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Advancing methods for research on household water insecurity: Studying entitlements and capabilities, socio-cultural dynamics, and political processes, institutions and governance

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Abstract

Household water insecurity has serious implications for the health, livelihoods and wellbeing of people around the world. Existing methods to assess the state of household water insecurity focus largely on water quality, quantity or adequacy, source or reliability, and affordability. These methods have significant advantages in terms of their simplicity and comparability, but are widely recognized to oversimplify and underestimate the global burden of household water insecurity. In contrast, a broader definition of household water insecurity should include entitlements and human capabilities, sociocultural dynamics, and political institutions and processes. This paper proposes a mix of qualitative and quantitative methods that can be widely adopted across cultural, geographic, and demographic contexts to assess hard-to-measure dimensions of household water insecurity. In doing so, it critically evaluates existing methods for assessing household water insecurity and suggests ways in which methodological innovations advance a broader definition of household water insecurity.

Keywords

household water insecurity; methods; methodological; qualitative; ethnography; measurement

Household water insecurity (HWI) has serious implications for the health, livelihoods and wellbeing of people around the world. Recent scholarship challenging the World Health Organization's metric of "access to an improved water source" suggests that water insecurity is far more pervasive than official estimates suggest, particularly in low and middle income countries (Satterthwaite 2016, 2003, Nganyanyuka et al. 2014, Onda et al. 2012, Wescoat et al. 2007). There is an emerging consensus that HWI is much more than "access to an improved water source," and must be measured as such. The tasks of accurately defining and measuring water insecurity are critically important for challenging the social, cultural, economic and political processes that marginalize communities and ultimately undermine development efforts to reduce household water insecurity (Loftus 2015, Swyngedouw 2013).

The concept of water insecurity has gained much traction in both academic literature and global development institutions in recent years. HWI has been defined as "inadequate, unreliable, and unaffordable water for a healthy life" (Jepson 2014). However, a definition of water insecurity that focuses *solely* on availability or quality may obscure other important

dynamics (Nganyanyuka et al. 2014, Obeng-Odoom 2012, Subbaraman et al. 2015), including social, cultural, and political relations (Jepson et al. 2017b), as well as ecological processes upon which they draw (e.g., Kujinga et al. 2014, Scott et al. 2013, Grey and Sadoff 2007). Scholars increasingly emphasize the importance of conducting research on water in the context of relational frameworks, such as the hydrosocial cycle (Linton and Budds 2014), and complex frameworks such as coupled social-ecological systems (Liu et al 2007) and sociohydrology (Srinivasan et al. 2017). Recently Jepson et al (2017b) have argued that a "human capabilities" approach offers a useful conceptual advance on the current preoccupation with physical access. While researchers are creating more comprehensive metrics to measure HWI (e.g., Boateng et al. 2017, Tsai et al. 2016, Stevenson et al. 2016), in general they do not yet properly address the socio-economic, cultural, and political relations at work in producing household water insecurity. To accomplish this, we suggest that researchers must develop robust methods for more comprehensively assessing household water insecurity, its causes, and its effects.

Household-level research is notoriously complicated by the problem of defining the "household", and most social science disciplines have developed well-established approaches to address this. Following Netting et al. (1984: xxii), we define a household as "a fundamental social unit…for pooling and sharing of resources." Yet, households vary in their capacity to access water based on factors such as family size, acute/chronic illness and disability, and age composition (Geere et al. 2010). Further, the negative physiological impacts of water insecurity, such as dehydration, might be felt more acutely by some demographic subgroups, or by some individuals within the household (Rosinger 2015a, 2015b, Wutich and Brewis 2014). Factors operating at other scales of analysis shape household water insecurity as well. At the societal level, cultural and political structures embed social relations with power dynamics that in turn may expose otherwise similar households to different levels of water insecurity. For example, processes of land tenure, disinvestment, spatial exclusion, and dispossession can increase racial/ethnic-minority households' risk of experiencing water insecurity (Loftus 2011, Switzer and Teodoro 2017). HWI research thus requires attention to complex interacting processes at multiple levels of analysis, and with attention to socio-spatial differentiation.

