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Potable Water under Pressure: Effects of the Syrian Crisis and Recent Drought on Northwest Syria

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Abstract

The study investigates the impact of the Syrian crisis and the recent drought on the potable water situation in Northwest Syria, comparing various aspects of water availability and quality before and after 2011. 380 key-informants were surveyed, including water-well owners, well-digging companies, water-trucking suppliers, agricultural pharmacies, and service offices within local councils. The surveys covered all nine districts in northwestern Syria across the Aleppo and the Idleb governorates. The survey findings reveal significant shifts in water sources, an almost halving in water availability and per capita consumption, and a notable decrease in water quality. Coping mechanisms include random well drilling and reduced hygiene practices. Water pumping stations face challenges with functionality, and there is a shift towards clean energy sources, particularly solar energy. Challenges identified by the survey respondents include drought, fuel costs, and damaged water networks. The study highlights the urgency of addressing the potable water crisis in Northwest Syria and suggests specific interventions to enhance water sustainability and governance.

Keywords

Water, Potable, Crisis, Drought, Northwest Syria

1. Introduction

Even though the UN declared access to clean water to be a fundamental human

right in 2010, billions of people worldwide still lack access to it. Mismanagement, conflict, and climate change exacerbate water scarcity in the Middle East and North Africa (MENA) region [1]. Due to increased susceptibility to its impacts, climate change has severely impacted the state of the world, particularly in underprivileged areas [2]. Additionally, by making poverty and economic shocks worse, it increases the likelihood of war [3]. Water supplies have been under more stress recently as a result of population growth, economic development, and climate change [4]. Climate change has caused periodic droughts and inconsistent rainfall in Syria, which has had a major negative impact on human life and the economy and aided in the start of the Syrian crisis [5] [6].

The majority of Syrians had consistent access to potable water prior to 2011. Water infrastructure has been extensively destroyed by the conflict, resulting in a 40% decrease in access over the last ten years [1]. One important obstacle is the high cost of water [7]. Food security has been worse due to recent extreme droughts and low water levels that have impacted energy production and agriculture [8]. Funding reductions, well depletion, and a lack of resources all limit humanitarian activities [9] [10]. Since more than half of northern Syria is dependent on tainted water, waterborne illnesses and a cholera outbreak became pressing concerns in 2022 [11].

Access to potable water in Northwest Syria is not only constrained by infrastructural damage but is also influenced by political dynamics and governance issues. Local authorities often lack the capacity to manage water resources effectively due to ongoing conflict and fragmentation of governance structures [12]. This disjointed governance has led to a reliance on informal water markets and private water vendors, which frequently deliver untreated water at exorbitant prices [13]. The International Federation of Red Cross and Red Crescent Societies (IFRC) highlights that many communities are forced to prioritize immediate access to water over safety and quality, contributing to public health crises, including increased cases of acute watery diarrhea and cholera [13]. Furthermore, the politicization of water resources complicates humanitarian interventions, as factions may manipulate water supply as a tool of control, hindering equitable access to safe drinking water [14].

The intersection of climate change, armed conflict, and water scarcity has profound implications for the future of water security in the region. Researchers have indicated that the ongoing climate crisis is likely to exacerbate existing vulnerabilities in water systems, particularly in areas already affected by displacement and conflict [15]. The World Bank [16] warns that failing to address the intertwined issues of water scarcity and climate change could result in a "water trap," where communities become increasingly reliant on unsustainable sources of water, thereby perpetuating cycles of poverty and conflict. Addressing these interconnected challenges requires a comprehensive approach that integrates climate resilience, governance reforms, and targeted humanitarian aid to restore and enhance water access for vulnerable populations in Northwest Syria.

The study aims to analyze and document the compounded impact of the Syrian crisis and recent drought conditions on potable water availability and quality in

Northwest Syria. It seeks to provide an in-depth understanding of how these factors have affected water infrastructure, resource management, community access to safe drinking water and the urgent needs and potential solutions for sustainable water management in the region.

