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Physical Water-Supply Infrastructure in Pastoral Drylands in Ethiopia, Kenya and Somalia: A Rapid Evidence and Gap Map

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Systematic Review

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Abstract

Physical water supply infrastructure such as boreholes, wells, pans and piped schemes plays a fundamental role within the pastoral systems of the horn of Africa. However, information regarding their impact on outcomes such as conflict, mobility, rangeland and equity can be difficult to find in the literature. A rapid evidence and gap map was created using English language studies between 1990 and November 2026. This identified 259 physical water supply studies in the pastoral and agropastoral drylands in Ethiopia, Kenya and Somalia. After triaging these studies, 82 were shortlisted. Of these, 59 unique studies met the inclusion criteria. These were categorized by country, publication, study design, water supply type and outcome. The majority of studies focused on Kenya (n = 31) and Ethiopia (n = 24) with a small number from Somalia (n = 6). Most studies were from 2025 and 2026 (n = 17) with the outcomes of supply (n = 31) and governance (n = 18) being reported most frequently. Only a few studies focused on conflict (n = 6). Of these, a small number were single site (n = 2), some were purposively sampled (n = 1), but none compared sites with and without water supply, nor were they longitudinal. The highest number of studies were focused on supply of boreholes and wells (n = 10). A minimal number of studies were reported on sand dams and rainwater harvesting (n = 3) and equity (n = 5). Within these three countries there are no studies providing evidence to whether water supply infrastructure increase or reduce conflict using a testing method. Only continental studies have an event design.

Introduction

Within the pastoral and agropastoral drylands of Ethiopia, Kenya and Somalia water supply is rarely just a simple water source. It determines where herds can be kept during the dry season, who has access to the location and on what terms and how much grazing pressure is placed on certain areas of rangeland. There is literature from the area looking at how pastoralism and resource use change with water availability (Opiyo et al., 2011; Tachiiri, 2000), impact on soil status due to grazing around a water point (Gebremeskel & Pieterse, 2006), and how ownership and management is organized for wells and ponds (Beyene, 2009; Staro, 2013). However, boreholes, pans and piped schemes have been put into place throughout the drylands (Demisachew & Abiyot, 2019; Kedir et al., 2015).

There is variable evidence. A recent qualitative study looked at new boreholes in Ethiopia and Kenya, and found informants indicated that households with boreholes did not benefit during the 2020–2022 drought. Boreholes had led to settlement, less mobility, elite capture and conflict over borehole income (Balfour et al., 2025; Wachira et al., 2025). Another study looked at a single borehole in Wajir County using a household survey. It found that approximately a third of respondents had conflict over water and most resolved the issues through negotiation (Omosa, 2003). A third study looked at water points (mostly pans) in Tana River County using interviews to look at water and peace between host and non-host communities (Huho & Asokan, 2026). As these were all single studies using one method and one time point it would be difficult for someone wanting information on the extent of evidence, types of water supply, country and outcomes to find a single source of information.

Evidence and gap maps help solve this issue. They provide a summary of all studies within a topic. It organizes them by intervention and outcome to show areas of high and low evidence. There is no pooling of results or appraisal of study quality like in a systematic review (White et al., 2020). This project provides an evidence and gap map looking at physical water supply in the drylands of Ethiopia, Kenya and Somalia. Three questions were asked:

How many studies are there and how are they distributed by country, year, publication and study design?

What types of water supply and what outcomes have been looked at?

What do studies looking at conflict say and what study design have been used?

This map intentionally looks at a narrow exposure with a wide outcome. Boreholes, wells, water points, pans, ponds, berkads, piped and sand dams/rainwater harvesting have been included. Irrigation and large dams have been excluded. Conflict, mobility, rangeland, livelihoods/resilience, health, deequity/gender, governance and supply have been included as these are all areas that water supply infrastructure has been assessed within the literature. If only conflict was looked at then it would have highlighted how little studies there are.

Methods

Design

An evidence and gap map was created using the guidance from Campbell (White et al., 2020). This shows what studies are available and what they have been looking at. No results have been pooled and study quality has not been assigned. The number of studies refer to how many there are within the literature.

