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Greywater Integration for Urban Greenery: A Framework for Public Buildings Architectural Design in Kabul Arid Climate or Semi-Arid Climate

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Abstract

Kabul's green spaces struggle due to water shortages and unreliable irrigation, often depending on water trucks in emergencies. This study explores a practical solution using greywater from public buildings to water nearby greenery, reducing the demand for fresh water. Through site visits, interviews, and data collection, we assessed the feasibility of this system. Results and Findings show that Greywater reuse in public buildings has a high potential for water savings, but its adoption requires education, financial incentives, and urgent policy interventions to establish clear guidelines and quality standards. The research introduces a framework for integrating greywater systems into public buildings, offering both economic and environmental benefits. The study highlights the importance of collaboration between architects, policymakers, and local authorities to develop better water management solutions.

Keywords: Water Scarcity, Urban Greenery, Design Framework, Sustainability, Kabul.

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1. Introduction

Kabul the capital of Afghanistan, has experienced rapid urban growth over the past two decades. According to World Population Review, Kabul's population exceeded 4.7 million in 2024, making it one of the fastest-growing cities in the region [1]. This population increase has put immense pressure on infrastructure, particularly the water supply. The city's semi-arid to arid climate (rainfall is sporadic), with annual precipitation ranging between 300 and 400 millimeters [2]. These climatic conditions cause periodic droughts, making water management a critical concern for urban planners and residents alike.

Greenery in Kabul, such as public parks, roadside plantations, and community green spaces, plays an essential role in improving air quality, reducing urban heat islands, and enhancing aesthetic appeal. However, maintaining these green spaces is challenging due to water scarcity and insufficient municipal resources. In many cases, municipal authorities rely on water trucks to carry water from one location to another, particularly during peak summer months. This practice is not only expensive but also inconsistent. Moreover, according to The Kabul Time press "Kabul municipality has asked the people to cooperate in beautification of the city, watering trees and development of culture. [3]". When operational capacities are limited, greenery suffers from neglect, often leading to the drying out of plants and a decline in the overall health of urban landscapes. While households in Kabul often face daily water shortages, certain buildings especially larger public facilities such as universities, hospitals, government offices, and washing services can produce significant amounts of greywater from sinks, showers, and laundry areas. Greywater, as defined by Wikipedia, is relatively clean wastewater generated from sources including sinks, showers, baths, washing machines, or dishwashers excluding toilets and industrial effluents [4]. In many modern cities, greywater has been recognized as a valuable resource, particularly in regions where freshwater is scarce. By treating greywater to a safe standard, it can be reused for irrigation, and other non-potable purposes.



Fig. 1. Irrigation of Kabul urban greenery by municipality's water truck [3]



Fig. 2. Roadside plantation [Authors]

Despite the potential benefits, the concept of greywater reuse is not yet commonly practiced in Kabul's public and private buildings. Reasons for this include inadequate awareness, lack of well-defined regulations for greywater, financial capacity, and limited technical expertise. Moreover, architectural designs in Kabul have historically focused on security, insulation from extreme weather, and cultural norms, leaving limited consideration for sustainable water systems within the structure of buildings.

1.2 Objectives

This research aims to develop a framework for integrating greywater reuse systems into Kabul's public buildings, specifically to irrigate urban greenery. By analyzing Kabul's context its arid climate, existing water infrastructure, and public building designs; we propose strategies to harness greywater effectively.

By tapping into greywater as a resource, public buildings can play a pioneering role in reshaping water management practices and setting a precedent for other structures, both public and private. Ultimately, this approach aims to make Kabul's urban environment more resilient, sustainable, and aesthetically vibrant; a goal that resonates with the broader movement toward greener cities worldwide.

1.3 Literature Review

Overview of Greywater Reuse

"Greywater is the amount of domestic wastewater that excludes toilet flushing, and it is usually divided into two types: light greywater, whose sources are bathrooms, showers, tubs, hand basins, and sometimes laundry; dark greywater, which includes laundry facilities, dishwashers, and in some studies also kitchen sinks" [5]. Greywater reuse has been gaining attention as a sustainable water management practice, especially in arid and semi-arid regions. The World Health Organization (WHO) provides general guidelines on treating greywater to reduce pathogens, making it suitable for non-potable uses such as irrigation (watering plants) and toilet flushing [6]. These guidelines emphasize simple filtration and disinfection techniques that can be scaled according to local conditions and available resources.

