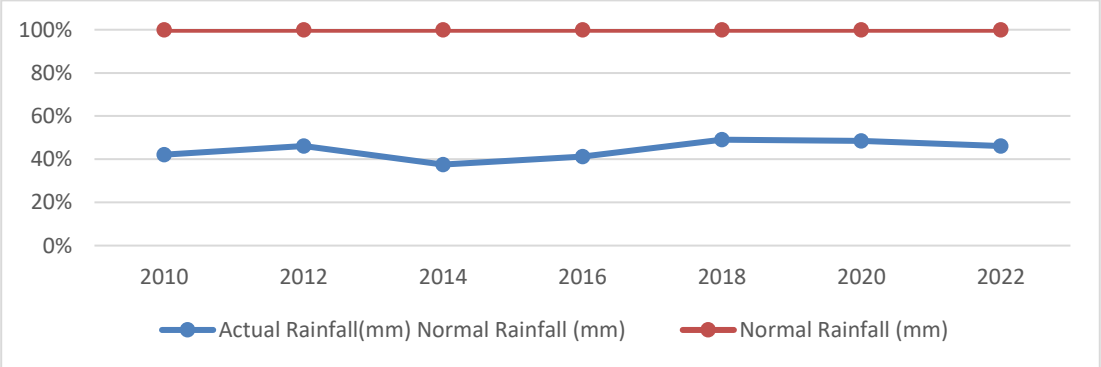
According to a report by the National Water Informatic Center, the maximum actual rainfall in the past 12 years occurred at 947.3mm in 2013, this year's 11.91% positive deviation from Normal. Then, after four years in 2018, the actual rainfall in Kanpur Nager occurred at 814.9mm and a -3.74mm deviation from normal rainfall. The minimum actual rainfall

occurred at 413mm in 2015 a -51.21mm Deviation from Normal Rainfall. Various years in the Study region underscore the fact that the courses of change in rainfall patterns.

Table No: - 1 Changing Rainfall Report Pattern in Kanpur Nagar.

Year	Actual Rainfall (mm)	Normal Rainfall (mm)	Deviation from Normal (%)
2010	617.5	846.5	-26.81
2011	717.4	846.5	-15.23
2012	726	846.5	-14.23
2013	947.3	846.5	11.91
2014	508.6	846.5	-39.91
2015	413	846.5	-51.21
2016	593.3	846.5	-29.91
2017	562.2	846.5	-33.59
2018	814.9	846.5	-3.74
2019	799.5	846.5	-5.55
2020	799.5	846.5	-5.55
2021	797.2	846.5	-5.82
2022	723.2	846.5	-14.5

Source: - National water Informatic center, Rainfall Report of Kanpur Nagar.



Source: - Jal Jeevan Mission Uttar Pradesh

The shifting of rainfall patterns can mainly affect the kharif crop's food productivity. Food grain production all over India mostly depends on the southwest monsoon rainfall. Rainfall Fluctuation due to the EL Nino and LA Nino effect. Major drought events in the study region are associated with these EL NINO and LANINO events. Gangetic Plan, we find a strong relationship between the El NINO events and Drought (Bhatla et al. 2015). The Gangetic Plan Faces four drought years i.e., 1992,2009,2010,2012 (Bhatla et al. 2015). Delay and a weak monsoon are also responsible for the decline in crops showing 25- 40 percent in Kanpur and its adjoining district. Kanpur region comes under the central plain zone, resulting in late monsoon occurrence in minimal rainfall 36.3% and 54% front of normal rainfall.
Witnesses to the LA NINA event in Kanpur in 1998, 2000, and 2010 showed that low rainfall causes minimum water table fluctuation because of less infiltration.

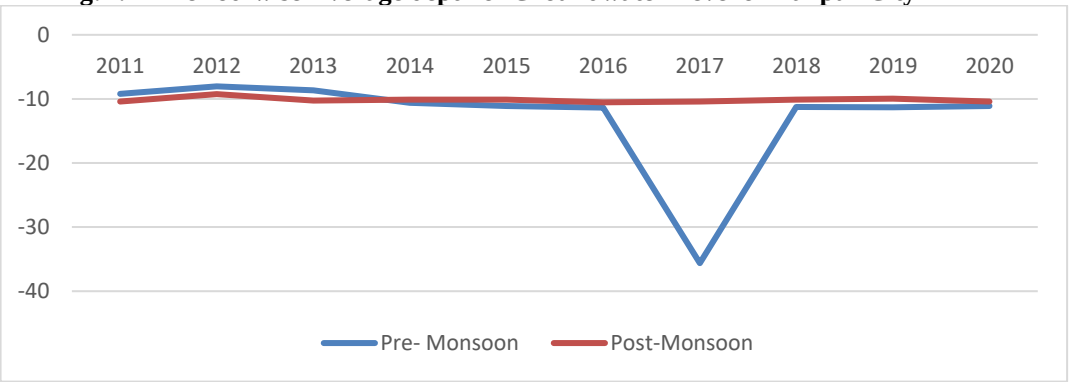
Table No:-2 Water Level in Kanpur Nagar

Year	Pre-Monsoon (M)	Post Monsoon(M)	Average water level (M)
2014	12.9446	12.9952	12.9699
2015	14.084	13.5968	13.8404
2016	14.9476	14.754	14.8508
2017	17.1368	19.1454	18.1411
2018	20.579	19.5464	20.0627
2019	21.0584	20.1548	20.6066
2020	21.3792	19.8168	20.598
2021	20.4624	17.6508	19.0566
2022	18.648	16.6898	17.6689

Source: - Department of Drinking Water and Sanitation.