Eligibility Criteria

Only studies looking at physical water supply in the pastoral or agropastoral drylands of Ethiopia, Kenya and Somalia (including Somaliland). Physical water supply includes boreholes, deep and hand dug wells, water points, pans, ponds, berkads, piped, sand dams and rainwater harvesting. Irrigation, large dams, studies looking at only sanitation and studies where water was an underlying factor have been excluded. All studies have been categorised by outcome. To qualify a study had to look at water supply, either through a water source or scheme, and report some information on the supply, use, management or impacts. Experimental and observational studies have been included. Qualitative, mixed method studies, technical or modelling and reviews have also been included. Only English language studies from 1990 to November 2026 have been included. Peer reviewed articles, theses, agency/institutional reports, conference, pre-prints and repository deposits have all been included.

Search Strategy

The main search was performed using OpenAlex (Priem et al., 2022). The search was done on the titles and abstracts. The search was filtered to only include studies between 1990 and 2026 and only in English. The search consisted of 3 blocks of keywords linked by AND. The first block looked at pastoral and dryland terms, the second looked at water supply (borehole, water point, water pan, berkad and hand dug well) and the third looked at the 3 countries and their main pastoral sub regions. This was split into 5 parts based on the years of publication. All 259 results were found. Conflict terms were purposefully excluded from the search string so studies looking at mobility, rangeland, health and other outcomes would be included to show there are no conflict studies.

To pilot the search and ensure the search was comprehensive one search was performed in Consensus (Top 100 Results) and 4 searches were performed in SciSpace (Top 100 each, Ethiopia, Northern Kenya, Somalia/Somaliland and a thematic search looking at conflict, mobility and rangeland). This gave a total of 345 results. Two searches were completed in Consensus to help form the search string (25 and 30 results). These were not kept. To ensure there was good recall 6 seed studies were used. 5 of these were included in the Top 100 from Consensus. Of these only 2 are included in the final corpus (Wachira et al., 2025 and Beyene, 2017). The other 4 were excluded due to the inclusion criteria. Three were excluded due to;

Piemontese et al., (2024) looked at modelling post drought dynamics in 5 drylands in Africa using anthropological literature.

Döring, (2019) looked at groundwater availability and communal violence across Africa and the Middle East.

Döring, (2026) looked at reviewing 235 studies of water and communal conflict in 30 countries.

None of these used the physical water supply as the unit of analysis in the 3 study countries.

Screening

All screening was done individually. Using the 259 studies from OpenAlex, 82 were shortlisted. Of these 48 were clearly included whilst the other 34 were borderline. These 34 were coded using the abstract. 15 of these were included and 15 were excluded. The 48 clearly included studies had 4 excluded as they were unable to verify the reference details, a study design was proposed but no study was completed, conflict was only mentioned as a risk in the environmental assessment and 1 duplicate. Of the 34 borderline studies, 15 were included, 15 were excluded. Examples of excluded studies were looking at lake shores, no component of water supply or multi-site conference abstracts. 3 studies were excluded as it was unclear if the study related to water supply. 1 study was merged with an existing study as it was a duplicate report. If a report and journal article were discussing the same fieldwork then these were considered as one study (Balfour et al., 2025 and Wachira et al., 2025). In the end there were 59 unique studies within the corpus. This is shown in Fig. 1.

Coding

Each study was coded with information on the country, year of publication, type of publication, study design, water supply type, outcomes and how in-depth the study was read. The water supply type had 6 categories (Borehole/well, Pan/Pond/Surface reservoir, Sand Dam/Rainwater harvesting, Mixed, Water point (Unspecified) and General Supply). The outcomes had 8 categories (Conflict, Mobility, Rangeland, Livelihoods/Resilience, Health, Equity/Gender, Governance, Supply). Multiple outcomes could be reported within one study. 8 studies were read in full or key sections (Balfour et al., 2025, Shetahun, (2024), Kanno et al., (2025), Yusuf & Abdi (2025), Firdissa et al., (2025), Adi et al., (2026), Omosa (2003), Huho & Asokan (2026)), and the remaining 51 were coded using the abstract or catalogue. For the 6 studies including conflict outcomes information was extracted on the setting, sample size, data collection period, comparison and key findings.

