

OVERVIEW

Water in war: Understanding the impacts of armed conflict on water resources and their management

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Abstract

Armed conflict has the potential to disrupt water systems that are crucial to environmental and human wellbeing. Yet there is no comprehensive overview of scientific evidence on the impact of armed conflicts on water resources and their management. This paper assesses the relevant scientific evidence through a systematic literature review. We discern conceptual, empirical, and methodological approaches adopted in the reviewed publications and synthesize the overarching research results. Common research topics across the body of literature include the role of water resources in armed conflicts, either as a casualty or as a weapon used by conflict parties, and the implications of armed conflict on water resources management, such as basic service provision and water governance. The analysis also pinpoints the research field's focus on empirical studies based on a small number of cases, and highlights a lack of conceptual engagement with the notion of armed conflict. Future research on water resources and their management in conflict settings needs to be more transparent on conceptual frameworks and assumptions to facilitate knowledge integration across different studies.

This article is categorized under:

Planning Water > Engineering Water

Water Governance > Human Water

KEYWORDS

armed conflict, service provision, water governance, water management, water resources

1 | INTRODUCTION

Water resources are crucial for sustainable development and play a central role in achieving the Sustainable Development Goals (Tignino, 2011; UN-Water, 2016). Armed conflicts can disrupt water systems in diverse ways, with negative consequences reaching from basic service provision to development efforts. Over the past decades, several international organizations have been monitoring the impacts of conflict on water and other development indicators. In 2011, the World Bank reported that populations in developing countries affected by conflict are

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BOX 1 WATER AS A DRIVER OF CONFLICT

Over the past three decades, the potential of competition over water resources to spark conflict or lead to cooperation has been the main focus of the research on the relationship between water resources and conflict (Gizelis & Wooden, 2010; Gleick, 1993; Wolf, 2007; Zeitoun & Mirumachi, 2008). It is therefore important to clearly distinguish this research theme of “water as a driver of conflict” from the study of conflict impacts on water systems, which is investigated in this article.

While we will discuss transboundary water management as a process that can be affected by armed conflict within or between the riparian countries, we do not analyze the body of literature on water as a driver of conflict or cooperation. A recent review of this literature can be found in Petersen-Perlman, Veilleux, and Wolf (2017).

disproportionately affected by a lack of access to safe water and improved sanitation. According to the same report, children born in conflict-affected countries are nearly twice as likely to lack access to an improved source of water, compared to children born in peaceful developing countries (World Bank, 2011). A more recent report by the United Nations Children's Fund (UNICEF) pinpoints that children in prolonged conflicts are more likely to die from diseases linked to the lack of clean water than from violence directly related to the conflict itself (UNICEF, 2019).

Despite the attention by international organizations, academic research on the impacts of conflict on water systems has been scarce (Gates, Hegre, Nygård, & Strand, 2012). Instead, scientific attention has primarily been focused on the issue of water as a driver of conflict or cooperation over shared resources (see Box 1). In the only extensive review on the impacts of armed conflicts on water resources, Francis (2011) focuses on the impacts of modern warfare, defined as warfare since the First World War, on freshwater ecosystems. His analysis does not, however, include conflict impacts on water resources management or development processes. Junk (2002) considers the impact of political instability on wetland management and conservation. He draws this connection by viewing political instability as a hindrance to economic development, which would subsequently lead to a lack of funding and inefficient management in wetland conservation.

Considering the high relevance of and sparse scientific attention on the impacts of conflict on the water sector, this paper assesses the body of scientific literature on water resources and water management during armed conflict in order to identify future research priorities. This is achieved through a systematic literature review with the objectives to (a) discern the conceptual, empirical, and methodological approaches adopted in studying the impacts of conflict on water systems, and (b) synthesize overarching results and identify research gaps from a conceptual analysis of relevant scientific studies.

When addressing the impacts of armed conflict on both water resources and water management in this paper, the latter is understood in a very broad manner. “Water management” as used in this paper refers to the technical, operational, and organizational aspects of the development and use of water resources (Pahl-Wostl, 2009). For the purpose of this review, we also include water governance in this broad term, commonly defined as the institutional and administrative processes that steer and regulate water management (Rogers & Hall, 2003).

Throughout this paper, the term “conflict” is used interchangeably with “armed conflict,” unless indicated otherwise. An armed conflict is defined as a conflict in which the conflict parties resort to armed force or violence, leading to a situation of protracted confrontation which results in damage to property or human life (ICRC, 2008). While this definition is not explicit on the scale of the conflict, it is commonly applied to inter-state conflicts between countries or intra-state conflicts on a sub-national level, rather than to micro-level conflicts such as police violence (O'Connell, 2009).

The remainder of this paper is structured as follows: First, we elaborate on the selection of relevant publications and the review methodology. We then provide an overview of the scientific literature on water resources and their management in conflict settings from an empirical, conceptual, and methodological perspective. We subsequently present the central research themes identified from the review, first related to the role of water resources in conflicts, and then related to water resources management in conflict settings. Finally, we conclude with a reflection on the review results and present avenues for future research to strengthen the scientific evidence on conflict impacts on water management.

2 | REVIEW METHOD

We apply a systematic literature review method to create a comprehensive and unbiased overview of the scientific literature on water resources and their management in conflict settings. Systematic reviews are characterized by a fixed set of criteria to ensure the inclusion of all relevant studies and a set of specific questions posed to the individual publications. They are thus designed to minimize biases in the selection and analysis of the scientific literature (Petticrew & Roberts, 2006).

2.1 | Selection of publications for review

In line with the abovementioned objective of the paper, we focus the review on scientific literature only. There is a significant amount of gray literature on water resources and water management in conflict-affected settings, particularly in the context of humanitarian interventions (as discussed in Zeitoun, Eid-Sabbagh, & Loveless, 2014). However, this body of literature is not included in the review, since the methodology applied in such reports is often unclear and many do not adhere to the academic peer-review principle.¹

In addition to the publications' thematic focus, which is captured with the search query outlined below, we used the following inclusion criteria to identify relevant scientific publications:

- The publication is a peer-reviewed journal article (original research or review), book chapter, monograph or conference paper.
- The publication is indexed in Scopus or Web of Science.
- The publication is written in English.

There was no restriction on the year of publication to capture the first occurrence of water and armed conflict being discussed in the scientific literature.

The search query used for the Scopus and Web of Science search engines was “water AND conflict AND (‘violen*’ OR ‘armed’ OR ‘acute’ OR ‘protracted’).” The term “water” is used without any limitations to cast a wide net which also captures literature that is not explicitly on water resources or water management, but on related topics such as water bodies, water services or water governance. The term “conflict” on the other hand is linked to multiple qualifying adjectives to limit the search results to publications on armed conflict as defined above. Based on their common use in scientific studies on the linkages between conflict and natural resources, we identified four relevant adjectives: (a) “violen*,” accounting for both “violent conflict” and the mention of “violence” (e.g., Ide, 2015; Weiss, 2015), (b) “armed” conflict (e.g., Pinera, 2012; Theisen, 2008; Zeitoun et al., 2014), (c) “acute” conflict (e.g., Homer-Dixon, 1991), and 4) “protracted” conflict, which may also include protracted crises (e.g., Weinthal & Sowers, 2019). Database searches in Scopus and Web of Science were conducted in May 2019, creating a list of 768 unique publications. Figure 1 provides an overview of the search and screening process to create a dataset of publications to be included in the review.

