
**AN EMPIRICAL STUDY ON THE IMPACT OF RAINWATER HARVESTING IN REDUCING
DEPENDENCY ON NMMC WATER SUPPLY IN NAVI MUMBAI**

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ABSTRACT

The growing urbanization in Navi Mumbai has increased dependence on a single centralized water source the Morbe Dam which has led the city vulnerable to climate variability and infrastructure strain. Despite high annual rainfall, decentralized rainwater harvesting (RWH) remains underutilized. This study investigates the relationship between awareness, perceived effectiveness, willingness to adopt RWH, and household dependency on municipal water supply. Using a quantitative, descriptive design, primary data were collected from 74 residents through a structured questionnaire. Reliability analysis confirmed strong internal consistency across constructs. Correlation results revealed significant positive relationships between municipal water dependency and awareness ($r=0.789$), perceived effectiveness ($r=0.761$), and willingness ($r=0.681$). Regression analysis showed that awareness ($\beta=0.514$, $p<0.001$) and perceived effectiveness ($\beta=0.427$, $p=0.0016$) significantly predicted dependency, while willingness did not. Overall, the model explained 69.4% of variance in dependency. Findings suggest that knowledge and belief in RWH effectiveness are stronger determinants of reducing reliance on centralized supply than willingness alone. Policy interventions should therefore prioritize awareness-building and demonstration of practical benefits to encourage adoption of RWH and enhance urban water sustainability in Navi Mumbai.

Keywords: Rainwater Harvesting, awareness, perceived effectiveness, willingness to adopt, sustainable urban infrastructure, Water scarcity.

1. INTRODUCTION**1.1 Background****1.1.1 Urban water Stress**

The global demographic landscape has undergone a significant transformation since 1990, characterized by a persistent and accelerating trend toward urbanization. While the moving of populations from rural areas to urban areas is not a new phenomenon, the amplitude of this shift has escalated in recent decades. Between 1990 and 2000, the average annual increase in the number of urban residents was approximately 57 million by 2018, this figure had risen to 82 million. In 1990, 43 percent of the world's population, which is approximately 2.3 billion individuals, resided in urban areas. By 2015, this proportion had expanded to 54 percent, representing nearly 4 billion people (UN-Habitat, 2016). By the year 2050, the global population is estimated to reach approximately 9.8 billion. Out of this total, 6.7 billion individuals will reside in urban areas, compared to 3.1 billion in rural settings. This projection suggests that 68 percent of the world's population will be concentrated in urban environments, underscoring the continuing trend of global urbanization (Roser, 2018).

This rapid expansion has given way to water stress related water scarcity. "Water scarcity" is defined as the point at which the cumulative demands of all users affect the supply or quality of water under prevailing institutional arrangements such that the needs of all sectors, including the environment, cannot be fully met. In practical terms, water scarcity occurs whenever there is inadequate access to water for drinking and sanitation. On the other hand, "water shortage" is considered a relative concept, which may arise at any level of supply or demand (Batten, 2018). Water shortage can be understood as a social construct, shaped by factors such as affluence, expectations, and customary behavior, or as the result of altered supply patterns, for instance those arising from climate change. Future water availability and quality are expected to be influenced by projected changes in the frequency and severity of floods and droughts, as well as associated risks (Vörösmarty, Green, Salisbury, & Lammers, 2000).

1.1.2 Rapid growth of Navi Mumbai

The rapid growth of Navi Mumbai has been marked not only by its planned urban expansion but also by the rise of unplanned settlements that complicate the city's developmental narrative. These settlements have emerged within the broader contradictions of global interconnectedness that shape the wider Mumbai metropolitan region. The coexistence of the global economy and the local economy in the urban landscape underscores the uneven nature of urbanization. Within this local economy, the spatial organization is complex—ranging from temporary shelters occupied by transient migrant populations, to more permanent

slums and shanties, as well as villages that predate the planned city itself. Importantly, the urban poor are far from a homogeneous group; they are differentiated by residential status, length of stay, and strategies for survival. While some residents rely on patron–client relationships to secure livelihoods and shelter, others engage in activism to assert their rights. Together, these dynamics illustrate the diverse ways marginalized populations negotiate urban life and survival in the context of a rapidly expanding planned city.(Shaw, 2003)

