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A CRITICAL STUDY ON INDIA'S WATER CRISIS: ASSESSING THE ROLE OF POLICIES AND TECHNOLOGIES IN SUSTAINABLE WATER MANAGEMENT

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ABSTRACT

India faces a severe water crisis, with increasing demand and depleting resources threatening its sustainable development. The **objective** of this study to investigates the critical role of policies and technologies in addressing the water crisis and promoting sustainable water management practices. The **key factors** contributing to water scarcity, evaluating government initiatives, and assessing technological advancements for efficient water use. The study followed here is **empirical research**. A total of 207 samples have been collected out of which all samples have been collected through convenient sampling methods.The content explores the **evolution** of water management, transitioning from traditional conservation systems to modern, unsustainable extraction practices. Government programs like the Jal Shakti Abhiyan and Atal Bhujal Yojana are critically analyzed for their impact. The **findings** reveal that while policies and initiatives are in place, their fragmented implementation and lack of public awareness limit their effectiveness. Technological innovations, though promising, remain underutilized due to financial and infrastructural constraints. The **conclusion** underscores the urgency of adopting integrated approaches combining policy reforms, advanced technologies, and community participation to mitigate the water crisis and achieve sustainable water management in India.

KEYWORDS: Water Governance, Technological Innovation, Water Conservation, Policy Reform, Sustainable Irrigation Systems

INTRODUCTION

India's water crisis highlights a shift from traditional, community-driven water conservation practices like stepwells, tanks, and rainwater harvesting to modern, unsustainable methods such as excessive groundwater extraction and inefficient infrastructure. Post-independence, rapid urbanization, industrialization, and agricultural expansion fueled the overuse of resources, exacerbating the crisis. While policies and technologies have gradually emerged to address water scarcity, their fragmented implementation and lack of integration with traditional systems have limited their impact, underscoring the need for sustainable, innovative solutions.

AIM OF THE STUDY

The primary aim of this study is to critically analyze India's ongoing water crisis through an assessment of the role of policies and technologies in fostering sustainable water management. By examining the policies, strategies, and technological interventions in water management, this study seeks to identify their effectiveness, gaps, and potential areas for improvement.

OBJECTIVES

The key objectives include evaluating the evolution of water management policies, analyzing the government's initiatives to address the water crisis, identifying factors

influencing water scarcity, investigating current trends in water management technologies, and comparing the effectiveness of traditional and modern water management approaches in tackling the crisis.

EVOLUTION OF THE STUDY

India's water crisis has evolved significantly over the years, driven by a combination of factors such as rapid population growth, increasing urbanization, industrialization, and climate change. Historically, India's traditional water management systems such as wells, tanks, and canals were sufficient to meet local water needs. However, with industrial development and a rising population, water demands have escalated dramatically. Groundwater extraction has reached unsustainable levels, particularly in agricultural regions where water-intensive crops are cultivated. Over the decades, water availability per capita has sharply declined, exacerbating the water crisis. Climate change has further worsened the situation by altering precipitation patterns, leading to more frequent droughts and floods, making water resource management even more challenging.

GOVERNMENT INITIATIVES

In response to the escalating water crisis, the Indian government has introduced several initiatives aimed at improving water management and conservation. The National Water Policy (NWP), first introduced in 1987 and revised in 2012, emphasizes the need for integrated water resource management, conservation, and equitable distribution. The government also launched the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) in 2015, which focuses on expanding irrigation infrastructure, promoting efficient irrigation techniques like drip and sprinkler systems, and ensuring that every farm in India has access to irrigation. The Swachh Bharat Abhiyan, aimed at improving sanitation and promoting clean water, has also made strides in promoting better water management practices across rural and urban areas. Additionally, state governments have launched localized initiatives for rainwater harvesting and groundwater recharge. Despite these initiatives, their implementation has been inconsistent, with challenges in enforcement and policy coordination at local levels. Furthermore, the gap between policy formulation and actual field application continues to hinder progress.

FACTORS AFFECTING

Several factors contribute to the persistent water scarcity in India. One of the primary factors is inefficient water usage, especially in agriculture, which consumes about 80% of the country's water. Despite technological advancements in irrigation, outdated practices like flood irrigation still dominate agricultural water use. Poor water infrastructure, such as leaking pipes and inadequate storage facilities, exacerbates the problem, leading to substantial water losses. Furthermore, the lack of effective water governance, coupled with an absence of clear water rights and poor coordination among various governmental agencies, has contributed to the mismanagement of water resources. Groundwater over-extraction, driven by unregulated pumping, especially in regions reliant on deep borewells, has led to a significant depletion of aquifers. Another significant factor is the growing demand for water due to India's rapid urbanization. Urban areas struggle to manage water distribution systems, and water supply often fails to meet the rising demand. Climate change, with its erratic rainfall patterns, also plays a critical role in exacerbating water scarcity. With changing monsoon patterns and the rising frequency of droughts, managing water resources has become increasingly difficult.

CURRENT TRENDS

The integration of modern technologies is a critical trend in addressing the water crisis in India. Advanced technologies like Artificial Intelligence (AI), remote sensing, Geographic Information Systems (GIS), and big data analytics are transforming how water resources are monitored and managed. AI-based

systems, for example, can optimize water distribution networks by predicting demand and monitoring consumption patterns in real time, thus reducing water wastage. Similarly, GIS and remote sensing technologies are increasingly used to assess groundwater levels, track water bodies, and manage water resources on a larger scale. Another significant trend is the application of smart irrigation systems, including drip and sprinkler irrigation, which aim to optimize water use in agriculture. These technologies offer solutions to reduce water consumption in farming, but their adoption has been slow due to financial constraints and lack of awareness among farmers. Additionally, wastewater treatment technologies, such as membrane filtration and reverse osmosis, have gained traction in urban areas for recycling water for industrial use, irrigation, and even potable water. Rainwater harvesting technologies are being implemented across various states, although there is still limited integration with larger water management systems.

COMPARATIVE ANALYSIS

India's water management approach has traditionally relied on practices such as rainwater harvesting, water storage in ponds, and community-managed water systems. These practices have been effective at a local level, particularly in rural areas. Rainwater harvesting, for example, is an ancient practice that has been revitalized in recent years due to policy incentives and community involvement. However, these traditional methods often lack the scalability required to meet the demands of rapidly growing urban centers. Moreover, these practices alone cannot address the country's large-scale water scarcity. On the other hand, modern technologies offer scalability and the potential for more efficient water management. Smart irrigation systems, for instance, ensure precise water delivery to crops, minimizing wastage. Similarly, modern technologies like AI, IoT, and remote sensing can monitor and manage water resources across vast areas, offering solutions for urban water management. However, the integration of these technologies with traditional water management practices could offer a holistic approach, particularly in rural areas where local knowledge and community involvement are crucial.

OBJECTIVES

- To analyze the key factors contributing to India's water crisis, including overpopulation, climate change, pollution, and inefficient water use practices.
- To evaluate the effectiveness of existing government policies and initiatives aimed at sustainable water management in addressing the crisis.
- To assess the role and potential of emerging technologies, such as IoT-based water monitoring, desalination, and precision irrigation, in improving water management practices.
- To provide actionable recommendations for integrating policies, technologies, and community-driven approaches to achieve long-term water sustainability in India.

REVIEW OF LITERATURE

1. **Garg, A., & Sharma, R. (2005)** This paper critically examines India's growing water crisis, linking it to ineffective policies and outdated management techniques. The authors identify a critical issue of coordination failures in water governance, where different levels of government and agencies lack a unified approach. They highlight that water usage policies are fragmented and insufficient, which exacerbates the scarcity problem. The paper stresses the need for policy reforms that focus on efficient and equitable water management. The authors advocate for the widespread adoption of technologies like rainwater harvesting and drip irrigation, which can conserve water by optimizing its usage. They

suggest that these technologies, combined with policy reforms, would lead to better water conservation in the long run. Furthermore, they argue that sustainable practices such as these need robust technological support, and comprehensive policy changes to make them feasible and effective across the country.

2. **Shah, T., & Verma, S. (2006)** Shah and Verma's paper focuses on India's critical issue of groundwater depletion. Groundwater, being a major source of irrigation for agriculture, is being over-exploited, leading to severe long-term consequences. The authors point out the failure of the government to regulate groundwater extraction effectively, which has contributed to the depletion of this vital resource. They argue that without substantial policy changes and better management practices, groundwater will become increasingly scarce. The paper calls for integrating community-driven management practices, where local communities play a significant role in the monitoring and sustainable use of groundwater resources. Additionally, the authors advocate for the use of advanced technologies like remote sensing to monitor groundwater levels and usage. This combination of community participation and technology could greatly improve groundwater management and sustainability.
3. **Ahuja, S. (2007)** Ahuja's review addresses inefficiencies in India's irrigation systems, which are a primary cause of water wastage in agriculture. The paper explores various technologies like drip and sprinkler irrigation, which have proven to be efficient in water usage but are not widely adopted due to a lack of policy support and awareness. Ahuja argues that farmers are hesitant to adopt these water-efficient technologies because of high upfront costs and insufficient incentives from the government. The paper suggests that to overcome these barriers, the government needs to create stronger policies that support the adoption of such technologies. Incentives such as subsidies, training programs, and improved access to financing for small farmers could encourage the use of water-efficient technologies. The review concludes by calling for a holistic approach to water management that combines technological innovation with supportive policies to foster sustainable agricultural practices.
4. **Iyer, R. R. (2008)** Iyer critiques India's water governance structure, arguing that it is poorly designed to handle the challenges posed by water scarcity and inequitable distribution. He points out that the country's water policies often overlook issues such as water rights, fair distribution, and the sustainability of water resources. Iyer suggests a complete overhaul of the water management system, with a focus on decentralization. By involving local communities in water governance, he believes that India can create more localized and effective solutions to water management. The paper stresses the importance of integrating technological innovations, such as efficient irrigation and water purification technologies, with these policy reforms. This approach, according to Iyer, would help ensure equitable and sustainable water distribution, particularly in rural areas where water scarcity is most severe.
5. **Singh, O., & Kumar, R. (2009)** This study explores the relationship between India's water policies and the technologies available to address water scarcity, particularly in the agricultural sector. Singh and Kumar highlight that traditional water management

techniques, such as flood irrigation, have contributed to the ongoing water crisis by wasting large amounts of water. They argue that to address these challenges, India must embrace modern technologies like water-efficient irrigation systems and soil moisture sensors. These technologies, when integrated into national water policies, could greatly enhance agricultural water use efficiency and sustainability. The authors suggest that policy reforms should incentivize the adoption of these technologies to ensure that farmers can access the tools they need to use water more efficiently. By incorporating technology into policy, the authors argue that India can improve agricultural productivity while conserving precious water resources.

