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OVERVIEW

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The role of water in environmental migration

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Abstract

Water has always been a driver of human mobility, migration, and displacement. But water is increasingly central to explaining environmental migration in the context of climate change. Most studies of the relationship between water and environmental migration are framed around punctuated, extreme weather events and disasters that either limit agricultural or livestock productivity or make a community physically unlivable. The chronic experiences of household water insecurity and poor water governance also shape migration decision-making through a variety of social, political, and economic factors, but these relationships have received considerably less attention. This article provides an overview of punctuated and chronic water-related triggers of environmental migration at the household level. We also offer a conceptual framework based on multiphasic response theory that highlights water's multiple roles in migration decision-making. We close by reflecting on key gaps in the climate-water-migration literature, identifying research questions that might help us better understand these relationships, and considering the implications

for sustainable development policies that could potentially ease pressures on water-related displacement.

KEYWORDS
climate change, displacement, extreme events, mobility, water insecurity

1 | INTRODUCTION

Migration has always been a central behavioral adaptation of human species to the local impacts of climate change. Our earliest ancestors may have been "rain chasers" while nomadic (Finlayson, 2014); effective forms of terrestrial mobility then allowed both the global spread of *Homo sapiens* and the capacity to mitigate drought (and other disaster) once communities settled and grew. The Mayan city of Tikal may have been abandoned over time due to toxic contamination of city reservoirs during droughts (Lentz et al., 2020), and in China, the ancient Shu Civilization may have deserted towns due to a combination of climate change and an earthquake-induced flood (Wen et al., 2013). Throughout human history, water has played an important role in environmental migration through drought, flood, disaster, or pollution.

Most studies of the relationship between water and environmental migration are framed around rapid-onset extreme weather events and disasters that either limit agricultural or livestock productivity or make a community physically unlivable (Zickgraf, 2021), in either case, theorized to trigger human movement (Stoler et al., 2021). These tend to be large scale, temporally punctuated migrations involving most if not all inhabitants of a place. A less-studied pathway is an everyday, chronic human experience of water insecurity, cumulatively shaping household-level decision-making to migrate through socio-environmental, political, or economic factors. Such chronic water struggles may be slow-onset in nature or degree, or persistent; we emphasize the descriptors punctuated and chronic in place of the more common distinction between rapid- versus slow-onset events.

Our goal in this overview article is to highlight all the potential ways that water shapes human movement to help future scientists and policy makers cultivate a more holistic understanding of the role of water in environmental migration. We begin by reviewing traditional migration theories in order to ground our sense of how water affects households and communities. We then provide an overview of the major pathways through which water can trigger migration, mobility, and displacement. We summarize punctuated extreme event triggers, particularly climate-induced extreme weather events such as floods and droughts which have received the most attention in the study of water-related migration. Next, we describe much less-studied chronic triggers of migration related to water pollution, water insecurity, and state-sponsored infrastructure projects. This article considers both punctuated extreme events and chronic triggers of environmental migration at the household level in particular. This overview expands the broader literature seeking to link climate change, environmental degradation, and migration (Warner et al., 2010). We also reflect on water's role in the *myth of return* for migrants (i.e., their ability to return to their origin once push factors have subsided), which can determine the relative permanence of a move, and close with a proposed research agenda for future study of the conditions and triggers of water-related migration.

However, first, we must clarify key terminology. Historically there has been no consensus definition of *environmental migration*, and its categorization has been contested (Oliver-Smith & Shen, 2009). We use the International Organization for Migration's (IOM) definition: environmental migrants are "persons or groups of persons who, predominantly for reasons of sudden or progressive change in the environment that adversely affects their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad" (International Organization for Migration, 2011). We also acknowledge three types of movement, as summarized in Table 1: migration, mobility, and displacement. Drawing on Adger et al. (2018), mobility refers to the spatiotemporal continuum of movement ranging from internal to international movement and temporary to permanent relocations in response to slow-onset and sudden-onset environmental change. Mobility does not necessarily constitute migration if movement is local and occurs within a defined range, as with some nomadic pastoralists, or if the household location does not change. *Migration* refers to the deliberate and planned movement of individuals and/or households based on the "changing attractiveness of places" (Adger et al., 2018, p. 31). Displacement, in an environmental sense, is an involuntary movement of populations from their current residence as a consequence of weather-related events. Migration and displacement can be temporary or permanent; while displacement is typically a reactive

TABLE 1 Definitions of key terms

Key term	Definition	References
Migration	Planned movement of individuals and/or households based on the changing attractiveness of places.	(Adger et al., 2018)
Mobility	The spatiotemporal continuum of movement ranges from internal to international movement and temporary to permanent relocations. The capacity and ability of households or individuals to physically move, whether permanently or temporarily, far or near.	(Adger et al., 2018)
Displacement	Short term, unforeseen involuntary movement of populations from their place of residence.	(Adger et al., 2018)
Environmental Migration	Short- or long-term movement resulting from the inability to manage sudden or long-term environmental degradation, disruption, or disasters, such as floods, worsening water insecurity, or drought.	(International Organization for Migration, 2011)
Water Insecurity	Inability to access and benefit from adequate, reliable, and safe water, especially for everyday household use.	(Jepson, Wutich, et al., 2017)
Household	The smallest residential unit within societies, defined by living under the same roof, with pooling of domestic labor and sharing of food and other material essentials.	(Netting, 1993)
Adaptation (adaptive strategy/capacity)	The capacity and ability to manage (cope with) environmental challenges, including household water unpredictability and shortage.	(Wutich & Brewis, 2014)
Flooding	A general and temporary condition of partial or complete inundation of normally dry land areas due to precipitation, overflow of bodies of water, or infrastructure failure	(FEMA, 2018)
Drought	A period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance.	(World Meteorological Organization, 1992)

mobility response, migration is generally a proactive response. We draw a distinction with the term *refugee*, which was defined by the United Nations in 1951 as a person who had fled their home to escape war, violence, or persecution (Zimmermann et al., 2011). Terms such as "environmental refugee" or "climate change refugee" have no basis in international refugee law (International Organization for Migration, 2020), so we avoid using them here.

