Journal of Infrastructure, Policy and Development 2024, 8(8), 5309.
https://doi.org/10.24294/jipd.v8i8.5309

Article

Sanitation infrastructure challenges in global south poverty pockets: Towards a multidisciplinary approach to sustainable health—The Jordanian case

Rania Aburamadan[1], Victoria Andrea Cotella[2,*], Radwan Darwish[3]

[1] School of Architecture, Applied Science Private University, Amman 11937, Jordan
[2] Faculty of Engineering and Digital Technologies, University of Bradford, Bradford BD7 1DP, UK
[3] Independent Researcher, Amman 11195, Jordan
*** Corresponding author:** Victoria Andrea Cotella, v.cotella@bradford.ac.uk

CITATION

Aburamadan R, Cotella VA, Darwish R. (2024). Sanitation infrastructure challenges in global south poverty pockets: Towards a multidisciplinary approach to sustainable health—The Jordanian case. Journal of Infrastructure, Policy and Development. 8(8): 5309. https://doi.org/10.24294/jipd.v8i8.5309

ARTICLE INFO

Received: 18 March 2024
Accepted: 22 April 2024
Available online: 29 August 2024

Abstract: Sanitation challenges are growing at unprecedented rates in the Middle East and North Africa (MENA) region, specifically in the country of Jordan, where more adversities are faced in the provision of inclusive and sustainable sanitation for marginalized communities. The overloaded water supply systems, strained by high population density in the face of political instability manifests itself in poor public health. How countries in the MENA region plan to handle these problems and improve the sanitation infrastructure is the starting point for this work. We aim to develop a comprehensive and multidisciplinary framework between stakeholders, aligned with the Sustainable Development Goals (SDGs), with a specific emphasis on SDG 6, for providing feasible, community-oriented approaches to sanitation issues in disenfranchised communities in Jordan through the Initiative Sanitation and Hygiene Networking in Jordanian Poverty Pockets (ISNJO) project. The findings will be used to formulate strategic guidelines and inform the development and subsequent initiation of innovative and multidisciplinary initiatives to tackle the sanitation and water scarcity challenges at hand.

Keywords: sanitation; water management; poverty pockets; Jordan; vulnerable communities; SDG 6

1. Introduction

Safe drinking Water, Sanitation, and Hygiene (WASH) are fundamental to the well-being of communities at large, often reflected in improved health, better livelihoods and opportunities, and greater access to education (Gimelli et al., 2018). As it stands, the issue of water contamination is severe, with estimates suggesting that 80%–90% of untreated urban wastewater is released directly into waterways, causing waterborne diseases, hindering tourism and economic development, and severely damaging the environment. For such reasons, lower-income countries in crisis areas face a critical need for capacity building (Wilson and Webster, 2018), and community collaboration (Shalowitz et al., 2009) to improve sanitation and hygiene systems. However, innovative methods and technologies remain crucial for achieving sustainable solutions.

Effective wastewater management and pollution prevention require both cost-effective approaches and sustainable financing models (United Nations, 2022). Cities in the Global South, however, face a growing challenge due to two interrelated trends (Beard and Mitlin, 2021). First, the urban population is projected to reach a massive

6.68 billion by 2050, with 5.56 billion concentrated in less developed regions (United Nations, 2019). Second, the threat of climate change looms over these regions, jeopardizing the sources and availability of urban water supplies (Abell et al., 2017). A significant portion of their urban residents currently lack basic necessities like safe drinking water, proper sanitation, and access to economic opportunities, recreational facilities, and health services (Smith, 2004). This necessitates meticulous planning and management of water resources in cities of the Global South.

Jordan, overwhelmed by significant water scarcity issues, was ranked as the second-poorest country in 2017 with a measly 100 m^3 of water per capita per year (Muhammad Anwar et al., 2021). The annual renewable water resources in Jordan are notably limited, being roughly one-fifth of the global standard (UN, 2016). Jordan has also experienced significant and rapid population growth due to influxes of Palestinian refugees since 1948 and over 1.4 million Syrians since 2010 (Hamed and Bressler, 2019), which puts additional strain on the country's already limited water resources.

Further, by 2018, Jordan had taken in 668,123 registered Syrian refugees, with a nearly even split of women (50.5%), men (49.5%), which collectively form 49.0% of the Syrian refugees, while children make up the remaining 51.0% according to (UHCR, 2022). While some (21%) live in refugee camps, the majority (79%) reside in host communities which are often insecure, overcrowded, and lack basic necessities like water, sanitation, hygiene, and reliable electricity. This situation raises serious ethical questions about possible human rights abuses within these settlements.

Furthermore, only 63% of the population has access to proper wastewater collection and treatment. The remaining population, particularly those in poverty-stricken areas, lack proper sanitation systems and are forced to resort to open defecation, putting them at further risk of disease and assault, especially for women (MoEnv, 2020; Welch and Kneipp, 2005). Perhaps most notably, these individuals suffer from diarrheal disease, which, if not addressed promptly, contributes to a large burden of transmissible diseases within densely populated communities. This underscores the role of safe WASH services that protect health at a population level (Prüss-Ustün et al., 2014).

To address these challenges, Jordan has undertaken several initiatives to reform its water sector, including policy and strategy development. The National Water Strategy (2016–2025) prioritizes providing affordable, quality water and sanitation services to underprivileged communities, alongside implementing water-saving technologies (Eichelberger et al., 2021; Rhodes-Dicker et al., 2022; UN, 2016). This aligns with the UN Refugee Agency's (UNHCR) emphasis on achieving SDG 6: Ensuring universal access to safe water and sanitation by 2030 (UNHCR, 2020). This "for all" approach demands the inclusion of vulnerable populations in national water and sanitation development plans.

Aims of the proposal and area of study: Jordanian poverty pockets

Several historical events have significantly impacted Jordan's population growth. These include the 1967 war and subsequent West Bank migration, the return of migrants from the Gulf region after the 1990–1991 Iraqi occupation of Kuwait, the influx of Iraqis after 2003, and the large upsurge in forced migration among Syrian

refugees starting in 2011 (Fallah et al., 2019). Estimates suggest a near tenfold population increase between 1970 and 2021 (Department of Statics, 2021). This rapid growth has critically strained existing infrastructure, leading to overcrowded and underdeveloped areas known as "poverty pockets".

Since 2002, Jordan has identified "poverty pockets" as districts or sub-districts where more than 25% of the population lives below the poverty line (UNICEF, 2019), which subsequently receive targeted interventions and remedial action in an attempt to alleviate poverty. In 2002, there were 20 such pockets, but the number fluctuated over the years, reaching 32 between 2006 and 2008 and dropping to 27 in 2010 (United Nations Development Programme, 2013).

As it stands, however, poverty remains a significant challenge in Jordan, with estimates suggesting that 35% of the population, or roughly 3.98 million people out of a total of 11.3 million, were classified as impoverished in 2023, compared to 24% in 2021 (Serajuddin et al., 2023). This situation is likely to worsen, with Jordan's population projected to rise by 15% by 2030 and double by 2050 (World Bank Group, 2022). This population growth, coupled with existing water scarcity, inadequate sanitation infrastructure, and a deteriorating sewage system militates the need for proactive solutions to prevent the situation from spiraling out of control.