1.1.3 Dependency on Morbe Dam

The Navi Mumbai region receives its potable water supply primarily from the Morbe Dam, a gravity dam constructed on the Dhavari River near Khalapur in the Raigad district of Maharashtra, India. The dam is owned and operated by the Navi Mumbai Municipal Corporation (NMMC). Designed with a total supply capacity of approximately 450 million litres per day (MLD), the system currently utilizes around 330 MLD to meet regional demand. Water drawn from the reservoir undergoes treatment at the Bhokarpada Water Purification Plant, also located in the Raigad district, before being distributed across Navi Mumbai.(Ram et al., 2017)

1.1.4 Sustainability Concerns

Global efforts to promote sustainable urban water infrastructure increasingly emphasize strategies such as water reuse. Yet, concerns are mounting that wastewater effluents often contain elevated levels of antibiotics, antibiotic-resistant bacteria, and antibiotic resistance genes. These contaminants may contribute to the rising prevalence of antibiotic resistance in human infections. Current evidence suggests that the aquatic environment can act both as a reservoir and a transmission pathway for antimicrobial resistance, but significant uncertainties remain. In particular, the extent to which waterborne resistance translates into clinical outcomes is not well understood, and the persistence of resistance genes across different water systems requires further investigation. Addressing these challenges will demand coordinated action. Engineers, public health researchers, and policymakers must work together to integrate antimicrobial resistance considerations into the design and operation of sustainable water systems. Investment in epidemiology, risk assessment, and advanced water treatment technologies will be essential to ensure that water reuse initiatives achieve their sustainability goals without inadvertently exacerbating public health risks. By bridging these knowledge gaps, future water strategies can balance ecological sustainability with the imperative of safeguarding human health.(Pruden et al., 2013)

2. PROBLEM STATEMENT

Navi Mumbai's rapid urbanization has brought with it a growing dependence on a single water source—the Morbe Dam. As the city expands and its population rises, increasing per capita demand has placed mounting pressure on this centralized reservoir. Relying on one source of supply leaves the city vulnerable to climate variability, delayed monsoons, infrastructure strain, and ultimately, long-term water insecurity. This dependence is particularly striking given the region's high annual rainfall, which remains largely untapped due to the limited adoption of decentralized rainwater harvesting (RWH) systems.

Yet, despite the potential of RWH to ease the burden on municipal supply, there is little empirical evidence on how awareness, perceived effectiveness, and willingness to adopt such systems shape residents' sense of dependency on centralized water. This study seeks to bridge that gap, situating Navi Mumbai's water challenges within the broader tension between centralized infrastructure and decentralized sustainability solutions.

3. RESEARCH OBJECTIVES

The present study aims to examine the impact of rainwater harvesting on reducing dependency on municipal water supply in Navi Mumbai.

3.1 Main Objective

To evaluate whether rainwater harvesting can reduce dependency on water supplied by Navi Mumbai Municipal Corporation (NMMC), primarily sourced from Morbe Dam.

3.2 Specific Objectives

To measure the level of household dependency on NMMC water supply.

To assess awareness of rainwater harvesting among residents.

To evaluate the perceived effectiveness of rainwater harvesting in reducing municipal water consumption.

To analyze the willingness of residents to adopt rainwater harvesting systems.

To determine the relationship between rainwater harvesting variables and municipal water dependency.

4. RESEARCH HYPOTHESES

4.1 Correlation Hypotheses

H₁₁: There is a significant positive relationship between awareness of rainwater harvesting and municipal water dependency.

H₁₂: There is a significant positive relationship between perceived effectiveness of rainwater harvesting and municipal water dependency.

H₁₃: There is a significant positive relationship between willingness to adopt rainwater harvesting and municipal water dependency.

4.2 Regression Hypotheses

H₁: Rainwater harvesting variables significantly predict municipal water dependency.

5. REVIEW OF LITERATURE

One of the most urgent challenges of rapid urbanization is Urban water scarcity. As cities expand and populations rise, the demand for water often outpaces the capacity of centralized supply systems. This growth places heavy strain on urban infrastructure, particularly water networks, making sustainable management strategies essential (UN-Habitat, 2016).

Global studies show that freshwater resources are increasingly vulnerable to climate change and population pressures. Rising demand and environmental stress have intensified water scarcity across many regions, threatening the resilience of global water systems (Vörösmarty et al., 2000). These trends highlight the need to explore alternative approaches that can complement conventional municipal supplies.