2 | METHODS

Given the expanse of literature related to water and migration, we began by conducting a narrative review. While not as exhaustive as a systematic review, this approach can be more appropriate when encompassing very broad research topics, and for identifying studies that do not rely on quantitative data techniques or where comprehensiveness and objective methods are not a priority for comparing similar studies (Collins & Fauser, 2005; Ferrari, 2015). Narrative reviews permit highlighting specific lines of research, justifying new research agendas (Ferrari, 2015), and synthesizing broad interdisciplinary sets of literature (Green et al., 2006). Narrative reviews also facilitate the inclusion of information that may not be a study's primary research objective. For example, migration may be beyond the scope of many water intervention studies, yet tangentially mentioned in the discussion of subsequent adaptations to water problems as an unmeasured observation. These relationships make the kinds of keyword searches used in systematic reviews less practical.

We consulted a wide range of interdisciplinary literature to strike a balance between the overwhelming scope of literature on punctuated, extreme-event-driven migration, and the lack of a well-defined literature on chronic water-related migration. We searched for literature published in English as of June 1, 2020 (and iteratively updated through March 31, 2021) in Scopus, PubMed, and Google Scholar, and then traced citations and used our team's knowledge of the water literature to explore related studies. We started with a set of keyword searches using the terms *water security* and *water insecurity* in combination with the migration-related terms in Table 1 and contextual terms such as *extreme events*, *climate change*, *floods*, *droughts*, *pollution*, *infrastructure*, *dams*, and *governance*. We iteratively updated our

categorization of the relationships between water and environmental migration to reflect the most common themes as they emerged in the searched literature.

3 | THEORETICAL LINKS BETWEEN WATER AND MIGRATION

The number of studies linking environmental change and mobility has grown rapidly in recent years (Hunter et al., 2015; Piguet et al., 2018; Zickgraf, 2021). This is linked to increasing awareness of the impacts of extreme weather events, rising sea levels, environmental degradation, and other environmental transformations on human well-being, human mobility, and international security (McLeman & Gemenne, 2018). Researchers from various disciplines (geography, demography, economics, environmental science among others) are contributing, employing diverse theoretical and methodological approaches (Veronis et al., 2018). A range of environmental factors, from slow- to sudden-onset, have been studied in relation to human mobility across the globe, although Piguet et al. (2018) report a majority of studies have focused on the Global South. There has also been an overall shift in the environmental migration literature from so-called "maximalist" approaches—which view environmental factors as primary drivers of migration—to "minimalist" approaches—which highlight the interaction of multiple factors that shape a variety of migration and displacement outcomes: internal, international, temporal, permanent, and voluntary or involuntary immobility (Veronis et al., 2018; Zickgraf, 2019).

Mobility patterns, and the factors that cause them, have been the subject of a large body of research (de Haas et al., 2020; Massey et al., 1993). Several theories have been developed to explain the emergence and perpetuation of migration flows. Some emphasize structure (historical–structural, mobility transition and dual labor market theories) or agency (neoclassical, human capital, and New Economics of Labor Migration), different scales of analysis (micro-, meso-, and macro-scales), and/or the dynamics of migration flows over time (networks, cumulative causation and migration system theories) (de Haas, 2021; Massey et al., 1993). While a full description of these theories is beyond the scope of this paper, it is important to note that the New Economics of Labor Migration (NELM) approach examines household decision-making concerning migration, an important body of research for scholars working within an environmental migration framework. NELM scholars critically responded to neoclassical approaches by emphasizing the microscale importance of migration and asserting that members of families and households make decisions about migration collectively (Stark, 1991; Stark & Bloom, 1985; Taylor, 1999). According to NELM, members of families and households make migration decisions collectively in an attempt to maximize their economic position through various mechanisms with the understanding that capital markets do not exist to provide insurance or investment loans (Massey et al., 1993; Taylor, 1999). From this perspective, migration is a risk-sharing behavior that diversifies income. This approach emphasizes the agency of resource-poor households to improve their livelihoods, demonstrating that households respond to relative deprivation and not absolute poverty.

Migration scholars have also proposed theories that incorporate multiple perspectives and assumptions rather than individual disciplinary perspectives (Massey et al., 1993). Such conceptual heterogeneity is possible when diverse migration theories are combined through four analytical scopes: scale of analysis (from micro to macro), diverse geographic contexts, temporal considerations, and across varied social groups (de Haas, 2010). Applying the capabilities framework to migration, de Haas (2014) suggests that we can accommodate conceptual heterogeneity by considering structure, that is, social institutions and factors that limit, constrain or enhance opportunities that individuals think they have, which may impede or facilitate the migration process, and agency, the actual capacity people have to make independent migration decisions and choices about their lives in the structural contexts with the possibility of influencing constraints and opportunities enforced by structure.

Following de Haas (2014), the structure of environmental change as a migration push factor is rarely independent of economic structures. When migration involves an environmental driver such as water insecurity, it is unclear to what extent a given migration decision is relatively more economically or environmentally motivated. Often, it is a combination of the two, especially to the extent livelihoods are dependent on, and sensitive to, environmental change (Afifi, 2011). This is an example of "minimalist" thinking from the perspective of environmental migration research, that is, examining how environmental factors interact with nonenvironmental factors to explain different mobility outcomes in different contexts.

Minimalist approaches have an important precedent in literature using the sustainable livelihoods framework. Scholars applying this framework draw on the capabilities approach to development (Sen, 1999), viewing migration as just one activity within a diversified portfolio of livelihood strategies that sustains the social reproduction of households

(de Haan et al., 2002). An important insight of this literature is understanding how migration was structured by meso-level institutions such as gender, kinship and household demographics (de Haan et al., 2000), echoing the NELM approach.