In this paper, we articulate household water insecurity as a concept that comprises both a *state* and a *relation*, which in turn requires a holistic approach to assessment and measurement. Our review of existing and emergent methods in this piece focuses primarily on economic, socio-cultural, and political dynamics important for a relational understanding of water insecurity. We have three goals. First, we review current HWI measurement methods, assessing their utility for evaluating water quality, quantity (or adequacy), sources (or reliability), and affordability. Second, we identify opportunities for methods that better assess the entitlements and capabilities, social and cultural dynamics, and political institutions and processes influencing HWI. Third, we draw attention to the need for methods that facilitate systematic, cross-cultural and cross-site comparative analysis in order to identify and address global patterns in HWI.

Established Methods for Assessing Household Water Insecurity

For 20 years, household water insecurity researchers have largely followed some variant of Webb and Iskandarani's (1998) definition: "water security is access by all individuals at all times to sufficient safe water for a healthy and productive life" (e.g., Mason 2012, Stevenson et al. 2012, Hadley and Wutich 2009). Four derivative concepts—water quality, quantity or adequacy, source or reliability, and affordability—have been subsequently included in most definitions of household water insecurity (Jepson 2014). Leading international and national agencies have also set standards for approaches to assess human water requirements, including the United Nations, World Health Organization, U.S. Environmental Protection Agency, and American Public Health Association (e.g., Bridgewater & APHA, 2012; WHO, 2011), although guidelines, recommendations, and legislation vary widely. Here, we review established methods linked to the four concepts identified above, as well as opportunities to better assess HWI related to each concept.

Water Quality

For domestic purposes, water quality typically refers to the safety of water for direct human consumption (i.e., ingestion) and, in some cases, washing and hygiene (considering water-borne and water-washed diseases, respectively). Water quality is measured by microbiological and physico-chemical contaminants that either pose direct health risks, or are indicative of a risk to human health (e.g., turbidity). Microbiological water quality is most commonly assessed by testing for the presence of fecal indicator bacteria such as *Escherichia coli* or thermo-tolerant coliforms. Fecal contamination in low- and middle-income drinking water supplies is often seasonal (Kostyla et al. 2015), and persists globally despite concerted efforts to address it since the first International Drinking Water and Sanitation Decade in the 1980s (Bain et al. 2014). The physico-chemical quality of drinking water is commonly assessed using metrics such as total dissolved solids, pH, turbidity, specific heavy metals, and levels of residual/free chlorine. Both types of water quality are traditionally tested by sampling and measuring indicators of contamination at a point of consumption in the household, within a distribution network, and/or at the water source. Many techniques have been developed to monitor microbial and chemical water quality (Allan et al. 2006, Bain et al. 2012), though not all are transferable to low-income settings, in part due to wide variation in levels of bacterial contamination (Pearson et al. 2008). Low-cost field assessment of emerging and persistent water contaminants such as bisphenol-A, phthalates, and agricultural nitrates and phosphates remains a significant research gap. More recent concepts, such as the "source-to-tap" framework and "one health" concept, combined with new analytics (e.g. metagenomics) hold promise in terms of radically revisioning our approach to water quality—including the potential for innovative methods that could refashion how we understand, and test, for water quality (e.g. Dunn et al. 2015).

Water Quantity or Adequacy

HWI is most often measured in terms of quantitative availability per person or, at the societal scale, proportion of available water accounted for by anthropogenic uses. Estimates of human daily drinking water requirements vary widely (Gleick 1996), and can depend on age, gender, breastfeeding status, physical activity, and culture, but relief organizations