Applicability to Public Buildings

Public buildings, such as hospitals, schools, offices, and community centers, also washing services often have high water usage due to the large number of occupants. This makes them prime candidates for greywater reuse systems. Research focusing in Sharjah on large buildings, the results demonstrate that greywater reuse in Sharjah can significantly reduce the impacts of desalination by reducing water demand, electricity consumption, and CO_2 emissions [7]. Another study conducted in Oman's arid and semi-arid climate (similar to or even more arid than Kabul) found that greywater reuse from mosques helped mitigate the challenges posed by limited freshwater resources [8].

Environmental Considerations

One major environmental concern is the risk of soil salinity when using greywater for irrigation. Soap residues, detergents, and personal hygiene products can alter soil

chemistry over time [9]. Additionally, ensuring a basic level of treatment often through simple filtration and biological processes can remove most harmful contaminants.

Policy and Regulatory Frameworks

Effective greywater reuse depends on clear policies and regulations. Many countries lack specific guidelines, causing uncertainty among building owners and designers. In regions like California, the state provides a detailed code for greywater use, outlining permissible sources, treatment standards, and end uses [10]. Such regulatory clarity fosters innovation and encourages wider adoption. For Kabul, establishing official greywater standards under the jurisdiction of municipal authorities and the National Environmental Protection Agency could help scale up reuse projects. Collaboration with international agencies might facilitate technical assistance and training programs for local engineers and architects.

The Context of Kabul

Kabul's water infrastructure faces significant limitations. "The rapid population growth, the increasing number of populations in recent years in Kabul city has led to increased groundwater extractions and widespread drying of wells. Other concerns for water withdrawals in the Kabul basin include frequent droughts, climate change (rising temperatures and decreasing precipitation), earlier snowmelt runoff, and shrinking glaciers" [11]. The city's dilapidated distribution network results in frequent shortages, compelling residents and institutions to resort to groundwater extraction. Although official data on total freshwater demand is incomplete, however, according to World Bank data Kabul city water demand is estimated a low range of 198,000 m^3/day as of 2022 compared to 98,800 m^3/day as of 2012 [12]. As a result, the city's greenery public parks, street trees, and gardens often suffer, leading to deteriorating environmental quality.

Despite these constraints, Kabul's public buildings hold untapped potential for greywater reuse. Universities, for example, can generate large amounts of relatively clean wastewater from laboratories and dormitories. Government offices have restrooms used daily by thousands of staff and visitors. Mosques, which often have ablution areas, already produce greywater that could be redirected for irrigation instead of simply being discharged into drains. Additionally, commercial buildings produce a much larger amount of wastewater. However, to implement these strategies effectively, it is crucial to have a structured approach that addresses design, regulation, and long-term sustainability.

Synthesis of Literature and Relevance to This Study

Research on greywater reuse shows that while it is feasible, challenges exist. Success depends on proper treatment, institutional support, and public awareness. In Kabul, where water is scarce, and greenery is declining, greywater reuse offers a practical solution. This study builds on global practices and local conditions to develop a framework suited to Kabul's needs. Focusing on public buildings, it explores how design, environmental factors, and policies can support large-scale greywater reuse. The next section outlines the methods used to collect data, assess local conditions, and develop the proposed framework.

2. Methodology

2.1 Research Design

This study employs a mixed methods research design, mixing qualitative and quantitative approaches to develop a framework for integrating greywater reuse in Kabul's public buildings. The process involves four key areas:

1. **Preliminary Investigation**: Gathering background data on Kabul's water infrastructure, climate conditions, and municipal regulations.
2. **Qualitative Interviews**: Conducting interviews with architects, municipal officials, and building managers.
3. **Technical Feasibility Analysis**: Assessing potential greywater volumes, treatment requirements, and associated costs.
4. **Framework Development**: Consolidating findings into a structured plan that addresses design, policy, and environmental factors.