Figure 1 depicts the population distribution across various districts in Jordan, visually represented by different shades of blue. The districts characterized by higher poverty rates are highlighted in red: Ar-Ruwayshid with a poverty rate of 69.6%, Al-Ḥusayniyah with 52.5%, and Al-Aghwar al-Janubi with 45.4% (HAQQI, 2012). It is worth noting that the poverty level in the northern region, specifically the "Jordan Valley", although not exceeding 60%, is high and a possible cause of future concern.

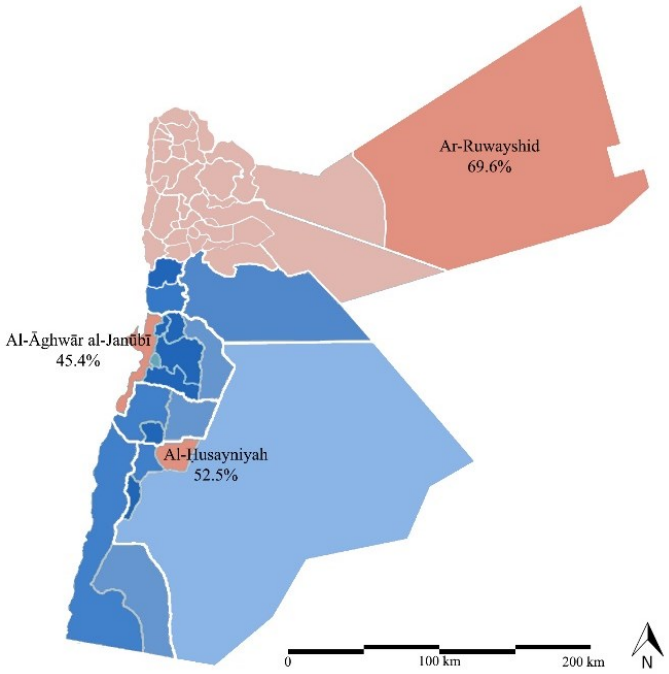

Figure 1. Districts in Jordan with the highest percentage of poverty are highlighted in red and the restin blue. The color gradient is according to population density.
Source: Author's elaboration with data from City Population Jordan.

In the times before the Syrian refugee crisis, Jordan grappled with similar challenges, with water scarcity, high youth unemployment, and underdeveloped infrastructure straining the country's resources. The influx of refugees further burdened what was, at the time, a fragile social fabric and overloaded the sanitation system, which was operated in the absence of a national water conservation strategy.

The most significant of these issues, however, is water scarcity, further exacerbated by population growth. The country is currently ranked fourth-worst globally in terms of water availability and faces a widening gap between supply and demand (Ersan, 2021; Lawrence et al., 2002). Both natural factors, including but not limited to recurring droughts, and human factors contribute to this strain. Without intervention, dwindling water supplies and population growth could halve Jordan's water use per capita by the year 2100, leaving many households with as little as 40 litres of water per person per day (Garthwaite, 2021).

Aside from country-wide problems, "poverty-pockets" are in serious jeopardy, with. inadequate sanitation systems and dwindling water resources creating serious health risks. To bridge this critical gap, the Initiative Sanitation and Hygiene Networking in Jordanian Poverty Pockets (ISNJO) project was undertaken by the Royal Academy of Engineering between 2020 and 2022.

The ISNJO project aims to develop a comprehensive, multidisciplinary framework aligned with the SDGs to address these challenges. Through qualitative data collection and collaboration with experts, the project seeks to identify key issues like communication breakdowns and deficient national sanitation strategies for sanitation.

Accordingly, this paper draws on the findings of the ISNJO project, with the first section providing a general introduction, followed by a background on the situation in Jordan, with an emphasis on poverty pockets. The second section provides details on the methodology used, which includes both data collection methods, like focus groups, interviews, and structured questionnaires, as well as the data analysis process. In this article, we will discuss the current state of Jordan's sanitation infrastructure, in order to improve sanitation practices, and reveal new avenues of research for future remedial interventions.

2. Materials and methods

The research methodology employed a multidisciplinary approach aligned with UN SDG 6 (ensuring access to water and sanitation for all). Data collection relied on the following methods: i) literature review of existing research (secondary data) (Section 3), and primary data gathered directly from the field by ii) focus groups discussions (Section 4.1) and iii) questionnaires organized through a series of workshops (Section 4.2).

The first method involved a comprehensive literature review of key documents related to sanitation and hygiene, with a particular focus on sanitation frameworks. This review process (Carswell, 1992; Friel et al., 2001) identified critical factors that could be categorized into two main groups The first group involves general critical factors encompassing aspects relevant to sanitation system monitoring, design, infrastructure, environmental conservation, and community engagement. The second

group involves specific critical factors related directly to the challenges and opportunities of sanitation frameworks in poverty pockets (inclusion, accessibility, wastewater management, community awareness, and environmental compliance).

Focus groups, as part of the second method, were organized through workshops to gather qualitative data on participants' experiences, perceptions, and needs regarding sanitation. The third method included a combination of close-ended questions with pre-defined response options and open-ended questions. A convenience sampling approach was used for data collection, surveying a total of 22 women.

Figure 2 provides a visual representation of the methodology employed in this study.

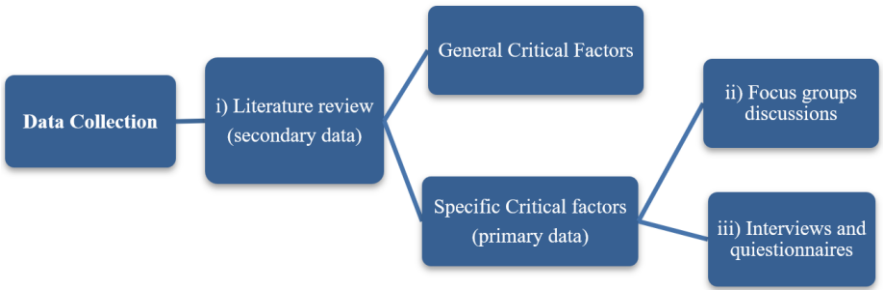

Figure 2. General approach to application of research methodology.
Source: Author's elaboration.

The research questions derived from the secondary data analysis directly addressed these needs:

- What are the main challenges faced by sanitation systems in densely populated poverty pockets?
- What sanitation practices were previously employed in these communities?
- What lessons can be learnt from sanitation practices in other contexts?

3. Secondary data presentation: Literature review

The present approach for developing a robust framework for sanitation systems focuses on four key pillars: Monitoring, design and infrastructure, environmental considerations, and community engagement, and will be used as the basis to structure the following literature review analysis. Regular monitoring is crucial for evaluating interventions and identifying areas for improvement (WHO/UNICEF, 2021). Effective design and infrastructure, addressing local needs and environmental conditions, form the backbone of functional sanitation systems (Russel et al., 2019). Integrating environmental considerations ensures sustainability, considering factors like water scarcity and pollution (Nel et al., 2017). Finally, community engagement fosters cultural sensitivity and social inclusivity, enhancing the acceptance and success of sanitation solutions (Nelson et al., 2021). The following sub-sections are structured based on the aforementioned pillars with the final goal of establishing a holistic framework for a sustainable and effective sanitation system.

