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Navigating the Waves: Understanding the Nexus of Bangalore's Water Crisis

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Abstract

Bangalore has been grappling with a water crisis for quite some time, and this study delves into the depths of this issue in the city of Bangalore, India, focusing on demographic factors and their associations with various aspects of the crisis. Data was collected through a structured questionnaire administered to residents of Bangalore, addressing primary source of water, experiences with water shortages, satisfaction with water quality, awareness of water conservation practices, perceived causes of the crisis, perception of crisis severity, engagement in water conservation practices, and household size. A comprehensive literature review was conducted to contextualize the study within existing research on water crises and demographic influences. Demographic analysis was conducted alongside Pearson chi-square tests to explore the relationships between variables. Results indicate significant associations between demographic factors such as age, gender, and employment status, and various aspects of the water crisis, including experiences with water shortages, satisfaction with water quality, awareness of conservation practices, perceived causes of the crisis, and household size. The interpretation of these tests provides insights into the nuanced relationships between demographic characteristics and perceptions/behaviors related to the water crisis. The findings underscore the importance of considering demographic factors in formulating water management strategies and policies. The research concludes with managerial insights highlighting the implications of the study for policymakers, urban planners, and water resource managers in addressing the water crisis in Bangalore effectively.

Keywords: Water crisis in Bangalore, Water management strategies, Policy implications for water management, Water resource management

1. Introduction

Bangalore, the capital city of the Indian state of Karnataka, is known for its pleasant climate, lush green spaces, and vibrant culture. However, the city has been grappling with a severe water crisis in recent years, which has raised concerns about its sustainability and liveability. The water crisis in Bangalore is a complex issue that has been exacerbated by rapid urbanization, population growth, and inadequate infrastructure, leading to a critical shortage of water supply in the city.

The water crisis in Bangalore is a result of several factors, including the over-extraction of groundwater, the pollution of water bodies, and the mismanagement of water resources. The city's water demand is projected to exceed the available supply by 2025, according to a report by the Bangalore Water Supply and Sewerage Board (BWSSB) (BWSSB, 2022). The demand for water in Bangalore is expected to reach 2,150 million liters per day (MLD) by 2025, while the available supply is estimated to be only 1,850 MLD.

The city's water supply infrastructure is inadequate to meet the growing demand for water. The BWSSB supplies water to only 70% of the city's population, leaving the remaining 30% dependent on private tankers and borewells (Kumar et al., 2020). The water supply infrastructure is also plagued by leakages and inefficiencies, leading to a significant loss of water.

The over-extraction of groundwater is another major contributor to the water crisis in Bangalore. The city's groundwater levels have been declining rapidly, with some areas experiencing a decline of up to 10 meters in the last decade (Kumar et al., 2020). The unchecked growth of industries, urban sprawl, and the proliferation of borewells have led to the depletion of groundwater resources, making it increasingly difficult to meet the city's water demand.

The pollution of water bodies is another significant challenge facing Bangalore's water resources. The city's lakes and rivers are heavily polluted due to the discharge of untreated sewage and industrial waste. According to a study by the Central Pollution Control Board (CPCB), 95% of the city's lakes are polluted, making them unfit for drinking or recreational purposes (CPCB, 2018).

The mismanagement of water resources is a significant issue in Bangalore. The city's water distribution system is plagued by inefficiencies, leading to a significant loss of water. The BWSSB estimates that 30% of the water supplied to the city is lost due to leakages and theft (BWSSB, 2022).

Addressing the water crisis in Bangalore requires a holistic approach that involves sustainable water management practices, conservation efforts, and policy interventions. Initiatives like rainwater harvesting, wastewater recycling, and community engagement programs have shown promise in mitigating the impact of the water crisis in the city.

Rainwater harvesting is a cost-effective and sustainable solution to the water crisis in Bangalore. The city's climate is characterized by a monsoon season, which provides ample opportunity for rainwater harvesting. The BWSSB has mandated rainwater harvesting for all new buildings in the city, and several community-led initiatives have been successful in promoting the practice (Sharma & Tiwari, 2019).