2. Materials and Methods

2.1. Study Area and Population

The study was conducted in Northwest Syria, covering the majority of Idlib Governorate and significant portions of northern Aleppo Governorate. The population of the region is 4.55 million, with 2.87 million Internally Displaced People (IDPs), including nearly 2 million living in 1,527 camps and informal sites [17]. The focus was on selected districts within these governorates: Ariha, Harim, Idleb, and Jisr-Ash-Shugur in Idleb, and Afrin, Al Bab, A'zaz, Jarablus, and Jebel Saman in Aleppo (Table 1).

Table 1. Number of survey respondents in different districts and across categories.

Governorate	District	Local councils	Water-well owners	Well-digging companies	Water-trucking suppliers	Agricultural pharmacies	Total
Aleppo	Afrin	7	32	0	14	2	55
Aleppo	Al Bab	3	31	1	4	0	39
Aleppo	A'zaz	4	23	0	8	0	35
Aleppo	Jarablus	2	53	0	18	2	75
Aleppo	Jebel Saman	2	10	2	4	2	20
Idleb	Ariha	3	4	5	10	2	24
Idleb	Harim	6	24	2	8	14	54
Idleb	Idleb	3	19	3	14	2	41
Idleb	Jisr-Ash-Shugur	4	10	1	22	0	37
Total	**9**	**34**	**206**	**14**	**102**	**24**	**380**

2.2. Sampling and Respondent Selection

Structured questionnaires were used to collect data on water access and practices from key informants. The sample size was calculated to be 380 respondents, with a confidence level of 95% and a margin of error of 5%. Respondents were chosen to represent key stakeholders: local councils, water-well owners, well-digging companies, water-trucking suppliers, and agricultural pharmacies. The total population of these stakeholders in the study area was 32,654. Respondents were selected randomly to ensure a representative sample of the districts.

2.3. Questionnaire Design

The questionnaire consisted of two main sections; The first section gathered

sociodemographic information about the participants. The second section focused on water access, resources, and the challenges associated with potable water, including questions on water sources, treatment techniques, groundwater levels, well-drilling practices, water quality, and the entities responsible for managing water resources. Respondents were encouraged to answer all questions that were relevant to their expertise.

2.4. Validity and Reliability Testing

The validity of the questionnaire was ensured through expert reviews and pre-testing with a small sample to refine the questions and ensure they captured relevant data accurately. Reliability was tested through consistency checks during data collection, ensuring that responses were stable and reproducible. Adjustments were made after pre-testing to improve clarity and ensure the reliability of responses.

2.5. Data Collection

The data collection process was carried out using the KOBO Toolbox application, which helped ensure the accuracy and consistency of the data collected. The questionnaire was available in both Arabic and English to accommodate a wide range of respondents. The data collection team consisted of 29 field technicians (7 females and 22 males) with diverse professional backgrounds, including economists, mechanical engineers, civil engineers, and agricultural engineers.

2.6. Data Analysis

The collected data were analyzed using response counts and changes observed between pre-2011 and post-2011 conditions. A coding process was applied to the responses to organize them and improve the credibility of the results. The data analysis included:

- Descriptive statistics to summarize water resources, quality, and access issues.
- Comparative analysis of water access before and after 2011.
- Qualitative analysis of responses related to challenges and support needed.

2.7. Ethical Considerations

Ethics approval for the study was obtained from the University of Bristol's Faculty of Engineering Research Ethics Committee (Review reference: 2023-14678-16259).

3. Results

3.1. Status of Potable Water before and after the Crisis in Northwest Syria

3.1.1. Sources of Potable Water

Prior to 2011, people in the study area primarily relied on public wells and networks for potable water, with only a small percentage using private wells and water trucking. After 2011, dependence on public wells and networks decreased, while reliance on water trucking and private wells increased (Table 2).

