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Synthesis Paper

Between a rock and a hard place: A geosocial approach to water insecurity in Kabul

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ABSTRACT

Approximately 50% of the global population currently experiences severe water scarcity, a situation likely to intensify due to climate change. At the same time, the poorest population segments bear the greatest burden of water insecurity. This intersection of geophysical, geochemical, and socio-economic dimensions of water (in) security challenges requires a geosocial perspective, one that attends simultaneously to geophysical, geochemical, and socio-economic dimensions. Our qualitative study, conducted through 68 semi-structured interviews across two distinct sub-basins in Kabul, revealed disparities in groundwater levels, water quality, water prices, and lived experiences of water insecurity. While environmental stressors like drought and groundwater contamination contribute to water insecurity, socio-economic factors such as gender and property ownership exacerbate these impacts: Women and children bear a heavy burden of securing water, with children's involvement in water-fetching leading to instances of violence. Furthermore, trucked water costs 33 times that of piped water, echoing alarming global trends where less privileged communities endure disproportionately greater challenges of water inaccessibility. We outline policy implications for monitoring groundwater abstraction and underscore the need for tailored strategies to combat water scarcity, such as pro-poor water strategies. Additionally, our work draws attention to the role of local gatekeepers who have informally regulated water usage in response to drought-induced scarcity, particularly in the absence of functioning government policies, underscoring the importance of collaboration with local stakeholders to ensure sustainable access to water. We argue that a geosocial approach to water (in)security can provide high-resolution findings and reveal critical gaps between common metrics and the realities of water (in)security, which also underlines the need for integrated approaches incorporating both quantitative and qualitative research.

1. Introduction

An estimated 2.3 billion people live in water-scarce regions, with 733 million residing in highly and critically water-stressed areas, primarily in low- and middle-income countries [22,57]. Worldwide water scarcity, projected to worsen in the coming decades due to climate change and increase in water use [30], is expected to further exacerbate water insecurity [8]. Existing burdens of water insecurity (which encompasses difficulty in accessing clean water), are borne disproportionately by the poor, which magnifies the challenges to achieving the United Nations Sustainable Development Goals' target of universal and equitable access to safe and affordable drinking water by 2030 [48]. This series of interconnected challenges constitutes what Clark and Yusoff [12] call a *geosocial* problem, that is, one that cannot be adequately grasped without appreciating its simultaneously geological (natural) and political and economic (social) dimensions.

Water scarcity is typically defined as the imbalance between freshwater demand and its physical availability, with a threshold for scarcity below 1000 m^3/person/year [45]. The concept of water security/insecurity extends beyond mere physical water availability to include sustainable access to water in sufficient quantities and of quality acceptable for meeting a spectrum of needs from individual health and well-being

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to livelihoods, production, and environmental preservation; balancing these requires effective governance [11,13,24]. Water (in)security eludes universal quantification and metrics of water (in)security are instead compared based on relative levels across different locations [2,11], with varying thresholds to delineate secure/insecure [11,66].

Water security is understood and assessed differently across disciplines. Octavianti and Staddon [42] identified at least 80 tools for measuring water security/insecurity, which they divided into two categories: first, resource-based metrics originating from engineering and natural sciences and relying on historical data related to water cycle components, such as precipitation, surface runoff, and infiltration, as well as indicators including water supply access, water quality, and flood frequency – examples include AWDO [2], WSI[5], WSD [21], and GWSI [18]; and second, experiential metrics originating in the social sciences, designed to assess individual and household water insecurity experiences through (most often quantitative) surveys capturing present conditions with recent recall periods. These experiential metrics may be used to identify vulnerable groups and evaluate interventions aimed at enhancing water supply and hygiene, and human well-being – examples include HWISE [66], IWISE [65], and HWIAS [55].

The challenge of operationalizing and measuring water insecurity quantitatively is compounded by the fact that the term may encompass distinctly different phenomena in different contexts. In one setting, water insecurity may derive from biochemical contamination or naturally occurring elements in bedrock, such as arsenic (see Ref. [31]). In another, it may be due to the high price of water of acceptable quality, making it unaffordable for the poor. Although these scenarios may often co-occur (e.g., polluted groundwater forcing people to rely on expensive bottled water), they tend to be studied by different communities of scholars and practitioners, each employing distinct methods and tools.

Another approach within the social sciences is to study water insecurity using qualitative methods to explore the complex realities of access to water on the ground, without presuming uniform meanings or understandings across countries and settings [3,15,16,51,67]. Exploratory qualitative methods allow a context-sensitive and bottom-up perspective [14,19,25], and can bring into view aspects of water (in) security that transcend the conventional divide between natural and engineering issues, as well as social and economic ones. This approach aligns with the recent call by Bercht [7], who emphasized the need to "appreciate qualitative research as being of equal value to quantitative research." It also makes possible a *geosocial* approach to water security, by which (in an application of the term that is more precise than that of Clark and Yusoff) we mean one that attends simultaneously to geophysical, geochemical, and socio-economic dimensions of water insecurity.

This article demonstrates this approach through a qualitative study of water insecurity in Kabul. It places these findings in the context of a broader research initiative aimed at informing an intervention to promote locally-made clay water filters [28,27,29]. Crucially, we explore the lived experience of water insecurity in two sites that contrast markedly in water quality and availability, and consider them within the context of a city that has experienced consecutive droughts in the past several years alongside rapid urban expansion leading to increased demand for water. A key question we address is: How do people experience and navigate access to water, in two sites with sharply contrasting water quality and availability but broadly similar social and economic profiles?