Synthesis

The studies were grouped by country, year, publication and study design. A cross tab was created between the water supply type and the outcomes. This produced Fig. 2. The number of studies are listed in each cell. If a study had multiple outcomes they would be included in multiple cells so the total amount of studies in each column will be higher than the actual amount.

Results

Corpus

The corpus consisted of 59 studies from a total of 60 reports. 31 were from Kenya, 24 from Ethiopia and 6 from Somalia. 2 studies were from both Kenya and Ethiopia (Balfour et al., 2025 and Lane et al., 2025). The earliest study was from 1999 and 4 were published before 2005. There was a large increase in output towards the end of the time period with 17 studies being published in 2025 and 2026 (28.8%). This is a large increase compared to the 10 years between 2005 and 2014 (12 studies). 40 studies were journal articles with the remaining being theses (7), agency/institutional (6), conference (3), repository (2) and pre-print (1). The most common study design was surveys/comparisons (16). This was followed by qualitative/case study (13) and spatial/remote sensing/modelling (10). The full results are shown in Table 1.

Table 1
Characteristics of included studies (N = 59)

Characteristic	n	%
Country		
Kenya	31	52.5
Ethiopia	24	40.7
Somalia	6	10.2
Year		
1999–2004	4	6.8
2005–2014	12	20.3
2015–2024	26	44.1
2025–2026	17	28.8
Publication		
Journal Article	40	67.8
Thesis	7	11.9
Agency/Institutional Report	6	10.2
Conference	3	5.1
Repository	2	3.4
Pre-print	1	1.7
Study Design		
Quantitative (Survey/Comparison)	16	27.1
Qualitative/Case Study	13	22
Spatial/Remote Sensing/Modelling	10	16.9
Measurement (Field/Lab)	9	15.3
Mixed Methods	6	10.2
Review/Program	5	8.5
Water Supply Type		
Borehole/Well	17	28.8
General Supply	12	20.3

Characteristic	n	%
Country		
Pan/Pond/Surface Reservoir	10	16.9
Water Point (Unspecified)	9	15.3
Mixed	8	13.6
Sand Dam/Rainwater Harvesting	3	5.1
Depth Read		
Read in full or Key Sections	8	13.6
Coded from Abstract/Catalogue	51	86.4

Water Supply Types and Outcomes

A cross tab between water supply type and outcomes was created (Fig. 2). The most common outcome was supply (yield, functionality, status and reliability) with 31 studies. This was followed by governance (18), livelihoods/resilience (15), health (8), conflict (6), mobility (6), rangeland (6) and equity/gender (5). Boreholes and wells were the most common (17) and had the highest concentration within the map. Overall there were 6 cells with 5 or more studies with 4 of these being within the supply column. There were 15 blank cells. Sand dams and rainwater harvesting appeared in only 3 studies. None of these were related to conflict, mobility, rangeland, equity or governance. Water points (unspecified) tended to look at grazing and mobility with no studies looking at supply. Pans and ponds featured in 2 of the 5 equity studies but none of the mobility or rangeland studies.

Studies Including Conflict Outcome

6 studies included conflict as an outcome (Table 2). Omosa (2003) completed a survey with 100 households (75 men, 25 women) around a single borehole in Dadajabulla, Wajir County. Approximately a third of the household had conflict with water. 65% had no conflict but Omosa stated this was partly due to respondents answering the questions as it was convenient. This could not be investigated due to the study design. 42% had conflict with clan members. 91% stated there are water user associations. 82% of men and 76% of women stated conflicts were resolved through negotiation. Balfour et al. (2025) and Wachira et al. (2025) were the same fieldwork. 12 sites were purposively sampled as successful. 18 focus groups, 39 interviews and 225 participants (83 women). Informants reported conflict due to settlement around boreholes, less mobility, elite capture and borehole income. Huho & Asokan (2026) completed interviews with 50 water users in Bisan Hargeisa, Tana River County. 25 were from host communities and 25 from non host communities (22 women and 28 men). 6 key informants were also interviewed in October 2021. 90% of water sources were pans. Thematic coding was used with

frequency counts. Shetahun (2024) completed a study looking at resource conflict in South Omo. Beyene (2017) completed a mapping study looking at natural resource conflict in southern Ethiopia amongst pastoralists. Omar et al. (2025) completed a review looking at climatic pressures on water availability in Somalia. Both were coded using the abstract.