Research Methodology Flow Chart:

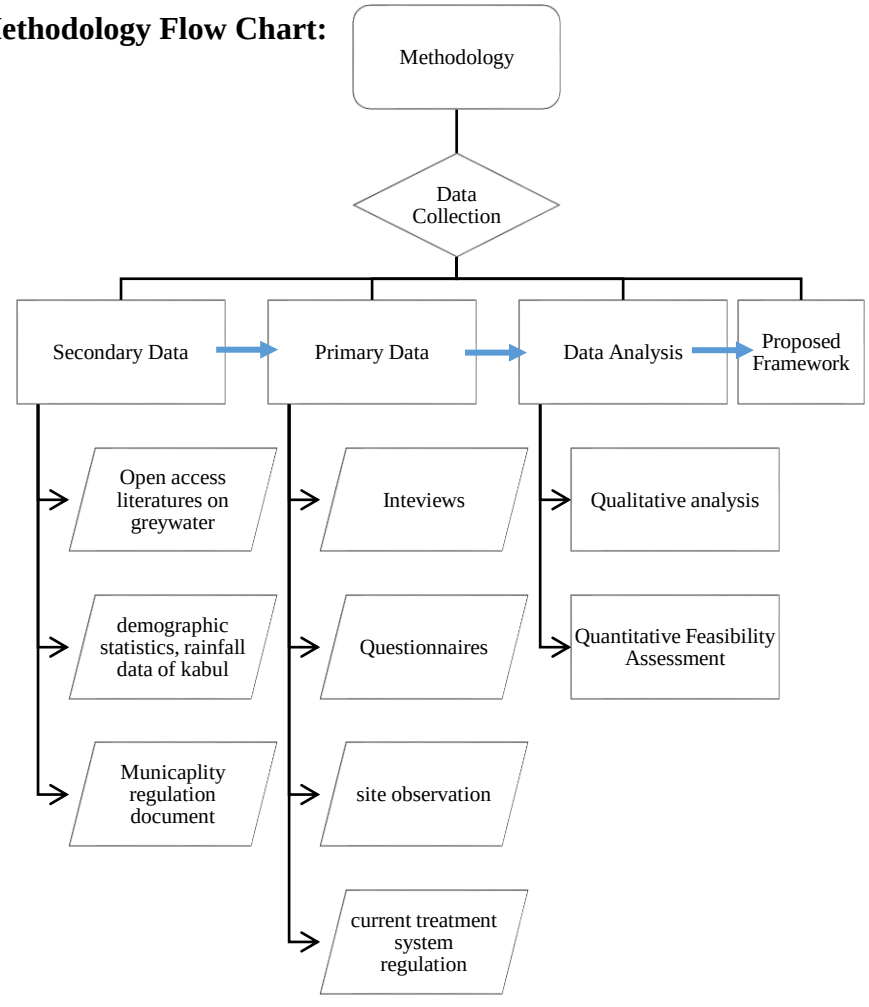


Fig. 3. Flow Chart

2.2 Data Collection

Secondary Data

The secondary data used in this research were obtained from publicly available reports and datasets provided by the World Population Review, World Bank, WHO, Kabul Municipality, and relevant open-access literature. These resources provided demographic statistics, rainfall data, and general information on Kabul's water and urban greenery.

Primary Data (Qualitative)

We conducted semi-structured interviews with stakeholders, consisting of municipal engineers, architects, and building managers of public institutions. The interviews focused on three main themes:

1. **Existing Water Management Practices**: How public buildings in Kabul currently manage wastewater.
2. **Regulatory Barriers**: Awareness of any guidelines or laws related to greywater.
3. **Design Constraints**: Physical and architectural challenges in buildings with greywater systems.

Participants were selected based on their involvement in building management or urban planning projects. We ensured a diverse pool of interviewees to capture a wide range of perspectives.

2.3 Data Analysis

Qualitative Analysis

Transcribed interviews were analyzed using thematic coding. First, we identified keywords or phrases such as "greywater", "water scarcity", "financial constrain", "regulations", and "design constraints". Next, we grouped these codes into broader categories (e.g.: "technical feasibility" and "policy environment"). This process helped reveal common patterns and concerns, such as a general lack of regulatory clarity and the need for simple, low-cost treatment systems.