3.1. System-monitoring and policies requirement

The importance of on-site water supplies and sanitation facilities in low-income countries for achieving UN SDG 6 is undeniable. A key challenge that presents itself,

however, is the fragility of these systems due to inadequate monitoring and maintenance (Nayebare et al., 2019). Stakeholders are now implementing targeted interventions to cultivate the strengths of such sanitation systems, while simultaneously addressing their weaknesses (Huston and Moriarty, 2018).

Sanitation systems, when effectively monitored, are recognized as crucial factors for achieving the SDGs, and are considered integral components of a multidimensional approach to sustainable development, empowering communities while protecting human health and the environment (Hwang et al., 1999). They also help alleviate poverty at a population-level, by creating jobs and improving education through better hygiene facilities in schools.

A well-designed monitoring strategy is essential for successful sanitation initiatives, acting as a diagnostic tool that provides real-time assessment of system performance while guiding adjustments (Hollander et al., 2020). This proactive approach ensures interventions are tailored to the geographical location, population characteristics, environmental conditions, among other influential factors. By offering continuous feedback, a robust monitoring system becomes the backbone of any sanitation system, promoting resilience and sustainability.

Effective monitoring also requires supportive policies and regulations. While studies show comparable efficiency between private and public sanitation operators in developing countries (Estache and Rossi, 2002), significant access inequalities persist, particularly in sub-Saharan Africa (Bayu et al., 2020). Established standards exist for wastewater treatment and reuse, but regulations for sludge reuse and decentralized sanitation systems remain lacking and absent in some cases.

The urgent need to address inadequate water and sanitation facilities in low-income countries, as highlighted by the SDGs, necessitates comprehensive interventions and improved monitoring practices. Recognizing sanitation as a cornerstone of sustainable development and integrating it within the SDG framework is crucial to achieving universal access, reducing poverty, and improving human well-being.

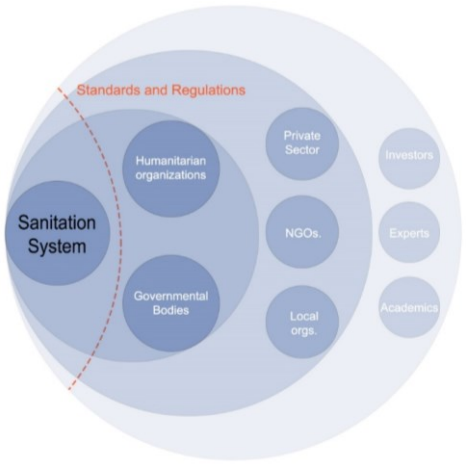

Figure 3. Stakeholders' involvement in a sanitation system.
Source: Author's elaboration.

Figure 3 illustrates the complex interplay between policies and regulations, and the sanitation sector at various levels. While a number of stakeholders contribute

resources (NGOs, charities, government agencies, private sector), the current policy landscape often hinders advancements (as depicted in the figure). This can exacerbate existing social inequalities, as some stakeholders hold greater influence over the sanitation sector than others.

To achieve comprehensive policies, a broader range of decision-makers is needed, including elected officials, community leaders, and local governments. Stakeholder engagement, particularly considering user needs, requires different levels of involvement. Community and user consultation are crucial for designing effective and inclusive sanitation systems, ensuring participation from marginalized populations, who are the foremost victims of deficient sanitation systems (Dash et al., 2019).

3.2. Design and infrastructure

This analysis focuses on designing sustainable and cost-effective sanitation systems for vulnerable communities, with an emphasis on fostering community participation. As such, three main types of sanitation systems are identified: i) on-site systems: These belong to individual dwellings and are self-contained; ii) decentralized systems (DEWATS) (Gutterer et al., 2009): Examples include constructed wetlands, which offer a lower-cost alternative to traditional sewerage systems and iii) centralized systems: These are typical sewerage systems with a network of pipes that collect wastewater for treatment at a central facility.

In many developing urban areas, the lack of adequate sewerage infrastructure is a major challenge. Existing networks in some countries, like Jordan (Klassen, 2020), have even collapsed due to population growth. Decentralized systems, with their lower installation and maintenance costs, present a promising alternative in such situations.

However, there are still hurdles to overcome, predominantlykey challenge lying in the tendency of governmental bodies to prioritize cost management through a centralized approach (Reymond et al., 2016). Furthermore, some disparities even exist within developed countries, with some areas lacking proper sanitation infrastructure altogether, while others boast well-organized and systematic systems. Geographical factors also play a role, where providing sanitation services for an entire city often requires a combination of systems implemented at different scales and tailored to the specific needs of various districts (Parkinson et al., 2014).

Planning a city's sanitation development chain is an essential process that takes into account various factors: Financing, community acceptance, capacity building, the existing environment, relevant regulations and policies, and the choice of technical solutions. A comprehensive citywide sanitation plan must address the specific physical, socioeconomic, and service-related conditions in different areas (Mehta and Mehta, 2013). The case of the water crisis in Iran (Yazdanpanah et al., 2013) exemplifies the limitations of conventional development strategies in promoting sustainable sanitation management.

Sustainable solutions become more achievable when governments and the private sector work together to integrate technology, in the era of Industry 4.0, and social considerations, with a shared vision defined by all stakeholders (Spuhler et al., 2020). Community awareness and acceptance are also vital for ensuring the long-term sustainability of sanitation systems (Omisore et al., 2017).

3.3. Environmental preservation and healthy practices

Access to safe water is a fundamental human right and essential for achieving the UN SDGs. However, Jordan faces a significant challenge as the world's second-most water-scarce country, according to (UNICEF, 2016). With annual renewable water resources falling well below the scarcity threshold, this phenomenon is spreading to urban areas. This, coupled with intermittent water supply, disrupts daily life and negatively impacts sanitation systems, the natural environment, and cultural heritage.

To address this challenge, adopting water-saving technologies and practices across all sectors, including agriculture, industry, and households, is crucial (Brent et al., 2020). Promoting responsible water use is especially important in informal settlements with high populations, where water scarcity and pollution are often most severe.

Green technologies have emerged as viable and cost-effective solutions for managing these problems. Rainwater harvesting systems (RWH) are a particularly promising approach, especially in areas lacking reliable piped water supplies. Studies by García-Montoya et al. (2015), Ullah et al. (2020), Khanal et al. (2023) and Istchuk and Ghisi (2023) highlight the effectiveness of RWH in meeting water demands in both urban and rural settings. Such systems can be implemented with proper storage as part of a decentralized sanitation approach in informal settlements, helping achieve healthy living environments and community well-being.

These sustainable practices can also be adapted in Jordan, improving living conditions and community health in a bid to ultimately achieve the SDGs (RainwaterTanksDirect.com.au, 2018). A research group at the University of Sains Malaysia's School of Humanities implemented a rainwater harvesting system in 2011, resulting in a significant reduction in water consumption from 170 m^3 to 80 m^3 per week, a decrease of 52.9% (Weng Chan et al., 2016). This case study showcases the broader potential of RWH in mitigating water scarcity and improving living conditions.