It appears none of the 6 studies compared sites with and without water points, were longitudinal or used an event design. 3 of the studies were single sites or purposively sampled successful sites.

Table 2
Studies Including Conflict Outcome

Study	Settting	Water Supply	Design/ Data	Read
Omosa (2003)	Dadajabulla, Wajir, Kenya	Borehole	Household Survey, n = 100 (75 Men, 25 Women), June-July 2002 (Masters Thesis)	Read in full
Balfour et al. (2025); Wachira et al. (2025)	12 sites, Kenya & Ethiopia	Boreholes	Qualitative, 18 Focus Groups, 39 Interviews, 225 Participants, Purposive (Successful Sites) (2024)	Read in full
Huho & Asokan (2026)	Bisan Hargeisa, Tana River, Kenya	Pans (90% of water sources)	50 Water Point Interviews (25 Host, 25 Non Host) & 6 Key Informants, October 2021	Read in full
Shetahun (2024)	South Omo, Ethiopia	Water Points (Setting)	Qualitative Study of Resource Conflict	Read in full
Beyene (2017)	Southern Ethiopia	Water Points (Unspecified)	Narrative Analysis, Mapping Conflict	Read abstract
Omar et al. (2025)	Somalia	Generic Supply	Narrative Review	Read abstract

Other Outcomes

Supply was mostly found within technical and monitoring literature. Kanno et al. (2025) looked at 37 water points across 5 zones in the Somali Region of Ethiopia. Most were ponds, micro dams and natural pans. 3 were dry during the main rains of 2025. 7 required major rehabilitation and 1 was fenced. Ndekezi et al. (2023) looked at field performance of sand dams in south eastern Kenya. Yusuf & Abdi (2025) looked at modelling use of hand dug wells in Harawa District using logistic regression. Adane et al. (2026) looked at spatial analysis and groundwater modelling of 51 borehole yields in the Lower Omo subbasin.

Governance studies looked at how access and management is organised. Firdissa et al. (2025) looked at conflict with women not being included in water committees using focus groups and interviews in Borana kebeles. Adaka & Mugambi (2018) looked at sustainability of community managed projects in

Merti, Isiolo County using a survey. Staro (2013) looked at water ownership within the Garri as a pastoral adaptation.

6 studies looked at mobility. These varied in methods used. Tachiiri (2000) looked at GIS and remote sensing using data from 1975/6. Opiyo et al. (2011) looked at mobility using a survey in Mwingi and Kitui. Berhanu (2024) looked at participatory mapping to identify livestock routes. Hussein (2005) looked at the pastoral system within Somaliland using a thesis. Ismail (2026) looked at secondary analysis of survey data from 7212 respondents to understand seasonal water source transitions in Somalia. The qualitative borehole studies have been discussed above. 6 studies looked at rangeland. Gebremeskel & Pieterse (2006) and Gebremeskel (2006) looked at field gradients around watering points in Ethiopia. Adi et al. (2026) looked at vegetation transects (with control) and Landsat imagery at a borehole in Amballo, Marsabit County.

Health studies looked at sampling water quality or exposure at water sources. Kurui (2018) looked at microbial quality of water pans in Baringo. Jaro et al. (2023) looked at faecal exposure risk in Turbi ward. Shivairo et al. (2014) looked at livestock poisoning at a borehole in Kargi. 5 studies looked at equity. Afullo & Danga (2013) looked at equity using a survey of 4872 households and focus groups on water journeys in dryland Kenya. Gebresenbet (2012) looked at gender analysis in Harshin District, Jijiga Zone. Mwaura et al. (2017) looked at livelihoods by estimating the economic value of water pans in Ijara, Garissa County (Mengistu, 2016) has undertaken survey work to understand how Borana households cope with droughts (n = 199).