Rainwater harvesting (RWH) is widely recognized as one such solution. Rooftop systems capture rainfall that would otherwise be lost as runoff, providing a supplementary source for domestic use. Research suggests that harvested rainwater can meet non-potable needs such as flushing, gardening, and cleaning, thereby easing reliance on municipal networks (Fewkes, 1999).

Yet adoption depends not only on technical feasibility but also on social and behavioral factors. Studies on environmental behavior emphasize that awareness and knowledge strongly influence sustainable practices. Residents who understand the benefits and operation of RWH are more likely to support its use. Perceived effectiveness is equally important: when households believe RWH can meaningfully reduce dependence on municipal supply, they are more inclined to adopt it. Demonstrating practical benefits is therefore critical to shaping public attitudes toward decentralized water solutions.

Despite growing recognition, uptake remains uneven. In fast-growing cities such as Navi Mumbai, dependence on centralized supply continues to dominate. Research on Navi Mumbai's development underscores the strain that rapid expansion places on infrastructure and public services (Shaw, 2003).

Much of the existing literature has focused on environmental and technical aspects of RWH, while behavioral dimensions remain less explored. In particular, the links between awareness, perceived effectiveness, willingness to adopt RWH, and reliance on municipal systems are underexamined in the Indian urban context. This study aims to fill that gap by empirically investigating these relationships among residents of Navi Mumbai.

6. RESEARCH METHODOLOGY

6.1 Research Design

This study employs a quantitative and descriptive research design to explore how awareness and perceived effectiveness of rainwater harvesting influence dependency on municipal water in Navi Mumbai. By focusing on measurable perceptions and behaviors, the research aims to uncover patterns and relationships between key variables. The design is analytical in nature, as it not only describes existing conditions but also tests hypotheses using statistical techniques to identify significant associations.

6.2 Data Source

The analysis is grounded in primary data collected through a structured questionnaire distributed via Google Forms. The survey was carefully designed to capture residents' perspectives on four critical dimensions:

Dependency on Municipal (NMMC) Water Supply**Awareness of Rainwater Harvesting****Perceived Effectiveness of Rainwater Harvesting****Willingness to Adopt Rainwater Harvesting**

By gathering responses across these dimensions, the study provides insights into how individuals perceive their reliance on centralized water systems and their openness to decentralized sustainability solutions.

6.3 Sample Size and Sampling Technique

The study is based on 74 valid responses collected from residents of Navi Mumbai. A convenience sampling approach was adopted, with participants selected based on accessibility and willingness to take part in the survey. To ensure diversity and representation, respondents were drawn from different residential nodes across Navi Mumbai, reflecting the city's varied urban landscape.

6.4 Measurement Scale

The questionnaire employed a 5-point Likert Scale to capture perceptions, where:

1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5 = Strongly Agree

To analyze responses more effectively, composite indices were created by averaging related items. These indices include:

Municipal Water Dependency Index

Awareness Index

Perceived Effectiveness Index

Willingness Index

This structured measurement approach allowed the study to quantify attitudes and behaviors, providing a clear basis for examining the relationship between rainwater harvesting perceptions and reliance on municipal water supply.

6.5 Reliability Analysis

To ensure internal consistency of the measurement scale, **Cronbach's Alpha** was calculated. Cronbach's Alpha is used to check whether the questions under each section are consistent and reliably measure the same concept.

Construct	Cronbach's Alpha (α)	Interpretation
Awareness	0.938	Excellent
Willingness to Adopt	0.910	Excellent
Dependency on Municipal Water	0.866	Good
Perceived Effectiveness	0.849	Good

As the Cronbach's Alpha values for all the constructs is above 0.70 it indicates good internal consistency. Therefore, the scales are reliable for further analysis.

6.6 Statistical Tools Used

The data collected from 74 respondents were analyzed using Microsoft Excel, employing a set of statistical techniques to ensure reliability and to examine relationships among the study variables.

Reliability Testing (Cronbach's Alpha):

Cronbach's Alpha was applied to test the internal consistency of the measurement scales. All constructs recorded alpha values above **0.70**, confirming good reliability of the indices used.

Correlation Analysis (Pearson's Correlation):

Pearson correlation analysis was conducted to assess the strength and direction of relationships between the variables, providing insights into how awareness, perceived effectiveness, and willingness relate to municipal water dependency.