Wastewater recycling is another promising solution to the water crisis in Bangalore. The city generates a significant amount of wastewater, which can be treated and reused for non-potable purposes like irrigation and flushing. The BWSSB has set up several wastewater treatment plants in the city, but the capacity needs to be increased to meet the growing demand for water (BWSSB, 2022).

Community engagement programs are crucial in addressing the water crisis in Bangalore. The city's residents need to be aware of the importance of water conservation and the impact of their actions on the city's water resources. Community-led initiatives like water audits, water conservation workshops, and water meter installations have been successful in promoting water conservation and reducing water waste (Sharma & Tiwari, 2019).

This study aims to provide a comprehensive analysis of Bangalore's water crisis, focusing on its causes, impacts, and potential solutions. By employing a multidisciplinary approach that integrates qualitative interviews, quantitative surveys, and spatial analysis, we seek to capture the diverse perspectives of stakeholders involved in water management. Our goal is to generate insights that inform evidence-based policymaking and empower communities to address the challenges posed by the water crisis. Through collaboration with local stakeholders and engagement with diverse communities, we aim to identify innovative strategies for water conservation and management, ultimately contributing to a more sustainable and equitable water future for Bangalore.

1. Literature Review

The literature on water crisis in urban areas, particularly focusing on Bangalore, reveals a multifaceted understanding of the challenges and potential solutions. Raju, Manasi, and Latha (2008) highlight the emerging groundwater crisis in Ward No. 39 of Bangalore, shedding light on the localized issues within the city. Ramachandra et al. (2014) propose an integrated wetlands ecosystem model as a sustainable approach to mitigate the water crisis in Bangalore, emphasizing the importance of ecosystem-based solutions.

Goldman and Narayan (2020) analyze Bangalore's hydro-social regimes through the lens of urban transformation, providing insights into the complex socio-political dynamics shaping water management practices. Thippiah (2017) explores the vanishing lakes and over-exploited groundwater in Bangalore, emphasizing the environmental implications of rapid urbanization and water mismanagement.

Drangert and Sharatchandra (2017) advocate for a third generation of water management strategies, focusing on reducing, treating, and reusing water resources to address urban water scarcity effectively. Ghosh (2021) discusses the water stress and crisis in large Indian cities, including Bangalore, within the context of sustainable climate action and water management.

Grönwall (2008) examines access to water rights and obligations in Bangalore, highlighting the complexities of water governance in urban settings. Bijani (2012) emphasizes the importance of citizen participation in water management, underscoring the need for inclusive and participatory approaches.

Maheshwari and Pillai (2001) discuss the challenges of water management in India and advocate for a balanced approach to address the water crisis. Ramasamy (2020) provides an introspective analysis of the significant challenges facing Bangalore, including water scarcity and management issues.

Manasi and Umamani (2013) present a case study of rainwater harvesting initiatives in Bangalore as a means of water conservation in urban areas. Thara (2017) examines water commodification, law, gender, and poverty in Bangalore, highlighting the socio-economic dimensions of water access and distribution.

Paul et al. (2018) conducted a water mass balance analysis of Bangalore city, revealing insights into the urban metabolism and water usage patterns. Raj (2013) explores the concept of sustainable urban habitats and urban water supply, focusing on unaccounted for water in Bangalore.

Baradwaj (2014) investigates awareness and participation in sustainable urban water management, using the case study of Jakkur Lake in Bangalore to illustrate community engagement initiatives. Martinez (2022) examines the role of water access in sustainable livelihoods in informal settlements in Bangalore, highlighting the social implications of water scarcity.

Bhattacharyya and Prasad (2020) discuss water scarcity in Delhi and propose mapping solutions to address the challenges of urban water management. Ramachandra et al. (2016) provide an overview of the water situation in Bangalore, offering insights into the environmental and socio-economic factors influencing water availability and usage patterns.