By screening the title and abstract of the 768 publications in the full list of search results, we first categorized them as relevant or not relevant for the review. As shown in Table 1, four categories allowed for the distinction between irrelevant publications from unrelated fields and those from fields related to the study of water during armed conflict.

While only Category 1 (Water during conflict) publications were relevant for the review, the distinction between the other categories provided some insight on the distribution of scientific interest related to water and conflict. Among all publications related to water in the full list ($n = 176$), only 31% ($n = 54$) dealt with some aspect of water during conflict (Category 1), while 69% ($n = 122$) analyzed the role of water as a conflict driver or its potential in conflict resolution (Category 2). Category 3 additionally showed that water is considered a relevant resource in the study of the nexus of conflict and natural resources, as 117 publications on other natural resources, such as land or extractive resources, were also included in the search results. These publications mentioned “water” in their abstracts, and were thus captured by the search term, but did not provide any specific discussion on linkages between water and conflict that would qualify them for either Category 1 or 2.

The resulting dataset of publications included in the review comprises 48 manuscripts. It contains all publications in Category 1, minus two publications of which the authors were unable to obtain the full text and four publications that, upon closer assessment of the full text, turned out not to be scientific studies.

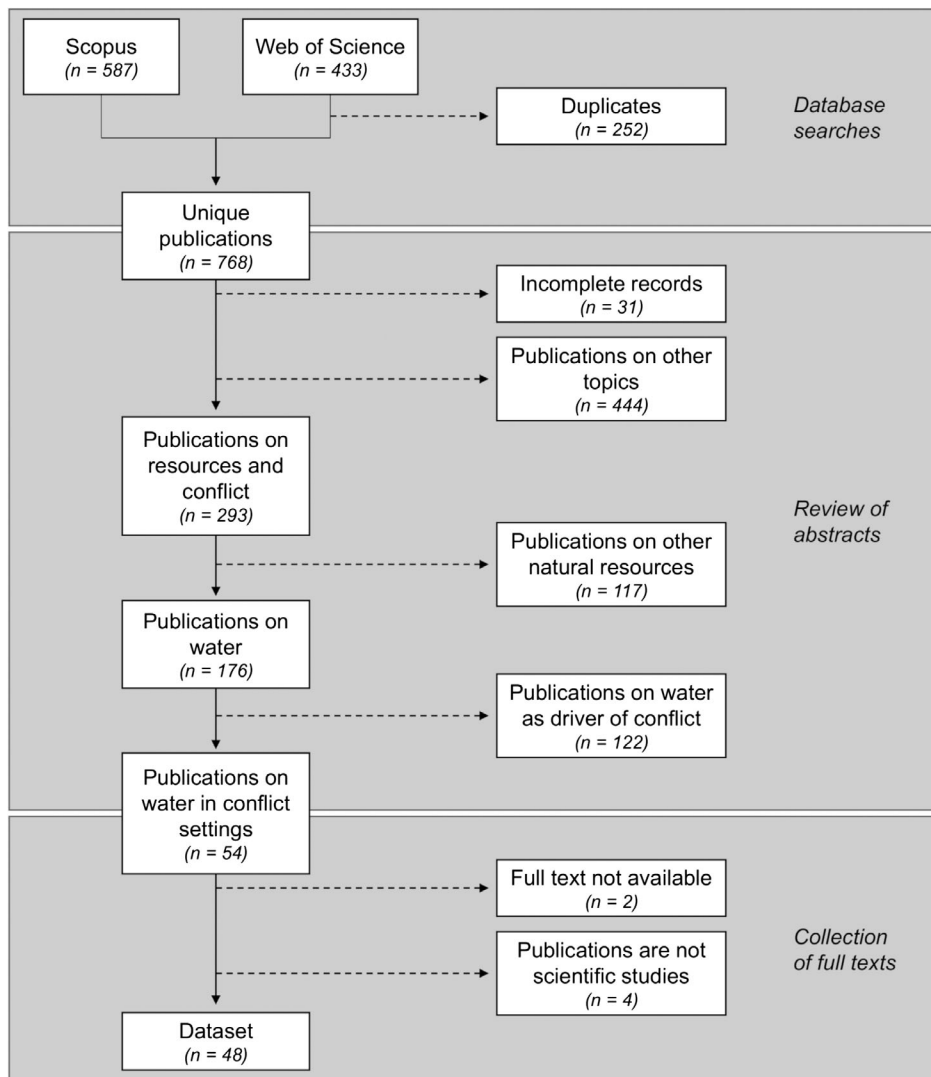


FIGURE 1 Search and screening process applied to identify all relevant publications to be included in the systematic review. The search query used in the database searches was “water AND conflict AND (‘violent*’ OR ‘armed’ OR ‘acute’ OR ‘protracted’),” with a cut-off date on April 30, 2019

TABLE 1 Classification scheme to rank the relevance of publications produced by Scopus and Web of Science database searches for water in conflict-affected settings. Only publications assigned to Category 1 were included in the full-text review

Category	Included in the review?	Number of publications
1. Water during conflict	Yes	54
2. Water as conflict driver	No	122
3. Other natural resources (e.g., land, extractive resources)	No	117
4. Unrelated publications and incomplete records	No	475

2.2 | Review process

The full-text review process was guided by a review matrix to ensure consistency across the dataset. In addition to information on the publications' key messages, the matrix covered a range of categories, which can be grouped into three themes that are subsequently used to present the review results: (a) empirical characteristics, such as geographic focus and type of water resources analyzed in the study, (b) conceptual frameworks, and (c) methodology, including research design, unit of analysis and data collection methods. Depending on the specific matrix category, data entries were possible as free text, single choice or multiple choice. An outline of the review matrix is included as Annex S1 to this paper.

Based on this matrix, each publication in the dataset was reviewed by two different members of the research team. After the first round of reviews, the review matrix was slightly updated to include additional multiple choice options,

namely the inclusion of wetlands in the “water resources” category and the inclusion of field measurements in the “data collection methods” category. The comparison of the two sets of matrix entries per publication served to reduce bias in the review results. Discrepancies between the two rounds of review were discussed with the whole research team where necessary.

2.3 | Limitations

The search query that we used to identify relevant publications from the literature databases included different types of conflict, but not the term “war.” This term was omitted after a preliminary search on “war” and “water” in Scopus produced approximately 5,000 hits, which predominantly contained literature from unrelated disciplines and publications on potential “water wars” and maritime warfare.

The International Committee of the Red Cross’s (ICRC’s) definition of armed conflict that we adopted in this paper can be applied to conflict on any scale. However, this definition is predominantly used to describe inter-state conflicts or conflicts on the sub-national level, rather than micro-level expressions of violence. In consequence, it is likely that there is literature on the impact of such micro-level conflicts on water which was missed in the database search and is therefore not included in the review sample. Such literature might for instance discuss restrictions to water access for households or individuals due to domestic abuse or police violence.

3 | CHARACTERIZATION OF THE SCIENTIFIC EVIDENCE

The following assessment of the scientific research on water in conflict settings is based on our dataset of 48 publications. It provides a characterization of the empirical, conceptual, and methodological approaches adopted in studying the impacts of conflict on water resources and their management.