Table 2. Sources of potable water in Northwest Syria before and after 2011.

Governorate	District	Drinking water sources were used before 2011			Drinking water sources that were used After 2011		
		Public wells and networks	Private wells	Water trucking	Public wells and networks	Private wells	Water trucking
Aleppo	Afrin	84%	11%	4%	39%	22%	39%
Aleppo	Al Bab	76%	18%	6%	30%	22%	48%
Aleppo	A'zaz	77%	16%	7%	47%	23%	30%
Aleppo	Jarablus	82%	11%	7%	40%	28%	31%
Aleppo	Jebel Saman	86%	5%	9%	49%	21%	30%
Idleb	Ariha	84%	5%	9%	48%	21%	31%
Idleb	Harim	89%	6%	5%	46%	19%	35%
Idleb	Idleb	88%	3%	9%	46%	17%	37%
Idleb	Jisr-Ash-Shugur	85%	9%	5%	48%	22%	30%
2	**9**	**83%**	**9%**	**7%**	**44%**	**22%**	**35%**

n = 366, Respondents were Local councils (34), Water-well owners (206), Water-trucking suppliers (102) and Agricultural pharmacies (24).

3.1.2. Availability of Potable Water

Eighty-two percent of respondents reported a 46% decrease in potable water availability in Northwest Syria after 2011. The highest decrease was observed in Jisr-Ash-Shugur, with a reduction of 36%, followed by Harim at 47% (Table 3).

Table 3. Availability of potable water in Northwest Syria before and after 2011.

Governorate	District	Increase after the crisis	Decrease after the crisis	The same	% of decrease in water availability after 2011
Aleppo	Afrin	9%	81%	11%	47%
Aleppo	Al Bab	6%	86%	8%	57%
Aleppo	A'zaz	16%	81%	3%	52%
Aleppo	Jarablus	15%	71%	14%	46%
Aleppo	Jebel Saman	7%	53%	40%	48%
Idleb	Ariha	15%	85%	0%	42%
Idleb	Harim	2%	93%	5%	47%
Idleb	Idleb	3%	86%	10%	43%
Idleb	Jisr-Ash-Shugur	0%	100%	0%	36%
2	**9**	**8%**	**82%**	**10%**	**46%**

n = 366, Respondents were Local councils (34), Water-well owners (206), Water-trucking suppliers (102) and Agricultural pharmacies (24).

3.1.3. Consumption of Potable Water

The Syrian crisis and recent drought significantly impacted per capita consumption of potable water in Northwest Syria. Consumption decreased by 45%, from 59 liters per capita before 2011 to 32 liters per capita after 2011. The highest decline was observed in the Harim and Idleb regions, which host the largest number of displaced people camps in Northwest Syria (Table 4).

Table 4. The quantity (liter per capita per day) of water (for drinking and hygiene) available in Northwest Syria before and after 2011.

Governorate	District	Before 2011	After 2011	% of decrease in potable water quantity
Aleppo	Afrin	64	32	−50%
Aleppo	Al Bab	64	32	−50%
Aleppo	A'zaz	68	34	−50%
Aleppo	Jarablus	62	42	−32%
Aleppo	Jebel Saman	46	31	−32%
Idleb	Ariha	47	31	−34%
Idleb	Harim	61	28	−54%
Idleb	Idleb	67	31	−53%
Idleb	Jisr-Ash-Shugur	52	29	−44%
2	**9**	**59**	**32**	**−45%**

n = 366, Respondents were Local councils (34), Water-well owners (206), Water-trucking suppliers (102) and Agricultural pharmacies (24).

There were multiple reasons for this decrease. Ninety-two percent of respondents cited drought and decreased rainfall, 82% mentioned random well drilling, 76% pointed to the large number of IDPs, 68% identified damage to water pumping stations, and 61% highlighted the lack of spare parts for pumping stations.