2. Methods

2.1. Site selection approach and contextualization

The site selection process for the study was informed by the local understanding of the authors and by information from secondary sources. This included consultations with established contacts at Kabul University and insights obtained from the Kabul Managed Aquifer Recharge Project [33]. These brought to attention multiple sites facing challenges related to water availability and high rates of water-borne diseases (as indicated by data collected from health centres by KMARP). In choosing sites, consideration was given to their distance from the city centre and proximity to a local police station, to ensure the safety of our research team members and to guarantee a quick response in case of emergency. The principal study sites for this research were the districts of Doghabad and Bagrami in the Kabul metropolitan area (Fig. 1), each located in a unique watershed: the Upper Kabul and Logar basins, respectively. In 2020, Doghabad had an estimated population of 50,000, and Bagrami had an approximate population of 100,000 (Kabul had a total population of 4.1 million). Two resource-based indicators–-water quality and water level–provide essential context for the remainder of this paper.

Water quality: The groundwater in Doghabad was generally suitable for drinking, with total dissolved solids (TDS) levels below 1000; however, it was contaminated with *E. coli* (6 colony-forming units (CFU) per 100 mL, where safe is defined as 0 CFU/100 mL), making it unsafe for drinking per WHO guidelines [58]. This number (6 CFU/100 mL) was reported from the nearest sampling point to the study location, while contamination levels in nearby areas reached up to 250 CFU/100 mL, as documented in Hamidi et al. [29]. The groundwater in Bagrami was highly saline, exceeding the safe TDS threshold (>1000) for drinking but adequate for irrigation purposes (Fig. 1) – see Hamidi et al. [29] for more information.

Water level: Climate-induced droughts, reduced river recharge, and over-abstraction have lowered groundwater levels, making groundwater harder to obtain in parts of Kabul in the past two decades [27]. For instance, data from Hamidi et al. [27] indicate that the shallow groundwater level in parts of Doghabad experienced a drawdown of around 15 m between 2007 and 2020 (see Fig. 1). In contrast, the groundwater level in Bagrami remained stable during the same period.

Nonetheless, the socio-economic and demographic characteristics of Doghabad and Bagrami show a high degree of similarity – see Table 1, adapted from Hamidi et al. [28]. For instance, both regions show comparable educational attainment among family heads, with the majority having a high school education or higher, and similar percentages for primary and middle school education levels. Household income distributions are also similar, with both areas having a substantial proportion of families earning less than 10,000 Afghanis (125 USD) per month. The average age of residents is nearly the same in both regions, in the mid-30s. However, some minor differences include Doghabad having a higher proportion of long-term residents, with nearly half of its population having lived in the area for more than ten years, compared to just over 22 % in Bagrami. Additionally, Bagrami residents had a larger average household size.

2.2. Research design

We employed semi-structured interviews as the principal method within a cross-sectional qualitative research design. The data collection instrument was a semi-structured interview guide that included open-ended questions on main water sources, storage, and knowledge of water quality; knowledge of health risks from poor water quality; and water treatment knowledge and practices in the household; plus questions on the demographic and household characteristics of the participants (see Supplementary material). The main topics of the interview guide were informed by the existing literature on access to water and household water purification practices, including Mubarak et al. [37], Sigel [49], UNICEF/WHO [56], and Wutich [61]. The flexible and open-ended format of the semi-structured interview approach enabled residents to share their experiences regarding access to water from their own perspectives, and highlight realities on their terms without the research team imposing or favouring specific types of factors.

The two sites represented a cross-section of greater Kabul in their ethnic diversity, the mixtures of socio-economic status included in them,