6. **Joshi, S., & Yadav, R. (2010)** Joshi and Yadav critique India's water policies, highlighting the lack of proactive measures for water conservation. Their review argues that current policies fail to incorporate emerging technologies such as water recycling, desalination, and wastewater treatment, which could significantly enhance India's ability to manage its freshwater resources. The authors suggest that these technologies should be central to policy decisions, as they can provide alternative sources of water and reduce reliance on overexploited freshwater resources. The paper calls for a shift in water management strategies, advocating for more innovative and sustainable solutions to address the country's growing water scarcity. Furthermore, the authors emphasize the need for greater investment in research and development to make these technologies more accessible and affordable for widespread use across different sectors of the economy.
7. **Gupta, S., & Patnaik, P. (2011)** Gupta and Patnaik's paper explores the role of irrigation technology in mitigating water scarcity in India. While acknowledging the introduction of micro-irrigation technologies such as drip and sprinkler systems, the authors note that their adoption has been slow. They identify several barriers to adoption, including a lack of awareness, insufficient training, and financial constraints faced by farmers. The paper argues that these challenges can be overcome by a holistic approach that combines technological advancements with an updated policy and legal framework. The authors recommend stronger incentives from the government, including subsidies, training programs, and financing options to encourage the widespread adoption of these water-efficient technologies. They stress that these changes are necessary to ensure better water distribution and conservation in India's agriculture sector.
8. **Singh, A. (2012)** Singh's review focuses on urban water management policies in India, where issues like water scarcity, inefficient distribution, and inadequate wastewater management have become increasingly pressing. The author critiques the current policies, arguing that they do not adequately address the growing water needs of urban populations. Singh calls for the promotion of technologies such as smart meters, which can optimize water usage and detect leaks, as well as water-saving appliances that can reduce household water consumption. The paper also advocates for the implementation of wastewater recycling systems, which could reduce the demand for fresh water and enhance overall water efficiency in cities. Singh's review emphasizes that urban water policies must evolve to incorporate

these modern technologies to ensure the sustainable management of urban water resources.

9. **Sharma, S., & Singh, H. (2013)** Sharma and Singh highlight the policy failures that have led to the over-exploitation of water resources in India. They argue that current water management practices are unsustainable and have resulted in the depletion of water sources, especially in regions dependent on agriculture. The paper explores the potential of various technological innovations, including Geographic Information Systems (GIS), remote sensing, and automated irrigation systems, to improve water management and distribution. The authors suggest that India's water management policies must integrate these technologies to achieve better conservation, equitable distribution, and efficient use of water resources. The paper concludes by stressing the need for policy reforms that facilitate the adoption of these technologies at both the local and national levels to address water scarcity effectively.

10. **Reddy, P., & Joshi, S. (2014)** Reddy and Joshi analyze the role of the private sector in addressing India's water crisis, particularly through the adoption of water conservation technologies like rainwater harvesting. The authors argue that while there has been some progress in the adoption of such technologies, the policy environment remains insufficient to facilitate widespread implementation. They suggest that the private sector can play a crucial role in driving technological innovation and providing effective solutions to water scarcity. However, for the private sector to contribute meaningfully, the government must create a policy framework that incentivizes the private sector's involvement in water conservation. The authors emphasize the importance of public-private partnerships in scaling up the adoption of water-saving technologies and ensuring long-term sustainability in water management practices.

11. **Vaidyanathan, A., & Sahu, A. (2015)** Vaidyanathan and Sahu focus on agricultural water management, advocating for the widespread adoption of modern irrigation technologies like drip and micro-irrigation systems. These technologies, they argue, can significantly reduce water wastage in agriculture, which is the largest consumer of water in India. Despite the proven benefits of these technologies, the paper critiques the policy environment for not providing sufficient incentives or support for their adoption. The authors suggest that to promote the use of water-efficient irrigation technologies, the government must implement stronger policy measures, including subsidies, access to affordable financing, and training programs for farmers. By fostering these practices, India can achieve more sustainable water management in agriculture, reducing both water waste and the environmental impact of over-exploitation.

12. **Khanna, D., & Jain, S. (2016)** Khanna and Jain examine the legal and regulatory frameworks for water management in India, highlighting the disconnect between technological advancements and the absence of enforceable water policies. The paper argues that despite the availability of advanced water management technologies, India's water policies remain weak and poorly enforced, leading to the continued depletion of water resources. The authors emphasize the need for stronger legal frameworks that support the adoption of these technologies. This

includes stricter regulations on water usage, the establishment of clear water rights, and penalties for violations. The paper suggests that aligning technological innovations with robust legal frameworks will create a more sustainable and effective water management system in India, ensuring that technological solutions are implemented efficiently and consistently across the country.

13. **Mehta, M., & Desai, V. (2017)** Mehta and Desai focus on the role of decentralized water management, particularly in rural India. They argue that empowering local communities to manage their own water resources is essential for effective water management, as local knowledge and participation can lead to more context-specific and sustainable solutions. The authors propose integrating low-tech solutions such as rainwater harvesting with high-tech innovations like satellite-based monitoring to create comprehensive water management strategies. They stress that the Indian government must adopt policies that promote decentralized water management and provide the necessary resources and training for communities to effectively manage their water resources. This approach, according to the authors, will lead to more resilient water systems that can better withstand regional challenges like droughts and water scarcity.

14. **Agarwal, N., & Chaturvedi, S. (2018)** Agarwal and Chaturvedi explore the potential of information technology (IT) in improving water management in India. They highlight the use of technologies like Geographic Information Systems (GIS), cloud computing, and data-driven solutions to monitor, analyze, and manage water resources more effectively. Despite significant advancements in IT, the authors argue that the adoption of these technologies in water management has been slow due to outdated policies and regulatory frameworks. They recommend that the government modernize its policies to encourage the widespread adoption of IT solutions for water management, which could lead to more efficient allocation and conservation of water resources. The paper also calls for investment in research and development to make IT solutions more accessible and affordable for various sectors.

15. **Thakur, R., & Yadav, S. (2019)** Thakur and Yadav review the evolution of India's water management policies, with a particular focus on the integration of new technologies. They examine innovations like water-efficient irrigation technologies, desalination, and wastewater treatment plants, which have the potential to address India's growing water management challenges. The authors conclude that India's water policies need to become more flexible and adaptive to incorporate these new technological solutions. They advocate for policy reforms that allow for the dynamic integration of emerging technologies, ensuring that the country's water management system can evolve alongside technological advancements. This, they believe, will help India meet its growing water demands and address the challenges posed by water scarcity in the future.

16. **Sharma, P., & Kaur, R. (2020)** Sharma and Kaur examine the role of water policy in India's agricultural sector, where inefficient water management practices have led to widespread water scarcity. They argue that current policies fail to integrate modern technological innovations like moisture sensors and automated irrigation systems, which could greatly improve water

management in agriculture. The authors suggest that the government should provide incentives for farmers to adopt these technologies, including subsidies and access to training. By incorporating these technologies into agricultural water policies, they argue, India can significantly reduce water usage and improve the sustainability of its farming practices, ensuring long-term water security for the country.

17. **Kumar, R., & Singh, M. (2021)** Kumar and Singh focus on the challenges of urban water management in India, particularly issues like water leakage, inefficient distribution, and inadequate wastewater treatment. They argue that India's urban water policies are outdated and fail to address the growing demands of rapidly expanding urban populations. The authors suggest that urban water policies must be updated to incorporate modern technologies like sensors, artificial intelligence (AI), and big data analytics. These technologies can help optimize water distribution systems, predict water demand, and monitor consumption patterns, reducing water wastage and improving overall efficiency. The paper emphasizes that India's urban water management must evolve to include these innovations to ensure sustainable water usage in cities.

18. **Nair, R., & George, S. (2022)** Nair and George critique India's outdated water policies in the context of climate change. The authors argue that current policies do not adequately address the challenges posed by climate variability, which has intensified water scarcity and distribution problems. They advocate for incorporating climate-resilient technologies, such as drought-resistant crops and rainwater harvesting systems, into water policies. This would help mitigate the effects of climate change and ensure a more sustainable water supply for future generations. The paper calls for urgent policy reforms to better align water management practices with the realities of climate change, preparing India for future water challenges.