3.1 | Empirical focus and trends

The reviewed publications span the period from 1992 to 2019, with a clear increase in numbers over the past 15 years (Figure 2). While the Vietnam War led to the first public and scientific attention on the environmental impacts of wars (Orians & Pfeiffer, 1970), studies that focus on water in conflict settings only commenced in the early 1990s after the Gulf War. Indeed the two earliest publications identified in this review investigate the impact of the Iraqi invasion of Kuwait on water resources (Literathy, 1992) and the implementation of water and sanitation programs in Iraq during the Gulf War (Etienne & Nembrini, 1995).

Seven out of 48 publications analyze issues on a global scale rather than specific countries or regions. These are predominantly studies of international law regarding the use and protection of water during conflict. Among the remaining publications, there is a clear geographic focus on the Middle East, Africa, and Asia (Table 2). While studies

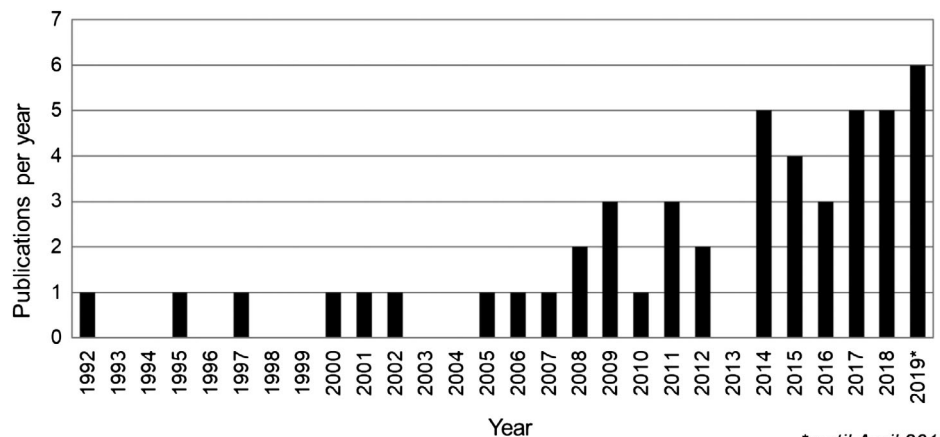


FIGURE 2 Number of publications on water in conflict-affected settings per year, as per the research dataset. Publications for 2019 only include publications up until the cut-off date at the end of April 2019

* until April 2019

Global region	Number of studies ^a
Middle East	20
Africa	11
Asia	11
Europe	3
Latin America	2
Australia and Oceania	0
North America	0
Worldwide	7

TABLE 2 Distribution of studies on water in conflict-affected settings that were identified in the systematic review over the global regions

^aPublications covering more than one region ($n = 3$) are counted for all relevant regions.

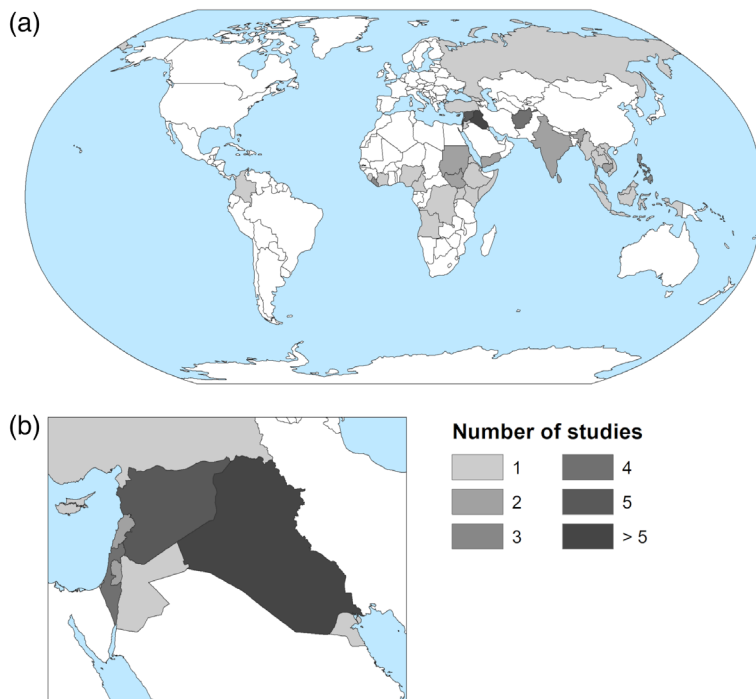


FIGURE 3 Geographic distribution of studies on water in conflict-affected settings per country across the world (a) and in the Levant (b). Publications investigating multiple countries are counted as one study on each country

on the Middle East have dominated the field from its onset, studies on Africa and Asia only emerged in the early 2000s. Figure 3a maps the geographic distribution of all studies. It shows that three out of the four most commonly discussed countries are located in the Middle East (Figure 3b): Iraq ($n = 8$), Syria ($n = 5$), and Israel ($n = 4$). The quartet is completed by Afghanistan ($n = 4$).

Nearly two-thirds of the publications ($n = 31$) study only one country, with their unit of analysis on the local, sub-national, or national level (Figure 4). Ten publications cover more than one country, either in comparative analyses or in the investigation of transboundary river basins or inter-state conflicts. Three of these publications include countries from different regions. The aforementioned seven publications of worldwide coverage predominantly analyze issues on the global scale, with the exception of Gates et al. (2012)'s statistical analysis of conflict impacts on national development indicators.

Figure 4 also shows the sub-national level as the most common unit of analysis, accounting for one-third of all publications ($n = 16$). These studies often refer to administrative units within a given country, such as provinces or governorates. It should be noted that the unit of analysis of a given study does not necessarily correspond to the level at which the conflict in question takes place. Rather, a large number of publications assess the impacts of conflict on a sub-section of the total affected area, such as the impacts of a country-wide civil war on a sub-national unit or city.

FIGURE 4 Number of publications on water in conflict-affected settings that cover one country (black), multiple countries (dark gray) or the whole world (light gray), per units of analysis applied in the respective study

