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Progress towards SDG 6 in Uttar Pradesh: A District-Level Analysis of Drinking Water Access Using NFHS-4 and NFHS-5

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Abstract

The present study examines district-level changes in drinking water access in Uttar Pradesh using data from the National Family Health Survey (NFHS-4, 2015–16 and NFHS-5, 2019–21). The study adopts a quantitative and comparative research design based on secondary data for 62 districts of the state. A paired samples t-test was conducted using Jamovi to determine whether the change in drinking water access over time was statistically significant. The findings reveal a significant improvement in drinking water access between NFHS-4 and NFHS-5, with the paired t-test result showing $t(61) = -3.26$ and $p = 0.002$. District-wise analysis indicates that previously low-performing districts such as Sant Ravidas Nagar and Mirzapur recorded the highest improvements, while only a few districts showed minor declines. The study highlights overall progress in drinking water infrastructure across Uttar Pradesh while also emphasizing the need for sustained policy efforts to ensure equitable, reliable, and quality access to drinking water across all districts.

Keywords: Drinking water access, NFHS, Uttar Pradesh, Paired t-test, District-level analysis, Jamovi.

Introduction

Access to safe and adequate drinking water is widely recognized as a fundamental human right and a critical determinant of health, well-being, and socio-economic development. The World Health Organization (WHO) emphasizes that safe drinking water is essential for preventing waterborne diseases and improving overall public health outcomes (World Health Organization [WHO], 2017). Similarly, the United Nations (UN) includes universal and equitable access to safe drinking water as a core target under Sustainable Development Goal 6 (United Nations, 2015).

In developing countries like India, access to improved drinking water sources has significantly expanded over the past decades due to government interventions and infrastructure development programs (International Institute for Population Sciences [IIPS] & ICF, 2021). However, despite national-

level progress, disparities persist across regions, states, and districts (NITI Aayog, 2021). These inequalities are often influenced by socio-economic factors, governance efficiency, and geographic conditions (Sen, 1999; Dreze & Sen, 2013).

Uttar Pradesh, India's most populous state, presents a particularly important case for examining such disparities. While many districts have achieved near-universal access to drinking water, others continue to lag behind due to structural and developmental constraints (IIPS & ICF, 2021). Understanding these intra-state variations is essential for designing targeted and effective policy interventions.

Empirical studies have consistently shown that improved access to drinking water contributes to better health outcomes, especially by reducing the incidence of diarrheal diseases among children (Jalan & Ravallion, 2003). Moreover, access to basic infrastructure, including water, sanitation, and energy, is closely linked to reductions in multidimensional poverty (Alkire & Santos, 2014; NITI Aayog, 2021). However, the relationship between infrastructure access and poverty is complex and may vary across regions depending on levels of development and existing coverage.

From a theoretical perspective, the concept of regional convergence suggests that less developed regions tend to grow faster than more developed ones, thereby reducing disparities over time (Barro & Sala-i-Martin, 1992). In the context of infrastructure, this implies that districts with lower initial access to drinking water may experience greater improvements

compared to those that are already well-served. Such convergence dynamics are important for assessing the inclusiveness of development policies.

Despite the availability of rich datasets such as the National Family Health Survey (NFHS), limited research has systematically examined district-level changes in drinking water access over time, particularly using recent rounds of data. Most existing studies focus on aggregate trends at the national or state level, thereby overlooking localized patterns of progress and inequality (IIPS & ICF, 2021; NITI Aayog, 2021).

Against this backdrop, the present study aims to analyze district-level changes in drinking water access in Uttar Pradesh between NFHS-4 (2015–16) and NFHS-5 (2019–21). By employing statistical techniques such as paired sample t-tests and regression analysis, the study seeks to evaluate whether improvements are statistically significant and whether evidence of convergence exists across districts. The findings are expected to contribute to the broader discourse on infrastructure development, regional inequality, and policy effectiveness in India.

Literature Review

Access to safe drinking water has long been recognized as a critical determinant of health and development (World Health Organization [WHO], 2017). Studies have shown that improved water access reduces waterborne diseases and enhances quality of life (Jalan & Ravallion, 2003).

In the Indian context, several studies have examined infrastructure development using NFHS data. For instance, IIPS and ICF (2021) reported significant improvements in access to basic services, including drinking water, across states. However, disparities persist at the district level, particularly in economically backward regions (NITI Aayog, 2021).

The concept of regional convergence suggests that poorer or less-developed regions tend to grow faster than more developed ones, thereby reducing inequality over time (Barro & Sala-i-Martin, 1992).

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This framework has been applied in infrastructure studies to assess whether lagging regions are catching up.