19. **Patel, M., & Khan, F. (2023)** Patel and Khan emphasize the need for a systemic shift in India's water policies to address the water crisis effectively. They argue that current policies underutilize technological advancements like AI, advanced monitoring systems, and big data analytics, which could significantly improve water management. The authors critique existing policies for their rigid and outdated frameworks, which fail to leverage these new technologies. They advocate for more adaptable and forward-thinking policy structures that encourage the integration of cutting-edge technologies to solve India's water management problems. By embracing technological innovations, the authors believe India can enhance its water management systems and address the growing water crisis.

20. **Chandra, P., & Soni, A. (2024)** Chandra and Soni provide a comprehensive review of the intersection between water policy, technology, and sustainable water management in India. The paper identifies significant shortcomings in current water policies, particularly in integrating modern technologies such as IoT-based water management systems, which could revolutionize how water is managed. They suggest that India's policy frameworks need to be restructured to better incorporate these technologies, ensuring long-term sustainability in water resource management. The authors argue that this integration of technology and policy would enable better water distribution, conservation, and usage, helping India

manage its water resources more effectively and sustainably in the future.

21. **Singh, R., & Bhatia, S. (2024)** This study emphasizes the importance of integrating community-driven water management strategies with advanced technological solutions to address India's water crisis, particularly in rural areas. The authors argue that, while technological solutions like drip irrigation and remote sensing hold promise for improving water efficiency, the involvement of local communities is essential for sustainable water management. By empowering communities to manage their water resources using modern tools, the authors suggest that it is possible to create more resilient and efficient systems for water conservation. The review underscores the need for policies that foster community participation and support the deployment of modern technologies in local water management practices.

22. **Joshi, N., & Sharma, T. (2024)** Joshi and Sharma focus on the increasing pressure urbanization places on water resources and explore how modern technologies can help manage this challenge. They specifically highlight the role of Artificial Intelligence (AI) and Internet of Things (IoT) in urban water management, proposing that these technologies could optimize water distribution systems, predict demand patterns, and reduce wastage. Despite the potential of these technologies, the paper argues that India's urban water management policies remain outdated and fail to fully support the adoption of AI and IoT. To address this, the authors call for policy reforms that would enable the integration of these technologies, leading to more efficient and sustainable water management in India's growing cities.

23. **Patil, G., & Soni, R. (2024)** Patil and Soni examine the current state of wastewater treatment technologies in urban India, arguing that effective treatment and reuse of wastewater could significantly alleviate pressure on freshwater resources. The paper highlights several advanced technologies, such as membrane filtration, reverse osmosis, and bio-remediation, that can be used to treat wastewater for reuse in irrigation, industrial processes, and even potable water supplies. The authors stress the need for robust policy frameworks that support the widespread adoption of wastewater treatment technologies. They conclude that the government must provide financial incentives and policy support to overcome the challenges in scaling up these technologies across urban areas.

24. **Rani, S., & Verma, H. (2024)** Rani and Verma's review investigates the barriers preventing the widespread adoption of water-saving technologies in India's agricultural sector. Despite the availability of water-efficient irrigation systems like drip and sprinkler irrigation, the authors argue that their adoption has been slow due to factors such as lack of awareness, inadequate training, and financial constraints. The paper emphasizes the need for stronger incentives from the government, such as subsidies and training programs for farmers, to promote the adoption of these technologies. The authors also call for a more cohesive policy that aligns agricultural water management with sustainable technology adoption, aiming to enhance water conservation in farming practices.

25. **Kaur, A., & Jha, P. (2024)** Kaur and Jha's study focuses on the role of Artificial Intelligence (AI) in optimizing water distribution systems in India. They highlight how AI technologies can be

used to predict water demand, monitor distribution systems in real time, and identify potential issues like leaks or inefficiencies. However, the paper notes that India's water policies have not adequately addressed the integration of AI into water management. The authors argue that AI has the potential to transform water management, but this can only be achieved with supportive policy frameworks that encourage research, development, and the implementation of AI solutions in both urban and rural water systems.

26. **Bansal, S., & Malhotra, V. (2024)** Bansal and Malhotra explore the role of public-private partnerships (PPPs) in addressing the water crisis in India. They argue that while PPPs can drive innovation in water management, such as the development of new water-saving technologies and infrastructure, they face significant challenges in implementation due to inconsistent policy support and regulatory hurdles. The authors suggest that the government should create a conducive policy environment to foster greater collaboration between the public and private sectors. They emphasize that clear legal frameworks and incentives for private companies are essential to ensure the success of PPPs in the water sector, which can lead to more sustainable water management practices across the country.
27. **Mishra, M., & Dey, T. (2024)** Mishra and Dey review the impact of climate change on India's water resources, stressing the need for water management strategies that are resilient to climate variability. They argue that climate change exacerbates the country's water scarcity issues, with changing precipitation patterns and increasing droughts making water management even more challenging. The paper advocates for the integration of climate-resilient technologies, such as drought-resistant crops and efficient irrigation systems, into national water policies. The authors propose that India's water policies should not only address current water scarcity but also plan for future climate-related challenges, ensuring long-term water security.
28. **Kumar, A., & Gupta, S. (2024)** Kumar and Gupta analyze the emerging challenges in urban water management in India, particularly issues related to water leakage, unaccounted-for water, and inadequate wastewater treatment. They argue that current urban water management policies are insufficient to address these challenges and call for a comprehensive overhaul of urban water governance. The paper emphasizes the need for the integration of modern technologies like smart water meters, AI systems, and big data analytics to optimize water distribution, prevent losses, and monitor consumption patterns. The authors conclude that policy changes must be made to support these technological innovations, which can significantly improve the efficiency and sustainability of urban water management.
29. **Chawla, P., & Rani, D. (2024)** Chawla and Rani explore the integration of traditional and modern water management practices in rural India. They highlight how traditional methods, such as rainwater harvesting and community-managed water systems, can complement modern technologies like Geographic Information Systems (GIS) for better water management. The authors argue that policies should promote a hybrid approach that combines the best of both worlds, allowing rural communities to leverage modern tools while preserving traditional knowledge. The review calls for

government support in promoting these hybrid models through funding, training, and policy incentives, ensuring more efficient and sustainable water use in rural areas.

30. **Sharma, N., & Patel, J. (2024)** Sharma and Patel discuss the intersection of policy, technology, and sustainable water management in India. They identify the underutilization of modern technologies, such as IoT-based water management systems, as a major barrier to effective water governance. The paper argues that India's water policies are not adapting quickly enough to technological advances and recommends a restructuring of these policies to better incorporate innovations that could enhance water conservation and distribution. The authors stress the need for a forward-thinking policy framework that fosters collaboration between government agencies, technology providers, and local communities to ensure the sustainable management of India's water resources.

METHODOLOGY

The study employs an **empirical** research method to assess the role of policies and technologies in sustainable water management. A **convenient** sampling method was used to gather data from **207** respondents residing in and around Chennai, ensuring accessibility and relevance to the region's water management challenges. The **sample frame** focused on individuals from various backgrounds, including households, local authorities, and technology experts, to capture diverse perspectives.The **independent variables** considered in the study include demographic factors such as age, gender, and educational qualifications, which influence perceptions and awareness of water policies and technologies. The **dependent variables** are based on the research objective and include measures such as awareness, effectiveness, and implementation of water management policies and technologies.For **data analysis**, the study utilized SPSS software to perform statistical evaluations. Bar graphs were used for visual representation of data trends, while the chi-square test was applied to assess the relationship between independent and dependent variables. These statistical tools ensured a robust and reliable analysis of the collected data, providing insights into the role of policies and technologies in mitigating water management issues.

HYPOTHESIS

[HYPOTHESIS 1]

H1 : There is an relationship between the Educational qualification and their responses on the question of agreement levels on the role of river-linking projects in solving water scarcity issues.

H0 : There is no relationship between the Educational qualification and their responses on the question of agreement levels on the role of river-linking projects in solving water scarcity issues.

[HYPOTHESIS 2]

H1 : There is an relationship between the Occupation and their responses on the question of agreement levels on the role of river-linking projects in solving water scarcity issues.

H0 : There is no relationship between the Occupation and their responses on the question of agreement levels on the role of river-linking projects in solving water scarcity issues.

[HYPOTHESIS 3]

H1 : There is an relationship between the Residence and their responses on the question of the awareness levels of water-saving technologies like drip irrigation and other efficient techniques.