usually aim at providing 20–25 liters per person per day. Public health concerns may be particularly salient when water usage for direct consumption and food preparation falls below 5 liters/person/day (Howard and Bartram 2003). Water quantity is gauged most easily when household water meters are employed or when direct provision (as in emergency situations) is the primary supply mechanism. In the absence of these, measures of water availability in the environment (such as rainfall, as in Pande and Savenijie 2016) are sometimes used as proxy measures of household water availability, although this may be disconnected from access in households—theoretical availability is not the same thing as actual access. Moreover, the absolute volume of water brought into a household does not necessarily indicate the nature of water usage, where intra-household power dynamics may mean water is internally allocated asymmetrically or diverted away from personal health and hygiene. Direct observation of water collection and usage is perhaps the most realistic and reliable measure (White et al., 1972), but remains extremely time intensive on a large scale and may be biased if observation leads to behavior change. On an individual level, urine specific gravity is a reliable, precise measure to assess water intake, but may be difficult to implement in some research contexts (Rosinger 2015a). The volume of household water usage can also be estimated though observational surveys that incorporate container measurements and household reporting of water collection frequency and allocation (Pearson 2016, Geere et al. 2010, Majuru et al. 2012, Wutich 2009). Mobile device-enabled data collection and GPS tracking have also been explored to measure the effect of travel distance during fetching on quantitative water availability at the household level (Geere et al. 2016).

Water Source or Reliability

The type of water source and its distance from the household have long been used as indicators of water access or quality (WHO/UNICEF 2015, 2017, Bain et al. 2012; Onda et al. 2012; Jiménez and Pérez-Foguet 2008; Satterthwaite 2003). When such measures are used, the underlying assumption is generally that household water insecurity is mitigated when piped water is made available in the dwelling or compound (WHO/UNICEF 2017). Yet, even the gold standard of water service delivery—in-home piped water from a municipal provider—may be unreliable if intermittent or liable to cut-off due to system inadequacies or payment disputes (Lee and Schwab 2005). Water procured outside of the home may be periodically or seasonally inaccessible due to a broken pump handle, disputes between neighbors, climatic factors, or other disruptions. In 2017, the WHO/UNICEF Joint Monitoring Program launched a new “drinking water service ladder” to facilitate monitoring during the Sustainable Development Goals era. This ladder of five service levels moves beyond the simple “improved/unimproved” classification that underpinned the Millennium Development Goals (MDGs) to include criteria of drinking water accessibility, quality, and availability, and is operationalized according to source type (including on or off premises), collection time including queuing, presence of fecal contamination, and intermittency (WHO/UNICEF 2017). This classification scheme does not fully address newer water services, such as tanker or packaged/bottled water, which are becoming important sources despite highly variable quality and reliability in some places (e.g. Stoler 2017). Better measurement precision is needed to assess the dynamic reliability of water sources in cross-cultural contexts.

Water Affordability

The most common measure of household-level affordability is the cost of water as a percentage of household income. Analyses of affordability in the United States, for instance, typically calculate average residential water bills as a percentage of median household income, with values of less than 2.5% declared "affordable" (e.g., Janzen et al. 2016; Mack and Wrase 2017). Internationally, the United Nations Development Program defines affordable water as that which costs no more than 3–5% of a household's income (Hutton 2012, Smets 2012). Although these approaches enjoy intuitive appeal, they have been criticized as misleading and inaccurate (EFAB 2014; Davis and Teodoro 2014). Specifically, the binary nature of these conventional approaches—either "affordable" or "unaffordable"—is problematic because affordability is rarely a strictly either/or phenomenon; water is affordable relative to the costs of other things and the household's total economic resources (cash and noncash). Simple income percentage-based metrics are not sensitive to other essential household costs (e.g., food, housing, medicine, home energy, taxes), and so income percentage standards can lead to overestimates or underestimates of affordability. More accurate and comprehensive (but seldom used) affordability metrics account for not only the direct service costs households pay through water bills, but also direct capital costs (e.g., connection fees, water tanks, or on-site purification technology) and the opportunity costs associated with water acquisition, including time spent traveling to and from water sources (Hutton 2012). But even the broadest cost measures still exclude costs such as the physical impacts of hauling water and missed opportunities for work or school due to water carriage (cf. Geere and Cortobius 2017), although these are issues at times taken up in qualitative and critical water security studies.