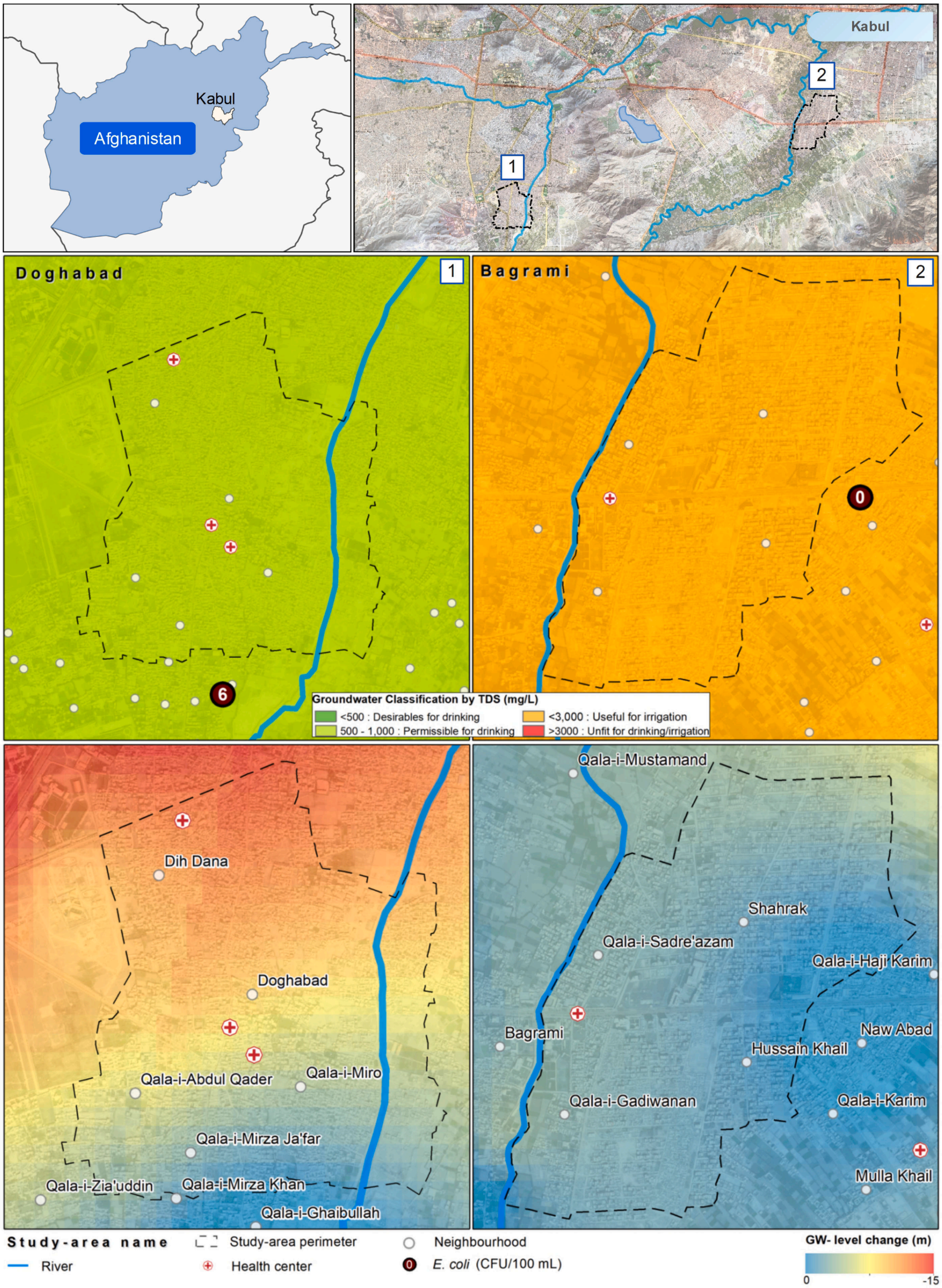

Fig. 1. Top panel: Location of study areas within Kabul, Afghanistan. Middle panel: Groundwater Total Dissolved Solids (TDS) concentrations indicating suitability for drinking and irrigation, alongside *E. coli* counts in 2020. Bottom panel: Groundwater level changes from 2007 to 2020..
Source: Satellite imagery from the National Statistics and Information Authority (2020), with OpenStreetMap superimposed. Created with ArcGIS 10.8

and the relative turnover of residents (e.g., Bagrami included substantial numbers of people displaced from other provinces). To explore the diversity of residents' living environments, participants were selected purposefully based on their residence location, age, gender, ethnicity, economic status, and variability in access to water resources (i.e., the primary source of drinking water). Following emerging practice in low- and middle-income country development research, we further employed high-resolution (50 cm) satellite imagery (provided by the National Statistic and Information Authority or NSIA – 2020) to support the spatial distribution of the sampled households [10,23,26]. Concurrent analysis and residents' guidance supported the sampling process, which continued until all selection criteria were successfully incorporated into this study. The research was implemented from May to July 2021, shortly before the Taliban assumed governmental authority in August 2021. The period between May and September in Kabul is characterized by high summer temperatures, often reaching 36 °C or above [60], and an increased demand for water compared to the rest of the year.

In total we carried out 68 interviews (36 in Doghabad and 32 in

Table 1
Socio-economic and demographic characteristics across study sites.

Indicators	Doghabad N = 497 *n* (%)	Bagrami N = 416 *n* (%)
Highest education level of the family head		
No education	122 (24.55)	104 (25.00)
Primary	38 (7.65)	33 (7.93)
Middle	53 (10.66)	44 (10.58)
High school	135 (27.16)	113 (27.16)
Bachelor's Degree or Equivalent	127 (25.55)	103 (24.76)
Post-graduate Degree	22 (4.43)	19 (4.57)
Household income per month (in Afghanis)		
2500 or less	48 (9.66)	29 (6.97)
Between 2500 and 10 000	180 (36.22)	164 (39.42)
More than 10 000	269 (54.12)	223 (53.61)
Duration of living in the house		
1 year or less	62 (12.47)	68 (16.35)
Between 1 and 5 years	126 (25.35)	142 (34.13)
Between 5 and 10 years	69 (13.88)	112 (26.92)
More than 10 years	240 (48.29)	94 (22.60)
Age (SD)	34 (13.70)	33 (14.19)
Household size (SD)	9 (5.18)	12 (6.55)

Source: adapted from Hamidi et al. [28].
Notes: Total number of observations = 913. USD/AFG = 80 (in August 2021). Mean is presented for Age and Household size with Standard Deviation (SD) in the bracket.

Bagrami) with a typical length of 30–40 min. Interviews were recorded using digital voice recorders. Refusals to participate were limited and primarily due to participants having concerns about audio-recording their responses (in 4 cases, persons with equivalent characteristics were recruited to substitute for candidates who refused). Male participants were mainly interviewed by a male researcher (Corresponding Author), and female participants were interviewed by two female research assistants. All participants were provided with an Information Sheet before obtaining recorded verbal consent (see Supplementary Material 2). The interview guide, consent form (see Supplementary Material 3), and explanatory scripts were translated and back-translated following World Health Organization guidelines [59]and the interviews were carried out either in Persian Dari or Pashto, depending on the native language and the preference of the interviewee.