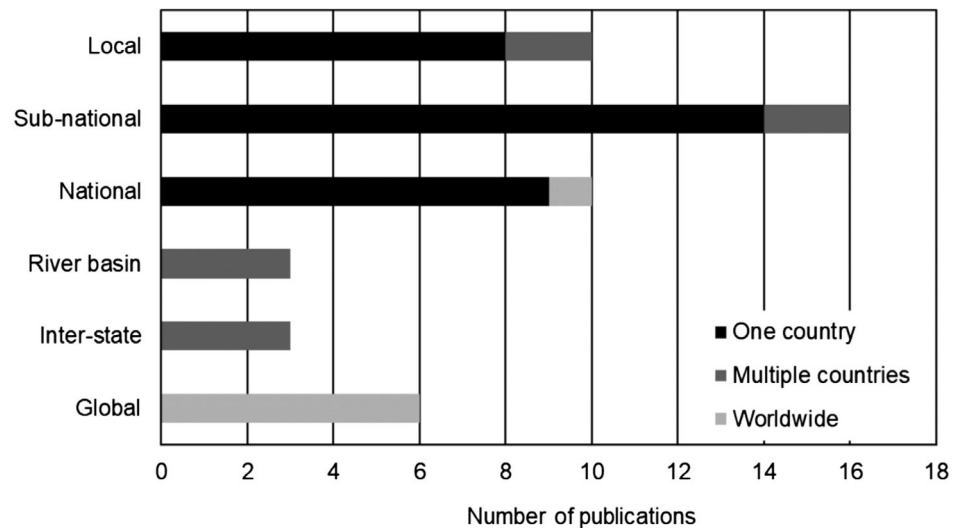
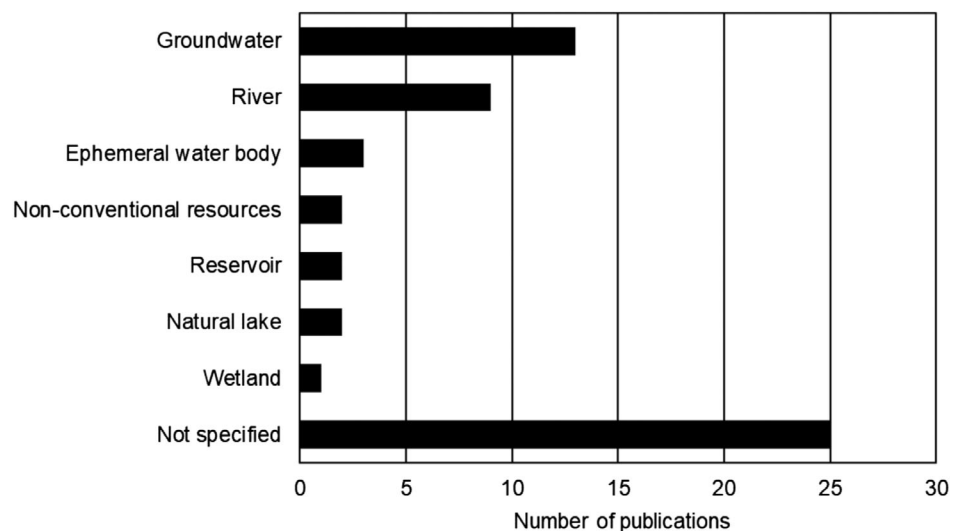


FIGURE 5 Types of water resources investigated in publications on water in conflict-affected settings. Multiple mentions are possible where publications discuss different types of water resources, with the exception of the category “not specified”



Half of the reviewed publications ($n = 25$) do not specify the water resources relevant to their study (Figure 5). This is particularly the case for publications analyzing service provision or international law. In the former case, it is often not relevant where the water comes from, but rather how it reaches the user. In the latter case, the collective term of water resources and their civilian uses is generally more important than a specific resource. The remaining publications predominantly focus on groundwater aquifers ($n = 13$) or rivers ($n = 9$). Non-conventional water resources were only referred to in two studies (Gunawardana, Tantrigoda, & Kumara, 2018; Kartin, 2001), which include mentions of rain-water harvesting, treated wastewater, and desalination.

3.2 | Conceptualization of conflict and its impacts

The majority of publications ($n = 40$) do not engage with the term “conflict” on a conceptual level. Instead, conflict is considered as part of the study context and terms such as “armed conflict” or “war” are used without prior definition. Only eight papers explicitly define “conflict.”

Out of those eight, two statistical analyses (Djimeu, 2014; Gates et al., 2012) rely on the Uppsala Conflict Data Program’s definition of armed conflict as “a contested incompatibility which concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths” (Wallensteen & Sollenberg, 2001, p. 643).

The remaining six publications provide qualitative definitions of conflict. Key elements of these definitions include a multiplicity of actor groups as conflict parties, specific reference to violence or the use of arms, and territorial struggle. Damluji (2016) bases his definition of armed conflict on international humanitarian law which necessitates the state to be one conflict party and the state's territory to be the conflict site. Kartin (2001) and Weinthal and Sowers (2019) use “protracted conflict” rather than “armed conflict” in their studies on the Israeli-Arab conflict. While they emphasize the use of arms and violence in their definitions, they differentiate protracted conflicts from other armed conflicts based on the absence of a “distinguishable point of [conflict] termination” (Kartin, 2001, p. 277) and the high likelihood of civilian casualties and damages (Weinthal & Sowers, 2019).

Similar to the lack of clear definitions of conflict, the majority of publications ($n = 31$) do not apply any analytical framework to the description of conflict impacts. Instead, they provide empirical descriptions of observations by the authors. These include, for example, damage to water infrastructure (Mason & Khawlie, 2016; Philip, 2014), changes in power dynamics and control over water resources (Desai & Sanghvi, 2017; Zieba, Yengoh, & Tom, 2017), and financial challenges faced by water service providers (Carbonnier, 2006). While these accounts provide empirical insights, they do not build on any theoretical framework related to conflict impacts.

Several publications ($n = 8$) operationalize conflict impacts as numerical values, a group of studies which predominantly comprises statistical analyses and modeling exercises. In the case of statistical analyses, conflict impacts are understood as changes in quantitative indicators. For instance, El Bcheraoui, Jumaan, Collison, Daoud, and Mokdad (2018) monitor the changes in multiple health-related indicators, including access to untreated water sources, between 2013 and 2016 in Yemen. Modeling studies on the other hand include conflict impacts as explicit parameters in their models or as changes in the value of model parameters. For instance, Faour and Fayad (2014) develop an assessment model to estimate the impact of the Syrian civil war on future water availability in coastal areas of Syria, which includes factors such as water demand fluctuations due to internal displacement and infrastructure damages.

The most common qualitative approach to analyzing conflict impacts is the distinction between “direct” and “indirect” impacts ($n = 6$). According to Solomon et al. (2018, p. 285), direct impacts “may be physically linked to military action and [...] typically arise within the immediate short-term,” while indirect impacts “can be reliably attributed to the conflict but they usually tangle with many factors and only fully manifest themselves in the medium to longer term.” Zeitoun et al. (2014) alternatively refer to direct impacts as “primary” and indirect impacts as “secondary”. Additional categories include “reverberating effects” (Weinthal & Sowers, 2019) and “cumulative impacts” (Zeitoun et al., 2017), both referring to the combination and interplay of conflict impacts on different elements of the water system and beyond.

Publications that analyze international law tend to conceptualize conflict impacts based on legal frameworks. In the assessment of conflict-caused damage to infrastructure, Gleick (2019) and Zeitoun et al. (2014) distinguish between discriminate destruction, that is, damage caused by intentional, targeted attacks, and indiscriminate destruction, that is, collateral damage to water systems as a side effect of strikes on other targets. Other approaches to the conceptualization of conflict impacts include the use of specific international humanitarian law documents such as the Geneva Conventions of 1949 (Brajic, 2017) and the Environmental Modification Convention of 1977 (Mrljić, 2011).

3.3 | Methodological approaches

The reviewed publications cover a range of research designs, as well as data collection and analysis methods. The majority of studies take a qualitative research approach ($n = 29$). Common data collection methods in these studies are interviews, focus group sessions, observations during fieldwork, and the review of documents such as policy plans and project reports. Literature reviews, either as a significant element of the research or as dedicated review papers, are also adopted as a qualitative approach, rather than for quantitative meta-analyses.

Quantitative research accounts for a quarter of the publication dataset ($n = 12$). It predominantly includes statistical analyses and models, either using survey data collected by the respective research team or based on secondary data. An additional seven publications apply a mixed method approach.