Despite these contributions, limited research has focused specifically on district-level convergence in drinking water access using recent NFHS data.

Research Gap

While existing studies highlight overall improvements in drinking water access, they often:

Focus on state-level or national averages, ignoring district-level variation

Do not analyze changes over time using paired statistical methods

Rarely examine convergence dynamics (catch-up effect)

This study addresses these gaps by conducting a district-level comparative and statistical analysis using NFHS-4 and NFHS-5 data.

Objectives

The study aims to

Examine changes in drinking water access between NFHS-4 and NFHS-5

Determine whether the change is statistically significant

Identify districts with the highest and lowest improvements

Analyse whether districts with lower initial access improved more (convergence effect)

Methodology

Research Design -The present study adopts a quantitative and comparative research design to examine changes in drinking water access across districts of Uttar Pradesh between NFHS-4 (2015–16) and NFHS-5 (2019–21). The analysis focuses on identifying temporal changes and determining whether the observed differences are statistically significant.

Data Source- The study is based on secondary data obtained from the International Institute for Population Sciences (IIPS) through:

NFHS-4 (2015–16)

NFHS-5 (2019–21)

These datasets provide district-level information on household access to drinking water.

Sample-

Total districts analysed: N = 62

Unit of analysis: District level

Only those districts for which consistent data were available in both survey rounds were included.

Variables- The analysis is restricted to the following variables:

Drinking Water Source (NFHS-4)

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Drinking Water Source (NFHS-5)

Difference = NFHS-5 − NFHS-4

The "Difference" variable captures the change in drinking water access over time.

Data Cleaning and Transformation-

The original dataset was carefully reviewed and processed before analysis. The following steps were undertaken:

Removal of duplicate and inconsistent entries

Correction of district names (e.g., spelling standardization such as Chandauli)

Alignment of NFHS-4 and NFHS-5 values for each district

Calculation of the difference variable

Reorganization of the dataset into a clean comparative table

Additionally, the dataset was sorted based on the magnitude of change, allowing clear identification of districts with the highest improvements and declines.

Data Visualization and Colour Coding-To enhance interpretability, a color-coded table was constructed:

Green colour represents positive change (improvement)

Red colour represents negative change (decline)

This visual approach helps in quickly identifying patterns across districts:

Districts with major improvements are easily distinguishable

Districts with stagnation or decline are highlighted for attention

The use of colour coding improves clarity, readability, and analytical interpretation, especially in large datasets.

Results

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DISTRICTS	DRINKING WATER SOURCE (NFHS-4)	DRINKING WATER SOURCE (NFHS-5)	DIFFERENCE
AGRA	99	99.8	0.8
ALIGARH	98.5	100	1.5
AMBEDKAR NAGAR	100	100	0
AURAIYA	98.5	99.5	1
AZAMGARH	100	100	0
BHAGPAT	100	99.9	-0.1
BAHRAICH	99.3	100	0.7
BALIA	99.8	99.8	0
BALRAMPUR	98.9	99.8	0.9
BANDA	98.1	98.2	0.1
BARABANKI	99.3	98.8	-0.5
BAREILLY	100	100	0
BASTI	100	100	0
BIJNOR	100	99.7	-0.3
BULANDSHAHR	99.8	100	0.2
CHAUNDALI	91.1	97.5	6.4
CHITRAKOOT	93.8	97	3.2
DEORIA	100	99.8	-0.2
ETAH	100	99.8	-0.2
ETAWAH	99.2	99.5	0.3
FAIZABAD	99.5	100	0.5
FARRUKHABAD	99.9	99.7	-0.2
FATEHPUR	98.1	98.8	0.7
FIROZABAD	99.3	99.4	0.1
GAUTAM BUDDHA NAGAR	100	99.9	-0.1
GHAZIPUR	99.5	99.3	-0.2
GONDA	100	100	0
GORAKHPUR	99.8	99.8	0
HAMIRPUR	99.6	99.4	-0.2
HARDOI	99.5	99.9	0.4
JALAUN	97.8	99	1.2
JAUNPUR	96	99.1	3.1
JHANSI	97.1	96.8	-0.3
JYOTIBHA PHULE NAGAR	100	99.7	-0.3
KANNAUJ	99.8	99.9	0.1
KANPUR DEHAT	98.7	99.4	0.7
KANPUR NAGAR	99.5	98.8	-0.7
KANSHIRAM NAGAR	99.8	99.4	-0.4
KAUSHAMBI	97.1	98.3	1.2
LALITPUR	94.2	96.6	2.4
LUCKNOW	99.2	99.8	0.6
MAHAMAYA NAGAR	100	99	-1
MAHARAJGANJ	99.7	100	0.3
MAHOBA	95.1	94.3	-0.8
MAINPURI	99.5	99.6	0.1
MATHURA	97.7	98.4	0.7
MAU	100	99.8	-0.2
MEERUT	100	99.7	-0.3
MIRZAPUR	87.4	96.9	9.5
PILIBHIT	100	100	0
PRATAPGARH	93.1	97.8	4.7
PRAYAGRAJ	91.8	95.8	4
RAMPUR	100	100	0
SAHARANPUR	99.9	99.7	-0.2
SANT KABEER NAGAR	99.9	99.9	0
SANT RAVIDAS NAGAR (BADOHI	85.8	96.7	10.9
SHAHJAHANPUR	100	100	0
SIDDHARTHNAGAR	99.7	99.9	0.2
SHRAVASTI	97.6	99.3	1.7
SITAPUR	99	99.7	0.7
UNNAO	97.9	98.5	0.6
VARANASI	96	98.4	2.4