The audio recordings of the interviews were transcribed verbatim and translated into English. Preliminary data analyses were performed concurrently, which also informed the sampling process. The formal qualitative analysis of the transcripts involved thematic analysis in the original interview language to preserve the original context and maximise the informational content of the interviews for the analysis [25]. The English translations were used to convey the main themes in the presentation of this research. The coding and thematic analysis were implemented using NVivo 12 [46].

To gain secure access to the study areas, the local division of the Kabul police, the district or village chief, the Imam of the nearby mosque, and the Kabul Police headquarters were informed about the study (see Supplementary Material 4). The ethics application was approved by the Department of Anthropology at Durham University (Reference: ANTH-2020-11-28 T00 10 33-lgww95).

3. Results

Our results on the geosocial dimensions of water insecurity in Kabul are presented in two parts. Initially, we describe the challenges of accessing water in Doghabad and Bagrami, including the reliance on various sources such as groundwater and private networks due to the absence of state-owned water supply networks. We also explore the roles that gender and age play in water access, and how factors like homeownership versus tenancy influence water insecurity. Following this, the second part considers the temporal dynamics of water insecurity, taking into account the impacts of seasonal droughts, electricity supply failures, and conflict. A key aspect of this section is the exploration of groundwater contamination, highlighting its effects on water security. Additionally, it highlights the collective actions undertaken by communities to safeguard water access.

3.1. Variability in access to water across Kabul's sub-basins

3.1.1. Sources and experiences in accessing water

In neither Doghabad nor Bagrami is water provided by the government supply network. Instead, groundwater remains the primary source for general domestic uses for the majority of households in these study sites, similar to the rest of Kabul. In addition to groundwater from wells and handpumps, a substantial number of residents rely on bottled water, water trucking, and private supply networks for their drinking water. Table 2 depicts the primary sources of drinking water in each site, as reflected in the interviews.

Community members described the daily challenges they faced in accessing safe drinking water, such as having to transport water over long distances and weighing the effort and expense of obtaining water of presumed higher quality against the risks of consuming water from more easily accessible sources that might be contaminated. For example, one household in Doghabad, where water was geochemically safe for drinking but contaminated with *E. coli*, bought bottled water from the market, and at other times boiled it in hopes of preventing water-borne diseases. The senior woman of the household described:

> *One of my children is sick, his father is also on medication and he brings bottles of Alkozia* [a brand of mineral water] *from the market for himself. The other children use the water which we buy from suppliers in gallon containers for 50 rupees* [Afghani currency]. *If it* [bottled water] *is not available for two or three days, then we boil the water and let it cool down before drinking. We don't have a purifier – we cannot afford it; we are poor. The lack of jobs adds to many problems that we have.* (210616_017, Female, 53, Doghabad)

Other families in Doghabad who could not afford bottled water relied on a private supply network, subscribing to companies that provided water via pipes, drawing from groundwater boreholes. However, this was available in only one part of the district, and the network was unreliable (as described further below). Some, who had wells in their households, drew water from them. A large number of others, including

Table 2
Primary household water sources and prices in the two study areas in Kabul.

Water source	Price/m^3 Afghani (USD)[a]	Availability in the study area: *Doghabad*	*Bagrami*
Privately owned sources in the household (e.g., well, handpump)	No charge	✓	✓
Public water sources (e.g., well, handpump, tap)	No charge, except for maintenance	✓	✓
Government-supplied water (AUWSSC[b]) – urban	25 ($0.31)	✖	✖
Private supply network – *peri-urban*	30 ($0.38)	✓	✖
Water trucks (20 AFN for 20 Litres)	1000 ($12.50)	✖	✓
Bottled water (50 AFN for 19 Litres)	2631 ($32.88)	✓	✓

Source: Qualitative research fieldwork.
Notes: The average monthly household income in Kabul was between 100 and 150 USD.
[a] 1 USD = 80 AFN (as of August 2021).
[b] Afghanistan Urban Water Supply and Sewerage Corporation.

the poorest households, obtained their water from public handpumps (see Fig. 2, forms of water source in Kabul). In Bagrami, where the high salinity of groundwater made it unsuitable for drinking, the majority of households relied on water trucks for their water supply. Here, water trucks were the only option for most households, except for the affluent ones, which either filtered their water or had boreholes deeper than 100 m within their property (an amenity that requires a large investment to obtain, not less than $2000).

The cost of one cubic meter of water from various sources is detailed in Table 2. The large price differences across the available sources of drinking water raise the question: Why should people opt for relatively expensive sources? This was primarily driven by perceptions of water quality, mediated in some cases by trust between customers and suppliers. Convenience and opportunity played a secondary role. Interviews showed generally high levels of trust between users and vendors regarding trucked water. As one 19-year-old woman said: "*I think they bring it from the company, they purify the water and sell it.*"[1] She trusted the vendors and did not question the quality of the trucked water. Others did inquire about water quality, but tended to take the vendors' explanations at face value. Vendors encouraged custom (and consolidated relationships) by offering water to households two or three times in a row on credit if they could not afford it at the time of buying water.

Water from private supply networks was perceived to be of better quality, and it required less effort to access within the household compared to fetching water from public wells. However, the private water supply was intermittent; it had low pressure, and was often turbid. As one household noted, despite subscribing to a private network, they often got no water all morning, and had to "*leave the things that are not washed until the water flows in the pipes. Sometimes the water only flows in the afternoon.*"[2] The household accordingly adapted their daily domestic work schedule to the availability of water:

> *When filling the gallon containers today, it took a long time to fill them. It took an hour or two. The flow rate is slow and the water is turbid. The flow rate of water in our house depends on how much water they release. It has sand in it. During this week, the water was turbid for 2–3 days and when I left the water* [for some time]*, the sand settled down in all the buckets.* (210616_005, Female, 36, Doghabad)

Furthermore, the problem of low pressure in the water pipes made households put extra effort into collecting water; one informant from Doghabad highlighted that they had to "*use buckets and gallon containers*[3] *as well as the hose bib"*— referring to the tap placed in the house perimeter at a short distance from the connection to the main supply pipe. Such experiences with poorly functioning infrastructure were a common aspect of the daily realities of accessing water.