A central element in the design of research on conflict-affected countries is the question of both necessity and feasibility of fieldwork. “Fieldwork” is understood here as the collection of data in “the field,” meaning that the researcher travels to the studied area (McCall, 2006). These studies are thus distinguished from those exclusively relying on remote data collection or desk research. Challenges to fieldwork in conflict-affected settings include logistical concerns related to the access to the field and to research participants, ethical concerns related to the treatment of politically sensitive

information, and security concerns related to the wellbeing of both the researcher and the researched (Barakat, Chard, Jacoby, & Lume, 2002; Peter & Strazzari, 2017).

The publications exhibit an even split between studies that included fieldwork ($n = 23$) and those that did not ($n = 24$).² The majority of fieldwork was conducted for in-depth analyses of a single case or comparative analyses of a few cases, while fieldwork becomes less common with increasing number of cases. Figure 6 indicates one medium- n comparison for which fieldwork was conducted, however, this only included three out of the six cases analyzed in the publication (Pinera, 2012). As previously mentioned, statistical analyses were either based on original survey data, in which case the research included a fieldwork period in which data was collected, or on secondary data, in which case no fieldwork took place.

3.4 | Common research themes

Several common research themes emerged from the review dataset; these themes can be grouped into two broader categories: the role of water during armed conflict, highlighting the position of the natural resource in conflict settings, and the impacts of conflicts on water management, focusing on the implications for human systems. The following two sections synthesize the research results presented by relevant publications on each research theme, thereby providing an extensive overview of the existing scientific evidence.

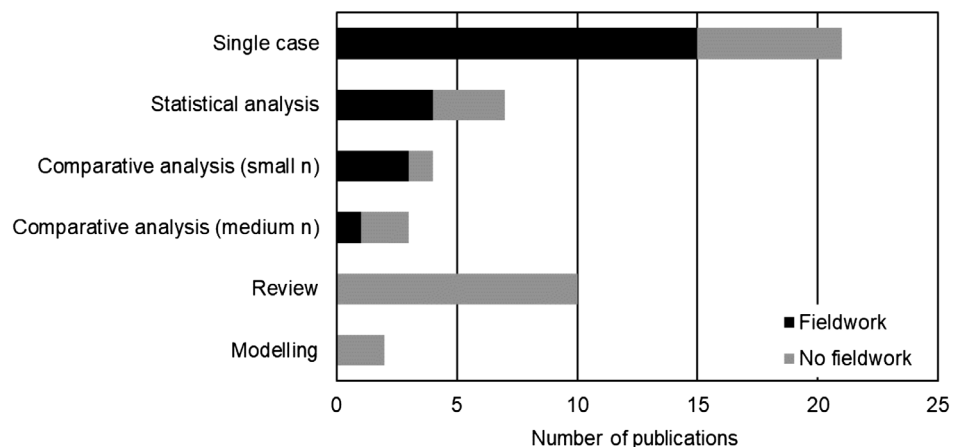
4 | THE ROLE OF WATER DURING ARMED CONFLICT

Water resources and aquatic ecosystems are highly vulnerable to conflict impacts; this is a consequence of their potential role as a conflict trigger, weapon or military target, and thus their central geographical position in the conflict area, and of their high connectivity across national borders (Francis, 2011). The following two subsections highlight the role of the natural resource water in conflict settings, covering both the impacts of armed conflict on water resources and the weaponization of water.

4.1 | Conflict impacts on water resources

In a review of literature on the impacts of modern warfare after 1914 on freshwater ecosystems, Francis (2011) identifies different pathways in which conflict can affect water resources. Modern warfare, starting with the First World War, is assumed to have more extensive effects on ecosystems than earlier, less industrialized wars due to the higher potential of modern weapons to cause environmental harm. Francis (2011) concludes that the effects of war can materialize both directly by causing damage to water resources and contamination from weapon residue, and indirectly by increasing the frequency or intensity of detrimental processes. Such processes may occur naturally, for example, erosion, or anthropologically, for example, industrial pollution. In a review of literature on the ecological causes and impacts of

FIGURE 6 Number of publications on water in conflict-affected settings that did (black) or did not (gray) include fieldwork, per research design category. Fieldwork is understood as research which includes the physical act of visiting “the field” to collect data. The category “Review” includes both scientific literature reviews and reviews of non-scientific Documents that are not related to a specific case, for example, international law review papers



armed conflict in the Horn of Africa, Solomon et al. (2018) also highlight pollution as the main conflict impact on water resources.

Studies on environmental pollution caused by conflicts identify several possible pollution sources. For instance, during the Gulf War, water resources in Kuwait were heavily polluted from oil spills following attacks on oil fields (Literathy, 1992), increasing the concentration of trace metals along the coast in the Persian Gulf (Bu-Olayan, Subrahmanyam, Al-Sarawi, & Thomas, 1998) and impacting regional aquaculture (Mathews, Kedidi, Fita, Al-Yahya, & Al-Rasheed, 1993). During the Syrian civil war, discharge of untreated wastewater into the environment, both intentionally and unintentionally, deteriorated the water quality in affected areas (Faour & Fayad, 2014). Following the civil war in Sri Lanka, explosive remnants of war, such as landmines, remained scattered throughout the landscape. Gunawardana et al. (2018) report higher-than-usual concentrations of heavy metals, fluoride, and calcium in the groundwater in these areas. Other possible sources of contamination include hazardous waste from industries and waste disposal sites, pathological waste from hospitals that were damaged in the conflict, the unregulated incineration of municipal waste, and the use of chemical weapons (Literathy, 1992).

The contamination of water resources due to damage to infrastructure is a recurring theme in studies on the impacts of conflict (Philip, 2014). Specific examples include the damage to wastewater treatment plants in the Gaza Strip during the Israeli military operations “Cast Lead” in 2008 (Mason, Zeitoun, & El Sheikh, 2011) and “Protective Edge” in 2014 (Weinthal & Sowers, 2019) from which untreated wastewater leaked, and damage to sewage lines and a wastewater treatment plant in Israel during the 2006 Lebanon War, where large amounts of sludge were consequently deposited directly into the Mediterranean Sea (Zeitoun et al., 2014).

Another effect of conflicts on water resources is linked to the forced movement of populations. During Sierra Leone's civil war in the 1990s, Freetown saw a sharp population increase, when many internally displaced persons (IDPs) settled in the capital, putting additional pressure on already strained water resources in the area (Kallon, 2008). More recently, the forced migration of a large number of refugees from Syria to Jordan has exacerbated water shortages in the receiving areas. At the same time, however, the decrease in irrigated agriculture in southern Syria led to an increase in water availability in the Jordanian reservoirs that are located further downstream along the shared Yarmouk river (Müller, Yoon, Gorelick, Avisse, & Tilmant, 2016). Baumann and Kuemmerle (2016) made similar observations regarding the abandonment of agricultural lands in conflict zones and their subsequent expansion in areas receiving IDPs, citing example cases from Africa, Asia, and the Middle East.

4.2 | Using water as a weapon

In recent years, the weaponization of water and water infrastructure gained public and scientific attention due to the activities of the so-called Islamic State (IS) in Syria and Iraq. The fight for control over dams along the Euphrates and Tigris rivers has been the focus of several studies that assessed the capacities and shortcomings of international law in protecting water resources and preventing the use of water as a weapon (see for instance King, 2015; von Lossow, 2016; Kibaroglu, 2019).