H0 : There is no relationship between the Residence and their responses on the question of the awareness levels of water-saving

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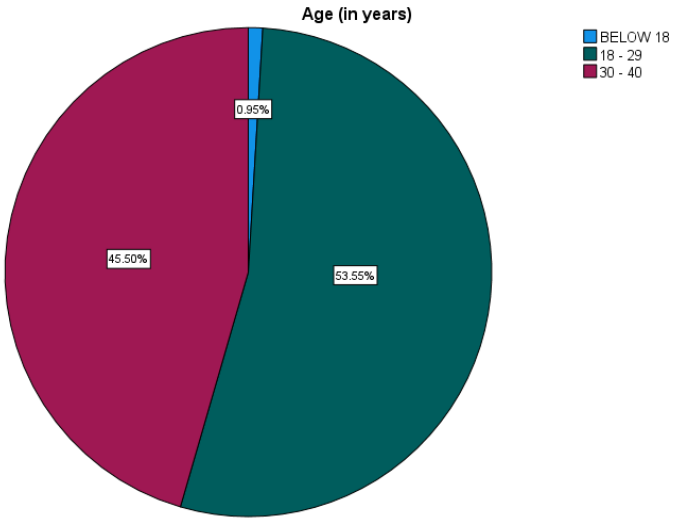
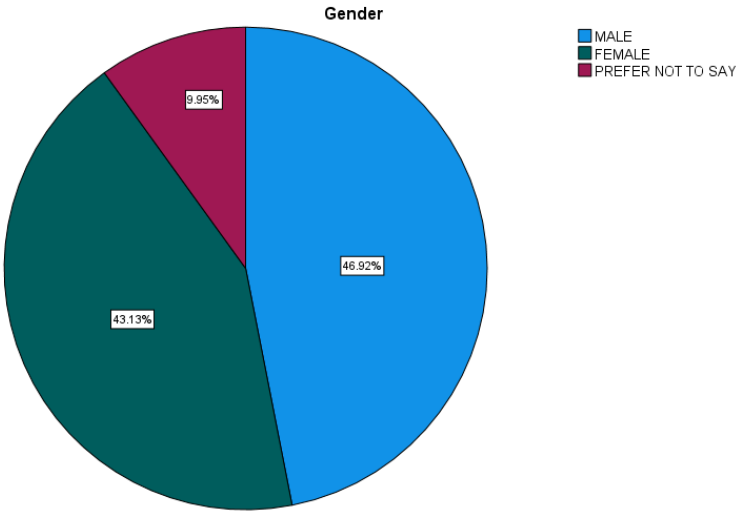
ANALYSIS

FIGURE 1



LEGEND : The above pie chart shows the age distribution of respondents, highlighting the majority in the 18–29 age group.

FIGURE 2



LEGEND : The above pie chart illustrates the gender composition of respondents, including those who preferred not to disclose their gender.

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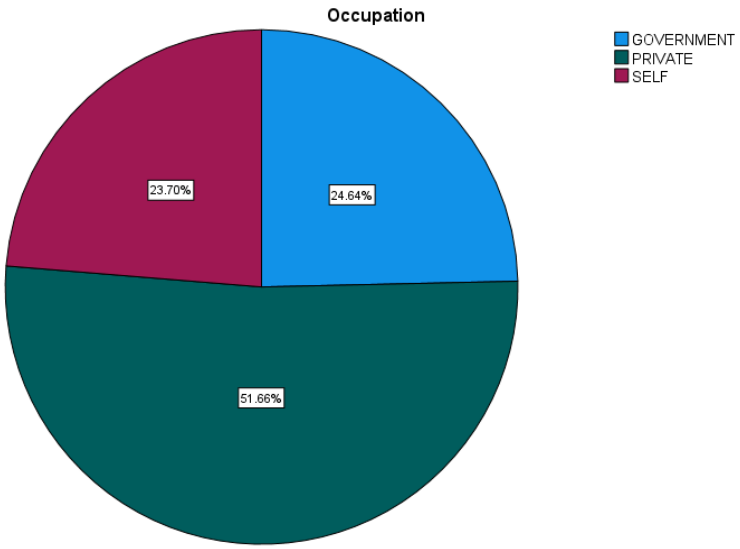
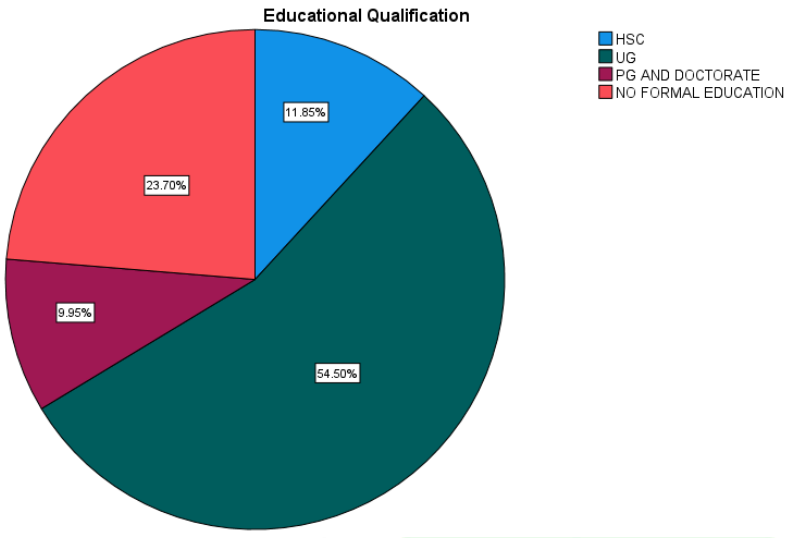
FIGURE 3



LEGEND : The above pie chart depicts the occupational sectors of respondents, including private, government, and self-employment categories.

FIGURE 4



LEGEND : The above pie chart shows the educational qualifications of respondents, ranging from undergraduate to no formal education.

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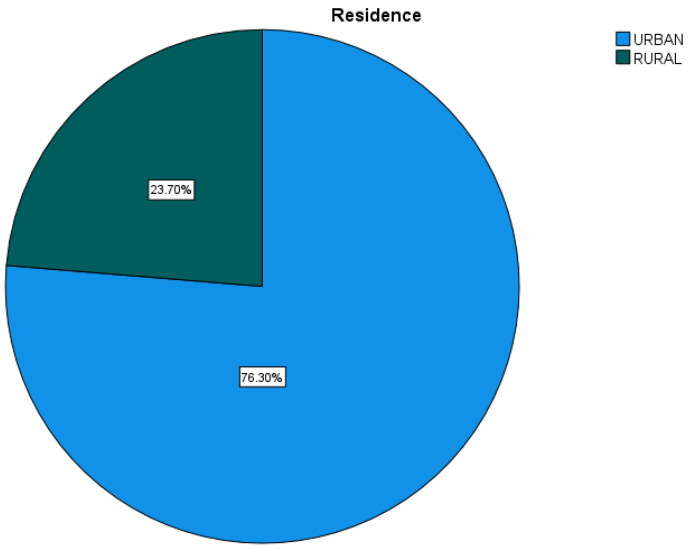
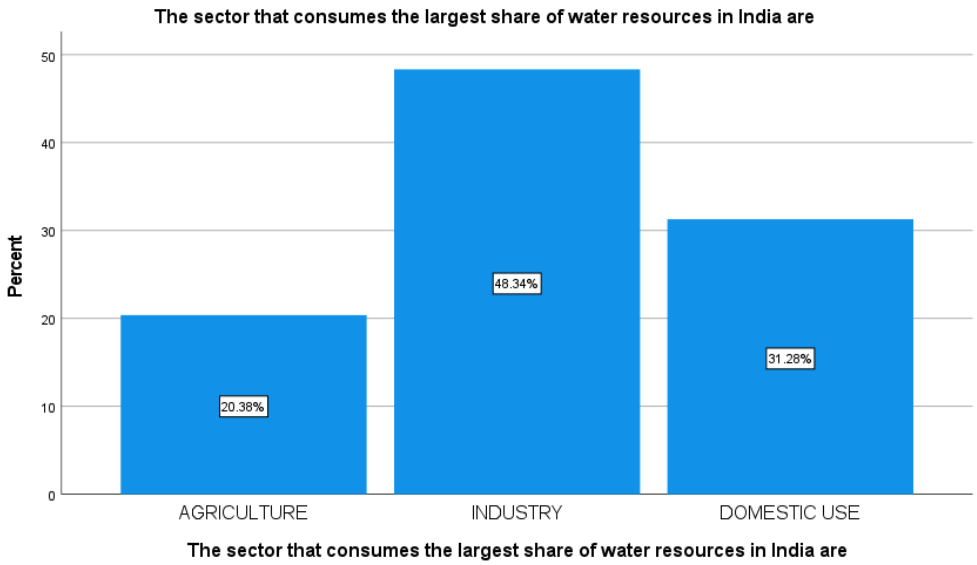
FIGURE 5



LEGEND : The above pie chart illustrates the residential distribution of respondents, categorizing them as urban or rural residents.

FIGURE 6



LEGEND : The above bar graph shows the distribution of water consumption across industrial, domestic, and agricultural purposes as reported by respondents.