Six studies have been conducted in Somalia. Four are literature reviews or program/policy summaries (Ali, 2026; Ali et al., 2022; Farah, 1999; Omar et al., 2025), one is qualitative thesis (Hussein, 2005) and one is household survey data (Ismail, 2026).

Sensitivity of publication type

Due to the mixture of publications within the corpus, Table 3 shows the number of studies focusing on each outcome domain for only the 40 journal articles. Supply performance (n = 23) and governance (n = 11) remain the most common domains. There are still very few studies on conflict (n = 4), mobility (n = 2) and rangeland condition (n = 2). When looking at just journal articles we can see how limited the data available is on mobility and rangeland. Four out of the six studies on mobility and rangeland are either theses, reports or other. This does however not affect the overall trends.

Table 3
Outcome Domain by Publication Type

Outcome domain	All studies (n = 59)	Journal articles (n = 40)	Other (n = n = 19)
Supply performance	31	23	8
Governance	18	11	7
Livelihoods & Resilience	15	9	6
Health	8	6	2
Conflict	6	4	2
Mobility	6	2	4
Rangeland condition	6	2	4
Equity & Gender	5	3	2

Note: If a study covers more than one outcome domain, it will have been counted in each category. Other includes theses, agency/institutional reports, conference items, repository items and pre-print.

Discussion

The literature has shown to be focused around whether water points are effective and how they are managed. Of the 59 studies, 31 focuses on supply performance and 18 focus on governance. The most important outcomes from the perspective of individuals living with these structures are who moves where once a borehole is installed, what happens to the grass surrounding it, who gets left out and whether there is conflict. Between five and eight studies look at these outcomes and most are site specific. Conflict is the biggest gap with 6 studies. However, none look at whether there is a difference between sites with and without a water point, or longitudinal data, or conflict events. This means that based on the information within this literature we cannot claim that water infrastructure is reducing conflict within these three countries. However, we do have a collection of varied narratives. At site specific boreholes most conflicts were resolved by negotiation and clan structures (Omosa, 2003). However, conflicts were linked to resolution, less mobility, elite capture and borehole revenue at successful borehole sites by informants (Balfour et al., 2025; Wachira et al., 2025). These can be seen as hypotheses with a mechanism behind them. Therefore, they are a good place to start; however, they are not tests. None of the three studies behind these findings were from a single location or were selected due to being a successful site therefore we cannot comment on how common these mechanisms are.

The main criticism of this being a gap is that there are studies within this corpus that look at comparative designs with conflict events. One study looked at conflict events by combining groundwater availability with violent events between 1990–2014 in Africa and the Middle East. It found that lack of access to groundwater was associated with increased risk of communal violence (Döring, 2019). However, this was not included in this mapping. Firstly, because it looked at groundwater availability

rather than constructed supply and secondly because it was carried out at a continental scale. Another study modelled post-drought dynamics in five African drylands. It concluded that poor governance of small water infrastructure can cause erosion of traditional adaptation strategies (Piemontese et al., 2024). This fits with the mechanisms seen in the Horn of Africa studies. However, this gap is at the point of decision making around infrastructure. This means it is site specific, county specific and program specific. It is likely that this gap exists due to few locations having an old registry of water points which could be linked to event data.

The finding that households with boreholes did not do any better in the 2020–2022 drought (Balfour et al., 2025) should be highlighted further. This is based on informants rather than actual outcomes. However, this goes against the premise that increased permanence in supply will increase resilience. The mobility literature explains why this may be the case. If a supply is encouraging settlement, it could limit the options available to mobile herders during a drought. The mobility studies looked at all relate to either movement in relation to water availability (Opiyo et al., 2011; Tachiiri, 2000) or mapping of routes (Berhanu, 2024). None of the studies read in full looked at movement before and after introduction of new water points. Most mobility studies were coded using abstracts meaning that the design may not have been mentioned. Therefore, the mechanism cannot be tested in this corpus.

Some studies have designs which show how they could have been done. One study used vegetation transects with a control alongside a borehole and used Landsat data (Adi et al., 2026). This is the closest to having a comparative design. However, it is only one borehole within one location. This shows how the study could have been designed but does not demonstrate any effects. Another study created an inventory of 37 water points at site level including condition and functionality (Kanno et al., 2025). This would have allowed the data to be georeferenced and linked to conflict events or movement. Together these two studies show what the study most needed in this field would have been. A registry of water points with dates linked to repeated measurements of movement, vegetation and conflict.