In the climate adaptation literature, some researchers have concluded that how environmental change shapes mobility outcomes of households is highly contingent on local conditions (Black et al., 2011; Hunter et al., 2015; Warner, 2011). Black et al.'s (2011) influential model points to the importance of conceptualizing the complex interplay between specific environmental and nonenvironmental factors (economic, political, social, and demographic) across macro, meso, and micro scales on migration decision-making. In addition to economic, political, social, and demographic drivers to migration, some studies have shown that nonmaterial dimensions of decision-making have an important impact on adaptation to climate change and mobility outcomes for households. For example, risk perception and perceived adaptive capacity (Grothmann & Patt, 2005), and place attachment and rootedness (Adams & Kay, 2019), shape mobility outcomes. In contexts of environmental change, Tebboth et al. (2019) draw on the capabilities approach to explain how mobility endowments and entitlements mediate individual and household resilience.

Research on migration and environmental change has often investigated the more straightforward displacement of people from natural hazards, particularly refugee movements (e.g., Lister, 2014; Lopez-Carr & Marter-Kenyon, 2015). Fewer studies have examined migration events specifically catalyzed by chronic environmental deterioration (Ervin et al., 2020; Lonergan, 1998). But, emerging work on environmental causes of global urbanization (Adamo, 2010), such as climatic change and migration in Pacific islands suffering sea level rise (Berchin et al., 2017; Moore & Smith, 1995), is expanding this literature, as is research on migration in response to drought (e.g., Ezra & Kiros, 2001; Findley, 1994; López-Carr, 2012).

In order to link chronic water-related triggers at the household level to migration, we propose a conceptual framework that builds on multiphasic response theory. This theory frames migration as a last-resort response to population and environmental pressures after exhausting alternative socioeconomic options (e.g., Bilsborrow, 1987; Carr et al., 2009; Davis, 1963). A large literature explores migration links to agricultural intensification and deforestation (Carr et al., 2006; Dias et al., 2016; Geist & Lambin, 2002), but here we emphasize the household-centered approaches of multiphasic response theory and NELM. Population scholars have extensively researched connections among household responses to resource scarcity (traditionally land and money/assets) and migration; similarly, economists investigate household responses to scarcity and off-farm labor. While these disciplinary literatures are largely siloed from each other, analogous links between water scarcity and migration are likely quite inter-related in the complex decision-making of individuals and households—particularly given how, in extreme cases, the temporally dynamic nature of household water scarcity can require daily adaptation (Price et al., 2019).

Figure 1 depicts our positioning of household water scarcity within multiphasic response theory, sensitive to structure-agency frameworks and NELM approaches. Households will respond to punctuated and chronic water-related triggers in one or multiple ways simultaneously or sequentially, and in the context of demographic, political-economic, and socio-ecological processes at multiple scales. Urban households are more likely to recalibrate water budgets within the household (e.g., Tomaz et al., 2020), whereas rural households are more likely to adjust agricultural water use and planting decisions (e.g., Bryan et al., 2013). In either case, these adaptations may be related to economic diversification strategies directly (by shifting labor to less water-intensive jobs or crops) or indirectly (such as by limiting labor opportunities requiring hydration or regular laundering of uniforms). Individuals and households may thus change consumption, water use, land use, labor, capital investments, or even family planning strategies before resorting to migration. These adaptations to water availability or reliability, especially once in situ options have become exhausted (e.g., water and land management and/or off-farm labor) may ultimately include the decision for a household member to out-migrate. Once a decision, or series of decisions, is made, other responses may follow sequentially or simultaneously, with multi-scale feedbacks on the external structures and processes that shape subsequent household decision-making. Note that urban migration may limit individual and household options connected to natural resources that are, generally speaking, available in rural contexts; urban water management more often requires negotiating with a different mix of public and private water services, and different forms of water sharing arrangements. Thus, unlike in more rural locales, achieving water security presumes a minimum capacity for monetary water expenditures from savings and/or wage labor.

4 | PUNCTUATED TRIGGERS OF MIGRATION

In these final sections, we outline how water shapes migration, mobility, and displacement using a nuanced lens that includes structure and agency at multiple scales, particularly the agency of individuals within households to make