Quantitative Feasibility Assessment

We conducted a basic quantitative assessment to estimate potential greywater volumes. Using the World Health Organization's guidelines for building occupancy data and average per capita water usage for arid regions, we projected daily greywater generation for each building type.

2.4 Site Observations

Where possible, we visited a sample of public buildings, including one school campus, one government office complex, one mosque, and one hospital, and carpet and car washing service. During these site visits, we observed existing plumbing layouts, the availability of open space for potential storage tanks, and the proximity of green areas. We noted that:

- Many older buildings have separate pipelines for ablution areas, particularly mosques within the premises.



Fig. 4. ablution area of Imame-Azam Mosque (masjid) 5th district Kabul. [Authors]



Fig. 5. outdoor spaces of Imame-azam Mosque (masjid 5th district Kabul. [Authors]

- Outdoor spaces often contain garden areas or landscaped patches that remain under-irrigated.



Fig. 6. Nahid Shahid Hight School [Authors]



Fig. 7. Nahid Shaid High School outdoor spaces. [Authors]

These observations confirmed that while conditions vary from one institution to another, there is a consistent interest in sustainable water use.

2.5 Limitations of the Methodology

While the multi-phase approach offers robust insights, several limitations must be acknowledged:

1. **Security Constraints**: In some areas of Kabul, security issues limit the ability to conduct in-depth field research such as government public buildings.
2. **Data Reliability**: Official statistics on water usage may be outdated or incomplete.
3. **Sample Size**: The number of interviewed stakeholders might not fully represent the variety of perspectives in such a large city.

3. Results

Water Usage Patterns in Public Buildings and Services

The data gathered indicate that public buildings in Kabul vary considerably in water consumption depending on occupancy, function, and building age. Hospitals, for example, use large quantities of water for patient care and sanitation. Universities and government offices see fluctuating water demands influenced by working hours and seasonal variations in student or staff presence. Moreover, washing services such as Car wash and Carpet/rug **washes services** consume much water however, the greywater in return is also high; if treat it properly it can become an advantage. From our site observations and stakeholder interviews for instance in one average mosque in Kabul named **Imame-Azam Mosque** located in District 5, it emerged that an estimated 90% of the total water used in these facilities ends up as greywater—primarily from handwashing areas, ablution area, showers, and, in some cases, laundry services. Bellow some of these are presented.

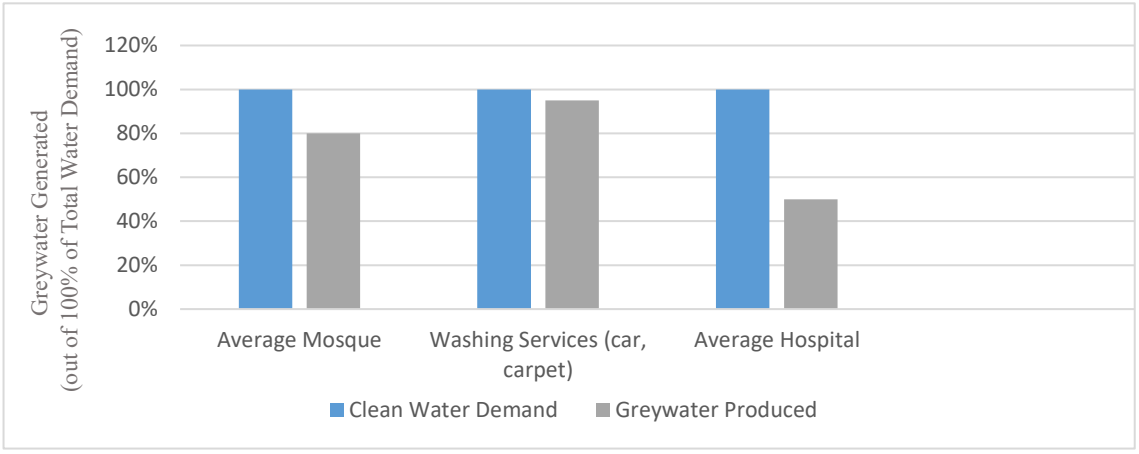


Fig. 8. indicates the amount of fresh water intake and its output as a greywater

In order to make it understandable examples are demonstrated and calculated in the table below:

Table 1. Shows the potential of irrigation with different categories of building

	Daily fresh Water demand	Greywater produced	Water needed per m2 for irrigation	Can irrigate
Imame-Azam mosque	750 m^3	650 m^3	1 acre (4047 m) land needs 5500 – 7000-gal (20800 – 26500 liter) water for irrigation ➔ 5-6 liter / $1m^2$	100 m – 130 m urban greenery
X washing Service in the 5^{th} district	6000 m^3	5900 m^3	//	900m – 1200m urban greenery
Gulbahar Center	N/A	N/A	//	Entire Zarnigar Park.