In the past decade, international NGOs have drilled deep wells or boreholes in Doghabad, some of which we observed. However, the number of boreholes were insufficient. As one informant from Dih-Dana of Doghabad noted, people consequently waited in the queue for a long time:

> *This water is very good; it* [water quality deterioration] *hasn't happened yet. The only issue is that we hardly get water; we have the well and can use the pump* [to get water]*, and the water is clean. The problem is that in the whole region, there is only one well.* (210616_014, Female, 30, Doghabad)

In the Bagrami area, we came across a handpump that had been constructed by NGOs but was not being utilized by the public because of the high salinity of local groundwater (Fig. 2e).[4]

3.1.2. Gender and age dimensions of water access

Gender was an important factor affecting access to drinking water and the amount of effort required to obtain it, without any substantial variation between the two sites. For instance, adult men and male children might collect water[5] from public sources during the busy times of noon and evening (210619_015_R1, Female, 21, Bagrami). But during the remainder of the day – and in households without male children, or where the adult men were working – the responsibility of fetching water fell on girls or women of the household. They collected water from public water sources or from neighbouring households during the day, particularly during off-peak hours (when men were at work).

At the times when girls and women were fetching water from public sources, particularly the peak hours (when most men were collecting water), priority in the queue would be given to women and in particular the elderly. When not fetching water from public sources, women or girls might "*get from the neighbours' houses*," as a 28-year-old mother from Bagrami said, noting it was only her "*two daughters* [who] *bring water*."[6] Women and girls navigated and negotiated access to water by visiting their neighbours' houses and engaging in conversations with the women who lived there while fetching water from a well or handpump. In short, women dominated water fetching activities whereas in most cases men do it only "*sometimes … when I'm at home*."[7]

Reports published by the media and some NGOs indicate that children in Kabul, particularly girls, regularly miss school to fetch water [39]. However, participants in our research did not report any instances of children missing school solely due to fetching water. Instead, they explained that children would drop out of school due to broader economic problems. In some cases, girls attended school while boys had to work; in other cases, only the boys from the household attended school.

One striking finding from Doghabad was the occurrence of interpersonal violence among people fetching water from public sources; and in particular, the vulnerability of children to such violence. During droughts and electricity disruptions (about which more below) community members flocked to public water sources, leading to crowding. The involvement of children in such conflicts partly stemmed from the common practice of sending them to fetch water and partly from their involvement in selling water. Children from lower-income households sometimes took the opportunity to fetch water from public handpumps and sell it to shops and community members to generate income (visible in Fig. 2, Panels c and d). These public handpumps were usually crowded and monitored by a community member. On one occasion during fieldwork, we observed a handpump in an area where people were queuing to collect water, including children who fetched water for selling. When the person monitoring the pump realized that it was the second or third time that the same group of children had fetched water to sell to shops, he prohibited them from taking any more water from the handpump. When one of the children did not comply, he resorted to insults and then escalated to slapping and punching the children before others intervened to settle the conflict. Such incidents were more likely to take place during the peak hours, at noon, or evening –when most households fetched drinking water. These pressures were particularly intense in Doghabad during drought times; in Bagrami, where the water level was more stable, we did not document such incidents.

1 210621_002_R1, Female, 19, Student, Bagrami.

2 210616_011, Female, 21, Doghabad.

3 210617_004_R2, Female, 26, Doghabad, Doghabad. In this study, we use the term "gallon containers" for describing the plastic containers commonly used in Afghanistan for storing and fetching water and is mainly referred as "بشکه, Boshke" or "گالن, Gallon".

4 The installation date of the handpump was unclear due to an unreadable label. The handpump appeared recently installed, was operational, but yielded saline water. Typically, handpumps have a working lifespan of 5 years, though they can last 7–10 years.

5 Plastic gallon containers are used to fetch water and are carried either by hand or wheelbarrow.

6 210619_006_R1, Female, 38, Bagrami.

7 210520_004, Male, 63, Doghabad.

Fig. 2. Access to water in different locations in Kabul: (a) Preparing a gallon container by washing it before filling it from a water tanker in Bagrami; (b) The locally assembled vehicle utilized for water trucking; (c) Water collection at a handpump in Doghabad; (d) Children obtain water from a public tap; (e) NGOs-constructed handpump in the Bagrami area remains unused due to the high groundwater salinity. *Photo credit*: Corresponding Author.