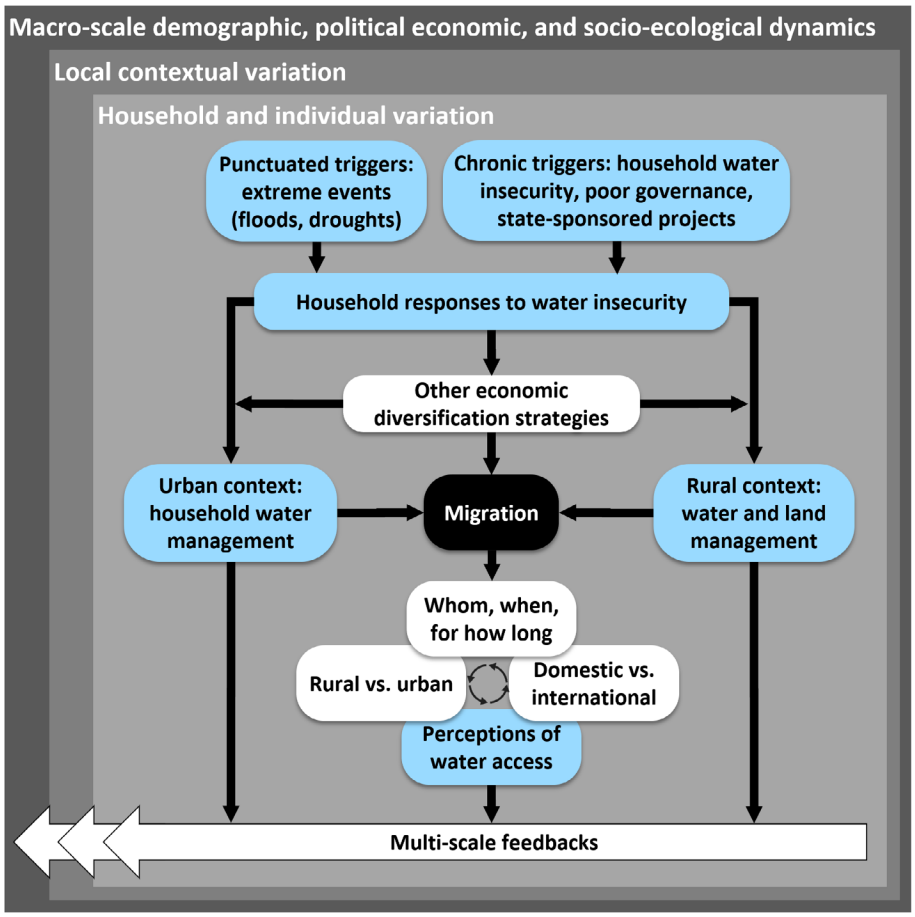

FIGURE 1 Household multi-phasic responses to water insecurity that may lead to migration, operating with contextual variation at the macro, local, and household level

multiple sequential and simultaneous decisions to adapt to water scarcity. We begin by summarizing the role of climate change in water-related movement, with examples of how extreme events trigger punctuated movement by virtue of too much or too little water. We then summarize chronic, "everyday" factors that increase the propensity of movement related to pollution, household water insecurity, state-sponsored infrastructure projects (such as dams), and other contextual vulnerabilities that interact with water to produce human movement. Casting these triggers as punctuated versus chronic raises questions about the conditions and thresholds for triggering migration decisions. Extreme climate events have received the most migration research attention, and the imagery of these rapid-onset events in the popular media tend to emphasize the human toll of major storms, heat waves, droughts, and other hazards. Importantly, extreme events, themselves, may not always be the cause of migration. Instead, damage to water infrastructure may be the catalyst for movement, as seen after Hurricane Maria (Cloos & Ridde, 2018). We begin by summarizing the role of climate change in water-related migration, mobility, and displacement with the caveat that attributing any form of migration solely to climate change is myopic given the complexity of human movement (Nielsen & Reenberg, 2010). We then highlight forms of migration, mobility, and displacement that are associated with droughts and floods, the most common and devastating water-related extreme events.

4.1 | The role of climate change

Climate change is projected to drastically alter water availability on a global scale due to changes in precipitation and evaporation (Konapala et al., 2020). The frequency of both low and high extreme precipitation events is expected to increase (Fischer & Knutti, 2016; Trenberth, 1999), as will heavy precipitation events over equatorial and extratropical regions, particularly the tropical Pacific Ocean and the Asian monsoon regions, and decrease over subtropical regions

(Pfahl et al., 2017). Widespread droughts are projected, with severe droughts over water scarce regions such as southern and western Africa, southern North America, and the Mediterranean (Ukkola et al., 2020; Zhao & Dai, 2017). Recent evidence also suggests increases in the frequency of intense precipitation as well as decreases in the frequency of light precipitation (Fischer & Knutti, 2016). In other words, there will be less frequent rain, but when it does rain it will be heavier.

Such heavy precipitation events can contribute to flash floods and landslides, which not only threaten human lives but also cause economic loss. Yet, extreme low precipitation events can contribute to droughts, impacting food and energy production. Extreme heat events like heat waves further compound household water needs during droughts. Thus, both high and low extreme precipitation events—and their unpredictability—can increase water insecurity. While less frequent precipitation events have a direct impact on water insecurity by simply decreasing water availability and reservoir levels, heavy precipitation events have an indirect effect on water insecurity through the distribution of water between soil and surface water (Eekhout et al., 2018) and on water quality (Poncelet et al., 2010; Rakib et al., 2019). An increase in precipitation intensity allied to a decrease in precipitation frequency could lead to a redistribution of water and a subsequent reduction in soil water content, increase in erosion, and increase in water inflow in streams and reservoirs (Eekhout et al., 2018). The reduction of soil water content causes vegetation stress, and cascading increases in erosion. Increased erosion leads to sediment deposition in reservoirs, threatening supplies of drinking water as well as water for agricultural and industrial purposes. The overall impact of these processes is a reduction of water security (Eekhout et al., 2018).

It is important to note that floods and droughts are compound events. Although precipitation frequency and intensity are major causes of floods and droughts, extreme events result from a combination of factors that include weather conditions, topography, and land use and cover. Below, we outline how floods and droughts, in particular, appear to influence migration, mobility, displacement.

4.2 | Floods

Flooding can be caused by inadequate drainage, by flooding from small streams or major rivers in which houses have been built in the catchment areas or on the banks, or from coastal flooding and high tides (Douglas et al., 2008). Floods frequently cause internal displacement within a community, and can also lead to migration, especially when they oscillate with drought (Rain et al., 2011).

When houses flood due to temporary rains, seasonal monsoons, or infrastructure failure (stormwater drains overflowing), households are left with few options: movement from home to those of less-affected relatives, a communal living space, guest house, hotel, or to leave the community entirely. Therefore, floods can lead to migration, mobility, and displacement. In the wake of flood events, households must respond to changing water availability or worsened water quality for their domestic and irrigation needs; drinking water needs are most urgent. In coastal poor urban communities, like in Lagos, Nigeria, flooding events affect livelihoods, the ability to get to work, and access to food and potable water (Adelekan, 2010). In areas that experience seasonal flooding, like the Mekong Delta, research has found that seasonal flooding often pushes farmers to urban centers to boost their livelihoods, but that repeated flooding events which lead to crop destruction can lead people to migrate (or be displaced) elsewhere (Dun, 2011). However, extreme flooding also has the possibility of restricting movement (Findlay, 2012; Gray & Mueller, 2012). Extreme flooding in Bangladesh was found to be inversely associated with out-migration in the previous 12 months due to being "trapped in place" (Chen et al., 2017). Low-income households in coastal cities can also be trapped in hazard zones when flood-induced outmigration triggers housing market re-sorting, which produces new patterns of climate gentrification and vulnerability in both the origin and destination locations (de Koning & Filatova, 2020).