An engineer from the Planning and **Project Development Department of Kabul Municipality** in an interview mentioned that in 2012, the World Bank estimated the cost of Kabul's water infrastructure at around $750 million, and today, it has increased to approximately $1 billion which is a significant expense that the government currently cannot afford to cover. He also explained that Gulbahar Center and the municipality have signed a memorandum of understanding stating that all wastewater from Gulbahar Center will be filtered and then pumped to Zarnigar Park for irrigation through the underneath street piping system. This agreement benefits both parties: Gulbahar Center, which previously had to transport two to three trucks of wastewater daily a costly process can now permanently resolve this issue by implementing a filtering system, while the municipality saves on the expenses associated with transporting water or extracting fresh water for the large park.



Fig. 9. Gulbahar Center Kabul [14]

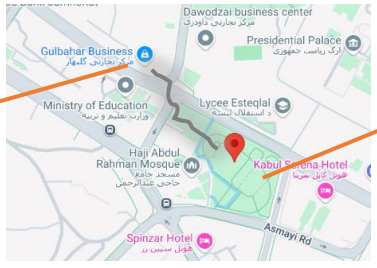


Fig. 10. Google Earth



Fig. 11. Zarnigar Park Kabul [15]

Municipality regulation

We have reviewed the municipality document **"طرزالعمل شاروالی کابل"** and found that it lacks clear regulations regarding greywater treatment. Additionally, we interviewed Mr. Abdul Waris Amiri, an MEP engineer at the **Kabul municipality**, who explained that currently all wastewater including black water from toilets and greywater from sinks is routed through a single pipeline to a septic tank. We noted that although this practice is widely accepted, it is not ideal. Mr. Amiri also highlighted that if wastewater is properly treated, not only greywater but even certain chemicals from the wastewater could be reused for agriculture, offering additional benefits. He expressed support for developing a framework and guidelines for greywater treatment systems and advocated for their inclusion in the building code and municipal regulations. At the end of the conversation, we also obtained a piping plan from the municipality, which illustrates the current wastewater management system.

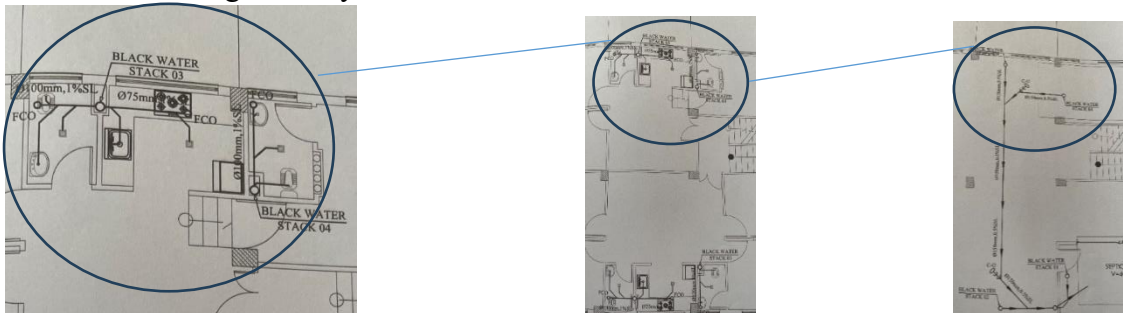


Fig. 12. wastewater treatment plan taken from municipality as an example of single route piping system currently accepted. [Authors]

Attitudes toward Greywater Reuse
Qualitative interviews revealed that while many building managers expressed curiosity about greywater reuse, they also voiced concerns regarding potential health risks. However, once the basic treatment process was explained (i.e., filtration and chlorination), most respondents found it a promising avenue for maintaining greenery. In fact, some managers pointed to the frequent water shortages that cause plants to wither, indicating readiness to adopt any system that could alleviate the problem.