In urban areas, on the other hand, with overloaded or dysfunctional traditional sanitation systems, a combination of rainwater harvesting (RWH) and container-based sanitation (CBS) can be used as part of a holistic ecological framework (Tilmans, et al., 2015). CBS, offered by social enterprises, NGOs, or city utilities, has been successfully implemented in cities like Cape Town and Manila as part of CityWide Inclusive Sanitation (CWIS) strategies (Russel et al., 2019). While CBS offers advantages in space-constrained and population-dense areas, its viability in poverty pockets and potential social acceptance barriers require further consideration.

While container-based sanitation (CBS) offers advantages, some considerations remain. For instance, research conducted in Haiti showed that household CBS services can be more expensive than public facilities (Tilmans et al., 2015). However, in 2021, the AKYAS Sanitation company introduced CBS for the first time in the Za'atari Refugee Camp, aiming to reduce water consumption in the arid Mafraq region (Toilet Board Coalition, 2021).

Beyond the immediate benefits of water conservation, these technologies contribute to climate change mitigation and support the overall sanitation framework. Their implementation still requires addressing challenges such as social acceptance and tailoring solutions to specific needs within poverty pockets. This highlights the

importance of comprehensive strategies to achieve the SDGs (Garrica et al., 2015).

3.4. Community empowerment

Aligned with SDG 5 ("Achieve gender equality and empower all women and girls"), the research group developed sensitive questionnaires to collect data from women. These women, as members of society, experience sanitation challenges in various settings—at home, work, and within their communities. The strategy prioritizes the inclusion of women and girls as they are more prone and sensitive to sanitation issues (Wendland et al., 2017), and seeing their crucial role in passing on knowledge to families and children.

Further, women's lower access to education and limited work opportunities (with only 14.3% female labour force participation compared to 53% among male, according to (The Jordan Times, 2022)) implies that they spend more time at home managing water-dependent daily activities. This belies their role in developing sanitation solutions.

A study justifies the workshop's exclusive focus on women and girls, as it highlights how social norms and gender roles limit women's work opportunities (World Bank, 2018). Over 90% of female respondents reported that male family members, particularly husbands, hold significant sway over their decisions to work. Additionally, marriage, childcare, and household chores were identified as key factors restricting women's economic participation.

4. Primary data presentation: Fieldwork

Following the literature review stage, fieldwork was carried out to collect primary data, and included focus group discussions, in-depth interviews, and questionnaires conducted through a series of workshops with stakeholders. The insights gathered were organized around the four previously discussed pillars of any sanitation system: monitoring, design and infrastructure, environmental conservation, and community engagement.

4.1. Focus group discussion

The COVID-19 pandemic necessitated that all workshops be virtual, which proved surprisingly effective. This format ensured continuous engagement and collaboration among participants despite physical distancing measures. Participants, representing diverse parties like governance, private sector, academia, NGOs, and local communities, tackled existing issues across three key areas: monitoring strategies, design and infrastructure considerations, and environmental conservation practices.

While virtual interactions have limitations, the sessions allowed stakeholders to share insights, discuss challenges, and propose solutions related to sanitation in high-density areas.

Focus groups were carefully selected and consisted of sanitation system experts and academics, both local and international (Philipsen and Vernooij-Dassen, 2007). Notably, this approach allowed the active participation of community members who are directly affected by sanitation problems. Their involvement not only validates the research findings but also ensures their active role in seeking viable solutions.

Table 1 illustrates the sanitation system stages as a roadmap for achieving the main goals to be addressed and the expected outcomes to be analysed. Qualitative and quantitative data collection were conducted throughout the stages.

Table 1. Methodological presentation of the 4 pillars, main goals and expected results.

Stage	Goal	Expected outcome for analysis
Monitoring and policies requirements	Recognise the existing sanitation policies and regulations on the delivery of sustainable sanitation systems.	Identify the advantages and disadvantages of existing sanitation policies and regulations. Determine sanitation policy incentives and barriers to developing sustainable sanitation systems.
Design and infrastructure	Identify the importance of sanitation infrastructures in influencing quality of life (QOL) among residents.	Identify the challenges of sanitation infrastructures. Introduce different types of infrastructure for sustainable sanitation systems. Introduce the principle of a resilient sanitation infrastructure.
	Discuss the influence of existing financial schemes on the delivery of sanitation systems.	Identify the advantages and disadvantages of existing sanitation financial programmes. Determine financial incentives and barriers to developing sustainable sanitation systems.
Environmental conservation	Ensure the importance of establishing sanitation systems for achieving a high quality of life from environmental, social, and economic aspects.	Determine how social aspects affect sanitation systems. Identify the issues of existing sanitation systems and raise awareness among local communities. Introduce approaches that rely on resilience, inclusivity.
	Evaluate the impact of sanitation systems on the local community and environment.	Introduce the concept of environmental sustainability. Introduce modern sanitation systems, and address the role of lifecycle assessment (LCA) as a tool to measure their environmental impacts.
Community engagement	Determine the effect of sanitation on social sustainability and QOL of residents.	Identify the current social issues of sanitation systems. Evaluate the effect of sanitation systems on QOL among residents. Introduce the concepts of social sustainability and QOL.

Source: Author's elaboration.

4.2. Questionnaires and interviews

A convenience sampling approach was used for data collection, surveying a total of 22 women (**Figure 4**). While this method offers ease of data collection, it is important to acknowledge that the sample may not be representative of the entire target population.

Figure 4. Women filling in the surveys as part of the research data collection process.

Source: Author's photos.

The survey data revealed that households within the sample have an average size of 5 to 10 people. Further analysis of responses from married women (more than half of the sample) indicated that they have a minimum of 4 children and a maximum of 8.

In terms of greywater usage, the survey results demonstrate interesting trends in how dishwater is managed within these households. The most common practice, utilized by 65% of households, is to use dishwater for watering plants. This is followed by outdoor cleaning (17%), floor cleaning (12%), and finally, only 6% of households reported using dishwater for septic tanks.

The survey employed a combination of closed-ended questions with pre-defined response options and open-ended questions to gather data categorized by participants' age, marital status, and family size. The focus of the survey was on common water-related issues faced by the community.

Participants expressed concerns about a range of water challenges, including foul odors, unsanitary water, water scarcity, shortages, and pollution. Most reports documented in previous studies seem to overlook these frequently encountered issues. While only two individuals reported sewage overflow issues, and one family identified water calcification and pipe blockages, a more widespread concern emerged regarding unpleasant smells emanating from the sewer system. Potential causes for these odors could include wastewater accumulation, decomposing water and waste, sewer blockages, cleanliness issues within the infrastructure, and the use of septic tanks.

5. Data analysis

The narrative data analysis approach (Creswell and Poth, 2017) involved coding and organizing initial findings to address the three research questions presented in section 3. Additionally, analyzing sanitation system stages (monitoring, design and infrastructure, environmental conservation, and community engagement) revealed some interconnected challenges.