The country trends reflect the literature. Kenya has the most studies (n = 31) followed by Ethiopia (n = 24). Somalia has very few studies (n = 6) with four being literature reviews or program/policy summaries. Only one study looked at household survey data and it was a pre-print from 2026 (Ismail, 2026). There has been a lot of recent output with seventeen studies written in the last two years. However, many of these have been reports and repository items and the pre-print. This may indicate increasing interest from donors and researchers but means that some of the recent evidence has not been as scrutinized.

There is little evidence on equity. Women are excluded from water committees (Firdissa et al., 2025). One study documented the burden of accessing water through a survey of 4872 households (Afullo and Danga, 2013).

Limitations

This is a rapid mapping therefore the limitations need to be considered when interpreting the numbers. The search was replicable however only one index was used (OpenAlex). Consensus and SciSpace were

used to find the top 100 ranked outputs. This means we cannot calculate recall. This means that the 59 studies are a sample of the literature. Reports and theses were only included if they were indexed in OpenAlex. The search was completed in English meaning studies published in Amharic, Arabic and Somali were excluded. The index also favored English language and Kenyan publications meaning Somalia is likely to be underrepresented.

This mapping was completed by one person therefore there are no inter-rater agreement statistics. Fifty-one studies were coded using abstracts or catalogues meaning there could be missing information on the design, type of water source or secondary outcome. Two conflict studies were only able to be coded using abstracts (Beyene, 2017; Omar et al., 2025). The water source and outcome categories are subjective. If a study looks at both a borehole and pan the study will be put under mixed types. The supply performance category is quite broad and includes technical and remote sensing studies looking at yield, condition and detection. This means it is leading due to the search string being based around water supply. Twenty one of the 59 studies were categorized under general supply and unspecified water sources meaning comparisons between different water sources are quite broad. The protocol was created on 4 th November 2026 prior to coding the search results and was not registered.

This mapping looked at the number of studies. If there are ten studies in a cell this means ten studies looked at this combination. This does not mean that the studies agree. If there is one study this tells us nothing about whether it is a good study. Quality was not appraised as this is the aim of an evidence and gap map (White et al., 2020).

Conclusion

Within the pastoral drylands of Ethiopia, Kenya and Somalia the literature has mainly focused on whether water infrastructure provides water and how it is managed. There is little evidence on how it relates to conflict, mobility, rangeland, health and equity with few studies looking at each outcome. None compare locations with and without water points. The narratives that are present mention specific mechanisms (settlement, less mobility, elite capture, borehole revenue and rules around access between clans) from Dadajabulla, twelve successful borehole sites and Tana River pans. A comparative design could test these mechanisms. A national/county level registry of water points with dates of construction linked to repeated measurements of mobility and conflict would turn these mechanisms into evidence.

Declarations

Author Contribution

U.M.M conceived the research question, study design, search strategy, eligibility criteria and study protocol was created by U.M.M. The data was collected by searching for the databases, screening of records, data extraction and coding. Data analysis was performed by U.M.M, verification of the analysis was done by U.M.M. Creation of Figures 1, 2 and Tables 1-3 were completed by U.M.M. The original draft

was written by U.M.M, then revised following feedback received. The final version was approved. U.M.M is responsible for the accuracy of the work and the integrity of the content.

Data Availability

The dataset, search terms, screening records will be available from the corresponding author upon reasonable request. They will be uploaded onto an open access platform with a DOI prior to publication.Search terms with dates and results: The search terms used within OpenAlex, the dates of searches and 259 search results.Screening results: The screening criteria applied to the 259 search results and subsequent inclusion/exclusion criteria applied to the 82 candidate studies and reasons for exclusion.Dataset: The dataset coding the included 59 studies by country, publication type, study design, water source type and eight outcome categories. The codebook can be found below (Appendix A).Review protocol and amendments: Review protocol dated 4th November 2026 and a record of any amendments.The original data sources were obtained from the OpenAlex database which can be accessed freely (https://openalex.org). Full texts of included studies have been obtained from the publishers and therefore cannot be redistributed. Each study within the dataset has a DOI/URL.