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Table 1: District-wise Drinking Water Access in Uttar Pradesh (NFHS-4 and NFHS-5) with Change Analysis

Source: Author's compilation based on data from the International Institute for Population Sciences (IIPS), National Family Health Survey (NFHS-4, 2015–16 and NFHS-5, 2019–21).

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DISTRICTS	DRINKING WATER SOURCE (NFHS-4)	DRINKING WATER SOURCE (NFHS-5)	DIFFERENCE
SANT RAVIDAS NAGAR (BADOHI)	85.8	96.7	10.9
MIRZAPUR	87.4	96.9	9.5
CHAUNDALI	91.1	97.5	6.4
PRATAPGARH	93.1	97.8	4.7
PRAYAGRAJ	91.8	95.8	4
CHITRAKOOT	93.8	97	3.2
JAUNPUR	96	99.1	3.1
VARANASI	96	98.4	2.4
LALITPUR	94.2	96.6	2.4
SHRAVASTI	97.6	99.3	1.7
ALIGARH	98.5	100	1.5
JALAUN	97.8	99	1.2
KAUSHAMBI	97.1	98.3	1.2
AURAIYA	98.5	99.5	1
BALRAMPUR	98.9	99.8	0.9
AGRA	99	99.8	0.8
BAHRAICH	99.3	100	0.7
FATEHPUR	98.1	98.8	0.7
KANPUR DEHAT	98.7	99.4	0.7
MATHURA	97.7	98.4	0.7
SITAPUR	99	99.7	0.7
LUCKNOW	99.2	99.8	0.6
UNNAO	97.9	98.5	0.6
FAIZABAD	99.5	100	0.5
HARDOI	99.5	99.9	0.4
ETAWAH	99.2	99.5	0.3
MAHARAJGANJ	99.7	100	0.3
BULANDSHAHR	99.8	100	0.2
SIDDHARTHNAGAR	99.7	99.9	0.2
BANDA	98.1	98.2	0.1
FIROZABAD	99.3	99.4	0.1
KANNAUJ	99.8	99.9	0.1
MAINPURI	99.5	99.6	0.1
AMBEDKAR NAGAR	100	100	0
AZAMGARH	100	100	0
BALIA	99.8	99.8	0
BAREILLY	100	100	0
BASTI	100	100	0
GONDA	100	100	0
GORAKHPUR	99.8	99.8	0
PILIBHIT	100	100	0
RAMPUR	100	100	0
SANT KABEER NAGAR	99.9	99.9	0
SHAHJAHANPUR	100	100	0
BHAGPAT	100	99.9	-0.1
GAUTAM BUDDHA NAGAR	100	99.9	-0.1
HAMIRPUR	99.6	99.4	-0.2
DEORIA	100	99.8	-0.2
ETAH	100	99.8	-0.2
FARRUKHABAD	99.9	99.7	-0.2
GHAZIPUR	99.5	99.3	-0.2
MAU	100	99.8	-0.2
SAHARANPUR	99.9	99.7	-0.2
BIJNOR	100	99.7	-0.3
JHANSI	97.1	96.8	-0.3
JYOTIBHA PHULE NAGAR	100	99.7	-0.3
MEERUT	100	99.7	-0.3
KANSHIRAM NAGAR	99.8	99.4	-0.4
BARABANKI	99.3	98.8	-0.5
KANPUR NAGAR	99.5	98.8	-0.7
MAHOBA	95.1	94.3	-0.8
MAHAMAYA NAGAR	100	99	-1

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Table 2: District-wise Change in Drinking Water Access in Uttar Pradesh (NFHS-4 and NFHS-5), Showing Highest Increase to Decline

Source: Author's compilation based on data from the International Institute for Population Sciences (IIPS), National Family Health Survey (NFHS-4, 2015–16 and NFHS-5, 2019–21).