In terms of monitoring (section 3.1), communication gaps and alienation of some stakeholders hindered a comprehensive assessment of the current sanitation situation. Weak policy and regulation, particularly regarding sludge reuse and decentralized systems, limits the development of effective solutions in the infrastructure (section 3.2). While interesting approaches like RWH and CBS are emerging, their broader environmental impact is not understood due to data gaps (section 3.3). Limited data on local perspectives makes it difficult to assess the social sustainability implications and impacts on QOL (section 3.4).

This study sheds lights on the complex, long-term nature of sanitation challenges in urban areas. Effective solutions require re-considering the interconnectedness of essential services, assessing both the direct and indirect effects these solutions might have, and re-evaluating the relief-rehabilitation-development continuum (Spuhler and Lüthi, 2020). A successful approach hinges on a paradigm shift in delivering assistance, with long-term funding aligned with the scale and duration of the challenges faced by urban populations in the Global South.

Regarding design and infrastructure, the discussion explored the implementation of sustainable and low-cost sanitation solutions for vulnerable communities. The emphasis was placed on designing infrastructure that encourages community

participation and respects the sociocultural context of the community, as reflected in **Table 2**. The research identified three main types of sanitation systems: i) on-site sanitation; ii) decentralized wastewater treatment systems (DEWATS); iii) centralized sewerage systems.

Table 2. Main challenges and possible solutions in the sanitation system.

Topic	Points of discussion
Sanitation challenges	Large disparities exist in developed countries when it comes to sanitation systems, with some areas suffering from deficient systems, while others enjoy a fully organised and systemised one. Any development plan must consider the living community and context within which members live.
Proposed solutions	Integrating technology into a comprehensive, socially-inclusive framework that actively involves community members.

Source: Author's elaboration.

Sanitation systems within urban planning aim to constantly evaluate service coverage and quality, guaranteeing that no one is left behind and that services meet prescribed standards (Robinson, 2021). In settlements with small areas but high population densities, safe wastewater management becomes a pressing need. Ongoing monitoring of usage and maintenance are essential, as many system failures occur due to insufficient attentiveness in these areas. However, monitoring at such a scale would be difficult if the design approach is not tailored to characteristics of the area. That said, the sanitation framework should be adaptable to diverse conditions, and should consider differences in climate and social acceptance.

Table 3 resumes the main outputs, in terms of policy and regulations, by highlighting the main challenges and accordingly solutions to be implemented:

Table 3. Main challenges and possible solutions in terms of policy and regulations.

Topic	Points of discussion
Sanitation challenges	Weak policies and regulation of sanitation systems, especially as it applies to sludge reuse and decentralised sanitation systems.
Proposed solutions	Stakeholders involved in decision making on sanitation development should form a multi-scalar approach including the public and private sector.

Source: Author's elaboration.

Water scarcity and reliance on traditional water solutions in impoverished areas worldwide negatively impact education, especially for girls who often have to travel long distances to collect water for their families. Fortunately, by integrating social perspectives and environmental sustainability into water management strategies, however, solutions can meet human needs while preserving ecosystems. This approach promotes equitable access to water resources, engages communities, and minimizes adverse environmental and health impacts. **Table 4** resumes the outputs in terms of environmental challenges:

Table 4. Challenges, solutions and implementations in terms of environmental challenges.

Topic	Points of discussion
Sanitation challenges	People in poverty pockets have difficulty accessing toilets which, in turn, insinuates that the following steps of a sustainable chain such as transferring, treating, and disposing of human waste are missing. Women and girls are also responsible for collecting water from remote areas for their families.
Solutions implemented	Applying green technologies as a component of the decentralized approach represents a solution in areas where there is no efficient sanitation network.
Sustainability application	Several RWH tanks were used in places like Malaysia, reducing water consumption by about half.

Source: Author's elaboration.

Empowering communities to actively participate in discussions about their problems helps ensure holistic problem solving and effective support for more targeted and specific practices. This participatory approach not only helps shed light on hidden challenges but also fosters a sense of ownership and responsibility within the community. When local members actively contribute to decision-making processes, their concerns are brought out of the shadows, leading to more inclusive and impactful interventions. **Table 5** resumes the outputs in terms of challenges, solutions and sustainability:

Table 5. Challenges, solutions and implementations as a result of community engagement interviews.

Topic	Points of discussion
Sanitation challenges	Lack of proper sewage systems along with pre-existing health and safety problems associated with septic tanks. Rodent and insect problems were reported due to poor maintenance of sewage systems, and in the rare cases that maintenance is carried out, little attention is paid to hygienic practices.
Solutions implemented	Problems of sewage overflows in households are mitigated by regular cleaning and sanitation practices, such as avoiding disposing of solid waste down drains and using household solutions to maintain waste levels.
Sustainability application	Several users conserve water and reduce waste by reusing water for irrigation and other domestic activities, as well as RWH.

Source: Author's elaboration.

6. Results

Table 6. Main challenges in the key area of sanitation.

	Current situation	Main challenges
Policy and regulations	• *.Weak regulations and lack of standards. • *.Decentralised sanitation systems. • *.Engineers prefer capital-intensive, complex and large-scale technical solutions that are difficult to implement.	• *.Participatory planning, including community members who are directly affected by sanitation problems is an important part of any sanitation solution, especially within informal settlements. • *.Mapping the monitoring report.
Integrated technology	Depending on where the sanitation system is located, geography can be an advantage or a disadvantage for tecnnology implementation.	• *.Good sanitation is implemented through integrated software and hardware. • *.Alignment with governance programmes is indicative of a good system. • *.Any development plan must take into account the community and any contextual factors that follow.
Gender equality	Solutions are not tailored to the needs of women and girls, and sanitation probems persist despite intervention	In some areas of the Global South, women and girls are still completing household roles without participating in decision making.
Raising awareness	• Illegal use or connections to the *.water system make maintenance and control of pipelines difficult. *.Unequal distribution of water among citizens and areas.	• *.Unsafe sanitation systems and practices in schools can be dangerous and can lead to the spread of disease if not addressed. • *.Little attention is paid to hygienic practices.

Source: Author's elaboration.

Table 6 summarizes the earlier findings under the three initial questions and indicates the importance of their inclusion in a comprehensive sanitation and health system. From these results, four categories were adopted in order to establish a strategy to improve the current state of water scarcity in the development of sanitation systems: i) policy and regulation; ii) integrated technology; iii) gender equality; and iv) raising awareness). Furthermore, this categorisation intends to guarantee that such an integrated approach produces results in line with the three pillars of sustainability: environmental, social, and economic, while respecting the principles of the SDGs.

7. Discussion

This paper presents findings derived from different fieldworks, which help guide the establishment of a multidisciplinary approach towards a sustainable sanitation system in the Global South (Jordan being a case study). To enhance the design of sanitation and hygiene systems, several valuable lessons have emerged: i) context-specific development; ii) tailored standards adapted to the geographical situation; iii) identifying and addressing challenges through ongoing evaluation; iv) proposing solutions that involve communities through awareness-building; v) ensuring social inclusivity. Integrating multiple interconnected sanitation approaches within the same area can enhance the safety and resilience of sanitation systems.