However, the use of water as a tool to achieve military objectives is no new phenomenon. First instances that are recorded in the Pacific Institute's Water Conflict Chronology date back several millennia (Gleick, 2019). Large portions of Iraq's water infrastructure were constructed as part of the British war efforts against the Ottoman Empire during the First World War to establish control along the Euphrates and Tigris rivers and gain a strategic advantage (Dowdeswell & Hania, 2014). For Israel, the expansion of irrigated agriculture, and thus the allocation of water resources to agricultural production, has constituted an important tool to solidify territorial control over the past decades (Kartin, 2001).

von Lossow (2016) distinguishes three motives to weaponize water in a conflict setting: political, tactical, and psychological. The political dimension entails the domination of the access to water as a means to consolidate one's own power position. This often manifests as exerting pressure on the opposing political leadership or on local populations to fall in line or suffer from the lack of water. The tactical approach is closely linked to the mental image conjured up by the term “water as a weapon.” From this perspective, water and water infrastructure are directly used for military gains, for example, by flooding an area to block the route for invading opponents as was done by Chinese forces in 1938 during the Second Sino-Japanese War (Lary, 2001). Psychologically, the mere threat of the weaponization of water resources can create an anxious atmosphere among local populations who would suffer extensive and potentially long-lasting damages.

In addition to its role in the weaponization of the resource, water infrastructure is also an attractive target, since a direct hit can have far-reaching and widely noticeable consequences. For instance, during the Gulf War, Kurdish forces targeted Iraqi water installations, which they perceived as symbols of the state's presence (Etienne & Nembrini, 1995). Deliberate attacks on water infrastructure were repeatedly condemned by the United Nations and are, nowadays, predominantly carried out by non-state actors or proxy conflict parties who act on behalf of seemingly uninvolved states (Gleick, 2019). Gleick (2006) particularly highlights the appeal of water facilities as a target for terrorist attacks in the form of destruction of infrastructure or contamination of water resources.

International humanitarian law contains provisions on the protection of civilians, civilian infrastructure, and natural resources during armed conflict. The 1977 Additional Protocols to the Geneva Conventions of 1949 prohibit attacks on facilities that are “indispensable to the survival of the civilian population,” including drinking water facilities and irrigation networks (Gleick, 2019, p. 1741). However, as pointed out in recent studies, international law is inadequate to protect water systems in modern-day conflicts which are no longer primarily fought between states, but include non-state conflict parties that do not abide by such conventions (Brajie, 2017; Damluji, 2016; Gleick, 2019).

5 | WATER MANAGEMENT IN CONFLICT-AFFECTED SETTINGS

While water resources can play various roles in conflicts as outlined above, most research focuses on the implications of conflict for human systems related to water management, including technical, operational, and organizational aspects. Four key aspects of this theme are discussed in the following subsections: the impacts of conflict on water governance; the implications for water service provision in conflict-affected settings; challenges and opportunities for trans-boundary water management in conflict settings; and the role of humanitarian actors in conflict-affected water management.

5.1 | Conflict impacts on water governance

Water governance is commonly defined as “the range of political, social, economic and administrative systems that are in place to develop and manage water resources [...] at different levels of society” (Rogers & Hall, 2003, p. 7). It includes, but is not limited to the role of the government, and exhibits several points at which conflicts can affect the interplay between actors.

Conflicts often considerably lower the operational capacity of government agencies and other key actors in the water sector. Such limitations can stem from the decrease in manpower as staff members lose their lives, get injured or flee the area during the conflict, from the loss of institutional memory due to the loss of data or of leadership staff or from a lack of finances as budget priorities are shifted toward ending the conflict itself (Vargas, 2007). The recent history of Iraq's water sector includes several examples. During the Gulf War, most international experts were evacuated from the country and local staff either fled or was mobilized to participate in the fighting. Those who remained often became apathetic in view of the conflict situation as such and of the lack of government support for their work in the water sector (Etienne & Nembrini, 1995). A decade later, during the US invasion of Iraq in 2003, the Ministry of Irrigation's building in Baghdad was looted and stripped of its computer systems. Extensive records, both related to human resources and to water supply, were lost (Etienne & Nembrini, 1995). Next to a decline in water supply coverage, the decrease in operational capacity can also affect water quality and ecosystem health. This was shown in Syria where the lack of governmental oversight led to a decrease in compliance with environmental regulations and an increase in the discharge of untreated wastewater (Faour & Fayad, 2014).

The weakened position of established actors in the water sector can open up spaces for new actors and lead to a shift in power dynamics as the role of the state is renegotiated (Allouche, 2014). Formerly centralized and hierarchical management systems might be transformed to meet localized demands for reconstruction or supply system maintenance, giving way to a decentralized system of “hybrid governance,” in which state actors work alongside local non-state actors such as community-led or private service providers (Meagher, 2012; Zeitoun et al., 2017). Such processes take place rather spontaneously in a context of little central oversight and thus provide an opportunity for local groups, armed or unarmed, to rise to power. Example cases from India show the “capture” of local self-governance institutions by local elite groups who would subsequently use their new position to serve their own political or economic interests (Nandwani, 2019). Desai and Sanghvi (2017) report similar cases of informal water service providers gaining power in

the absence of state oversight and forming strategic alliances with local leaders to solidify power positions, for example, through the establishment of a local service provision monopoly.

External actors, often international organizations, also play an important role in the re-shaping of water governance during and after conflict periods. Dowdeswell and Hania (2014) analyze the impacts of a new governance model introduced in the Iraqi water sector by the US forces after the fall of Saddam Hussein and the systematic removal of Ba'ath party members from public office. The model brought changes to governance arrangements from the national down to the local level and intended to improve public and private sector participation during the reconstruction. However, according to Dowdeswell and Hania (2014), the new system primarily benefited the military, private contractors and wealthy citizens. Sharing insights from Southern Sudan, Mugabi, Selle, James, and Lubanga (2005) highlight the risk of losing local ownership when external actors, here aid agencies, enter the governance arena and take over infrastructure development or service provision. They refer to the “dependency syndrome” where local actors are unable to develop sufficient capacities to take control and ownership of their own water sector after the end of the conflict. Trottier, Rondier, and Perrier (2019) report similar findings regarding the involvement of international actors in the Palestinian water sector in the West Bank.

5.2 | Implications for water service provision

Upholding water service provision is one of the biggest and most crucial challenges in conflict-affected regions. Household surveys, which were conducted in southern Syria in 2016 and 2017, show the devastating impacts of the civil war on municipal water networks: Before the civil war, piped water was the main source of water for more than 90% of households, whereas only 22.0% of households gave the same response in 2016, and 15.3% in 2017 (Sikder, Daraz, Lantagne, & Saltori, 2018). A survey of conflict-affected communities in South Sudan shows that the missing provision of drinking water is the most serious problem which local populations are facing, ranked above problems related to food, healthcare, and education (Ayazi, Swartz, Eide, Lien, & Hauff, 2015).