Ultimately, how flooding affects mobility, migration, or displacement depends on the various factors within each environmental context. But, it is often households that are Indigenous or otherwise socially and economically marginalized, to begin with that tend to suffer disproportionately from flooding events (Sultana, 2010). For example, a historic flood created unlivable conditions in nearly 40 of the 100 rural lowland communities of Tsimane', an indigenous group in Bolivia (Trumble et al., 2018). In response, households retreated deep into the forest, to temporary secondary homes in their fields, or to the main market town where they slept in open-air gymnasiums (Rosinger, 2018). The movement of the Indigenous population into market towns was compounded by discrimination, and most returned to their communities after the flooding subsided (defying the so-called *Myth of Return* discussed below). Women too are often at

heightened risk compared to men. Following floods, men in Bangladesh often migrate as a coping strategy in search of livelihoods, either fragmenting households and leaving women behind or uprooting the family (Sultana, 2010).

4.3 | Droughts

Beyond singular, extreme events, water insecurity related to periodic low rainfall or extended dry seasons has long defined arid and semiarid regions. Substantial areas of semi-arid sub-Saharan Africa are inhabited by nomadic or semi-nomadic pastoralists, who have historically used mobility to manage water needs (both for direct consumption and through adequate rain-fed pasture and livestock surface water sources) during dry seasons (e.g., Huho et al., 2011). These movements can be for a number of months each year, when conditions are driest and surface water sources evaporate. In northern Ethiopia, for example, up to 20% of those surveyed used such temporary migration as an immediate response to periodic drought (Hermans & Garbe, 2019), returning to origin once the rains began.

In the 20th century, movements of nomadic groups were increasingly constrained by state enclosures and the establishment of national parks, which undermined the sustainability of this transhumant mode of adaptation (Turton, 2011). In Uganda, one study found that about half of households relied on a surface water source that becomes unusable in the dry season because of evaporation (Pearson et al., 2015), meaning that they must find alternative sources rather than alter water usage activities to manage shortfalls. Research from Uganda and Tanzania observed changes in the type of water sources used during the dry season, with increased use of poor quality water and the risks that brings (Pearson et al., 2016). Of course, mobility may also be a response to food insecurity related to inadequate rain to feed crops or provide pasture for livestock, another more indirect mechanism. Because of the historical reliance on seasonal mobility in places like East Africa, the movement remains a practical necessity for many households even in the face of government efforts to promote sedentarism or punish trespassing, and the often tenuous nature of mobility patterns (Fratkin & Roth, 2006).

Severe drought will, of course, also lead to migration or displacement. Research in Nepal shows that those depending on agriculture migrate when springs, rivers, and irrigation canals have completely dried, making agricultural lifeways untenable (Joshi & Dongol, 2018). Even in the US, some researchers predict a mega-drought in the southwestern states without long-term planning, policy, and societal change (Gober et al., 2016). It is unclear how these major events may change patterns of movement and whether these will vary by rural/urban settings or particular dimensions of water conditions in specific places. However, such events are expected to increase and, as such, may be a growing area of research.

5 | CHRONIC TRIGGERS OF MIGRATION

This section summarizes the growing body of evidence that suggests that households also move or are displaced due to everyday experiences with water. These persistent, and often structural, factors are better described as chronic than slow-onset. Such experiences may be related to various dimensions of household water insecurity, or may stem from poor governance that fails to buffer households from the effects of climate change, tainted water supplies, exploitative water arrangements, government or industrial infrastructure projects, or other socio-environmental phenomena. We conceptualize these factors as contributing to the "slow drip" of migration (Stoler et al., 2021), a distinctly different pattern of movement that risks being overlooked when the focus is on dramatic, large-scale migration, or displacement waves triggered by extreme events.

5.1 | Household water insecurity

Water and sanitation insecurity contributes to almost 3% of global deaths and more than 100 million disability-adjusted life years, with most of this burden attributed to diarrheal diseases and associated mortality in young children (Prüss-Ustün et al., 2019). Adults are also affected through many mechanisms. For example, limited water access (Brewis et al., 2019) and drinking water salinity (Scheelbeek et al., 2017) have both been found to be related to high blood pressure, despite completely different mechanisms (stress vs. ingestion; Rosinger & Young, 2020). The effects of water insecurity are not limited to communicable and noncommunicable disease or economic livelihoods, but extend also to psychosocial health and social opportunity. The lack of access to safe and reliable water supply can increase time spent

away from educational opportunities for children and economic opportunities such as farming or other forms of employment in addition to reducing time for other household activities (Geere & Cortobius, 2017; Gross et al., 2018).

Water insecurity can also contribute to increased anxiety and depression, and also stress domestic relationships with the burden disproportionately falling on women (Choudhary et al., 2020; Stevenson et al., 2012; Wutich et al., 2020). It can also limit food preparation and increase water costs, leaving less disposable income for food, and the stress that engenders (Brewis et al., 2020; Stoler et al., 2020). All of these household disruptions may serve as (likely interacting) push factors, but our literature review did not identify any studies of direct links between these types of chronic household micro-events and experiences and decisions around climate migration.

When local environmental challenges such as water pollution threaten communities, the most effective solution may, in fact, be migration (Black et al., 2011). There is some evidence that water insecurity—specifically experienced as quantity shortages and pollution—is connected to migration (de Andrade Melim-McLeod, 2018; Hermans & Garbe, 2019; Rakib et al., 2019) and mobility (Pearson et al., 2015). In coastal areas of Bangladesh where the groundwater is heavily influenced by sea-level rise, communities faced increases in water scarcity and water salinity that increased consideration of migration as a climate change adaptation strategy (Rakib et al., 2019). In the United States, water system distribution deficiencies caused widespread lead pollution which resulted in a portion of the population being desperate to leave but trapped due to socioeconomic challenges (Morckel & Terzano, 2019; Sim, 2016).