Financial Barriers
While stakeholders agree on the long-term benefits of greywater systems, initial installation costs (for plumbing changes, filtration units, etc.) can be significant. Without subsidies or grants, public institutions might hesitate to allocate funding, especially given other pressing financial needs.

Policy Gaps
There is currently no specific municipal code or national legislation in Afghanistan that addresses the regulation of greywater reuse. This absence of formal policy creates significant uncertainty among stakeholders, including building managers, engineers, and municipal officials, who are hesitant to invest in greywater systems without clear legal guidelines and quality standards. Without an established regulatory framework, there is no standardized process for treating greywater to ensure it is safe for reuse, nor are there protocols in place for its monitoring and maintenance. This regulatory gap also prevents the development of incentives or support mechanisms that could encourage sustainable water management practices.

Key Findings

1. **High Potential for Water Savings**: More than half of the water in many public buildings can be captured as greywater.
2. **Positive Reception with Education**: Proper awareness and training significantly reduce apprehensions regarding greywater systems.
3. **Financial incentives**: subsidies or tax reductions, could encourage public buildings to invest in greywater treatment systems by offsetting initial installation costs.
4. **Urgent Policy Intervention**: Clear guidelines would encourage adoption by legitimizing greywater reuse and providing quality standards.

These findings clearly show that there is a great potential to reuse greywater in Kabul, despite the challenges. Public buildings generate a significant amount of greywater, and reusing it could lead to major water savings and cost reductions, while also supporting the maintenance of urban greenery. However, technical issues, financial constraints, and the lack of clear policies remain obstacles. Building on these insights, our proposed framework offers simple, practical guidelines designed to help architects, engineers, policymakers, and building managers effectively implement greywater systems that are well-suited to Kabul's dry climate and existing infrastructure.

4. Proposed Framework

This framework, based on literature, results, and findings, serves as a guide for incorporating greywater reuse into the design of Kabul's public buildings. It considers technical, environmental, and policy aspects to create a sustainable and practical solution. Additionally, it supports urban greenery by using treated greywater for irrigation, reducing reliance on fresh water.

4.1 Technical Components

Source Separation

The first step involves identifying and separating greywater sources mainly sinks, showers, and ablution areas. Newly constructed buildings can incorporate dual plumbing systems that channel greywater into a dedicated storage tank. For existing buildings, partial retrofits can be done where feasible, especially in areas already equipped with separate pipelines.

Treatment Mechanism

Basic greywater treatment includes:

- **Screening**: Removing large particles or debris.
- **Filtration**: Using sand or gravel filters to reduce turbidity.
- **Disinfection**: Applying chlorine or other disinfectants to kill pathogens. In advanced setups, biological filters (like constructed wetlands) can be integrated to further purify greywater before irrigation.

Some public buildings use **mechanical filters** or machine-based filtering systems, such as membrane filtration or UV disinfection, for better greywater treatment. Other options include natural methods like constructed wetlands. The choice depends on the building's needs, space, and resources.

Storage and Distribution

After treatment, greywater should be stored in tanks that protect against algae growth and contamination. Tanks can be placed above or underground or within the building's service areas to maintain cooler temperatures. Automatic drip irrigation systems can ensure efficient water use, delivering the treated greywater directly to the root zone of plants, and minimizing evaporation in Kabul's arid climate.



Fig. 13. Greywater treatment flow diagram

4.2 Architectural Integration

Architectural design for new public buildings should incorporate greywater piping, filter space, and storage into the initial blueprint. This could be done by allocating a "water hub" area within the basement, ground floor, or above ground level, ensuring easy access for maintenance. For existing buildings, architects can look at vertical service shafts or exterior add-ons to accommodate new plumbing lines.

The presence of visible treatment units or constructed wetlands can be transformed into a design feature, offering educational signage about water conservation. Green roofs irrigated by greywater not only improve insulation but also serve as a visual testament to sustainable practices.