Challenges in Well-established Methods for Studying Household Water Insecurity

Conventional, established methods have the important advantage of offering relatively simple, quantifiable, and cross-culturally comparable measurements, but they may also oversimplify HWI and obscure its global burden. Moreover, these methods largely concentrate on measuring the material state of water insecurity, but do not currently extend to evaluating the non-physical dimensions that can also generate or constitute water insecurity. These comprise the underlying economic drivers of water insecurity, cultural meanings and expectations, and the governance of water access and services (Jepson et al. 2017b). These issues are widely addressed within existing literature, yet are seldom linked to methodological approaches for assessing insecurity in practice (Jepson 2014). It is to these lacunae that we now turn.

Developing Methods for Assessing Relational Dimensions of Household Water Insecurity

Recent HWI research suggests that conventional approaches are inadequate to capture core dimensions of the experience of water insecurity (Linton and Budds 2014, Yates et al. 2017, Norman 2017). These findings warrant expanding the conceptualization of household water insecurity to include three relational dimensions in addition to traditional measures: entitlements and human capabilities, socio-cultural dynamics, and political institutions and

processes that produce water-related inequities (Jepson et al. 2017b). Although these dimensions have long been recognized as relevant (e.g., White et al. 1972), and increasingly are emphasized in the literature more broadly, researchers have been slow to incorporate them into a formal definition and operationalization of HWI. Methods to research this expanded notion of household water insecurity can be particularly difficult, in part because these dynamics are difficult to measure, let alone compare across sites. Here we identify three areas in which existing methods can be further developed to advance research on the relational dynamics crucial to understanding household water insecurity.

Entitlements and Human Capabilities

Methods for studying HWI tend to focus on the ways in which water insecurity impacts a household's economic wealth, with implications for status, function, and wellbeing. The entitlements approach (Sen 1981), applied to water, examines how people obtain water through relations that legitimize ownership claims or use rights, through trade, production, labor, inheritance, or transfer (Wutich and Brewis 2014). The human capabilities approach (Sen 2001), as it relates to water, focuses on the broader impacts of water insecurity on human wellbeing (Jepson et al. 2017b). Existing methods for studying HWI are more developed in the older and better-understood realm of entitlements than in the newer realm of capabilities, as shown in Table 1.

Methods for studying market-based water entitlements are well-developed in economics, public policy and allied fields. The simplest and most direct way to operationalize market-based entitlements to water is through the household affordability measures discussed in the previous section (see Hutton 2012, Davis and Teodoro 2014 for extensive reviews). Anand (2010) has long shown leadership in methodological work on water and entitlements, demonstrating how economic methods, such as water expenditures analysis (Anand 2001) and multiple choice contingent valuation (Anand and Perman 1999), can help scholars better understand the adequacy of water acquired at the household level. As Mehta (2006) explains, however, market-based approaches to entitlements must go beyond mere affordability to address broader market dynamics including issues of governmental involvement, development policies, and market exclusion. In an analysis of peri-urban water insecurity, for example, Mehta et al. (2014) demonstrate how water-related market dynamics are shaped by elite policies and resource capture. Such work points to the necessity of including non-market dynamics, even within the analysis of the role water markets play in shaping household water insecurity.

Methods for measuring non-market entitlements, such as gifts, reciprocity, and self-provision, are less developed than for market-based entitlements. Nevertheless, well-established methods can be used to research a household's non-market or hybrid entitlements to water. Participant observation and semi-structured interviews can be used to discover and describe local forms of water acquisition, as in the role of *yapa* (bonus gift) in Bolivia's informal water markets (Wutich et al. 2016). Observation, diary methods, and structured recall can be used to systematically assess how much water is obtained through a single or complex combination of non-market water entitlements, as in Eichelberger's (2010, 2017) exploration of reciprocal and community forms of water acquisition in Alaskan

villages. Even more robust methods may be required for systematic, comparative research relevant to the many research contexts in which non-market entitlements play an important role in household water insecurity dynamics. The literature on reciprocal exchange (e.g., Gurven et al. 2001, Jaeggi and Gurven 2013, Jaeggi et al. 2016) may offer some guidance relevant for efforts to operationalize reciprocal water exchanges. To advance our understanding of a broader range of non-market water-based entitlements, there is a need for a comprehensive conceptual and analytic framework that can facilitate cross-cultural identification and assessment of all forms of non-market water acquisition.