As a result of this decrease, many coping mechanisms were adopted by people such as digging more random wells by using paid machines which are available locally in the area (78% of the respondents), purchased additional quantities of water through the water truckers (70%), reduced the number of hygiene practices especially bath and showers (58%), reusing the water for other purposes such as washing or cleaning (54%), storing water in the artificial tanks usually are spread in the rural areas (51%), and not using drinking water for irrigation (50%).

3.1.4. Quality of the Potable Water

Ninety-three percent of respondents reported that the water was of good to high quality before the crisis, while only 48% reported the same quality after the crisis. Before 2011, only 7% of respondents described the water as low to medium quality, whereas 52% reported low to medium water quality after the crisis (Table 5).

Table 5. The quality of the potable water in northwest Syria before and after the crisis.

Governorate	District	Potable water quality before 2011				Potable water quality After 2011			
		High quality	Good quality	Moderate quality	Low quality	High quality	Good quality	Moderate quality	Low quality
Aleppo	Afrin	17%	72%	9%	2%	0%	45%	36%	19%
Aleppo	Al Bab	5%	84%	11%	0%	0%	19%	68%	14%
Aleppo	A'zaz	23%	65%	13%	0%	7%	37%	33%	23%
Aleppo	Jarablus	25%	54%	20%	2%	8%	47%	38%	8%
Aleppo	Jebel Saman	47%	47%	6%	0%	50%	38%	6%	6%
Idleb	Ariha	22%	78%	0%	0%	11%	56%	28%	6%
Idleb	Harim	30%	70%	0%	0%	2%	32%	45%	20%
Idleb	Idleb	56%	38%	6%	0%	9%	44%	25%	22%
Idleb	Jisr-Ash-Shugur	42%	58%	0%	0%	0%	27%	65%	8%
2	**9**	**30%**	**63%**	**7%**	**0%**	**10%**	**38%**	**38%**	**14%**

n = 342, Respondents were Local councils (34), Water-well owners (206), and Water-trucking suppliers (102).

Respondents reported multiple reasons for the perceived decline in the quality of potable water. These reasons include using tanker water as a source of drinking water (76% of the respondents), lack of maintenance and rehabilitation due to the insufficient operating funds for water stations (73%), lack of control over water tankers (69%), the decline in the water level in the wells (67%), increased cost of the treatment of potable water (66%), lack of technical operating experience (46%), and the use of potable water from contaminated sources (41%).

3.1.5. Status of the Water Pumping Stations in Northwest Syria

Water station in northwest Syria is referring to the motorized pumps that is distributing the potable water through the city/town's networks. The results showed that the number of water pumping stations in the study area is 362 stations, out of which 273 (75%) are functional. Harim has the largest number (113) of functioning water pumping stations, followed by Idleb and Afrin which were 39 and 30, respectively. Furthermore, Harim and Afrin have the largest number of non-functioning water pumping stations, 26 and 18, respectively (Table 6).

According to respondents from local councils, well owners, and water trucking suppliers, the main reasons for the non-functionality of water stations in Northwest Syria were lack of resources for operations and maintenance (73% of respondents), severe damage to stations (57%), damage to drinking water networks (54%), and aging water pumping stations (46%).

Before 2011, the electricity network was mainly used to operate water pumping stations, with a partial reliance on electric generators (diesel) and solar energy. On the other hand, and after 2011, reliance was mainly on electrical generators, then solar energy and less on the electricity network. Accordingly, there is a clear

increase in reliance on clean energy (solar energy) in Northwest Syria after 2011, as the percentage increased from 1% to 34% in the study area (Table 7).

Table 6. Number of water pumping stations and its functionality in Northwest Syria.