3.1.3. Water access in the context of homeownership

A major theme regarding water access inequalities was the advantage that homeowners had over tenants. At the time of research (May to July 2021), privately owned groundwater sources in households, such as wells and handpumps, were not registered or monitored by the government and remained free of charge. However, there were no regulations or by-laws requiring landlords to provide tenants with water or electricity. In the majority of cases, houses were rented without any commitment from the property owner to provide access to water through any means (piped water or digging wells), and some rented houses therefore did not have any water source.[8] A 30-year-old woman who was living in a rented house in Doghabad described a situation that was common for many tenants:

> *We rented this house for 5000* [Afghanis] *per month. In the beginning, the water pump was not working, and he* [landlord] *was providing water from his house; later he* [landlord] *repaired the water pump. But it doesn't provide us with enough water. Once we fill five gallon containers then the well dries up. If there is rain and snow it will have water; otherwise, the well dries up quickly* (210617_012_R2, Female, 30, Doghabad)

Tenants often had to fetch water from neighbours or public sources, or, if they could afford it, they might buy bottled water or water from trucks. Additionally, tenancy status appeared to have an adverse impact on households' tendency to spend money on improving their access to safe drinking water. A family that owned property might be willing to spend money on digging their own well deeper should it become necessary. In contrast, those renting property, and lacking security of tenure, were reluctant to spend money on the house to improve access to water: "*It's not our own house. If it was our own house then we might do something. We escaped from wars* [intense conflict in other provinces at the time of fieldwork], *and this place is temporary. The house owner is in Turkey*."[9]

3.2. Dynamics and stressors of water security

In the preceding sections, we compared the situations in Doghabad and Bagrami as observed in our research in 2021. However, the interviews also shed light on temporal changes in water conditions that these neighbourhoods have experienced over recent years.

3.2.1. Drought and collective action

High levels of abstraction of groundwater, coupled with droughts, have exacerbated the challenge of accessing drinking water in recent years. Especially in Doghabad, community members frequently referred to "dry wells," "droughts," and "dry years". In such times many households abandoned domestic wells and handpumps, and resorted to fetching water from neighbours or from distant areas. An example of this was a tailor whose household abandoned a 22-meter-deep well four years before the study and switched to a private water supplier. "*We would continue using the well if it had water,*" he said.[10] For others in the area, the challenges of accessing groundwater for drinking purposes were ever-changing. Among many examples was one family who initially relied on groundwater for domestic use from a non-kin neighbour and later from a relative before eventually deciding to dig a well

[8] 210619_015_R1, Female, 21, Bagrami.

[9] 210621_009_R1, Female, 33, Bagrami.

[10] 210517_001, Male, 40, Doghabad.

inside their own house.[11] When the well dried up, they reverted to fetching water from their neighbours. Subsequently, a private water supply company was established, providing a more stable solution for their water needs.

Alongside the efforts by individual households to enhance water access, there was a strong community drive for collective action. Community members collected money for public works, like building or maintaining water wells or handpumps. At the same time, due to the limited water sources in the area, the community elders had concluded that the water from the public handpumps should only be used for essential daily consumption. Community members used to water flowers and vegetables from these sources before the rule was established, but using water for these purposes was banned:

> *Sometimes* [during the year]*, the water* [from the handpump] *gets almost dry. They collect money from this area and dig it more. Last year, the water dried up, and my children had to go uphill to fetch water* [to streets located on the upper side of the neighbourhood]*. This year, by the grace of God, there is water. But they do not allow us to use it for watering trees or any other purpose. They told us to just use it just for drinking needs.* (210616_014, Female, 30, Doghabad)

Restricting non-essential water use helped to ensure access to drinking water for all. Gatekeepers within the community (e.g., the Social Council, which comprises the Wakil (village leader), elders, and Imam) were key to imposing and upholding these rules, particularly in the absence of (functioning) government policies.

3.2.2. Challenges due to groundwater contamination and electricity disruption

Concerns were expressed about water quality and research informants highlighted their communities' resilience in utilizing groundwater and surface water for drinking. The story of a 45-year-old woman in Bagrami[12] illustrates what such "resilience" meant in the local context: their household relied on groundwater using a handpump. However, the shallow groundwater was contaminated due to anthropogenic and geogenic activities (especially salinity), and this contamination reportedly spread to a larger area over the course of two years. To mitigate the health risks posed by the local water source, residents in the area began transporting water from Ghazi Dam, located 20 km away from Bagrami. Following this initiative, private companies emulated the practice and began selling water from the dam to the community using water trucks. However, not all private companies followed suit; some opted to import high-tech water filters instead. Consequently, some households temporarily switched to using "dam water"; others who could afford it, purified contaminated groundwater at home. Some households switched back and forth between these strategies.

Additionally, several issues are noteworthy that relate to the particular historical moment during which this study was carried out. As elaborated below, access to water and electricity are closely connected in Kabul. Besides the usual electricity disruption due to higher demand in summer, during the fieldwork there was also disruption due to an increase in conflict around the country. Pylons were bombed [43], cutting off electricity for millions living in Kabul and the provinces around. Such electricity supply disruption happened frequently during the study period and greatly impacted the situation of accessing safe drinking water in Kabul. Electricity was important for water supply in at least two ways: it was used to pump water from deep wells, and power purifiers. During blackouts, when water was inaccessible for these reasons, some people were able to use alternative drinking water resources such as bottled water. Others fell back on alternative energy sources such as solar energy, or would, as a 23-year-old woman in the Bagrami area explained, "*fill the water tanker using the generator*."[13] In many cases, these disruptions extended beyond the household, since the water trucking and bottled water companies (on which many households relied) also depended on the electricity grid for water treatment prior to distribution. As one participant highlighted, some families had to boil the well water for consumption because they were unable to purchase water during the electricity disruption:

> *It has been a long time* [since we started to boil water at home]*, during periods that we don't have electricity and had used up all the water at home* [supplied through water trucks]. *The companies have the machine to filter water and at the time that there isn't electricity, they won't sell water on the street. Thus, we* [resort to] *boiling water.* (210621_001_R1, Female, 25, Bagrami)

In sum, access to water was influenced by a complex and multi-layered interplay of factors, not solely limited to the impact of droughts (geographical), contamination (geochemical), supply problems (infrastructural), or poverty and marginalisation (socio-economic). For instance, the electricity disruption in Kabul occasionally prevented people from accessing safe drinking water by making it impossible to operate electric water pumps and water purifiers. Community members who relied on purifiers had to resort to boiling groundwater, and households who relied on electric water pumps had to fetch water from sources such as public taps, handpumps, or wells (available in some areas for common uses, mainly located either in the mosque or on the street – see Fig. 2).