Analysis of the data, based on the key concepts presented in **Figure 5**, reveals several interrelated themes fundamental to sanitation and health management in densely populated areas.

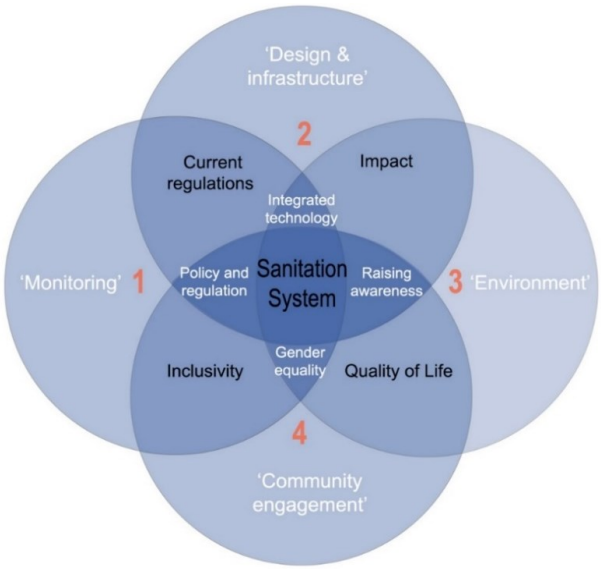

Figure 5. The role of a multidisciplinary framework in achieving a sustainable sanitation system.
Source: Author's elaboration.

One key finding is the need for new policies promoting inclusive management across diverse settlements. This would lay the groundwork for a more strategic and comprehensive approach to health system management. The analysis also emphasized the importance of integrating gender equality principles within sanitation and health initiatives. This aligns with inclusivity and quality-of-life goals, ensuring universal

access to hygienic practices without discrimination.

Community involvement emerged as another crucial factor, recognizing how contributions from those directly affected by the problem at hand can help aid decision-making processes in order to effectively address sanitation challenges. The data further highlights the value of engaging community centres to raise awareness about the effects of dysfunctional and deficient sanitation systems on both the environment and quality-of-life. Implementing training programs on new practices within these centres can cultivate communities with improved knowledge and changed behaviours.

Finally, the research underscores the importance of utilizing optimal technological solutions for sanitation. However, findings highlight the need for a multi-pronged approach that considers inclusive policies, gender equality, community participation, targeted awareness campaigns, and context-specific technological applications.

8. Conclusions

This study addresses the critical sanitation challenges in densely populated poverty pockets of the Global South, specifically in Jordan. Water scarcity and overloaded systems lead to adverse public health consequences. A new, integrated approach to sanitation in these low-income areas is crucial for achieving the goals of the New Urban Agenda 2030 and SDGs.

Our analysis revealed several interconnected challenges. Insufficient data and communication gaps hinder monitoring and assessments, while weak policies and regulations limit effective solutions, particularly for sludge reuse and decentralized systems. Limited data on local perspectives stresses the need for a holistic approach that considers social and cultural aspects of sanitation.

This study also offers novel lessons beyond Jordan. It highlights the complicated collaboration needed among stakeholders—government agencies, NGOs, private sectors, and academic experts. A multilayered approach is required, encompassing policy and regulatory improvements, integrated technologies, prioritizing gender equality, and public awareness campaigns led by government agencies.

Effective solutions demand acknowledging the unique socio-cultural and environmental complexities within these communities. Tailored frameworks, not a "one-size-fits-all" approach, are essential. Recognizing the impact of poverty on development is pivotal for creating culturally sensitive and sustainable sanitation solutions that improve public health and quality of life.

Future research should explore historical sanitation practices and delve deeper into social and cultural factors influencing sanitation behaviors to inform these solutions.

Author contributions: Conceptualization, RA and VAC; methodology, RA; formal analysis, RA; investigation, VAC and RD; resources, RA; data curation, VAC; writing—original draft preparation, VAC and RA; writing—review and editing, VAC and RD; supervision, RA; project administration, RA; funding acquisition, RA. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Royal Academy of Engineering, grant number DIA-2021-118.

Conflict of interest: The authors declare no conflict of interest.

References

Abell, R., Asquith, N., Boccaletti, G., et al. (2017). Beyond the Source: The Environmental, Economic and Community Benefits of Source Water Protection. The Nature Conservancy.

Amitrano, D., Martino, G., Iodice, A., et al. (2014). Sentinel-1 for monitoring reservoirs: A performance analysis. Remote Sensing, 6, 10676–10693. https://doi.org/10.3390/rs61110676

Andres, L., Boateng, K., Borja-Vega, C., et al. (2018). A Review of In-Situ and Remote Sensing Technologies to Monitor Water and Sanitation Interventions. Water, 10(6), 756. https://doi.org/10.3390/w10060756

Baker, A., Cumberland, S. A., Bradley, C., et al. (2015). To what extent can portable fluorescence spectroscopy be used in the real-time assessment of microbial water quality? Science of The Total Environment, 532, 14–19. https://doi.org/10.1016/j.scitotenv.2015.05.114

Bayu, T., Kim, H., & Oki, T. (2020). Water Governance Contribution to Water and Sanitation Access Equality in Developing Countries. Water Resources Research, 56(4). https://doi.org/10.1029/2019wr025330

Beard, V. A., & Mitlin, D. (2021). Water access in global South cities: The challenges of intermittency and affordability. World Development, 147, 105625. https://doi.org/10.1016/j.worlddev.2021.105625

Blakely, T., Baker, M., & Howden-Chapman, P. (2011). Does housing policy influence health? Journal of Epidemiology & Community Health, 65(7), 588–593.

Brent, D. A., Lott, C., Taylor, M., et al. (2020). What Causes Heterogeneous Responses to Social Comparison Messages for Water Conservation? Environmental and Resource Economics, 77(3), 503–537. https://doi.org/10.1007/s10640-020-00506-0

Campbell, T. (1987). Applying Lessons from Housing to Meeting the Challenge of Water and Sanitation for the Urban Poor. Journal of the American Planning Association, 53(2), 186–192. https://doi.org/10.1080/01944368708976651

Carswell, C. M. (1992). Choosing Specifiers: An Evaluation of the Basic Tasks Model of Graphical Perception. Human Factors: The Journal of the Human Factors and Ergonomics Society, 34(5), 535–554. https://doi.org/10.1177/001872089203400503

Cookey, P., & Cookey, M. (2021). Safe-Sanitation Adaptive-Integrated Management Systems (SAIMS). In: Water, Climate Change, and Sustainability. Wiley.

Creswell, J., & Poth, C. (2017). Qualitative Inquiry and Research Design. In: Choosing Among Five Approaches. SAGE Publications, Inc.

Dash, J., Kapur, D., Kapoor, M., & Singh, D. (2019). A Systems Approach to Capacity Building: Lessons from Sanitation Capacity Building Platform (SCBP), India. WASH Systems Symposium.

Department of Statics. (2021). Estimated population of the Kingdom until 2021. Available online: http://dosweb.dos.gov.jo/population/population-2/ (accessed on 25 May 2024).