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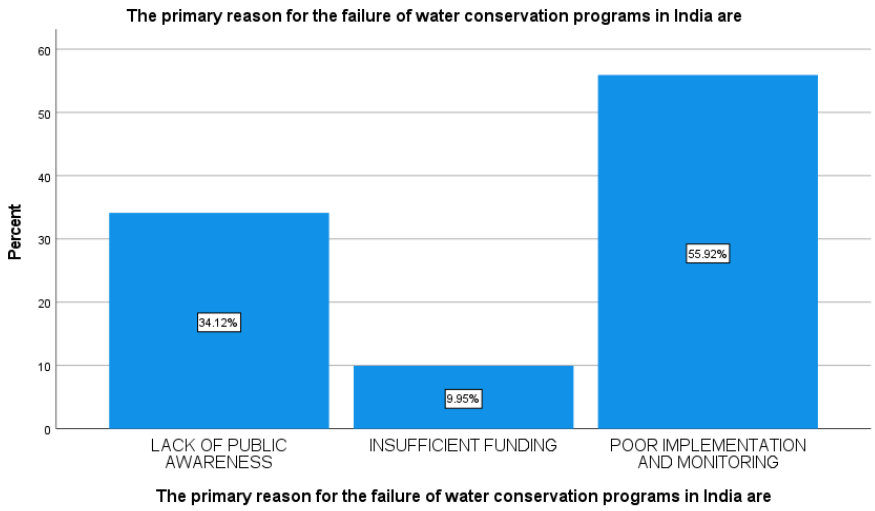
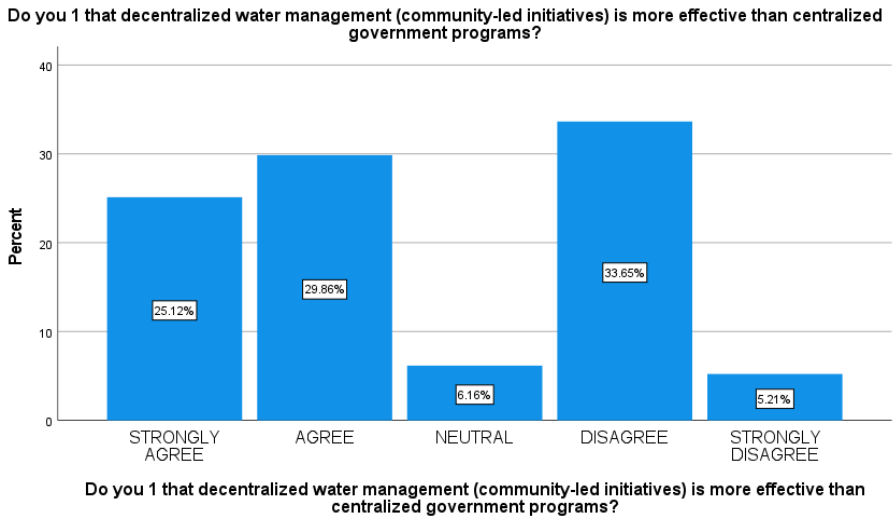
FIGURE 7



LEGEND : The above bar graph depicts respondents' views on the primary reasons for the failure of water conservation programs, including poor implementation, lack of awareness, and funding issues.

FIGURE 8



LEGEND : The above bar graph illustrates respondents' opinions on the effectiveness of decentralized water management and community-led initiatives.

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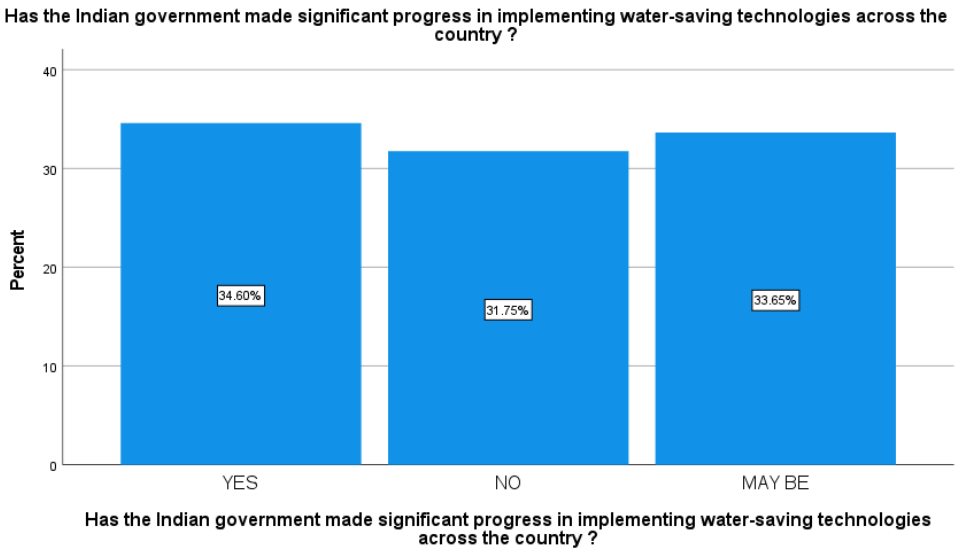
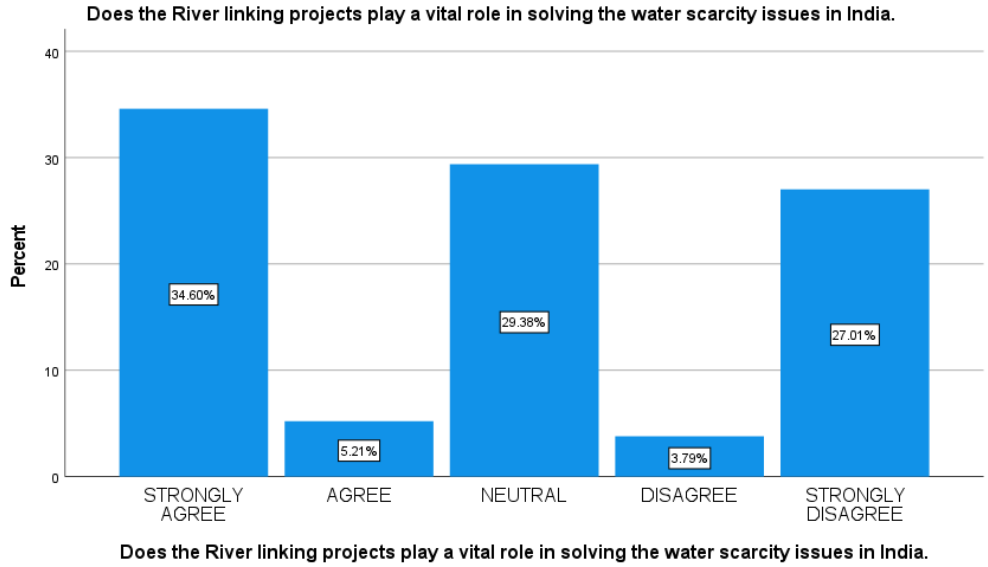
FIGURE 9



LEGEND : The above bar graph shows respondents' perspectives on the Indian government's progress in implementing water-saving technologies.

FIGURE 10



LEGEND : The above bar graph highlights respondents' agreement levels on the role of river-linking projects in solving water scarcity issues.

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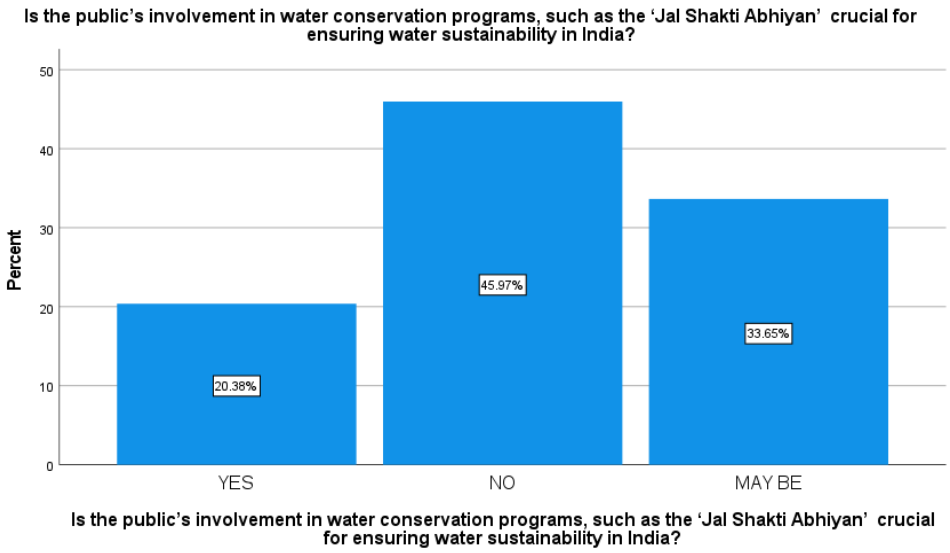
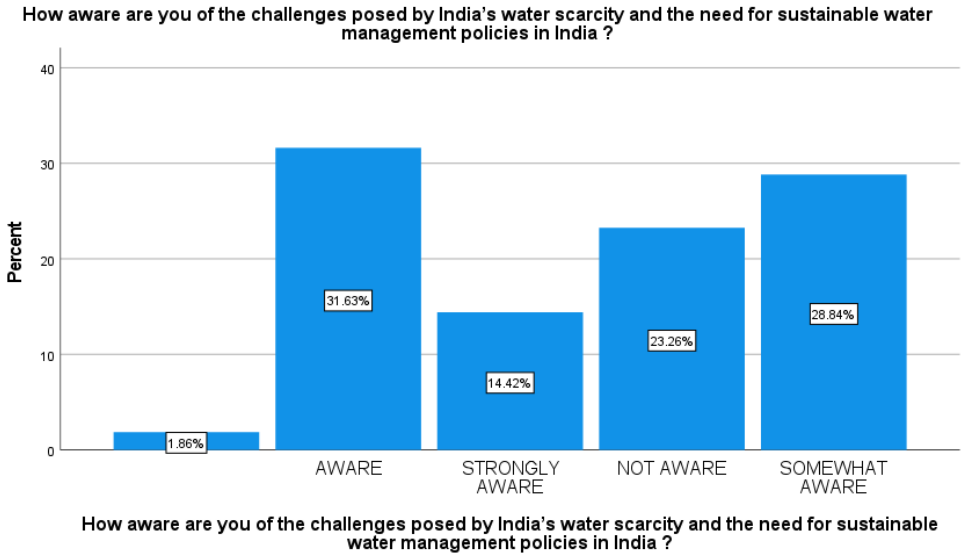
FIGURE 11



LEGEND : The above bar graph illustrates respondents' views on the importance of public involvement in water conservation programs like the Jal Shakti Abhiyan.