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Figures

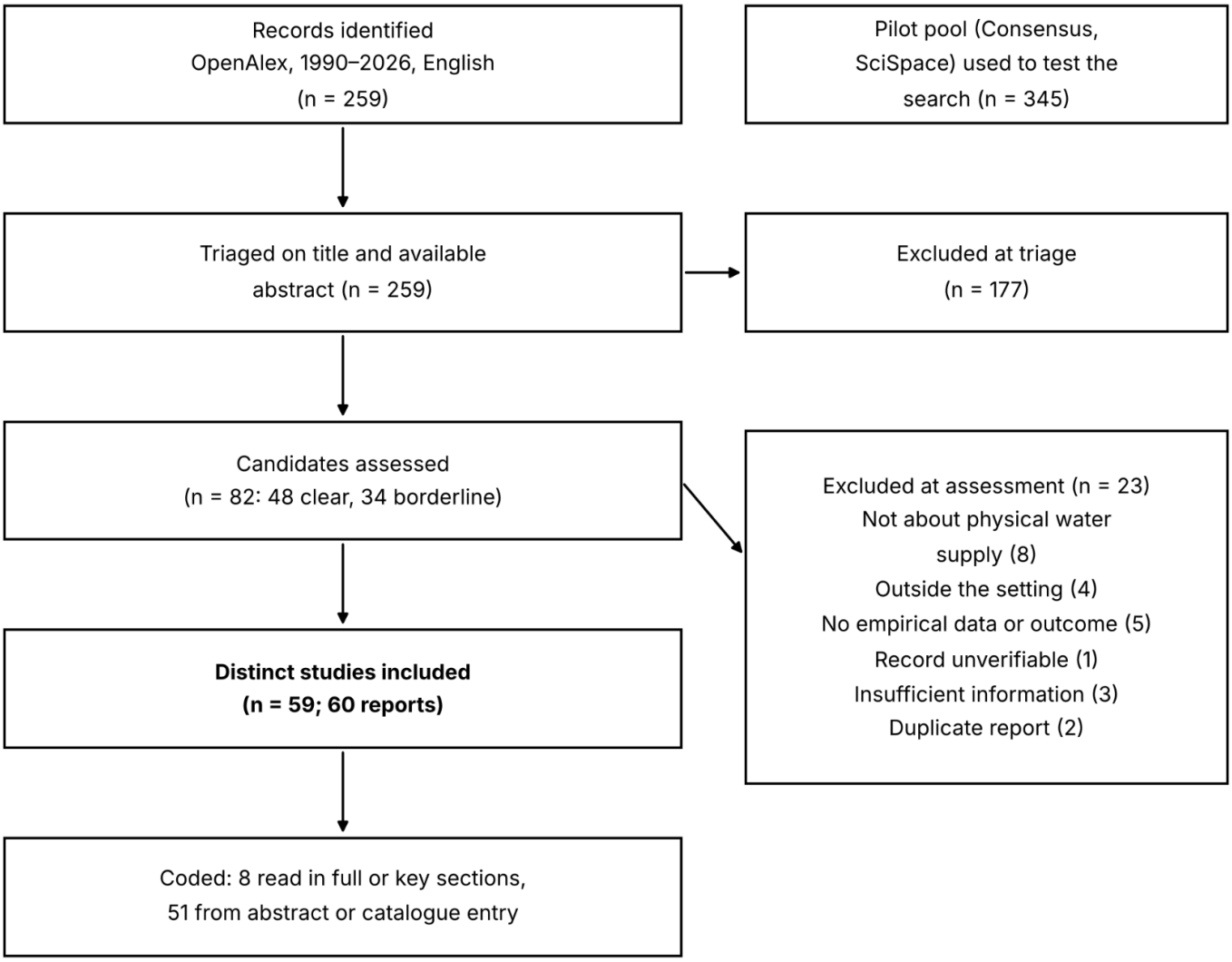


Figure 1

Flow of Records from Search to Included Studies

Note: The 345 pilot results (Consensus and SciSpace) have not been included in the triage. 1 study has been documented in 2 reports (Balfour et al., 2025 & Wachira et al., 2025).