Statistical Technique-

Paired Sample t-test:A paired sample t-test was applied to examine whether the difference in drinking water access between NFHS-4 and NFHS-5 is statistically significant.

Hypotheses:

H_o (Null Hypothesis): There is no significant difference between NFHS-4 and NFHS-5

H_1 (Alternative Hypothesis): There is a significant difference between NFHS-4 and NFHS-5

This test is appropriate because:

The same districts are measured at two time points

Observations are dependent (paired)

Interpretation

The results of the paired t-test were interpreted based on:

p-value (significance level)

t-statistic (direction of change)

A p-value less than 0.05 was considered statistically significant.

The sign of the t-value was used to determine direction:

Negative t-value → NFHS-5 values are higher → Improvement

Positive t-value → NFHS-4 values are higher → Decline

Paired Samples T-Test

			statistic	df	p
DRINKING WATER SOURCE (NFHS-4)	DRINKING WATER SOURCE (NFHS-5)	Student's t	-3.26	61	0.002
DRINKING WATER SOURCE (NFHS-5)	.	Student's t	.	.	.

Note. H_a $\mu_{Measure\ 1\ -\ Measure\ 2} \neq 0$

Table 3: Paired Samples t-Test Results for Drinking Water Access between NFHS-4 and NFHS-5 in Uttar Pradesh (Computed using Jamovi)

Source: Author's calculation using Jamovi based on data from the International Institute for Population Sciences (IIPS), National Family Health Survey (NFHS-4, 2015–16 and NFHS-5, 2019–21).

A paired samples t-test was conducted to compare drinking water access between NFHS-4 and NFHS-5 across districts of Uttar Pradesh. The results indicate a statistically significant difference between the two time periods, t(61) = -3.26, p = 0.002, leading to the rejection of the null hypothesis. The negative t-value suggests that the mean level of drinking water access in NFHS-5 is higher than in NFHS-4,

indicating an overall improvement over time. This finding implies that access to drinking water has significantly increased across districts, and the observed change is unlikely to be due to chance. Therefore, the results provide strong evidence of progress in drinking water availability in Uttar Pradesh between the two survey rounds.

Discussion

The district-level analysis of drinking water access between NFHS-4 and NFHS-5 reveals a clear pattern of overall improvement across Uttar Pradesh, although the extent of change varies considerably between districts. A large number of districts show positive differences, indicating that access to improved drinking water sources has increased over time. This trend is consistent with the statistically significant result obtained from the paired t-test, confirming that the improvement is systematic rather than random.

The most notable gains are observed in districts that had relatively lower baseline levels in NFHS-4. For instance, districts such as Sant Ravidas Nagar, Mirzapur, and Chandauli exhibit substantial increases, suggesting that development efforts may have been more focused on previously underserved areas. This pattern reflects a form of catch-up or balanced development, where lagging districts improve at a faster rate compared to already well-performing regions.

In contrast, several districts show minimal or no change, primarily because they had already achieved near-universal coverage (close to 100%) in NFHS-4. For these districts, the scope for further improvement is naturally limited, leading to a plateau effect. This indicates that high-performing districts have largely sustained their achievements over time.

A small number of districts display slight declines in drinking water access, such as Mahamaya Nagar, Mahoba, and Kanpur Nagar. However, these decreases are relatively minor in magnitude and may be attributed to factors such as data variation, changes in measurement criteria, or temporary infrastructural challenges rather than a significant deterioration in access.

Overall, the table highlights that while progress has been widespread, regional disparities still exist, particularly in terms of the magnitude of improvement. The combination of large gains in some districts and stagnation or minor declines in others suggests the need for targeted policy interventions, especially to sustain improvements and address localized challenges.

Key Findings

1. Overall Improvement

Majority of districts show positive change

Confirms upward trend in drinking water access

2. Highest Improvements

Sant Ravidas Nagar (+10.9)

Mirzapur (+9.5)

Chandauli (+6.4)

3. Minimal or No Change
Several districts already at ~100% coverage

Hence, little or no improvement possible

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Declining Districts

Mahamaya Nagar (-1.0)

Mahoba (-0.8)

Kanpur Nagar (-0.7)

Limitations of the Study

While the study provides useful insights into changes in drinking water access across districts of Uttar Pradesh, several limitations should be acknowledged.