There is, however, scant research surrounding contemporary migration caused by water pollution in itself. The locus of "pollution migration" within scientific literature has primarily focused on air pollution as a driver of migration. Studies of environmental migration have focused on the context of migration due to water scarcity, sea-level rise, and flooding events, with little direct attention given to the connection between migration as a result of water pollution (McAuliffe & Khadria, 2019).

The limited literature addressing water pollution and human migration that does exist generally acknowledges migration as being influenced by environmental change (e.g., Black et al., 2011). Migration, mobility, or displacement could be prompted by pollution, yet lack of resources for a move can trap residents in place (Morckel & Rybarczyk, 2018). For example, housing prices plummeted in Flint, Michigan, USA, following the lead crisis, destroying home equity that would have helped residents to relocate (Christensen et al., 2019). In Pennsylvania, shale gas exploration hurt housing prices, but most particularly for households that relied on private well water due to threats of contamination (Gopalakrishnan & Klaiber, 2014). The reverse may also be true whereby water pollution can also be worsened or triggered by rural–urban in-migration and insufficient infrastructure to sustain urbanization (Karn & Harada, 2001; Schwarzenbach et al., 2010).

Household water insecurity in the context of climate variability appears to contribute to population migration, but the converse is also often true: the availability and reliability of water resources—even if only perceived—can be pull factors bringing migrants to particular new areas or regions. Urban areas, which are usually located in close proximity to significant fresh-water resources, offer purified water, piped networks, and generally better infrastructure than in rural areas. Indeed, many urban residents in developing regions source their water from multiple sources, including private taps, local public water taps, boreholes, wells, surface water sources, kiosks with plastic tanks, water delivery services, packaged water, and friends and neighbors with private taps (Elliott et al., 2019; Keough & Youngstedt, 2019; Smiley & Stoler, 2020). Migration forces that have little or nothing to do with climate change or water insecurity may therefore also induce migration that then has substantial impacts on the capacity of places to cope with climate stresses. Population and development can stress water supplies in unexpected ways, particularly in small, rapidly growing towns without scalable water infrastructure. Residents may eventually experience new water-related migration pressures associated with in-migration of people from other water-stressed areas (Dickin et al., 2020). Such in-migration can also disrupt social norms and sharing arrangements for public water sources, particularly in urban slums (Adams et al., 2020). Thus, the distal causes of these cascading ripples of migration may be related to water problems in another geographic location, perhaps even at a different spatiotemporal scale.

Of course, these push and pull factors are often iteratively interrelated. Box 1 presents the case of Niamey, Niger, as an example of how water may simultaneously serve as economic and environmental push and pull factors.

5.2 | Governance and state-sponsored infrastructure

Poor governance exposes households to water failures or cripples household responses in several ways that may either trigger migration or trap households in place (Mirza, 2007). Governance shortfalls also often lead to a daily struggle for

BOX 1 Water and migration in Niamey, Niger

The case of Niamey, Niger, presents an interesting example of water as both an environmental and an economic pull factor. For residents of the city who cannot afford a direct piped water connection in their homes, door-to-door water vendors (known as *ga'ruwa* in Hausa) fill the gap. In Niamey, this job falls exclusively to men. Many of these vendors are Tuareg and Fulani migrants from Mali and Northern Niger. The Tuareg and Fulani groups practice transhumance, a type of pastoralism, through the Sahel and the Saharan regions of West Africa, but shifting rainfall patterns and land tenure disputes that favor sedentary groups have disrupted traditional practices and resulted in loss of livestock, a key material resource in these culture groups. Members of Tuareg and Fulani groups have moved to urban areas and assumed temporary, sedentary roles while working in various sectors of the urban economy to earn enough money to re-establish their herds. One such sector is water delivery.

The act of delivering water through the sandy, dusty streets of Niamey is something local residents—many of whom are from sedentary ethnic groups—largely choose not to do because it is a role perceived as "women's work." Tuareg and Fulani men, however, do not share this gendered cultural association with water delivery and have become a large percentage of those employed in this occupation. In summary, Tuareg and Fulani men have lost herds due to water shortages (a push factor), and the opportunity to work in water delivery in an urban area like Niamey with a more reliable water supply is a pull factor. In both cases, these drivers of migration are both economic and environmental. In Niamey, Tuareg and Fulani are thus often employed delivering the substance that forced them to migrate to the city in the first place (Youngstedt et al., 2016).

A *ga'ruwa* delivering jerry cans of water along a Niamey, Niger, street in 2015. Photo by Sara Beth Keough.

households to locate and manage water, expending time, and other crucial household resources. Government actions that result in exploitative water arrangements, or the sanctioning of industrial infrastructure projects, may also have severe consequences for households and communities. Government framing of climate-water-migration issues as a security issue, for example, can produce unintended consequences such as the expansion of hydrological infrastructure at the expense of improving community adaptive capacity to climate change, or even new border walls, as seen respectively in Jordan and Israel (Weinthal et al., 2015).

Weak or contested governance of water resources often leaves residents with limited or inequitable water options. Those with municipal water services may receive intermittent supply that may be reliable (as in some urban rationing schemes) or unpredictable (Galaitsi et al., 2016), forcing households to rely on similarly unpredictable water vendors (Price et al., 2019). These disruptions often force households to use lower-quality water and change their plans during the day (Smiley & Stoler, 2020). Both the interruptions to water services, and the constant changing of daily schedules around water availability, are universal experiences of water insecurity (Young et al., 2019), and are social disruptions

theorized to increase migration propensity (Stoler et al., 2021). When households have intermittent—though predictable—water availability, they can adapt by using timers and pumps to fill storage containers when municipal water is flowing, chaining household errands in ways that make water pickups more convenient, or otherwise accommodating water vending or delivery schedules. When water availability is unpredictable, the extra planning and opportunity costs associated with household water management are much more disruptive and thus is more likely a push factor for migration. But, again, these factors are not well understood because they comprise a significant gap in the environmental migration literature.