Governorate	District	# of water pumping stations	# of water pumping stations are functioning	# of water pumping stations are not functioning
Aleppo	Afrin	48	30	18
Aleppo	Al Bab	17	11	6
Aleppo	A'zaz	28	19	9
Aleppo	Jarablus	13	8	5
Aleppo	Jebel Saman	30	22	8
Idleb	Ariha	22	16	6
Idleb	Harim	139	113	26
Idleb	Idleb	46	39	7
Idleb	Jisr-Ash-Shugur	19	15	4
2	**9**	**362**	**273**	**89**

n = 342, Respondents were Local councils (34), Water-well owners (206), and Water-trucking suppliers (102).

Table 7. Sources of energy to run the water pumping stations in Northwest Syria before and after the crisis.

Governorate	District	Before 2011			After 2011		
		Electricity network	Electric generators (Diesel)	Solar energy	Electricity network	Electric generators (Diesel)	Solar energy
Aleppo	Afrin	78%	19%	4%	28%	42%	30%
Aleppo	Al Bab	77%	20%	2%	8%	75%	17%
Aleppo	A'zaz	75%	24%	1%	28%	39%	33%
Aleppo	Jarablus	76%	22%	3%	32%	37%	31%
Aleppo	Jebel Saman	90%	10%	0%	31%	25%	44%
Idleb	Ariha	89%	11%	0%	34%	22%	44%
Idleb	Harim	90%	10%	0%	38%	20%	42%
Idleb	Idleb	84%	16%	0%	30%	32%	38%
Idleb	Jisr-Ash-Shugur	88%	12%	0%	38%	33%	30%
2	**9**	**83%**	**16%**	**1%**	**30%**	**36%**	**34%**

n = 342, Respondents were Local councils (34), Water-well owners (206), and Water-trucking suppliers (102).

3.2. Challenges of the potable water in Northwest Syria

The most significant challenges facing potable water in Northwest Syria were drought and low precipitation (87% of the respondents), lack of potable water in

camps and communities (79%), high fuel costs (74%), high costs of water trucking (71%), deterioration of water networks in communities (70%), absence of water networks in the camps (66%), high cost of operating water stations (64%), Deterioration of the water pumps (61%), Lack of maintenance of the water pumps (61%).

3.3. Support Needed for the Potable Water Sector in Northwest Syria

Respondents indicated that the potable water in northwest Syria needs support and interventions such as using the solar energy as alternative energy (85% of the respondents), water quality control and sterilizing (81%), rehabilitation of affected water stations and water networks (80%), provision of running costs for water stations (78%), implementation of strategic water projects in the region (65%), provision of water trucking and water tanks (59%), and linking camps to the community water networks (59%), enhance governance and drinking water management (56%), enhance the cost recovery system (50%), and finally, ensuring drinking water for other purposes (40%).

4. Discussion

The findings of this study highlight critical shifts in the potable water landscape in Northwest Syria before and after the crisis that began in 2011. These shifts are essential not only for understanding the current state of water resources but also for informing strategies to address the region's ongoing challenges. The Syrian water crisis has been exacerbated by conflict, which has severely damaged infrastructure, displaced millions, and created significant governance and resource management obstacles [18].

The shift in potable water sources, marked by a decline in reliance on public wells and networks post-2011, reflects the multifaceted impact of the crisis on water infrastructure. Increased dependence on private wells and water trucking reveals the adaptive strategies communities have developed amid the deteriorating water supply. The Humanitarian Needs Overview [17] highlights that only 21% of camps in Northwest Syria are connected to water networks, forcing the majority of internally displaced persons (IDPs) to depend on costly and unsustainable water trucking [17]. The International Federation of Red Cross and Red Crescent Societies (IFRC) similarly reports that, despite primary water networks in most villages, frequent electricity and fuel shortages often limit access to adequate water supplies [13]. Prior to 2011, public wells and networks provided more stable access, but post-crisis, private wells and trucking have become essential, similar to trends in other conflict zones where crises disrupt traditional reliance on public sources [19] [20]. This raises concerns about water scarcity and quality, as unregulated sources often fail to meet health standards [21].