FIGURE 12



LEGEND : The above bar graph shows the awareness levels among respondents regarding water scarcity challenges and sustainable water management policies.

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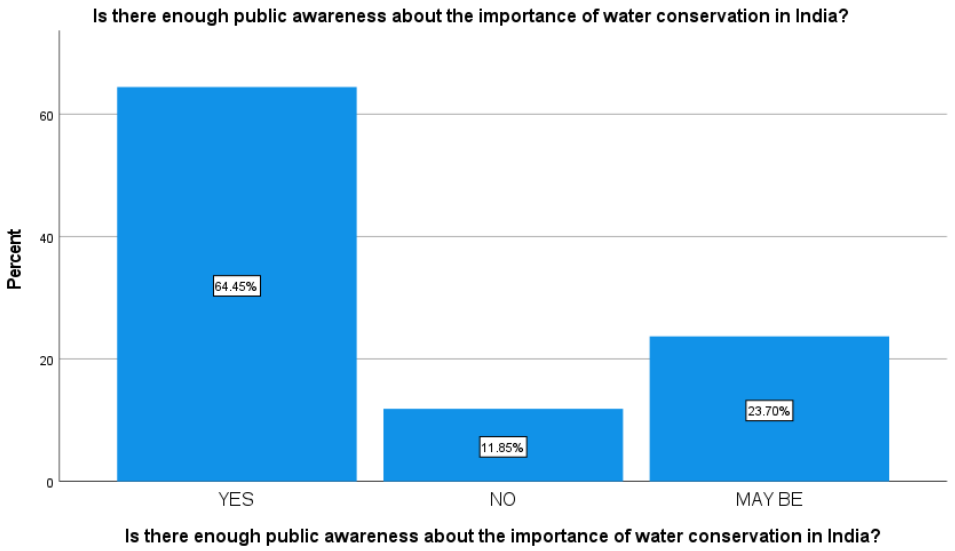
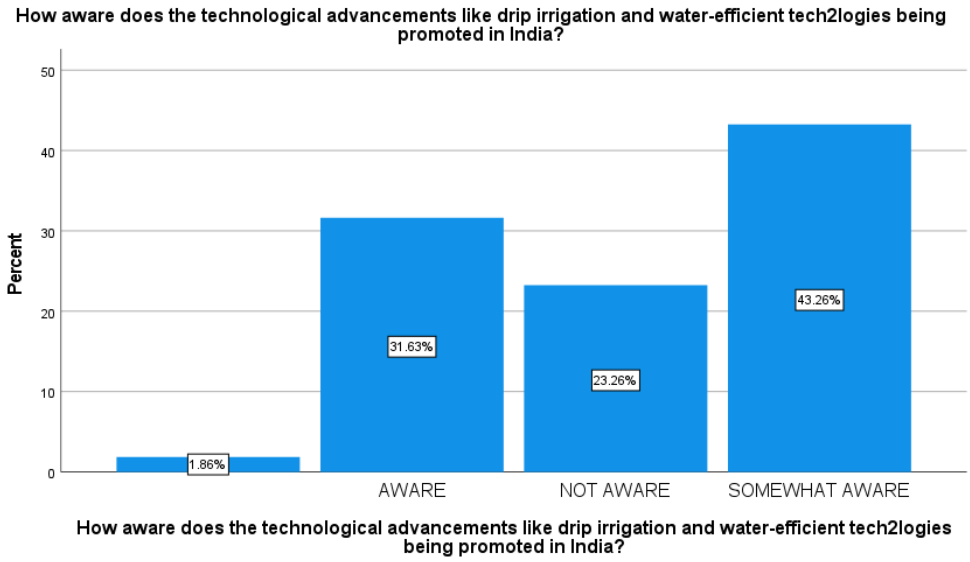
FIGURE 13



LEGEND : The above bar graph illustrates respondents' opinions on whether there is sufficient public awareness about water conservation in India.

FIGURE 14



LEGEND : The above bar graph depicts respondents' awareness levels of water-saving technologies like drip irrigation and other efficient techniques.

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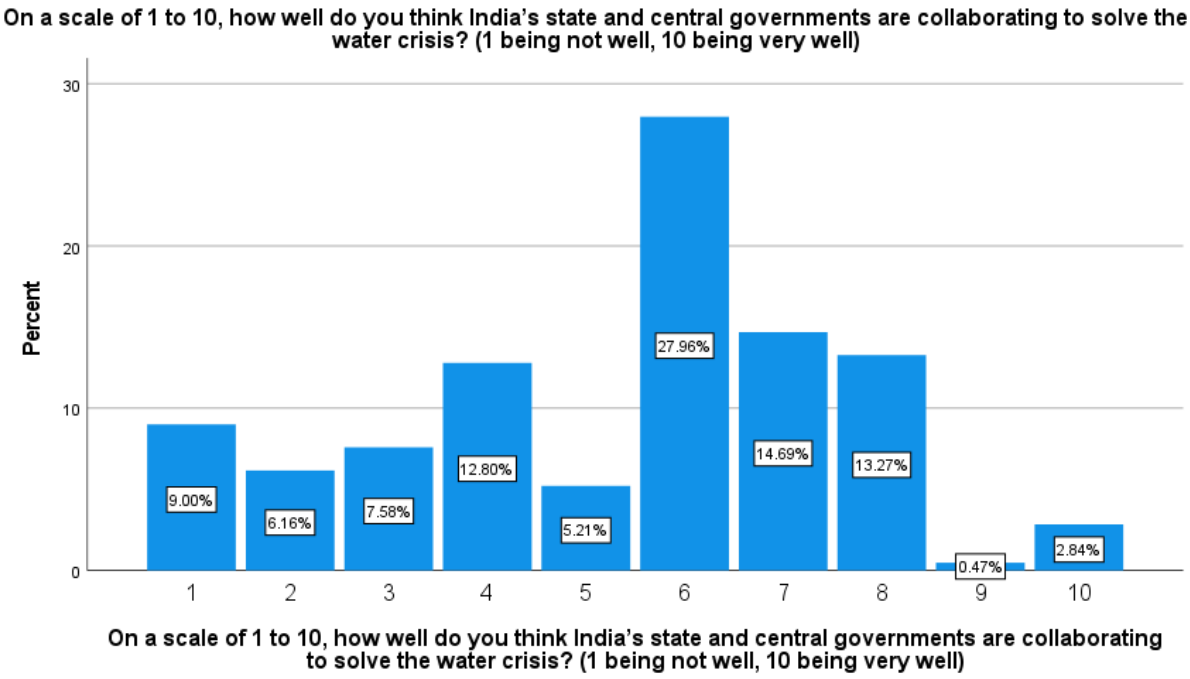
FIGURE 15



LEGEND : The above bar graph reflects respondents' ratings on the collaboration between state and central governments to address the water crisis.

CHI-SQUARE TESTS

CROSS TABLE 1

Does the River linking projects play a vital role in solving the water scarcity issues in India. * Educational Qualification Crosstabulation

			Educational Qualification				
			HSC	UG	PG AND DOCTORATE	NO FORMAL EDUCATION	Total
Does the River linking projects play a vital role in solving the water scarcity issues in India.	STRONGLY AGREE	Count	16	43	0	14	73
		Expected Count	8.6	39.8	7.3	17.3	73.0
	AGREE	Count	1	0	0	10	11
		Expected Count	1.3	6.0	1.1	2.6	11.0
	NEUTRAL	Count	0	41	21	0	62
		Expected Count	7.3	33.8	6.2	14.7	62.0
	DISAGREE	Count	8	0	0	0	8
		Expected Count	.9	4.4	.8	1.9	8.0
	STRONGLY DISAGREE	Count	0	31	0	26	57
		Expected Count	6.8	31.1	5.7	13.5	57.0
Total		Count	25	115	21	50	211
		Expected Count	25.0	115.0	21.0	50.0	211.0

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Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	185.247[a]	12	<.001
Likelihood Ratio	182.143	12	<.001
Linear-by-Linear Association	9.248	1	.002
N of Valid Cases	211		

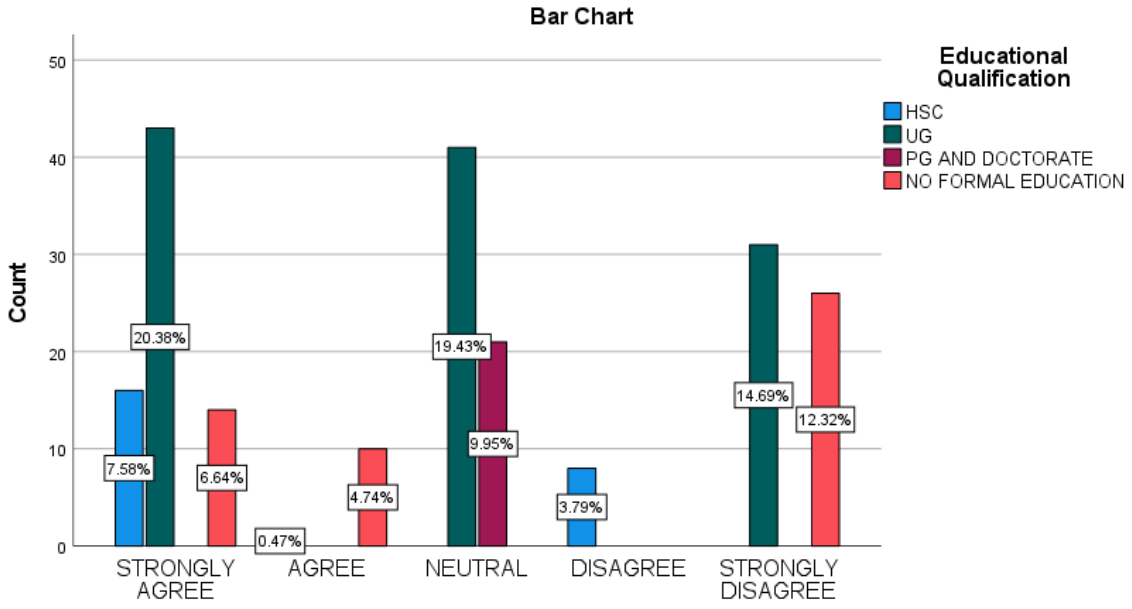
a. 7 cells (35.0%) have expected count less than 5. The minimum expected count is .80.