4. Discussion

In this study we have taken a novel geosocial approach to water insecurity. Our work in *peri*-urban Kabul reaffirms well-recognized disparities in water access [17,50,52], the cost of water [36], gender dynamics [1], and the impact of drought [38], and also offers new insights. A significant finding arising from our geosocial approach is the dynamic relationship between groundwater level and contamination and socio-economic inequality – issues frequently addressed by separate groups of scholars and practitioners. Additionally, our study contributes to the understanding of the limitations of current global water security metrics, the emergence of local gatekeepers managing groundwater use, the impact of power outages on water security (particularly in the context of drought and groundwater contamination), the influence of homeownership on investments in water infrastructure, and, importantly, how water insecurity increases the risk of violence against children. Below we consider the landscape of water insecurity that emerges from this perspective, and the implications for water insecurity measurement and policy.

4.1. The geosocial landscape of water insecurity in peri-urban Kabul

This study revealed important dimensions, intermittencies, and inequalities concerning access to water in Kabul. In geographical terms, the two study sites in Kabul were located in different sub-basins, with differing water quality and groundwater levels. Water trucking was common in Bagrami, where water quality did not meet drinking standards, while the residents of Doghabad relied solely on groundwater sources, except for a portion of the population that had access to a recently established private water supply network. These findings align with those of other studies in the city, showing access to safe drinking water in Kabul is deteriorating due to climate impacts [20], population growth [4], changes in water consumption behaviour [37], and groundwater over-abstraction [29]. Homeowners were systematically at an advantage over tenants: privately owned groundwater sources in households were utilized free of charge, and homeowners more inclined

[11] 210616_005, Female, 36, Homemaker, Doghabad.

[12] 210619_007_R1, Female, 45, Homemaker, Bagrami.

[13] 210621_007_R2, Female, 23, Bagrami.

(owing to this privilege) to invest in maintaining or improving them; tenants, on the other hand, often lacked any water sources on their premises, and landlords had no legal obligation to ensure water or electricity supplies. As a result, poorer households relied disproportionately on more expensive sources: for instance, the cost of bottled water was 87 times higher, and the cost of trucked water was 33 times higher, than the cost of piped water provided by private water supply networks. Similar situations, where low-income households pay more for access to water, have been observed in Mexico [47], Djibouti [32], Niger [6], and in India where truck water was 50 times more expensive than piped water [36].

Among the socio-economic factors, gender stood out as important for water security. Responsibility for securing water during a normal working day rested mostly on women and girls. The labour involved included brokering inter-household water transfers, a widespread practice in water-scarce settings where households depend on their neighbours for water [9,63,62]. Our research suggests that children were vulnerable to water-related violence due to their involvement in fetching and selling water (primarily in Doghabad, which was severely affected by drought). This included both psychological or verbal abuse and physical violence – neither of which appeared to be consistently reported or "told" to the parents by the children, perhaps due to fear of escalating conflicts (As one parent put it, "*it might have happened but my children didn't tell us.*"[14]) but which our direct observations during the qualitative data collection suggested were commonplace. Gender-and age-based violence and its relation to water insecurity remain underexplored, particularly in Afghanistan and the Central Asia region [53]. One lesson of this study is that access to safe drinking water is not necessarily equal to safe access to that water.

4.2. Implications for water (in)security measurement

Our research revealed high-resolution disparities in water availability, accessibility, affordability, and quality in Kabul. The data we obtained markedly conflicted with the 2020 report by the WHO/UNICEF Joint Monitoring Programme (JMP), which suggested that 96 % of the population in Kabul province had basic access to drinking water. The divergence between quantitative metrics and the realities on the ground calls for a critical reassessment of the methodologies used to measure water (in)security (and, consequently, to guide water policy). High-level statistics should be approached with caution due to issues of data accuracy and methodology, as highlighted by Thomas [54] regarding Afghanistan, Nganyanyuka et al. [40] in Tanzania, and the global figures considered by Onda et al. [44]. Nonetheless, such figures inevitably play an important role in contributing to resource-based metrics for assessing water (in)security. For instance, the Asian Development Bank (ADB) used JMP data as an indicator in the urban and rural water security dimensions for its Asian Water Development Outlook or AWDO [2]. Similar statistics form the basis of other resource-based metrics, as seen in studies by Nkiaka [41] and Gain et al. [18]. These metrics, including the AWDO, rank Afghanistan low in terms of water security. Even projects that use questionnaire surveys of individual experience to evaluate national water insecurity are of limited use in identifying extent, hot spots, or causes of water (in)security. For example, a recent survey of 1000 people using the IWISE scale suggests that 46.3 % of the Afghan population are moderately to highly water insecure [64]. Despite this sample being population-based with representation of major provinces, the level of granularity is insufficient for strong inferences regarded the patterning of experiences within the country. In sum, neither experiential scale-based nor resource-based metrics remain effective in providing input for designing interventions or guiding decision-making processes in allocating resources (other than at the country level), owing to overreliance on quantitative methods and designs within political boundaries.