The challenges faced by urban areas like Bangalore, particularly in the context of water access and sustainability, have drawn increasing attention from researchers. Martinez (2022) delves into the dynamics of Bangalore's transformation into a "Smart City" and raises critical questions about inclusivity, particularly concerning access to essential resources like water. Focusing on informal settlements, Martinez's study highlights the disproportionate impact of water scarcity on vulnerable populations and its implications for sustainable livelihoods. This research underscores the urgency of addressing water access disparities to ensure equitable development in rapidly urbanizing areas like Bangalore.

Complementing Martinez's focus on water access challenges, Reddy and Ramasamy (2013) offer an introspective analysis of the significant challenges confronting Bangalore. While not specifically centered on water issues, their study likely encompasses water-related concerns given the city's multifaceted urban challenges. By examining the broader socio-economic and infrastructural issues facing Bangalore, Reddy and Ramasamy provide valuable insights into the interconnectedness of various urban challenges, including water management.

Paul, Kenway, McIntosh, and colleagues (2018) contribute to the discourse on water sustainability in Bangalore through their study on the urban metabolism of the city. Their analysis employs a water mass balance approach, shedding light on the intricate dynamics of water usage, distribution, and management within Bangalore's urban ecosystem. By quantifying water flows and identifying areas of inefficiency or loss, their study informs strategies for optimizing water resource management and enhancing urban water sustainability.

These studies collectively underscore the complex and multifaceted nature of the water crisis in Bangalore. From issues of access and equity in informal settlements to broader challenges related to urban infrastructure and sustainability, researchers are grappling with the myriad dimensions of the water crisis in the city. Moving forward, interdisciplinary approaches that integrate insights from fields such as urban planning, environmental science, and social equity will be crucial for developing effective solutions to address Bangalore's water challenges and ensure a sustainable and equitable water future for all residents.

3. Research Methodology

3.1. Data Sources

This study examines the water crisis in Bangalore, focusing on the perceptions, experiences, and perspectives of stakeholders involved in water management. The data collection methodology employed is multi-faceted, aiming to gather a comprehensive dataset that reflects the diverse dimensions of the crisis. Utilizing a mixed-methods approach, the study employs quantitative surveys to capture insights into stakeholders' perceptions and opinions regarding the water crisis. The survey is distributed electronically through various channels, including social media groups, online forums, and direct outreach to stakeholders in the water management sector. By employing a rigorous data collection process, the study aims to ensure a statistically significant sample size, enabling robust analysis and reliable conclusions regarding the water crisis in Bangalore and its implications for sustainability and resilience.

3.2. Methodology

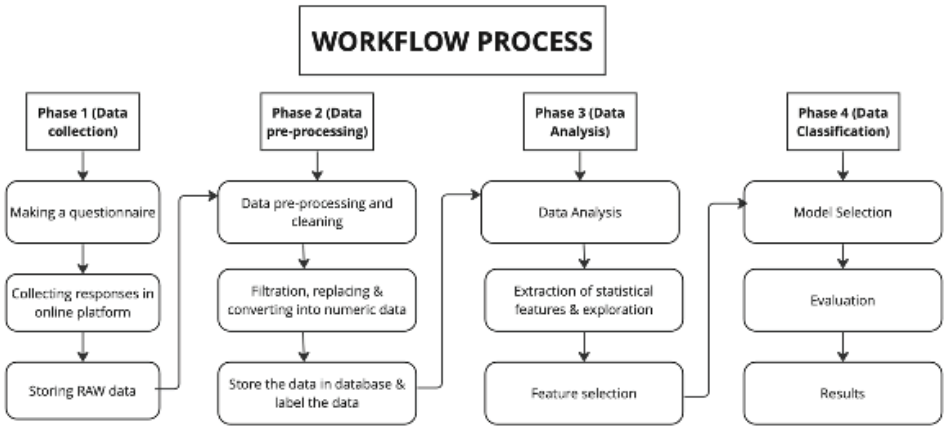
The first step in the four-phase workflow process for data processing is data collection, which is started by designing a questionnaire and using an online platform to collect replies.

Subsequently, the data proceeds to the second stage, known as data pre-processing, during which it is cleaned and organized by eliminating irrelevant information, filling in any gaps in the data, and transforming text data into numerical values to maintain consistency.