State-sanctioned privatization of water, often through water utility management contracts or public–private partnerships, often does not improve water services as promised and may result in higher water costs for households (Tariq et al., 2019). Such commodification schemes are often inconsistent with entitlements and capabilities approaches to household water security (Gimelli et al., 2018; W. Jepson, Budds, et al., 2017), which respectively refer to equitable availability and use of water through legitimized rights, and the broader use of water toward human wellbeing. Migration propensity is theorized to increase when privatized water access limits human capabilities, and especially when higher water costs or lower availability limits livelihoods. This is the case in both rural and urban contexts, whether limiting agricultural productivity, or limiting entrepreneurship opportunities through jobs such as food preparation, hairdressing, cleaning services, and other water-intensive services (Stoler et al., 2021). The extent to which water limits nonagricultural or nonlivestock livelihoods and prompts migration is also an obvious gap in the extant environmental migration literature.

However, state-sponsored infrastructure developments that address climate stress, such as dams or other water diversion projects, are well established as a significant driver of migration. There is a long legacy of displacement associated with water resource development in the Global South (Cernea, 1990) and occasionally in the Global North as well (Zagoršeková & Čiefová, 2019). China's Three Gorges Dam project displaced over a million people, and dam projects are part of a National New-Type Urbanization Plan that is expected to displace another 300 million rural Chinese (Wilmsen, 2018). Conservative global estimates place the numbers displaced by large dams at 60 million (Scudder, 2012), but this omits the impacts of dams on downstream populations, which may occur in part due to the end of natural flood cycles. When rivers are regulated by upstream dams, seasonal changes in river level and volume of flow can be severely dampened, with implications for farming and ecology downstream. Richter et al. (2010) estimate that over 470 million people's production systems have been substantially disrupted by large dams globally. Displacement from water diversion projects has been associated with adverse health outcomes, food insecurity, joblessness, and social exclusion (Cernea, 1990), all of which interact with the experience of water insecurity that these infrastructure projects often seek to mitigate. Ethiopia's hydro-agricultural state-building strategy is but one example of how the food-water-energy nexus has been politicized to justify dam development projects that displaced approximately 100,000 people, including households in many Indigenous communities (e.g., Verhoeven, 2013).

Finally, we note that the effects of poor governance are hardly exclusive to chronic migration triggers; governance commonly shapes vulnerability to extreme events, and subsequent environmental migration, in both origin and destination communities (Geddes et al., 2012; Warner, 2010). State-sponsored safety net programs, such as buyout programs intended to financially help vulnerable households relocate to less disaster-prone areas, can expedite a household's recovery, whereas not getting assistance and staying in place can worsen well-being. For example, those who accepted buyouts in New York and New Jersey urban areas in the US were less likely to report worsened stress than those who stayed and rebuilt their flood-damaged homes after Hurricane Sandy (Koslov et al., 2021). This also exemplifies how it can be difficult to disentangle the effects of punctuated events, like a storm, from chronic events, such as the ongoing stress of recovery over many years.

5.3 | You cannot go home again: The myth of return

Although water access, reliability, and affordability are key factors in migration, and often affected or magnified by climate change, the potential for solutions to water problems in migrants' place of origin can prompt a consideration for return migration (or mobility). Whether or not this return is actually possible or really happens, however, varies by individual and location. Hence the phrase "myth of return" is used to refer to a migrant's desire or plan to return "home" once the push factors that caused the migration have subsided or been remedied. The plan is considered a "myth" because often the reality of conditions in a migrant's place of origin returning to "normal," premigration status are unlikely. Furthermore, the longer migrants spend in their destination, and the more successful they are at finding

work, housing, food, and even bringing family members to live with them, the less likely a permanent return home will occur (Hiller, 2009). The notion of return, whether reality or not, is important in migration research because it emphasizes how mobility and migration can be nonlinear, circular, and cyclical, and reinforces the idea that migrants' destinations may be implicitly temporary, especially with displacement (Hunter, 2011; Sinatti, 2011).

The "myth of return" has not been a strong theme in research on water-related migration and climate change, but it has featured prominently in research on economic migrants (Markowitz & Stefansson, 2004; Thomas-Hope, 1999; Tsay, 2003; Waters, 2004; Zweig, 1997), especially in resource-dependent communities where migrants come often with intentions of only staying long enough to earn the money needed to get their financial lives in order (Hiller, 2009; Keough, 2012). Yet, there are several ideas in environmental migration research that make the "myth of return" an important concept. For example, the extent to which water was the key factor in migration decisions is important, as is migrants' perceptions of climate change. Climate change itself is not easily remedied, so a migrant who sees climate change as a cause of water access, quality, and affordability problems may assume the situation is not likely to change soon, thus making their migration more permanent. In the case of Hong Kong migrants in Vancouver, Ley and Kobayashi (2005) found that more than half of their respondents noted polluted water and air in Hong Kong as the reason why they planned to stay permanently in Vancouver. Water quality was *not* the reason for the migrants' initial move to Vancouver, but it was a significant factor in the decision not to return home. On the other hand, if the migrant sees probable and possible solutions to water issues, they may anticipate a solution to water-related problems in the near future and have a higher propensity to return, planning accordingly with this goal in mind. The nature of these "solutions," of course, is the difference between whether such return migration is a reality or a myth.

6 | CONCLUSION

The goal of this overview article was to highlight what is currently known or suspected about how water shapes human movement, insights that are important for future scientists and policy makers to plan for, and react effectively to, environmental migration. We provided a theoretical grounding for water-migration relationships in light of climate change, and an empirical overview of the diverse pathways through which water shapes human migration, mobility, and displacement. We categorized these pathways into punctuated and chronic triggers, and highlighted examples of how these different types of movement and their inter-relationships can be difficult to distinguish and disentangle. Indeed, even when a punctuated, water-related, extreme event does not prompt displacement, chronic water problems limit livelihoods and have negative social and health effects, and thus are often a crucial, overlooked determinant of migration propensity and mobility in settlements across the rural–urban spectrum. These water problems may directly trigger migration after some period of time, or may function indirectly as "stress multipliers" that enhance economic drivers of migration (Horwood, 2020).