The divergence between quantitative metrics and the realities on the ground as revealed by qualitative research calls for a critical reassessment of the methodologies used to measure water (in)security (and, consequently, to guide water policy). We therefore argue for the importance of holistic geosocial understanding of water (in)security – one that acknowledges the spatio-temporal peculiarities of water access at a sub-basin level, particularly through incorporating both quantitative and qualitative research. This has the potential to lead to more effective allocation of development aid, prioritization of interventions, and a comprehensive understanding of water (in)security.

4.3. Policy implications

Over the next few decades, climate change is expected to impact the hydrologic cycle (e.g., alter precipitation patterns, making some areas wetter and others drier), posing a critical challenge in sustainable access to water [35]. These impacts are further aggravated by socio-economic disparities. A geosocial perspective on water policy is warranted in light of this predicament. One clear implication of this approach is that technological interventions on their own are insufficient. The unused handpump built in Bagrami (where the groundwater is saline), while the communities in Doghabad needed additional wells, exemplifies the folly of ill-informed intervention. Similarly, while water filters are a promising way of responding to contamination problems, the use of filters could exacerbate the impacts of droughts and potentially restrict access to water, as a considerable amount of water is discarded during the purification process [34].

Our findings from Kabul underscore the importance of implementing monitoring measures on groundwater abstraction, which should be complemented by context-specific remedial actions such as the provision of alternative water sources, promoting water conservation, and price control mechanisms to counteract the substantial disparities in water access between high- and low-income families. In particular, we recommend implementing pro-poor water strategies. In Bagrami, such strategies might include initiatives led by institutions to map households facing water access challenges, coupled with a framework for water vendors/companies to supply water to these households and, in return, incentivize providers through financial benefits or a reduction in the pricing of extracted groundwater. The lack of tenancy regulations in Kabul further complicates the issue. Even in areas like Doghabad where groundwater is below salinity thresholds, many tenants do not have access to water on premises. Consequently, it should be mandated that landlords provide their tenants with water access, for example through establishing handpumps and water wells or subscribing to private water supply networks. Institutions could cover the initial costs incurred by landlords through incentives.

The emergence of gatekeepers who imposed restrictions on communal water use in the context of drought is a demonstration of policy response outside of formal political process. This underscores the importance of collaborating with local stakeholders to enhance water security, particularly in the absence of (functioning) government policies. This collaboration holds significant relevance for fragile states, as exemplified by events in Afghanistan post-August 2021. The drastic political changes left Afghanistan navigating a complex post-conflict landscape and with a government largely unrecognized by the international community. With centralized governance structures compromised, collaboration and partnerships between international organizations and emerging gatekeepers in local communities may prove critical for ensuring sustainable access to basic services such as clean water in such challenging contexts.

5. Limitations

The timing of the fieldwork for this study in the midst of intense conflict in Afghanistan (May–July 2021) complicated the task of

[14] 210617_015_R2, Female, 30, Doghabad.

carrying out semi-structured interviews, and affected respondents' willingness to take part. However, diverse voices were included through purposeful sampling, adhering to local customs and gender norms, and substituting decliners with persons of similar characteristics. Another limitation lies in the study being based on interviews rather than long-term observation. Nevertheless, the fact that the project was led by a local scholar well-versed in the water context helped mitigate this, employing broad contextual questions and non-participant observations during fieldwork. Additionally, the sampling strategy focusing on two distinct *peri*-urban areas limited the empirical generalization but not methodological generalization – the geosocial approach employed to uncover high-resolution water (in)security realities can be broadly applied. Further research across settings would illuminate unique local challenges.

6. Conclusions

Climate change, along with extreme weather events such as floods and droughts, poses serious threats to water security, further exacerbated by increasing demand and population growth – challenges that require geosocial analysis. In Kabul, we demonstrated that water insecurity was shaped by an intersection of geographic, socio-economic, environmental, and political (geosocial) factors. Distinct sub-basins with varying water quality and groundwater levels delineated how geographic factors played a role in determining the availability of potable water. Such geographical differences have resulted in a diverse range of water access approaches, from boreholes to water trucks and the establishment of private water supply networks. Economic disparities in water access, such as the 33-times cost difference between water trucking and piped water in Kabul, reflect a global problem where the economically disadvantaged often bear the greatest burden. These disparities highlight an urgent need for regulations and strategies that promote fair water distribution (i.e., pro-poor water strategies). Moreover, our findings highlight the critical role of socio-economic factors, particularly gender and property ownership, in determining water access. Women and children often bear the disproportionate burden of securing water, a reality that leads to various social challenges, including instances of violence. Adding another layer of complexity is the ever-changing environmental landscape, intensified by stressors like droughts and groundwater contamination. While technological interventions such as water filters hold promise, they also present challenges, such as the rejection of substantial water volumes during purification. Consequently, there exists an imperative to advocate for water conservation techniques. Furthermore, the emergence of gatekeepers, in the absence of (functioning) government policies, highlighted the essential role of collaborating with local stakeholders to enhance water security and ensure sustainable access to water. Lastly, relying on our geosocial approach, we emphasize a holistic perspective to exploring water (in)security at the sub-basin level through incorporating both quantitative and qualitative research.

CRediT authorship contribution statement

Mohammad Daud Hamidi: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Marco J. Haenssgen:** Writing – review & editing, Validation, Supervision, Methodology, Funding acquisition. **Milica Vasiljevic:** Writing – review & editing, Supervision, Methodology. **Hugh Chris Greenwell:** Writing – review & editing, Supervision, Resources, Methodology, Funding acquisition. **Edward G.J. Stevenson:** Writing – review & editing, Validation, Supervision, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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