Department of Statistics Jordan. (2022). Poverty statistics. Available online: https://dosweb.dos.gov.jo/population/poverty/ (accessed on 25 May 2024).

Eichelberger, L., Dev, S., Howe, T., et al. (2021). Implications of inadequate water and sanitation infrastructure for community spread of COVID-19 in remote Alaskan communities. Science of The Total Environment, 776. https://doi.org/10.1016/j.scitotenv.2021.145842

Ersan, M. (2021). Jordan struggles with dry dams, water deficit. Available online: https://www.al-monitor.com/originals/2021/11/jordan-struggles-dry-dams-water-deficit (accessed on 25 May 2024).

Estache, A., & Rossi, M. (2002). How different is the efficiency of public and private water companies in Asia? World Bank Economic Review, 16(1), 139–148. https://doi.org/10.1093/wber/16.1.139

Fallah, B., Krafft, C., & Wahba, J. (2019). The impact of refugees on employment and wages in Jordan. Journal of Development Economics, 139, 203–216. https://doi.org/10.1016/j.jdeveco.2019.03.009

Flick, U. (2009). An introduction to qualitative research, 4th ed. Sage Publications Ltd.

Friel, S. N., Curcio, F. R., & Bright, G. W. (2001). Making Sense of Graphs: Critical Factors Influencing Comprehension and Instructional Implications. Journal for Research in Mathematics Education, 32(2), 124. https://doi.org/10.2307/749671

García-Montoya, M., Ponce-Ortega, J. M., Nápoles-Rivera, F., et al. (2015). Optimal design of reusing water systems in a housing

complex. Clean Technologies and Environmental Policy, 17(2), 343–357. https://doi.org/10.1007/s10098-014-0784-x

Garriga, R. G., de Palencia, A. J. Fdez., & Foguet, A. P. (2015). Improved monitoring framework for local planning in the water, sanitation and hygiene sector: From data to decision-making. Science of The Total Environment, 526, 204–214. https://doi.org/10.1016/j.scitotenv.2015.04.078

Garthwaite, J. (2021). Stanford study reveals a deepening water crisis in Jordan—and a way forward. Available online: https://news.stanford.edu/2021/03/29/jordans-worsening-water-crisis-warning-world/ (accessed on 25 May 2024).

Gensch, R., Jennings, A., Renggli, S., & Reymond, P. (2018). Compendium of Sanitation Technologies in Emergencies. German WASH Network (GWN). Available online: https://www.washcluster.net/emersan-compendium (accessed on 25 May 2024).

Gimelli, F. M., Bos, J. J., & Rogers, B. C. (2018). Fostering equity and wellbeing through water: A reinterpretation of the goal of securing access. World Development, 104, 1–9. https://doi.org/10.1016/j.worlddev.2017.10.033

Gutterer, B., Sasse, L., Panzerbieter, T., & Reckerzügel, T. (2009). Decentralised Wastewater Treatment Systems (DEWATS) and Sanitation in Developing Countries. Water, Engineering and Development Centre.

Hamed, T. A., & Bressler, L. (2019). Energy security in Israel and Jordan: The role of renewable energy sources. Renewable Energy, 135, 378–389. https://doi.org/10.1016/j.renene.2018.12.036

HAQQI. Legislation, research, media. (2012). Report on the state of poverty in Jordan: based on data from the Household Income and Expenditure Survey 2010. Available online: https://dosweb.dos.gov.jo/population/poverty/ (accessed on 25 May 2024).

Hollander, D., Ajroud, B., Thomas, E., et al. (2020). Monitoring Methods for Systems-Strengthening Activities Toward Sustainable Water and Sanitation Services in Low-Income Settings. Sustainability, 12(17), 7044. https://doi.org/10.3390/su12177044

Hollander, D., Ajroud, B., Thomas, E., et al. (2020). Monitoring Methods for Systems-Strengthening Activities Toward Sustainable Water and Sanitation Services in Low-Income Settings. Sustainability, 12(17), 7044. https://doi.org/10.3390/su12177044

Horcher, A., & Visser, R. (2004). Unmanned aerial vehicles: Applications for natural resource management and monitoring. In: Proceedings of the 2004 Council on Forest Engineering (COFE) Conference “Machines and People, The Interface”.

Huston, A., & Moriarty, P. (2018). Building Strong WASH Systems for the SDGs: Understanding the WASH System and Its Building Blocks. IRC.

Hwang, S., Fuller-Thomson, E., & Hurlchanski, J. (1999). Housing and Population Health: A Review of the Literature. Sociology & Criminology Faculty Publications.

Istchuk, R. N., & Ghisi, E. (2023). Influence of Design Variables on the Financial Feasibility of Rainwater Harvesting Systems. Water, 15(6), 1112. https://doi.org/10.3390/w15061112

Khanal, G., Maraseni, T., Thapa, A., et al. (2023). Managing water scarcity via rainwater harvesting system in Kathmandu Valley, Nepal: People’s awareness, implementation challenges and way forward. Environmental Development, 46, 100850. https://doi.org/10.1016/j.envdev.2023.100850

Klassen, H. (2020). Water Scarcity in the Jordan River Valley. Available online: https://scholarsarchive.byu.edu/ballardbrief/vol2020/iss2/5 (accessed on 25 May 2024).

Lawrence, P., Meigh, J., & Sullivan, C. (2002). The Water Poverty Index: an International Comparison. Keele Economics Research Papers.

Mehta, M., & Mehta, D. (2013). City sanitation ladder: moving from household to citywide sanitation assessment. Journal of Water, Sanitation and Hygiene for Development, 3(4), 481–488. https://doi.org/10.2166/washdev.2013.134

MoEnv. (2020). Water Sector Green Growth National Action Plan 2021–2025. Global Green Growth Institute Jordan.

Muhammad Anwar, S. N. B., Alvarado, V., & Hsu, S.-C. (2021). A socio-eco-efficiency analysis of water and wastewater treatment processes for refugee communities in Jordan. Resources, Conservation and Recycling, 164, 105196. https://doi.org/10.1016/j.resconrec.2020.105196

Nayebare, J. G., Owor, M. M., Kulabako, R., et al. (2019). WASH conditions in a small town in Uganda: how safe are on-site facilities? Journal of Water, Sanitation and Hygiene for Development, 10(1), 96–110. https://doi.org/10.2166/washdev.2019.070

Nel, J. L., Le Maitre, D. C., Roux, D. J., et al. (2017). Strategic water source areas for urban water security: Making the connection between protecting ecosystems and benefiting from their services. Ecosystem Services, 28, 251–259. https://doi.org/10.1016/j.ecoser.2017.07.013

Nelson, S., Drabarek, D., Jenkins, A., et al. (2021). How community participation in water and sanitation interventions impacts

human health, WASH infrastructure and service longevity in low-income and middle-income countries: a realist review. BMJ Open, 11(12), e053320. https://doi.org/10.1136/bmjopen-2021-053320

Omisore, A. G., Babarinde, G. M., Bakare, D. P., et al. (2017). Awareness and knowledge of the sustainable development goals in a University Community in Southwestern Nigeria. Ethiopian Journal of Health Sciences, 27(6), 669. https://doi.org/10.4314/ejhs.v27i6.12

Parkinson, J., Lüthi, C., & Walther, D. (2014). Sanitation 21: A Planning Framework for Improving City-wide Sanitation Services. IWA.