As per the Water Level report of the Department of Drinking Water and Sanitation, the average water level is 17.37m in Kanpur Nagar. The maximum pre-monsoon water level occurred at 21.3792m in 2020 but the post-monsoonal water level declined to 19.8168. In 2014 Kanpur Nagar's water level was much lower than the average. The lowest pre-monsoon water level occurred at 12.9446m in 2014 and the post-monsoon water level was around 12.9952m. This situation continued till 2017, but the water level rose slightly after 2012.
Water levels change over time due to changes in the pattern of rainfall. The rainfall deficit in 2014, 2015, and 2016 was -26.81%, and -15.23%. and -14.23% respectively. Because of the low percolation of water level in the study region in these years declined. Demand for water in different sectors also rises. Industrial growth was affected from 2001-2011. The major source of income in the study region is from agricultural sectors. A large percentage of water use is in agriculture. Domestic water demand in Kanpur Nagar is 60,000 cubic meters per day. Due to the continued increase in population, the demand for water in this region will increase. Kanpur is well known for its leather, wool, and cotton industries and is also a commercial hub.
Rural-to-urban migration is the major cause of the study region's population growth. People move for better opportunities. Urbanization and climate change are also responsible for the decline in groundwater levels. Without planning and management, urbanization has severely degraded the ecosystem, mainly water supply and forest cover.

Fig: -: - 1 Period-wise Average depth of Groundwater Level of Kanpur City



Source: - Jal Jeevan Mission Uttar Pradesh

According to the Jal Jeevan Mission report, In the Initial years, the water level in pre-monsoon water level was in moderate condition -10.40m,9.25m,10.28m, -10.11m, -10.09m, and -10.53m between 2010 to 2015 but after 2015 it severely declined by -35.62m between 2016-2017. But in the post-Monson condition was reversed -10.43m water level in 2016-2017. Then after 2017, it came back into a previous situation around – 11.28m, -11.29m, and -11.11m in 2018,2019,2020. But in post-monsoon water level conditions were moderate from 2010 to 2020.
The groundwater level of the study region declined by 0.67m below average per year. This is due to excess population pressure and the expansion of urban areas, which are causing the decline in water levels to decline.

Findings and solution of the study

In Kanpur Nagar, the rainfall declines in 2014, 2015, and 2016 were -26.81%, and -15.23%. and -14.23% respectively resulted in the average water level declining in these 12.9m, 13.8m, and 14.9m years. Rapid urbanization and industrialization have caused pollution and decline the quality of ground water and are also responsible for water scarcity in the study region. The total water requirement is 600 million liters per day but the supply is only 385 million liters per day. The industrial region also causes air pollution causing an increase in the concentration of carbon dioxide which is responsible for climate change. water is contaminated due to tanning activity in the Jajmau area. Not fit for drinking purposes, toxic heavy metals affect biological function, and growth causing serious health problems. Crop production near the contaminated area takes up toxic metal in the soil and water. Tannery discharge of Jajmau containing heavy metal causes soil, surface water, and groundwater. Inflow of domestic waste and sewage into the water distribution network Water-intensive crops are produced in Kanpur Nagar like wheat, rice, Maize, etc.
There is a need to check after the treatment of the liquid waste to ensure toxic elements are not released to surface water bodies. Need to change less water-intensive crops, cropping patterns, and crop diversity like zero budget, natural farming, and organic farming. We need to decentralize the system of water management at the community level in Kanpur Nagar, like Delwara in Rajasthan and Cuttack in Odisha. Rainwater harvesting is an important tool to solve the water scarcity problem. Create an artificial lake behind the Ganga River that can collected for dry season or late monsoon time. Desalination helps to increase freshwater availability this method helps to remove dissolving salt and minerals from saline groundwater and rivers.

5 Conclusion

The study reveals that water level fluctuation is majorly influenced by precipitation variation. The region experienced a decreasing trend in rainfall and underground water level. Analysis of actual and normal rainfall and its deviation percentage from normal rainfall presented by the chart in which initial year rainfall decreased trend compared to normal rainfall but after 2017 it increased in trend and occurred very near to normal year rainfall. The change in rainfall had been noticed, but total rainfall has not changed in recent years. The declining trend in the water table was from 2014 to 2017 but after 2017 the groundwater increased due to better rainfall conditions. Agricultural production of the Kharif crop was hampered in the future due to insufficient water availability, but heavy rainfall conditions led to runoff, and a smaller number of rainy days created water-scarce conditions.

Major demand for water in different sectors i.e., Industrial, agricultural, and domestic purposes is filled by groundwater, which creates water stress. Global Events Like EL NINO and LA NINO conditions impact the change of rainfall, but groundwater levels fully depend on the infiltration of rainwater.

These Results indicate the necessity to formulate a water management strategy for the advanced impact of changing rainfall variation effect on groundwater recharge, we should conserve every drop of water so that the aquifer recharge becomes productive during low rainfall. Implement less water-consuming crops, water storage capacity of water resources by recharge, and different artificial methods for sustainable groundwater management. People's participation is important for water conservation to create awareness regarding water conservation and its sustainable management for present and future generations.

Declarations:
Conflicts of interest: There is not any conflict of interest associated with this study
Consent to participate: There is consent to participate.
Consent for publication: There is consent for the publication of this paper.
Authors' contributions: Author equally contributed the work

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