Regression Analysis (Multiple Linear Regression):

To evaluate the combined effect of awareness, perceived effectiveness, and willingness on municipal water dependency, multiple linear regression analysis was performed. The regression model is expressed as:

$$\text{Dependency} = \beta_0 + \beta_1(\text{Awareness}) + \beta_2(\text{Effectiveness}) + \beta_3(\text{Willingness}) + \epsilon$$

This model allowed the study to quantify how different factors collectively influence reliance on municipal water supply, offering a structured way to test the hypotheses.

7. RESULT**7.1 Correlation Analysis – Testing Hypotheses (H_{11} , H_{12} , H_{13})**

To explore the relationship between municipal water dependency and three key factors—awareness, perceived effectiveness, and willingness to adopt rainwater harvesting—Pearson's correlation analysis was conducted.

Key Findings

Dependency and Awareness: $r=0.789 \rightarrow$ Strong positive relationship

Dependency and Perceived Effectiveness: $r=0.761 \rightarrow$ Strong positive relationship

Dependency and Willingness: $r=0.681 \rightarrow$ Moderately strong positive relationship

All correlations were statistically significant at the 5% level.

Hypothesis Testing Results

H_{11} : Awareness has a strong positive correlation with municipal water dependency ($r=0.789$).

H_{12} : Perceived effectiveness shows a strong positive correlation with municipal water dependency ($r=0.761$).

H_{13} : Willingness to adopt rainwater harvesting demonstrates a moderately strong positive correlation with municipal water dependency ($r=0.681$).

Interpretation

The analysis reveals a clear pattern: individuals who are more aware of rainwater harvesting, who trust in its effectiveness, and who express greater willingness to adopt it also report a higher sense of dependency on the municipal water supply (NMMC).

This suggests that as people recognize their reliance on municipal water, they become more open to exploring alternatives such as rainwater harvesting. In other words, stronger awareness and positive attitudes toward rainwater harvesting are closely tied to acknowledging the limits of municipal water, which may serve as a motivating factor for adopting sustainable practices.

7.2 Multiple Regression Analysis – Testing H_1

To evaluate the combined influence of awareness, perceived effectiveness, and willingness on municipal water dependency, a multiple linear regression model was applied:

$$\text{Dependency} = \beta_0 + \beta_1(\text{Awareness}) + \beta_2(\text{Effectiveness}) + \beta_3(\text{Willingness}) + \epsilon$$

A multiple linear regression analysis was conducted to examine the combined effect of awareness, perceived effectiveness, and willingness on municipal water dependency. The overall model was statistically significant, $F \text{ value}=52.87$, $p\text{-value} < 0.001$, with a $R^2 = 0.694$ and adjusted $R^2 = 0.681$. This means that the three predictors together explain about 69.4% of the variance in dependency.

Looking at individual predictors:

Awareness ($\beta=0.514$, $p<0.001$) was a strong and statistically significant predictor.

Perceived effectiveness ($\beta=0.427$, $p=0.0016$) also showed a significant positive effect.

Willingness ($\beta=0.060$, $p=0.608$) did not reach statistical significance.

Hypothesis Testing

H_{11} : awareness significantly predicts municipal water dependency.

H₁₂: perceived effectiveness significantly predicts municipal water dependency.

H₁₃: willingness does not significantly predict municipal water dependency.

Thus, the overall hypothesis (H_i) is partially confirmed, indicating that while awareness and perceived effectiveness are significant predictors, willingness does not play a statistically significant role in this model.

8. DISCUSSION

The findings indicate that Awareness and Perceived Effectiveness are significant predictors of municipal water dependency. This suggests that individuals who are more informed about rainwater harvesting and who perceive it as effective are more likely to critically evaluate their dependency on municipal water systems.

Although Willingness is positively correlated with Dependency, it does not significantly predict Dependency when Awareness and Effectiveness are included in the model. This indicates that willingness alone does not independently influence dependency perception.

Statistically, this means that Willingness does not explain additional variance beyond what is already explained by Awareness and Effectiveness.

This suggests that Knowledge and belief in system performance are stronger determinants than mere intention. Willingness may be influenced by awareness and perceived effectiveness rather than acting as an independent driver.

9. CONCLUSION

The study concludes that Awareness and Perceived Effectiveness significantly influence municipal water dependency, whereas Willingness does not independently predict dependency when other factors are controlled.

Although respondents may express willingness toward rainwater harvesting adoption, this intention alone does not significantly alter dependency perceptions unless supported by awareness and perceived effectiveness.

Therefore, policy interventions aimed at reducing centralized water dependency should prioritize awareness-building and demonstrating practical effectiveness rather than focusing solely on encouraging willingness.

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