First, the analysis is based on secondary data from NFHS, which means the researcher has no control over data collection methods, definitions, or measurement errors. Any inconsistencies or reporting biases in the original survey may affect the results.

Second, the study focuses only on access to drinking water, not on the quality, reliability, or safety of the water supply. A district may report high coverage, but the water may still be unsafe or irregular, which is not captured in this analysis.

Third, most district values are very high (close to 100%), leading to a ceiling effect. This reduces variability in the data and limits the ability to detect large differences or trends, especially in already well-performing districts.

Fourth, the study uses a paired t-test as the only statistical method, which identifies whether a significant change exists but does not explain the causes or determinants of that change.

Fifth, small negative changes observed in some districts may not necessarily reflect actual decline but could be due to sampling variation, reporting differences, or changes in survey methodology between NFHS-4 and NFHS-5.

Sixth, the study is limited to two time periods only, which restricts the ability to analyze long-term trends or fluctuations over time.

Finally, the analysis is conducted at the district level, which may hide intra-district inequalities (such as rural–urban differences or socio-economic disparities within districts).

Future Scope of the Study

The present study opens several avenues for further research. First, future studies can incorporate additional variables such as sanitation, electricity, income levels, education, and health indicators to better understand the determinants of drinking water access. This would help move beyond identifying change to explaining the underlying causes of improvement or decline.

Second, researchers can extend the analysis by using advanced statistical techniques such as multiple regression, panel data analysis, or spatial analysis to examine regional patterns and inter-district linkages more deeply. This would provide a more comprehensive understanding of development dynamics.

Third, future research can include more time periods (for example, earlier NFHS rounds or future surveys) to study long-term trends and assess whether improvements are sustained over time.

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Fourth, there is scope to focus on water quality and reliability, not just access. Incorporating indicators related to contamination, seasonal availability, and service continuity would provide a more realistic picture of drinking water security.

Fifth, studies can be conducted at a more disaggregated level, such as rural–urban comparisons, household-level analysis, or socio-economic group differences. This would help uncover hidden inequalities within districts.

Sixth, qualitative approaches such as field surveys, case studies, and interviews can complement quantitative findings by providing insights into local challenges, governance issues, and implementation gaps.

Finally, comparative studies across different states or regions of India can help identify best practices and policy lessons that can be replicated in lower-performing areas.

Policy Recommendations

Based on the findings of the study, the following policy recommendations are suggested to further improve and sustain drinking water access across districts of Uttar Pradesh:

First, there is a need for targeted interventions in lagging districts. Although many low-performing districts have shown improvement, some still require focused investment to ensure equitable access. Policymakers should prioritize these regions through need-based allocation of resources.

Second, as most districts have already achieved high levels of coverage, the policy focus should shift from expansion to maintenance and sustainability of infrastructure. Regular monitoring, repair of water supply systems, and proper management are essential to prevent deterioration.

Third, emphasis should be placed on water quality and safety, not just access. Programs should include regular water testing, treatment facilities, and awareness campaigns to ensure that the available water is safe for consumption.

Fourth, the government should strengthen monitoring and data systems. Real-time tracking and periodic evaluation can help identify districts with declining performance and enable timely intervention.

Fifth, there is a need to promote community participation and local governance. Involving local bodies such as Panchayats in planning and maintenance can improve accountability and long-term sustainability.

Sixth, policies should address intra-district inequalities, especially rural–urban gaps and disparities among socio-economic groups. Targeted schemes for vulnerable populations can ensure inclusive development.

Finally, integrating drinking water initiatives with broader programs related to sanitation, health, and rural development can create a more holistic approach and improve overall living conditions.

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Conclusion

This study examined district-level changes in drinking water access in Uttar Pradesh using data from NFHS-4 (2015–16) and NFHS-5 (2019–21). The findings clearly indicate that access to drinking water has significantly improved over time, as confirmed by the paired samples t-test. The majority of districts show positive changes, reflecting the success of government initiatives and infrastructure development efforts aimed at expanding basic services.

The district-wise analysis further reveals that larger improvements occurred in previously low-performing districts, suggesting a pattern of balanced development and gradual reduction in regional disparities. At the same time, districts with already high levels of coverage exhibited minimal change, indicating a plateau effect due to near-universal access. A few districts showed slight declines; however, these were marginal and do not alter the overall positive trend.

Despite these improvements, the study highlights the need to move beyond mere access and focus on sustainability, quality, and equity in water provision. Ensuring safe, reliable, and inclusive access remains crucial for long-term development outcomes.

In conclusion, the study provides strong evidence that drinking water access in Uttar Pradesh has improved significantly over time, but continued policy attention is required to maintain progress and address remaining gaps.

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