Several studies focus on the impacts of conflicts on both the water supply infrastructure and the “support systems” (Sikder et al., 2018, p. 11) necessary for a seamless service provision. Zeitoun and Talhami (2016) identify three aspects of water supply systems that are at risk of disruption by a conflict: (a) people, for example, utilities' staff or private sector contractors, (b) hardware, for example, infrastructure, equipment, or machinery, and (c) consumables, for example, fuel or water treatment chemicals. This classification matches the findings by Etienne and Nembrini (1995) with regards to the impacts of the Gulf War on Iraqi water infrastructure, where the lack of spare parts, qualified personnel, and access to treatment chemicals led to insufficient system maintenance and operational errors. The same elements still contribute to the deterioration of water services in southern Iraq two decades later, leaving service provision reliant on foreign assistance (Zeitoun et al., 2017). In addition to people, hardware and consumables, water supply systems are dependent on a steady power supply. Electricity shortages are an oft-quoted reason for water service provision problems in conflict-affected areas, putting pumping stations and treatment plants out of operation (Etienne & Nembrini, 1995; Pinera & Reed, 2009; Sikder et al., 2018).

Next to the obvious humanitarian implications, the deterioration of water service provision has profound impacts on the position and capacity of water utilities. Based on a comparative study of urban water services in six conflict-affected countries, Pinera (2012) identifies three stages of decline. First, the factors outlined above constrain the water utility's ability to reliably provide water of sufficient quantity and quality. The poor service provision then causes the utility to lose credibility and authority toward its customers and the administration, potentially motivating customers to withhold payments until a satisfactory level of service is restored. Without the income from its customers, the utility is no longer financially self-sufficient and needs to downsize or cut salaries, or becomes dependent on external financial support.

No conclusive studies exist on how to solve the financial struggle of water utilities during conflict. Instead, measures suggested in scientific literature would have to be implemented prior to a conflict to strengthen the utility's resilience later on. Based on a statistical analysis of municipalities in Côte d'Ivoire, Sanogo (2019) concludes that fiscal decentralizing might lead to a more robust service provision during periods of conflict. The privatization of water services could be seen as a means to give utilities more freedom compared to functioning as a public service provider. However, Carbonnier (2006) points out that privatization can lead to problems during a conflict if there are no clear agreements between the government and the private utility company, particularly regarding the use of humanitarian aid funds by the private sector to uphold water services.

In the absence of functional state-run water service provision, informal providers often fill the supply gap (Allouche, 2014). The most common type of such informal providers are privately operated water trucks that take over the market in the absence of piped water supply via the municipal network (Pinera & Reed, 2009; Sikder et al., 2018). Another informal, highly localized approach to water provision is the use of hand-dug wells. In a survey of living conditions in East and West Mosul under IS occupation, 96.6% of respondent households indicated that they received their water from such an improvised well (Lafta, Cetorelli, & Burnham, 2018). Ong et al. (2009) also highlight the use of wells informally dug by local populations as a key coping mechanism in conflict-affected regions in the Philippines. While the emergence of such informal service providers is crucial to upholding water supply, it also comes with potential problems. In the absence of government agencies, informal providers usually operate with little to no oversight regarding water quality or price charged to consumers, leading to sharp increases in water prices (Pinera & Reed, 2009). They also assume a position of power within their communities and can become important allies for local political elites (Desai & Sanghvi, 2017).

The role of informal service providers is occasionally analyzed from the perspective of state legitimacy, as the provision of basic services like water is commonly seen as a state task (Brinkerhoff, Wetterberg, & Dunn, 2012). However, there is no consensus in the scientific literature on whether informal service provision undermines state legitimacy. Instead, the effect of increased informal provision in the absence of a trusted state provider depends on the situational context, such as the question of whether the state was seen as a legitimate service provider prior to the conflict (Kooy, Wild, & Mason, 2015; Mcloughlin, 2015).

5.3 | Transboundary water management in conflict settings

Around the globe, the majority of countries share surface water or groundwater bodies with at least one neighboring country (Wolf, 2007), which makes the question of transboundary water management in conflict settings an important, yet scarcely researched one. While predominantly concerned with the impacts of conflict on water management, this research direction is closely connected to questions of water as a driver of inter-state conflict or cooperation. As will be shown in the following paragraphs, armed conflict within a shared basin might even provide new incentives for transboundary cooperation.

Considering potential transboundary management during an interstate conflict between the riparian states, Libiszewski (1997) distinguishes two common perspectives in his analysis of the Israeli-Jordanian negotiations over water in the early 1990s. On one hand, the functionalist perspective entails that states are able to cooperate on matters of “low politics” such as resources management during a larger conflict and that negotiations over water might even create an opportunity for reconciliation between the two sides. On the other hand, from the realist perspective, cooperation over “low politics” is seen as impossible until the larger conflict is resolved, as all issues are intrinsically linked. Circling back to his case study, Libiszewski (1997) argues that both perspectives have some merit, yet the reality of the Israeli-Jordanian negotiations on water and the genesis of the peace treaty in 1994 lie somewhere in between the two positions.

As interstate conflicts are becoming increasingly scarce and “new wars” featuring non-state groups increasingly common, the implications of domestic conflicts and civil wars for transboundary negotiations are gaining importance. Since stable institutions play a key role in transboundary water governance and are a prerequisite for participation in multilateral platforms, civil wars that weaken state institutions can cause a deadlock in negotiation and cooperation processes (Kibaroglu, 2019). Political instability and a lack of state authority in one country can also create uncertainty regarding the availability of shared water resources in downstream countries, as shown by Mason and Khawlie (2016) for the case of the Hasbani basin which is primarily located in southern Lebanon, a region that has struggled with the presence of Hezbollah militants for decades. Similarly, the presence of Boko Haram in Nigeria adds uncertainty to the governance of the Lake Chad basin, which is shared by Cameroon, Chad, Niger, and Nigeria, and has already been the site of local conflicts over control and access to resources among nationals of the different countries (Zieba et al., 2017). The emergence of a strong non-state actor that takes control over water resources introduces a new dimension to transboundary water negotiations, as such non-state actors do not abide by formal agreements between states. The capture of key water infrastructure by IS in Iraq and Syria is a case in point. It is usually not in the interest of riparian states to include non-state actors in formal negotiations so as to deny them any legitimacy as a state-like actor. At the same time, the presence of armed non-state actors can also provide an entry point for transboundary cooperation between states as they collaborate to limit the control of such non-state actors over shared water resources (Kibaroglu, 2019).

Another possible pathway to cooperation over water resources, be it between states or on a lower level, is mutual dependency. The island of Cyprus constitutes an example. The political conflict between the Republic of Cyprus (RC) and the Turkish Republic of Northern Cyprus (TRNC) has exacerbated the island's water problems due to inconsistencies in water management on either side of the border and the refusal to engage in economically beneficial cooperation based on political considerations. There is, however, a functional shared water supply system linking the cities of Nicosia in the RC and Famagusta in the TRNC. The system pre-dates the political split of the island, which led to the water source being located on the TRNC side of the border, while the system's purification plant is located on the RC side (Nachmani, 2000).