By better understanding these pathways, we can better understand the context of water in migration decision-making for households, with implications for understanding the effects of other resource insecurities on migration, such as food and energy. Despite the trend in the transdisciplinary conceptualization of resource security, empirical integration has been slower (Ghodsvali et al., 2019), and global progress toward the Sustainable Development Goals is still monitored separately for food, water, and energy. Water's pervasive influence on movement presents the virtually unstudied possibility that water, sanitation, and hygiene (WASH) interventions potentially mitigate migration pressures and perhaps reduce environmental displacement and mobility. This approach echoes other calls for cross-sectoral integration of resource security interventions in global development (Workman et al., 2020). With respect to water, this approach comes at a crucial time as the development community is coming to grips with underperforming gold-standard WASH interventions (Cumming et al., 2019). The contemporary geopolitical trend of rising nationalism and anti-immigration rhetoric around the world also underscores the urgency of cross-sectoral attention to migration propensity. By linking water and migration processes, we might simultaneously address environmental and climate justice and improve capabilities for adaptation and resilience by giving local communities an evidence base that supports working with the state to reduce displacement.

Although this article describes the many connections between water and migration, we clarify how little empirical evidence explicitly coupled these processes. As a result, this interdisciplinary question has many opportunities for future research in many different fields. We summarize some of these in Box 2 around four key themes. First, although we know migration and mobility often serve as an adaptation strategy for water insecurity, we know little about the proportionate effects of socioeconomic characteristics, land use policy, unpredictability, and intermittency, using

BOX 2 Open research questions about the conditions and triggers of water-related migration

Migration as a water insecurity adaptation strategy

- How do rural–urban disparities in water insecurity interact with wealth, remittances, and capabilities for adaptation and resilience to shape migration?
- How does water unpredictability and uncertainty shape migration, and what are the implications of short- versus long-term water shocks?
- How does the use of multiple water sources as an adaptation strategy buffer against migration, and with what tradeoffs for households?
- Under what conditions are households trapped in place due to water problems, and how can these conditions be reversed?

Tipping points and thresholds

- Which sub-domains of water insecurity have the strongest influence on migration propensity, for whom, when, and for how long?
- Is there a general range of water insecurity that predisposes households to migration if triggered by an extreme event (economic collapse, natural hazard, etc.)?
- How are subdomains of water insecurity related to different types of movement—migration, mobility, and displacement—and in what socio-environmental contexts?

Household perceptions as a proximate determinant of water-induced migration

- How do households perceive water and related determinants in origin and destination communities?
- How do people perceive and describe water- or climate-related distress, and are these perceptions shaped by gender, embodiment, psycho-emotional, or other issues?
- How does health literacy shape perceptions of the link between water and movement?
- How does civic engagement on resource and infrastructural issues shape migration propensity?

Distal determinants of water-related household migration decisions

- How can we model climate-water-migration pathways?
- What traditional migration data sources could be enriched to improve measurement of migration propensity?

Note: Icons created by Gan Khoon Lay, visual language, Phonlaphat Thongsriphong, and Icongeek26 from the Noun Project.

multiple water sources, and water service shocks in shaping migration decision-making. Second, while extreme events have been well-studied, we know much less about the domains, tipping points, and relative or absolute thresholds of water insecurity that ultimately trigger (or limit) movement (Bardsley & Hugo, 2010). Third, household perceptions of water problems and migration options likely play an important role in decision-making, but we know little about the formation and salience of these perceptions with respect to movement. Finally, there have been limited attempts to directly model household-level climate-water-migration pathways within the environmental migration literature (Obokata et al., 2014; Piguet et al., 2018). If detailed migration and resource security data were collected together, we could achieve a population-level view of these processes and potentially improve the efficiency of sustainable development efforts.

In sum, water is an under-researched proximate and distal determinant of human migration, both temporary and permanent. By understanding the diverse pathways through which our interaction with water shapes migration decision-making, stakeholders from communities to governments can improve adaptation planning to mitigate future environmental displacement. This work is inherently multidisciplinary and will require cross-sectoral sustainable development that creates synergies by pursuing multiple SDG targets simultaneously. Activating and embedding such synergies in global development efforts—particularly those gained through improving water security—might be our best chance of achieving the SDGs.

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CONFLICT OF INTEREST

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

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Justin Stoler: Conceptualization (lead); funding acquisition (lead); project administration (lead); visualization (lead); writing – original draft (lead); writing – review and editing (lead). **Amber Pearson:** Visualization (supporting); writing – original draft (supporting); writing – review and editing (supporting). **Asher Rosinger:** Visualization (supporting); writing – original draft (supporting); writing – review and editing (supporting). **Alison Elizabeth Lee:** Writing – original draft (supporting); writing – review and editing (supporting). **Rodrigo Bombardi:** Writing – original draft (supporting); writing – review and editing (supporting). **Alexandra Brewis:** Writing – original draft (supporting); writing – review and editing (supporting). **Sara Beth Keough:** Visualization (supporting); writing – original draft (supporting); writing – review and editing (supporting). **David López-Carr:** Visualization (supporting); writing – original draft (supporting); writing – review and editing (supporting). **Cho-Hee Shrader:** Writing – original draft (supporting); writing – review and editing (supporting). **Christine E. Stauber:** Writing – original draft (supporting); writing – review and editing (supporting). **Edward Stevenson:** Writing – original draft (supporting); writing – review and editing (supporting). **Andrea Sullivan:** Writing – original draft (supporting); writing – review and editing (supporting). **Raymond A. Tutu:** Writing – original draft (supporting); writing – review and editing (supporting).

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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