The dataset is next examined using statistical techniques in the third stage of data analysis, which reveals patterns and trends that offer insightful information.

Eventually, a suitable model is chosen to categorize the data in the fourth phase of data classification, which is based on the analysis carried out in the preceding phase.

The results are then kept in a database for future use and reference. Because of the methodical and thorough approach to data processing that this structured workflow ensures, researchers are able to draw significant conclusions and make well-informed judgments based on the insights acquired from the dataset.



4. Results and Discussions:

4.1. Descriptive Statistics

The descriptive analysis provides a breakdown of several demographic variables.

Regarding age distribution, the majority of respondents fall within the age range of 30 to 49, with 18 respondents (21.4%) aged between 30 and 39, and 25 respondents (29.8%) aged between 40 and 49. The next largest age group is 20 respondents (23.8%) aged between 50 and 59. The older demographic, aged 60 and above, comprises 9 respondents (10.7%).

In terms of gender, the respondents are fairly evenly split, with 45 (53.6%) identifying as female and 39 (46.4%) as male. Looking at the educational background, the majority of respondents, 42 (50%), have completed high school education (category 1), followed by 21 respondents (25%) with a college degree (category 3), and 17 respondents (20.2%) with graduate studies (category 2).

Regarding employment status, the largest category consists of respondents who are employed full-time (category 1), with 68 respondents (80.9%). There are also 12 respondents (14.3%) who are employed part-time (category 2), and 5 respondents (6%) who are not currently employed (category 4).

TABLE 1: Descriptive Statistics of the respondent's characteristics

Variable	Category	Frequency	Percentage
Age	20-29	12	14.30%
	30-39	18	21.40%
	40-49	25	29.80%
	50-59	20	23.80%
	60+	9	10.70%
Gender	Female	45	53.60%
	Male	39	46.40%
Educational Background	3	21	25
	1	42	50
	2	17	20.2
Employment Status	1	68	80.9
	2	12	14.3
	4	5	6

1.1. Association between variables that are related and affect water crisis:

TABLE 2: Association between Age and Key Variables Related to the Water Crisis in Bangalore

Variable 1	Variable 2	Pearson chi square	P value
Age	Primary Source of water	8.559	0.381
	Water shortages	105.370	<0.001
	Water Quality satisfaction	46.235	<0.001
	Awareness of water conservation	28.589	0.005
	Causes of water crisis	79.047	<0.001
	Perception of crisis severity	57.846	<0.001
	Water conservation practises	55.788	0.019
	Household size	127.749	<0.001

The Pearson chi-square tests in Table 2 reveal significant associations between age and several key aspects of the water crisis in Bangalore, including experiencing water shortages, satisfaction with water quality, awareness of conservation practices, perceived causes of the crisis, perception of crisis severity, engagement in conservation practices, and household size. However, age is not significantly associated with the primary source of water used by respondents. These findings suggest that age may play a significant role in shaping individuals' experiences, perceptions, and behaviours related to the water crisis, highlighting the importance of considering age-specific approaches in addressing water-related challenges in Bangalore.

TABLE 3: Association between Gender and Key Variables Related to the Water Crisis in Bangalore

Variable 1	Variable 2	Pearson chi square	P value
Gender	Primary Source of water	0.042	0.979
	Water shortages	46.829	<0.001
	Water Quality satisfaction	20.286	<0.001
	Awareness of water conservation	3.045	0.385
	Causes of water crisis	22.856	0.002
	Perception of crisis severity	23.184	<0.001
	Water conservation practises	13.063	0.160
	Household size	47.692	<0.001

The Pearson chi-square tests in Table 3, conducted to examine the relationships between gender and various variables related to the water crisis in Bangalore reveal both significant and non-significant associations. Gender shows no significant association with the primary source of water used by respondents, as indicated by a high p-value of 0.979. However, significant associations are observed between gender and experiencing water shortages, satisfaction with water quality, perceived causes of the crisis, perception of crisis severity, and household size, with p-values less than 0.001 or close to it. Conversely, gender does not show a significant association with awareness of water conservation practices and engagement in water conservation practices, with p-values of 0.385 and 0.160, respectively.