Philipsen, H., & Vernooij-Dassen, M. (2007). Qualitative research: useful, indispensable and challenging. In: B Qualitative research: Practical methods for medical practice. Bohn Stafleu van Loghum.

Prüss-Ustün, A., Bartram, J., Clasen, T., et al. (2014). Burden of disease from inadequate water, sanitation and hygiene in low- and middle-income settings: a retrospective analysis of data from 145 countries. Tropical Medicine & International Health, 19(8), 894–905. Portico. https://doi.org/10.1111/tmi.12329

RainwaterTanksDirect.com.au. (2018). Sanitation and Proper Hygiene with Rainwater Harvesting. Available online: https://rainwatertanksdirect.com.au/blogs/sanitation-and-proper-hygiene-with-rainwater-harvesting/ (accessed on 25 May 2024).

Reymond, P., Renggli, S., & Lüthi, C. (2016). Towards Sustainable Sanitation in an Urbanising World. Available online: https://doi.org/10.5772/63726 (accessed on 25 May 2024).

Rhodes-Dicker, L., Brown, N. J., & Currell, M. (2022). Unpacking intersecting complexities for WASH in challenging contexts: A review. Water Research, 209, 117909. https://doi.org/10.1016/j.watres.2021.117909

Robinson, A. (2021). Monitoring and evaluation for rural sanitation and hygiene. Guidelines. Institute of Development Studies.

Russel, K. C., Hughes, K., Roach, M., et al. (2019). Taking Container-Based Sanitation to Scale: Opportunities and Challenges. Frontiers in Environmental Science, 7. https://doi.org/10.3389/fenvs.2019.00190

Serajuddin, D., Serajuddin, U., Wadhwa, D., & Welch, M. (2023). Atlas of the Sustainable Development Goals. World Bank.

Shalowitz, M. U., Isacco, A., Barquin, N., et al. (2009). Community-Based Participatory Research: A Review of the Literature with Strategies for Community Engagement. Journal of Developmental & Behavioral Pediatrics, 30(4), 350–361. https://doi.org/10.1097/dbp.0b013e3181b0ef14

Smith, L. (2004). The murky waters of the second wave of neoliberalism: corporatization as a service delivery model in Cape Town. Geoforum, 35(3), 375–393. https://doi.org/10.1016/j.geoforum.2003.05.003

Spuhler, D., & Lüthi, C. (2020). Review of frameworks and tools for urban strategic sanitation planning: considering technology innovations and sustainability. Journal of Water, Sanitation and Hygiene for Development, 10(4), 768–785. https://doi.org/10.2166/washdev.2020.062

Spuhler, D., Germann, V., Kassa, K., et al. (2020). Developing sanitation planning options: A tool for systematic consideration of novel technologies and systems. Journal of Environmental Management, 271, 111004. https://doi.org/10.1016/j.jenvman.2020.111004

The Jordan Times. (December). The Jordan Times. Available online: https://jordantimes.com/news/local/jordans-female-labour-force-participation-rate-stands-143-%E2%80%94-report#:~:text=AMMAN%20%E2%80%94%20The%20economic%20participation%20rate,NGO%20concerned%20with%20labour%20affairs (accessed on 25 May 2024).

Tilmans, S., Russel, K., Sklar, R., et al. (2015). Container-based sanitation: assessing costs and effectiveness of excreta management in Cap Haitien, Haiti. Environment and Urbanization, 27(1). https://doi.org/10.1177/09562478155727

Toilet Board Coalition. (2021). Akyas sanitation announces opening of Akyas toilet facilities in Za'atari camp, Mafraq, Jordan. Available online: https://www.toiletboard.org/akyas-sanitation-announces-opening-of-akyas-toilet-facilities-in-zaatari-camp-mafraq-jordan/ (accessed on 25 May 2024).

UHCR. (2022). Refugee Data Finer. Available online: https://www.unhcr.org/refugee-statistics/ (accessed on 25 May 2024).

Ullah, A., Hussain, S., Wasim, A., et al. (2020). Development of a decision support system for the selection of wastewater treatment technologies. Science of The Total Environment, 731, 139158. https://doi.org/10.1016/j.scitotenv.2020.139158

UN. (2016). National Water Strategy of Jordan 2016–2025. Available online: https://leap.unep.org/countries/jo/national-legislation/national-water-strategy-jordan-2016-2025 (accessed on 25 May 2024).

UNICEF. (2016). Water, sanitation and hygiene. Access to safe water and sanitation for every child. Available online: https://www.unicef.org/jordan/water-sanitation-and-

hygiene#:~:text=Challenges,which%20defines%20severe%20water%20scarcity (accessed on 25 May 2024).
UNICEF. (2019). National Social Protection Strategy 2019–2025. UNICEF.
United Nations. (2019). World Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420). United Nations.
United Nations. (2022). Sustainable Development Goals. Knowledge Platform. Available online: https://sustainabledevelopment.un.org/topics/water/unsgab/wastewater (accessed on 25 May 2024).
United Nations Development Programme. (2013). Jordan Poverty Reduction Strategy. Available online: https://www.undp.org/jordan/publications/jordan-poverty-reduction-strategy (accessed on 25 May 2024).
Welch, D., & Kneipp, S. (2005). Low-Income Housing Policy and Socioeconomic Inequalities in Women's Health: The Importance of Nursing Inquiry and Intervention. Policy, Politics, & Nursing Practice, 6(4), 335–342. https://doi.org/10.1177/1527154405283300
Wendland, C., Yadav, M., Stock, A., & Seager, J. (2017). Gender, Women and Sanitation. Global Water Pathogen Project.
Weng Chan, N., Wern Hong, C., Hui Lai, C., & Lim, H. (2016). The role of the university in community engagement for environmental and water education: the example of Universiti Sains Malaysia. In: Proceedings of the USM BALI CONFERENCE 2016 School of Social Sciences, School of Humanities & School of Housing, Building and Planning.
WHO/UNICEF. (2021). Progress on household drinking water, sanitation and hygiene 2000–2020: Five years into the SDGs. UNICEF.
Wilson, D. C., & Webster, M. (2018). Building capacity for community waste management in low- and middle-income countries. Waste Management & Research: The Journal for a Sustainable Circular Economy, 36(1), 1–2. https://doi.org/10.1177/0734242x17748535
World Bank. (2018). Hashemite Kingdom of Jordan Understanding How Gender Norms in MNA Impact Female Employment Outcomes. World Bank.
World Bank Group. (2022). Country Climate and Development Report: Jordan. World Bank Group.
World Food Program USA. (2021). 10 Facts About the Syrian Refugee Crisis in Jordan. World Food Program USA.
Yazdanpanah, M., Hayati, D., Zamani, G. H., et al. (2013). Water management from tradition to second modernity: an analysis of the water crisis in Iran. Environment, Development and Sustainability, 15(6), 1605–1621. https://doi.org/10.1007/s10668-013-9452-2