The significant 46% decrease in potable water availability post-2011 aligns with broader narratives of water scarcity in conflict-affected areas [22]. Regional disparities are also evident, with Jisr-Ash-Shugur experiencing a 36% reduction and

Harim a 47% decrease, the latter reflecting its high concentration of IDP camps [11]. Humanitarian Needs Overview [17] points to prolonged droughts and reduced rainfall as factors exacerbating access to potable water. This mirrors trends in regions like Yemen and South Sudan, where both conflict and population pressures from displaced persons severely impact water systems [23] [24]. The recent drought has intensified these challenges, as seasonal rainfall variability contributes to water shortages, underscoring the need for securing resources against both climate and conflict risks [25] [26].

The reduction in per capita water consumption, from 59 to 32 liters, highlights the region's adaptive responses to water scarcity. This shift parallels similar declines observed in displaced communities in Iraq and Somalia, where high population density exacerbates pressure on local resources [27] [28]. In Northwest Syria, these changes have prompted coping mechanisms such as rationing, reduced hygiene practices, and prioritization of drinking water, all of which reflect the vulnerabilities of communities in fragile settings [11] [29]. Immediate humanitarian actions should focus on addressing this need through enhanced water trucking services and sustainable solutions, such as solar-powered systems, to strengthen infrastructure resilience [13] [30].

Water quality has also significantly deteriorated, with only 48% of respondents reporting good to high-quality water post-crisis, attributed to unregulated sources like tanker water. The [17] identifies health risks from unsafe water, including increases in acute watery diarrhea (AWD), cholera, and malnutrition [17] [31]. Restoring damaged treatment infrastructure and implementing quality controls is crucial, as seen in other conflict zones where untreated sources lead to health crises [32] [33]. Yemen and Libya have faced similar risks, with outbreaks of cholera due to unregulated sources [34] [35].

The role of water pumping stations in northwest Syria remains essential for infrastructure. The high percentage of non-functional stations due to war damage and resource scarcity underscores the need for maintenance and rehabilitation. As HNO 2023 [17] reported, two-thirds of Syria's water treatment plants, half of the pumping stations, and one-third of water towers are currently non-operational. In response to fuel shortages and power grid instability, solar energy use in water pumping stations has become a positive trend. Pre-2011, stations relied on government electricity, but the conflict has driven communities to adopt diesel and solar alternatives [36] [37]. Solar energy offers a resilient and sustainable option for water access, comparable to adaptations in South Sudan's solar-powered systems during fuel shortages [38].

Challenges from drought, fuel costs, and deteriorating infrastructure emphasize the urgent need for a comprehensive response to Northwest Syria's water crisis [39]. Immediate measures, such as increased water trucking, must be paired with sustainable solutions like solar-powered pumps and infrastructure rehabilitation. Effective governance structures are also necessary for sustainable water resource management. Interventions, including solar installations, quality monitoring, and

infrastructure restoration, are essential. Similar success has been seen in Kenya's refugee camps with solar-powered water systems, providing a model for interventions in Syria [40] [41].

5. Conclusions

The potable water crisis in Northwest Syria highlights the severe vulnerabilities faced by communities amidst prolonged conflict, resource scarcity, and climate pressures. While communities have shifted from centralized water systems to decentralized sources such as private wells and water trucking, these alternatives have resulted in challenges in water quality, affordability, and access, particularly in overcrowded displacement camps. Droughts, unreliable energy, and political and socioeconomic barriers further complicate the situation, making it difficult to implement solutions.

While solar-powered water systems present a promising solution, their feasibility requires careful consideration of the region's complex political dynamics, the high costs of implementation, and limited access to resources. Restoring infrastructure, improving water governance, and ensuring consistent funding will be essential to overcoming these obstacles. Collaborative efforts with local authorities, international organizations, and community stakeholders will be crucial to developing tailored solutions that address both immediate needs and long-term resilience. Prioritizing these measures will help ensure that future interventions can create sustainable water systems that can withstand ongoing challenges.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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