HYPOTHESIS : H1 ALTERNATE HYPOTHESIS

There is an relationship between the Educational qualification and their responses on the question of agreement levels on the role of river-linking projects in solving water scarcity issues.

P Value : 0.001

RESULT : Alternate Hypothesis is ACCEPTED



LEGEND : The above figure shows the Cluster Bar chart on the relationship between the parameter of Educational Qualification and their responses on the question of agreement levels on the role of river-linking projects in solving water scarcity issues.

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CROSS TABLE 2

Does the River linking projects play a vital role in solving the water scarcity issues in India. * Occupation Crosstabulation

			Occupation			
			GOVERNMENT	PRIVATE	SELF	Total
Does the River linking projects play a vital role in solving the water scarcity issues in India.	STRONGLY AGREE	Count	0	59	14	73
		Expected Count	18.0	37.7	17.3	73.0
	AGREE	Count	0	1	10	11
		Expected Count	2.7	5.7	2.6	11.0
	NEUTRAL	Count	21	41	0	62
		Expected Count	15.3	32.0	14.7	62.0
	DISAGREE	Count	0	8	0	8
		Expected Count	2.0	4.1	1.9	8.0
	STRONGLY DISAGREE	Count	31	0	26	57
		Expected Count	14.0	29.4	13.5	57.0
Total		Count	52	109	50	211
		Expected Count	52.0	109.0	50.0	211.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	146.469[a]	8	<.001
Likelihood Ratio	197.611	8	<.001
Linear-by-Linear Association	9.022	1	.003
N of Valid Cases	211		

a. 5 cells (33.3%) have expected count less than 5. The minimum expected count is 1.90.

HYPOTHESIS : H1 ALTERNATE HYPOTHESIS

There is an relationship between the Occupation and their responses on the question of agreement levels on the role of river-linking projects in solving water scarcity issues.

P Value : 0.001

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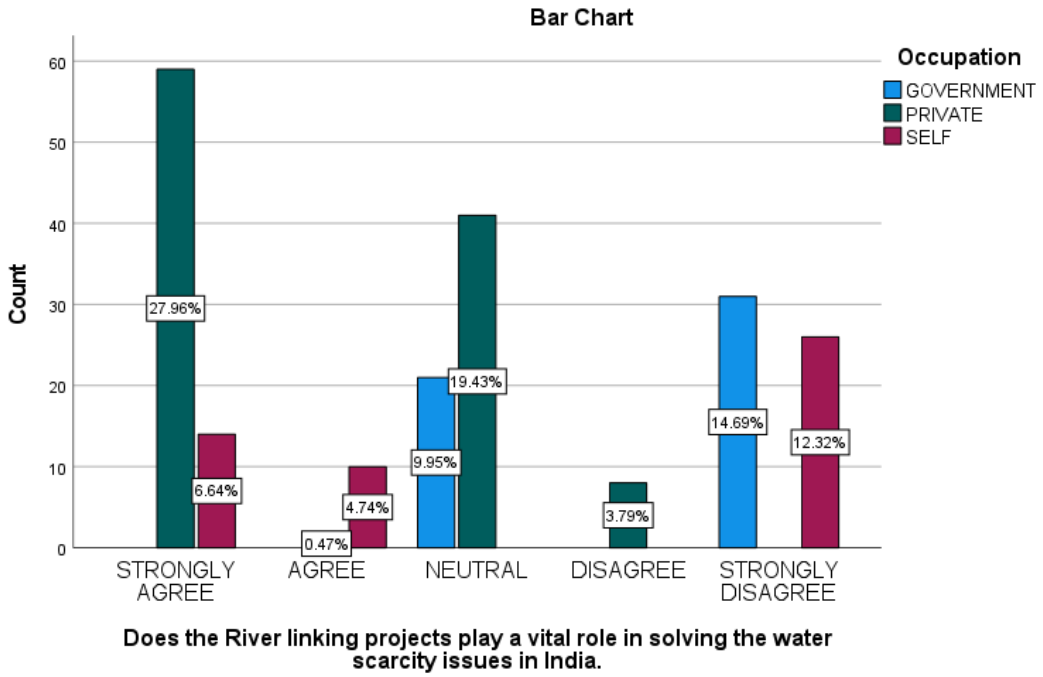
RESULT : Alternate Hypothesis is ACCEPTED



LEGEND : The above figure shows the Cluster Bar chart on the relationship between the parameter of Occupation and their responses on the question of levels on the role of river-linking projects in solving water scarcity issues.

CROSS TABLE 3

How aware are you of the challenges posed by India's water scarcity and the need for sustainable water management policies in India ? * Residence Crosstabulation

			Residence		
			URBAN	RURAL	Total
How aware are you of the challenges posed by India's water scarcity and the need for sustainable water management policies in India ?	AWARE	Count	68	0	68
		Expected Count	51.9	16.1	68.0
	STRONGLY AWARE	Count	31	0	31
		Expected Count	23.7	7.3	31.0
	NOT AWARE	Count	0	50	50
		Expected Count	38.2	11.8	50.0
	SOMEWHAT AWARE	Count	62	0	62
		Expected Count	47.3	14.7	62.0
Total		Count	161	50	211
		Expected Count	161.0	50.0	211.0

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Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	211.000[a]	3	<.001
Likelihood Ratio	231.070	3	<.001
N of Valid Cases	211		

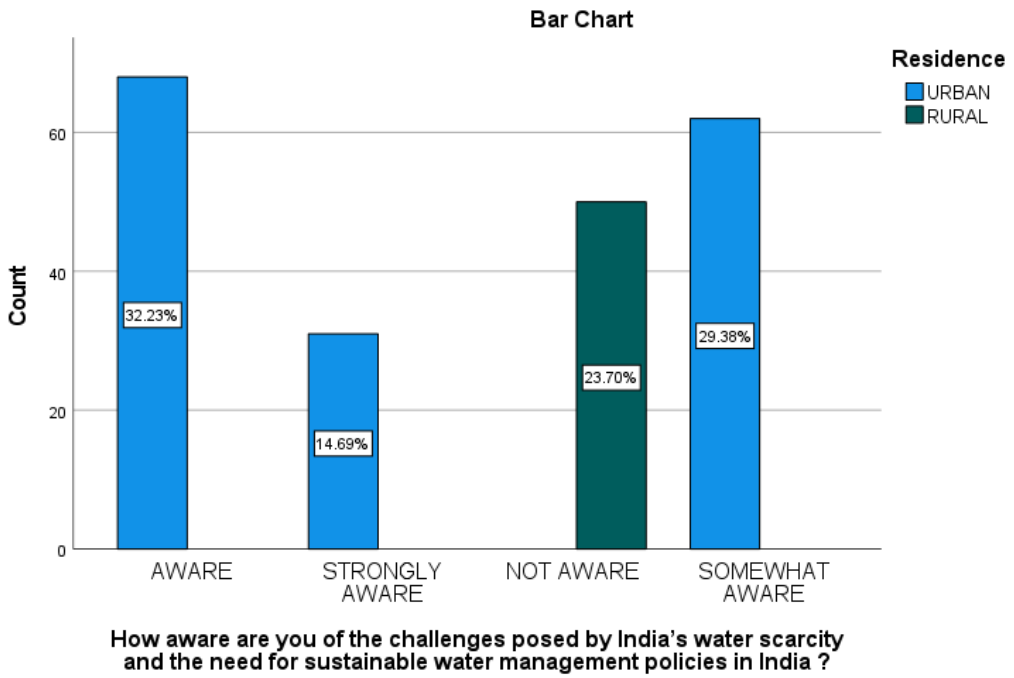
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.35.

HYPOTHESIS : H1 ALTERNATE HYPOTHESIS

There is an relationship between the Residence and their responses on the question of the awareness levels of water-saving technologies like drip irrigation and other efficient techniques.

P Value : 0.001

RESULT : Alternate Hypothesis is ACCEPTED



LEGEND : The above figure shows the Cluster Bar chart on the relationship between the parameter of Residence and their responses on the question of awareness levels of water-saving technologies like drip irrigation and other efficient techniques.