4.3 Environmental Safeguards

Choosing the right plants for greywater irrigation is important. Native or drought-resistant species handle slightly salty water better. Soil should be tested regularly to check for nutrient buildup or pH changes. Using biodegradable soaps and adjusting fertilizers can help prevent damage. To keep drinking water safe, greywater pipes must not connect with potable water pipes. Regular inspections and maintenance are necessary, and signs should be placed near irrigation areas. Kabul's extreme weather also matters storage tanks should be insulated or underground to prevent freezing in winter, and irrigation should be done in the morning or late afternoon in summer to reduce water loss from evaporation.

4.4 Municipal Guidelines and Policies

Introduce municipal codes and regulations mandating separate system for greywater for new large public buildings The Kabul Municipality, in coordination with Afghanistan's National Environmental Protection Agency, could develop a greywater reuse code. Such a document would define acceptable sources, treatment levels, and end-use categories. Regulatory clarity reduces perceived risks and encourages investment in sustainable infrastructure.

4.5 Education and Training

Establishing training programs for local engineers, architects, and building maintenance staff ensures that greywater systems are designed, installed, and operated effectively. Municipalities could coordinate workshops, while universities might incorporate water reuse modules into engineering and architecture curricula. Also, Public Workshops: Educate citizens about water scarcity and greywater's role in addressing it.

Benefits

- **Enhanced Urban Greenery**
- **Reduced Freshwater Demand**
- **Public Awareness**
- **Cost Savings**

Future Outlook

Using greywater in buildings can open the door to other water-saving methods in Kabul, like collecting rainwater or treating wastewater for reuse. Many cities worldwide are moving toward local water recycling systems, and Kabul can follow this trend. If public buildings lead the way, they can inspire other cities in Afghanistan to adopt similar solutions, proving that even dry regions can find smart ways to manage water.

5. Discussion

Significance of the Findings

Kabul has a great chance to use greywater in public buildings. Many places around the world have successfully done this, and Kabul's dry climate, water shortages, and growing population make it even more necessary. If greywater systems are put in place, they can cut down the city's reliance on municipal water, keep green spaces alive with steady irrigation, and encourage more people to think about sustainability.

Groundwater Depletion in Kabul

Kabul's growing population and urban expansion are putting a huge strain on groundwater. Most people and businesses rely on wells for their water, but these wells are drying up because too much water is being pumped out. Studies show that Kabul's water demand almost doubled in the last decade, but there isn't enough rain or proper water management to refill the underground reserves.

This overuse is causing three major problems:

1. **Water levels are dropping**: In some areas, wells have to be dug deeper every year because the water table is sinking.
2. **Shallow wells are running dry**: Many homes and businesses that rely on small wells are struggling to get water.
3. **The ground is becoming unstable**: When too much water is taken out, the soil weakens, which can lead to land sinking.

By reusing greywater from public buildings, we can reduce the need to extract fresh groundwater for irrigation. If large buildings recycle their used water, it would take some pressure off the underground water supply and help keep the city greener.

Climate Change and Kabul's Water Crisis

Kabul's weather is already dry, but climate change is making things worse. The biggest problems include:

1. **Less snowfall and faster glacier melting**: Kabul depends on snow-fed rivers, but warmer temperatures are making the snow melt too quickly, leading to water shortages.
2. **Unpredictable rainfall**: The city doesn't get much rain to begin with, and now it's becoming more irregular, causing more droughts.
3. **Hotter summers**: As temperatures rise, water evaporates faster, making it even harder to keep plants and trees alive.

Using greywater for irrigation is a simple and effective way to deal with these challenges. It reduces the demand for fresh water and makes urban greenery more sustainable. Rainwater harvesting could also be combined with greywater reuse to create an even better water-saving system.

Addressing Barriers

From a technical standpoint, older buildings may pose difficulties. However, the potential for immediate impact in newly constructed buildings is high, particularly if policies mandate greywater provisions at the design stage. Financial hurdles can be overcome through targeted subsidies, international funding, and local government incentives.

Despite the lack of formal regulations, the findings suggest that once a clear framework and standards are established, local institutions are likely to comply.
In terms of environmental concerns, soils in Kabul are prone to salinity buildup if greywater is not treated effectively. However, adopting simple filtration and disinfection, along with periodic soil flushing and careful plant selection, can mitigate these risks. These measures are not overly expensive or complex, making them suitable for Kabul's economic context.