5.4 | Role of humanitarian aid organizations

International organizations and aid agencies are important actors in many conflict-affected countries and take up key functions in the water sector when the capacity of state-run agencies and utilities is weakened. However, the conflict context presents obstacles to the implementation of humanitarian and development interventions. Etienne and Nembrini (1995) identify several constraints based on the experience of the ICRC in Iraq during and after the Gulf War. Planning of interventions and rapid response activities is hindered by insufficient reliable information and oversight due to the lack of qualified local staff in conflict areas, which complicates early estimates of the damage or number of casualties caused by an attack. Damage to and restrictions on communication and transportation networks further compound this problem. Estimates of the required type and amount of aid are usually only possible once the fighting has ceased and the area is accessible for both domestic and international staff.

Humanitarian organizations in conflict settings often assume state-like functions, such as service provision and infrastructure development, particularly in protracted situations in which a conflict has been going on for several decades. In doing so, they also need to account for systemic obstacles introduced by the state or one of the conflict parties. One example of such an obstacle is the permit system³ that Israel introduced in the occupied Palestinian territories regarding the construction of water infrastructure development (Weinthal & Sowers, 2019).

Where possible, it is usually in the interest of international organizations to be perceived as a neutral external actor, although this might carry additional challenges for the organization. Once again based on ICRC experiences in Iraq, Mattli and Gasser (2008) argue that the ICRC's neutrality was a key ingredient to building trust with local populations. In the context of the Iraq War starting in 2003, this meant that the ICRC did not rely on the security and logistical support provided to international organizations by the US coalition forces, so that the ICRC would not be seen as affiliated with a conflict party.

Aid agencies in conflict settings generally work on the basis of short-term humanitarian interventions that react to the most pressing needs, often leading to a disconnect with longer-term development objectives for the conflict-affected countries. This can be attributed to three main reasons (Pinera, 2012): Firstly, many organizations prefer to involve international experts rather than local organizations, who are not seen as efficient and qualified enough and might thus require additional training. This helps to achieve quick results, but also excludes the possibility of local capacity development. Secondly, local organizations might be considered as unsuitable partners due to concerns over corruption or for political reasons. The latter is the case in the Gaza Strip, where many international organizations enforce a "no contact" policy with local authorities as they are affiliated with Hamas, which is listed as a terrorist organization by many countries (Barakat, Milton, & Elkahlout, 2018; Mason et al., 2011). Lastly, there is also an incompatibility of long-term development objectives with the short-term funding mechanisms that are common for politically unstable regions, as funding agencies seek to minimize the financial risk in case of an escalation of violence (Pinera, 2012). Based on the analysis of military and civilian interventions in Afghanistan, Groninger, Ruffner, and Christenson (2015) determine that short-term water resources development interventions might still support long-term development goals as long as they account for the social realities and distribution of water resources in their target area.

6 | CONCLUSION

This paper set out to discern different approaches adopted in studying the impacts of armed conflict on water resources and water management, synthesize overarching results from relevant scientific studies, and identify future research directions. The analysis was based on the systematic review of scientific publications on water in conflict-affected

settings. A vast majority of analyzed publications studied the impact of conflicts on the sub-national, national or inter-state level. Therefore, the following conclusions should be considered with such conflict settings in mind, and might differ for other settings, such as micro-level expressions of violence.

The review results show several common approaches with regards to geographical focus and research design. Most studies are conducted on countries in the Middle East, Africa, and Asia, with a particular hotspot in the Levant. Studies rarely analyze international or transboundary issues, but rather focus on the national, sub-national, or local level. Single case studies are the most common research design, next to statistical analyses and studies on the status and implications of international law. Fieldwork in conflict-affected settings is challenging and predominantly conducted in in-depth analyses of single cases.

A lack of conceptual engagement with conflict settings is another key result of the review, evidenced by the low number of publications that clearly define or conceptualize conflict and its impacts. This leads to a significant body of literature on water in conflict settings that is based on a narrative engagement with or anecdotal evidence from individual case studies.

The synthesis of overarching results reveals several common research themes, which we grouped into two broad categories: (a) the role of water resources in conflicts, either as a target or casualty or as a weapon used by conflict parties, and (b) the implications of conflict on human systems related to water. The emphasis on the latter is an indication for the strong applied science focus of research on water in conflict settings, including many studies on the performance of water provision systems and humanitarian interventions. This might be a relic of early studies that were led by practitioners, such as NGOs or other international organizations, and of the common occurrence of collaborative research projects by academics and practitioners (such as Pinera & Reed, 2009; Sikder et al., 2018; Zeitoun et al., 2017).

Several studies in the review primarily focused on the issues of health and nutrition in conflict-affected settings, discussing reliable access to water as a prerequisite to improve medical care (Djimeu, 2014; Doocy, Lewy, Guenther, & Larrance, 2010; El Bcheraoui et al., 2018; Raminashvili, Zarnadze, Gerzmava, & Zarnadze, 2009; Wise, 2017). This highlights the fundamental importance of water for other sectors related to development under conflict conditions (Gates et al., 2012).

Based on these results, we identify two key issues regarding the scientific knowledge on water resources and their management in conflict settings. On the one hand, the overall documentation of conflict impacts remains limited. The increase in scientific publications in the field over the past decade indicates that this knowledge gap might decrease as the research community continues on its current path. On the other hand, there is a lack of knowledge integration across different case studies, geographical contexts or conflict settings. Most publications are single case studies that provide a snapshot of a specific conflict situation, whereas there are only a few comparative studies. Meaningful comparative analyses are difficult to conduct, as cases often vary widely with regards to the characteristics of the conflict and water resources, as well as other contextual factors. However, without such research that reaches farther than individual cases, it remains impossible to theorize the multitude of conflict impacts on water resources management.

There are three possible avenues for future research to close the gap in integrated knowledge on water in ongoing conflict. Firstly, researchers need to be explicit about the conceptual framework and contextual setting of their studies. This allows retrospective comparisons with other case studies and generalization based on common results. Secondly, the more advanced analysis of conflict impacts in related fields such as food security, health, and environmental protection can provide new perspectives. Next to empirical insights that are closely related to water, such studies can offer new conceptual and analytical frameworks to apply on water management in conflict settings. Thirdly, research conducted by non-governmental organizations and other actors outside of academia should be assessed where appropriate. This includes both the insights gained from empirical studies and project assessments, and the methods and frameworks applied by these research teams. Moving forward, there is thus not only the need for more evidence on conflict impacts on water resources and their management, but also for improving the quality and comparability of this evidence. Clear conceptual frameworks and methodologies are central to this endeavor.

CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

AUTHOR CONTRIBUTIONS

Juliane Schillinger: Conceptualization; formal analysis; investigation; methodology; visualization; writing-original draft; writing-review and editing. **Gul Ozerol:** Conceptualization; formal analysis; investigation; writing-original draft;

writing-review and editing. **Sermin Güven-Griemert**: Formal analysis; investigation; writing-original draft; writing-review and editing. **Michiel Heldeweg**: Writing-original draft; writing-review and editing.

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ENDNOTES

- ¹ For two positive examples of gray literature on water resources management in conflict settings, we recommend Abu-Lohom, Konishi, Mumssen, Zabara, and Moore (2018) and Diep, Hayward, Walnycki, Husseiki, and Karlsson (2017).
- ² One publication did not include sufficient information to determine whether data was collected on or off site.
- ³ For a detailed analysis of the permit system in the occupied Palestinian territories, refer to Selby (2013).

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[Water as a weapon and casualty of armed conflict: A review of recent water-related violence in Iraq, Syria, and Yemen](#)

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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