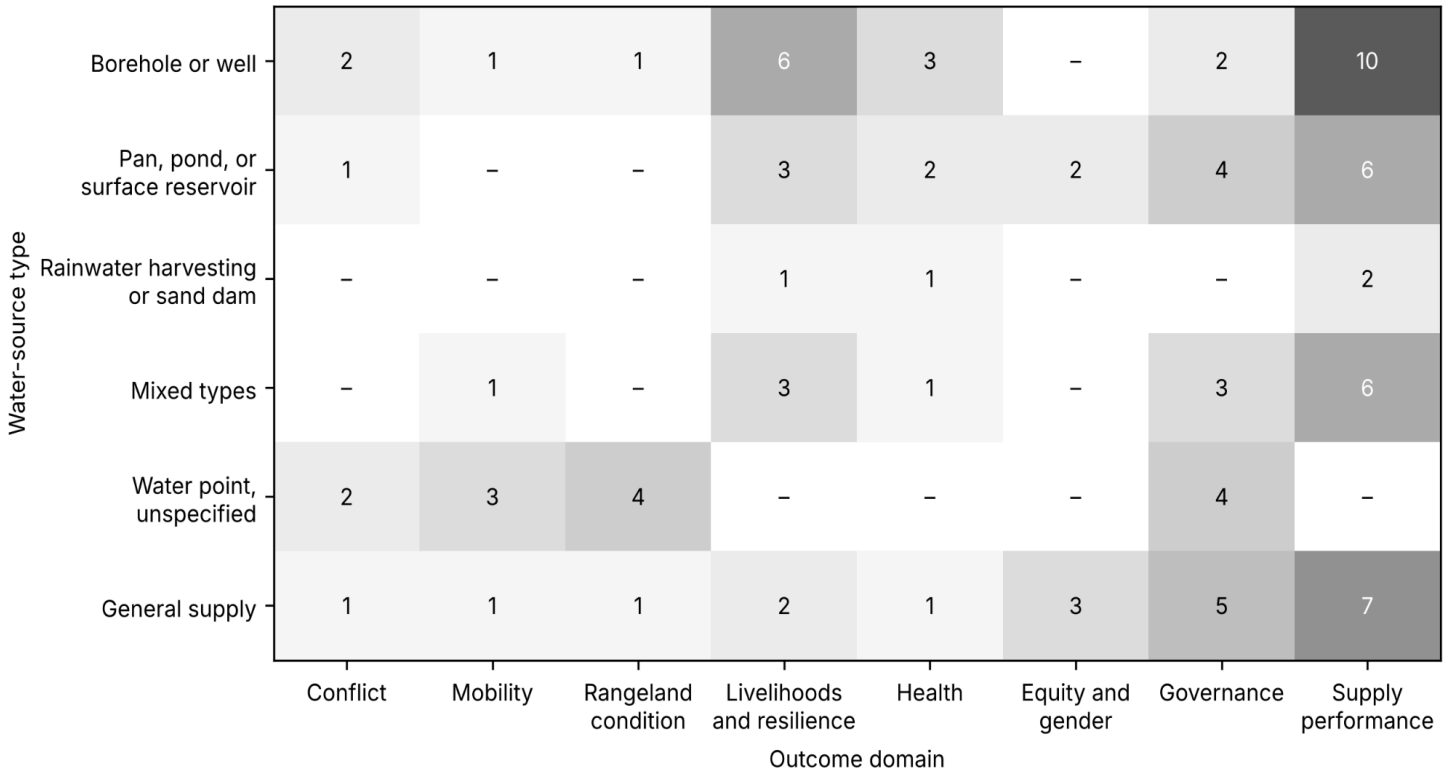


Figure 2

Number of included studies by water supply type and outcome

Note: Number of studies in each cell (N = 59). Where a study had multiple outcomes, it was included in multiple cells. This means the total number of studies in each column will be higher (6, 6, 6, 15, 8, 5, 18, 31).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- AppendixA.docx