These findings suggest that while gender may not influence certain aspects of the water crisis, it plays a significant role in others, emphasizing the need for gender-sensitive approaches in addressing water-related challenges in Bangalore.

TABLE 4: Association between Employment Status and Key Variables Related to the Water Crisis in Bangalore.

Variable 1	Variable 2	Pearson chi square	P value
Employment Status	Primary Source of water	21.558	0.001
	Water shortages	19.186	0.024
	Water Quality satisfaction	21.744	0.010
	Awareness of water conservation	24.838	0.003
	Causes of water crisis	47.148	<0.001
	Perception of crisis severity	25.943	0.011
	Water conservation practises	37.993	0.078
	Household size	133.526	<0.001

The Pearson chi-square tests in Table 4 conducted to explore the relationships between employment status and various variables related to the water crisis in Bangalore reveal both significant and non-significant associations. Employment status exhibits a significant association with the primary source of water, experiencing water shortages, satisfaction with water quality, awareness of water conservation practices, perceived causes of the crisis, perception of crisis severity, and household size, with p-values less than 0.05 or close to it. However, employment status does not show a significant association with engagement in water conservation practices, as indicated by a p-value of 0.078.

These findings suggest that employment status plays a significant role in shaping individuals' experiences, perceptions, and behaviours related to the water crisis in Bangalore, emphasizing the importance of considering employment-related factors in water management and policy-making efforts.

TABLE 5: Association between Household Size, Water Conservation practice, Water Shortage and Key Variables Related to the Water Crisis in Bangalore.

Variable 1	Variable 2	Pearson chi square	P value
Household size	Water Shortage	106.309	<0.001
Water conservation practice	Perception of crisis severity	234.489	<0.001
Water Shortage	Awareness of water conservation	28.590	<0.001

In the Pearson chi-square tests conducted, several significant associations emerged between different variables related to the water crisis. Specifically, there were significant associations observed between household size and water shortage, indicating that household size has a notable influence on the experience of water shortages within households. Additionally, the relationship between water conservation practices and the perception of crisis severity was found to be highly significant, suggesting that individuals who engage in water conservation practices tend to perceive the water crisis as more severe.

Moreover, water shortage was significantly associated with awareness of water conservation, highlighting the link between experiencing water scarcity and being aware of conservation efforts. However, it's important to note that the association between water conservation practice and water shortage was not significant, indicating that engaging in conservation practices may not necessarily alleviate the immediate effects of water shortages.

4. Conclusion

The water situation in Bangalore is a big problem that needs serious attention and solutions that cover many different areas. This research looked at how different things like age, gender, and jobs are connected to the water problems in Bangalore. What we found is that these factors are linked to how people experience things like not having enough water,

feeling okay about the quality of the water they get, knowing about ways to save water, what they think is causing the water issues, and how big their households are. This shows us that it's really important to think about who people are when we're trying to figure out and solve water issues in Bangalore.

For example, we saw that older people might see the water problem as more serious and might be more likely to do things to save water. This means that when we're trying to talk to people about saving water, we might need to have different messages for different age groups. Similarly, we found that women might have different experiences with water shortages and might be more affected by the quality of the water they get compared to men. So, we need to make sure our solutions to the water problem in Bangalore are fair for everyone, regardless of gender.

We also saw that whether someone has a job or not can affect how they deal with the water crisis. People with jobs might have different experiences with things like water shortages or how they feel about the quality of the water. This tells us that when we're planning things to help with the water problem, we need to think about how people's jobs might play a role.

Overall, this study helps us understand more about the water crisis in Bangalore and how it's connected to who people are. By knowing this, we can come up with better ways to solve the water problem. It's really important for policymakers, city planners, and people who manage water resources to use this information to come up with solutions that work for everyone. By working together and using what we learned in this study, we can make sure that everyone in Bangalore has access to clean and reliable water, no matter who they are.

Conflict of Interest Statement

The authors declare that they have no conflicts of interest related to this study.

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