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ESULTS

It is revealed among the respondents that 55.55% belong to the age group of 18 to 29, 45.50% fall within the age group of 30 to 40, and the remaining 0.95% are below 18.**(Figure 1)** It is revealed among the respondents that 46.92% identify as male, 43.13% identify as female, and the remaining 9.35% chose the "prefer not to say" option.**(Figure 2)** It is revealed among the respondents that 51.66% are employed in the private sector, 24.64% work in government jobs, and the remaining 23.70% are self-employed.**(Figure 3** It is revealed among the respondents that 54.50% have completed undergraduate education, 11.85% completed higher secondary school (HSC), and 23.70% have no formal education.**(Figure 4)** It is revealed among the respondents that 76.30% reside in urban areas, while 23.70% live in rural areas.**(Figure 5)** It is revealed among the respondents that 48.34% consume water for industrial purposes, 31.28% use it domestically, and 20.38% utilize it for agricultural purposes, which consumes the largest share of water resources in India.**(Figure 6)** It is revealed among the respondents that 55.92% identified poor implementation and monitoring, 34.12% cited a lack of public awareness, and 9.95% pointed to insufficient funding as the primary reasons for the failure of water conservation programs in India.**(Figure 7)** It is revealed among the respondents that 29.86% agree, 33.65% disagree, and 25.12% strongly agree with the statement that decentralized water management and community-led initiatives are more effective than centralized government programs.**(Figure 8)** It is revealed among the respondents that 34.60% answered "yes," 31.575% said "no," and 33.65% responded "maybe" when asked if the Indian government has made significant progress in implementing water-saving technologies across the country.**(Figure 9)** It is revealed among the respondents that 34.60% strongly agree, 5.21% agree, 29.38% are neutral, and 27.01% strongly disagree with the statement that river-linking projects play a vital role in addressing water scarcity issues in India.**(Figure 10)** It is revealed among the respondents that 45.97% said "no," 20.38% said "yes," and 33.65% said "maybe" in response to whether public involvement in water conservation programs like the Jal Shakti Abhiyan is crucial for ensuring water sustainability in India.**(Figure 11)** It is revealed among the respondents that 31.63% are aware, 14.42% are strongly aware, and 23.26% are not aware of the challenges posed by India's water scarcity and the need for sustainable water management policies.**(Figure 12)** It is revealed among the respondents that 64.45% believe there is enough public awareness about the importance of water conservation in India, 11.85% disagree, and 23.70% are unsure.**(Figure 13)** It is revealed among the respondents that 43.26% are aware, 31.63% are somewhat aware, and 23.26% are not aware of the promotion of technological advancements like drip irrigation and water-efficient technologies in India.**(Figure 14)** It is revealed among the respondents that 27.96% rated 6 out of 10 on how well they think India's state and central governments are collaborating to solve the water crisis.**(Figure 15)**

DISCUSSION

The results indicate that 48.34% of water usage is for industrial purposes, 31.28% for domestic use, and 20.38% for agricultural activities. While agriculture consumes the largest share of water in India, its low representation here may reflect the urban-centric survey sample or a lack of awareness about indirect water consumption in food production. This highlights the need for policy interventions targeting water-intensive industries while also addressing inefficiencies in agricultural and domestic water use. Encouraging industrial water recycling and promoting water-efficient practices in agriculture could mitigate over-extraction of water resources.**(Figure 6)** Poor implementation and monitoring were identified by 55.92% of respondents as the primary reason for the failure of water conservation programs, followed by a lack of public awareness (34.12%) and insufficient funding (9.95%). This

underscores systemic governance issues and the need for better accountability mechanisms. Public participation and awareness campaigns can improve program adoption, while increased funding can enable better infrastructure and training. Research should focus on identifying specific gaps in program execution and fostering community engagement to ensure sustainability.**(Figure 7)** Respondents were divided on the effectiveness of decentralized water management: 29.86% agreed, 25.12% strongly agreed, while 33.65% disagreed. This reflects varying levels of trust in local governance and community-led initiatives. Decentralization can empower local communities to address unique water challenges, but it requires capacity building and adequate resources. Research should explore case studies where decentralized water management has been successful to identify replicable models while addressing concerns related to accountability and coordination with centralized systems.**(Figure 8)** The mixed responses—34.60% said "yes," 31.575% said "no," and 33.65% said "maybe"—regarding the government's progress in implementing water-saving technologies reflect ambiguity in public perception. While technologies like drip irrigation and wastewater treatment plants exist, their adoption and visibility may be limited to certain regions. This highlights the need for more awareness campaigns and transparent reporting on government initiatives. Research should examine the regional disparities in technological adoption and their impact on water conservation.**(Figure 9)** Responses to river-linking projects were polarized, with 34.60% strongly agreeing, 5.21% agreeing, 29.38% neutral, and 27.01% strongly disagreeing. This indicates significant debate around the ecological, social, and economic implications of such projects. Proponents argue these projects mitigate water scarcity, while critics point to potential environmental degradation and displacement issues. Research should assess the long-term sustainability of river-linking projects and explore alternatives like watershed management and local rainwater harvesting systems.**(Figure 10)** When asked about public involvement in programs like Jal Shakti Abhiyan, 45.97% said "no," 20.38% said "yes," and 33.65% said "maybe." This reflects skepticism about the effectiveness of public engagement initiatives. While such programs aim to foster awareness and action, their reach and impact may be limited by insufficient promotion and follow-up. Research should evaluate how grassroots involvement can be effectively integrated into water conservation efforts through better communication and incentives.**(Figure 11)** Around 31.63% of respondents reported being aware of water scarcity challenges, 14.42% were strongly aware, and 23.26% were not aware. This indicates a moderate level of public understanding, but a significant portion remains uninformed. This gap highlights the need for educational initiatives focusing on water management's criticality. Research should explore innovative ways to enhance awareness, such as community workshops, social media campaigns, and integrating water conservation topics into school curricula.**(Figure 12)** A majority (64.45%) believe there is enough public awareness about water conservation, while 11.85% disagree, and 23.70% are unsure. Although the majority indicates optimism, the disagreement and uncertainty suggest that awareness campaigns may not be reaching all demographics effectively. Research should identify target groups with low awareness levels and develop tailored strategies to engage them.**(Figure 13)** Regarding awareness of technologies like drip irrigation, 43.26% were aware, 31.63% were somewhat aware, and 23.26% were unaware. This highlights the need to promote these technologies more effectively, especially in rural and agricultural communities where they can have the most impact. Research should focus on barriers to adoption, such as cost, accessibility, and knowledge gaps, to develop scalable solutions.**(Figure 14)** When rating state and central government collaboration, 27.96% rated 6 out of 10, indicating average

perceptions of their joint efforts. This suggests room for improvement in coordination and transparency between governments to address water crises. Research should examine the effectiveness of existing collaborative frameworks and recommend mechanisms to streamline communication and resource-sharing.**(Figure 15)**

LIMITATION

Due to the lack of time , the study was restricted within a limited sample frame. In a large area it was unable to be studied.There is a major constraint in convenient sampling method, the survey was conducted through questionnaire by google forms to collect responses from the people. Another limitation is the sampling size is 207 which cannot be used to assume the thinking of the entire in a particular country, state or city. The physical factors have larger impacts and thus limiting the study.

SUGGESTION

To address India's water crisis, it is essential to implement a more integrated and multi-dimensional approach that combines policy reforms, technological innovations, and community-driven efforts. Government policies should be more rigorously enforced, with a focus on decentralization and local-level implementation to ensure that water management practices align with regional needs. Public awareness campaigns are crucial for educating communities about water conservation methods, efficient usage, and the role of modern technologies. Additionally, there should be a stronger push towards incorporating advanced technologies like IoT-based water monitoring, smart irrigation systems, and desalination to optimize water usage and improve resource management. Increased investment in research and development of affordable and scalable water technologies is necessary to make these solutions accessible to underserved areas. Further, collaboration between government bodies, private sector players, and local communities will enhance the effectiveness of water management initiatives. Finally, integrating traditional water conservation practices with modern systems can offer a sustainable path forward, ensuring that both cultural heritage and technological advancements contribute to solving the water crisis

CONCLUSION

India's water crisis is a pressing challenge, with increasing demand and depleting resources posing a severe threat to sustainable development. This study critically examined the role of policies and technologies in mitigating the crisis and promoting sustainable water management. The objectives focused on identifying the factors contributing to water scarcity, evaluating the effectiveness of government initiatives, and assessing the potential of emerging technologies in addressing the crisis. The **findings** revealed that overpopulation, climate change, inefficient water use, and poor management practices are major drivers of the crisis. While government programs like the Jal Shakti Abhiyan and Atal Bhujal Yojana show promise, their fragmented implementation and lack of community engagement limit their effectiveness. Technological innovations, including IoT-based water monitoring, desalination, and precision irrigation, remain underutilized due to financial and infrastructural challenges. **Suggestions** include integrating traditional water conservation methods with modern technologies, strengthening policy implementation, fostering public awareness, and encouraging community-driven water management approaches. Expanding investments in research and development for cost-effective water technologies is also crucial. The **future scope** lies in adopting holistic strategies that combine robust policy reforms, advanced technologies, and active public participation. Collaboration with global leaders in water management can provide valuable insights and best practices. In **conclusion**, addressing India's water crisis requires a multi-dimensional approach that balances economic,

environmental, and social considerations. Sustainable water management is not just a necessity but a cornerstone for the nation's future growth and resilience.

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