Potential Synergies
Integrating greywater reuse with other initiatives such as rainwater harvesting, green roofs, and solar energy can amplify benefits. For example, a building equipped with a solar-powered pump can reduce operational costs for its greywater system. Combining green roofs and greywater irrigation could further insulate buildings, lowering energy demands. These synergies can be attractive to donors and policy-makers alike, as they address multiple sustainability goals simultaneously.

Broader Implications
Adopting greywater systems could transform how Kabul conceptualizes water usage. If public institutions, which often serve as community exemplars, successfully demonstrate the practicality of greywater reuse, the private sector might follow suit. This shift could also encourage local industries to develop specialized plumbing and treatment technologies, opening a new economic sector and creating jobs.
Moreover, the reliable watering of urban greenery has wider environmental and social implications. Healthy green spaces help reduce air pollution, moderate temperature extremes, and provide recreational areas that contribute to the overall well-being of citizens. In a city where environmental challenges often take a back seat to security and infrastructure concerns, such a project could serve as a positive model of sustainable development.

Limitations and Future Research
While this study offers a foundational framework, real-world implementation will require ongoing adaptation. Future research might focus on:

- **Longitudinal Studies**: Evaluating the performance of pilot greywater systems over multiple seasons.
- **Cost-Benefit Analysis**: Providing detailed economic models to estimate return on investment for different building types.
- **Policy Roadmaps**: Investigating legislative pathways and stakeholder collaborations that can formalize greywater use in Kabul.
- **Community Perceptions**: Conducting larger surveys to gauge public acceptance beyond building managers.

6. Conclusion

This research looked at how greywater reuse could help keep Kabul's green spaces alive, as they currently suffer from unreliable and unsustainable watering. By analyzing open-access data and speaking with key stakeholders, the study found that public buildings have great potential for greywater use, especially when included in the design from the start.

The proposed framework proves that upgrading older buildings, shifting public attitudes, and setting clear policies are challenges that can be solved. With financial backing, stronger regulations, and better education, institutions can successfully adopt greywater systems.

To ensure the successful adoption of greywater reuse, the following recommendations are proposed:

1. **For Policymakers and Municipal Authorities**
    - Establish clear greywater reuse regulations and integrate them into the Afghan Architectural Code and Municipality regulation document.
    - Develop subsidy programs or financial incentives to support greywater treatment installations in public and private buildings.
    - Require large public buildings (hospitals, universities, offices, mosques) to incorporate greywater systems in their design phase.
2. **For Architects and Engineers**
    - Promote dual plumbing systems in new constructions to separate greywater at the source.
    - Design cost-effective greywater treatment units suited for Kabul's infrastructure.
    - Provide training workshops on sustainable water management in architectural and engineering curricula.
3. **For Urban Planners and Environmental Agencies**
    - Encourage the integration of greywater irrigation in urban landscaping projects.
    - Develop pilot projects demonstrating greywater reuse in parks, schools, and government buildings.
    - Raise public awareness through education campaigns on water conservation and sustainability.

Beyond water savings, this solution helps maintain greenery, improves the city's look, and supports a more sustainable future. Given Kabul's water shortages and the need for more green spaces, greywater reuse stands out as a smart, long-term strategy.

Conflict of Interest

The author declares no conflict of interest.

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Authors Profile



Mohammad Zaki Rahimi is currently on his last semester of Master's degree in Building Architecture from Kabul Polytechnic University. He earned his Bachelor's degree in Architecture and also completed a second Bachelor's degree in Computer Science. He has worked with several construction companies and is an experienced private tutor teaching university-level students. His professional interests include Building Information Modeling (BIM), digital design tools, and interdisciplinary approaches that combine architecture with technology.



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Ahmed Masih Safi joined the engineering faculty of Kabul Polytechnic University in 2017 and graduated from Kabul Polytechnic University with a bachelor's degree in 2021. He is currently a master's student in architecture at Kabul Polytechnic University. His research area is the architecture of ancient buildings, building physics, sustainable architecture, and Islamic architecture.