The entitlements approach, while broader than the affordability approach in that it can more easily accommodate non-market exchanges, is still fundamentally an economic approach that may exclude important social and psychological dimensions of household water insecurity. The capabilities approach offers a potential alternative for addressing this critique. According to Goldin (2013: 315), there are ten dimensions of human capabilities relevant to the water sector: health and basic goods, education and literacy, basic mental and physical capabilities, self-respect and aspiration, autonomy and self-determination, awareness, understanding, significant relations with others, participation in social life, and accomplishment. Existing methods for assessing the opportunity costs of disruptions to water access, such as school attendance (Cooper-Vince et al. forthcoming) or labor market participation (Sorenson et al. 2011), provide a proxy measure of the impact of HWI on literacy/education and autonomy/accomplishment. Some newer metrics attempt to account for opportunity costs by measuring water affordability relative to other essential household costs and disposable income, or expressing water costs as hours of low-wage labor value (Davis and Teodoro 2014). Existing health and physical impact measures can also be leveraged to understand some dimensions of health and mental/physical impacts (Jepson et al. 2017a), though the link between capabilities and mental health and other health-related activities (e.g., healthy infant feeding, Young et al. 2011, Rosinger 2015b) remains under-examined. Beyond this, the link between HWI and other dimensions of capabilities (e.g., awareness, understanding) remain largely unexamined and unoperationalized. The challenge for future research is to design a more comprehensive methodological approach that assesses the human capabilities that are explicitly linked to household water insecurity.

Social and Cultural Dynamics

Social and cultural dynamics are crucial for understanding household water insecurity. Socio-cultural factors include the social and power structures that shape household water insecurity, the values and symbolism attributed to it, and how all of these impact lived experiences. Methods for understanding these phenomena at the social or cultural level are well-established, but vary in terms of their applicability and adaptability to understanding household-level variance (as summarized in Table 2). As well, issues of cross-cultural and multi-sited comparability remain difficult, given the empirically-based, context-rich, and ethnographic orientation of much of this work.

Social and power structures contribute to household water insecurity and exacerbate its consequences. For example, social processes (gender), cross-cut with additional dynamics and differences (race, class, caste, education, age, religion, rurality), can impact choices

individuals and households have with regard to water access, participation and acceptable use (e.g., Harris 2006, 2009, Harris et al. 2016). Political ecological research on social and power structures typically uses qualitative data (obtained from archives, interviews, observations) with critical discourse analysis to expose the nature and implications of power relations, vested interests, and dominant discourses (e.g., Boelens and Seemann 2014, Eichelberger 2014, 2016, Mehta 2014, Loftus 2015, Zwarteveen 2015, Staddon et al 2012, O'Reilly 2006, Harris 2008). Both political ecological and hydrosocial cycle (Linton and Budds 2014) approaches excel at integrating households into multi-scalar analyses of water insecurity, but new concepts and methods more focused on household-level dynamics are needed. Such new methods could enable researchers, for instance, to assess longitudinally how households move in and out of water (in)security, depending on how each household's unique profile of individuals interfaces with powerful social groups, dominant discourses, and complex ecosystem dynamics. In addition, there is little in the way of identifying unique or shared dynamics or attributes that might be important to characterize HWI in diverse times and places.

Research on lived experiences of HWI describes, tracks and explains impacts of water insecurity on households. Ethnographic case studies describe the intersecting factors shaping the lived experiences, water-related health concerns, household coping mechanisms, and cultural roles and knowledges involved in water insecurity at individual, household and community levels (e.g., Eichelberger 2016, 2017, Mason 2012, Ferguson 2005, Whiteford and Cortez-Lara 2005, Ennis-McMillan 2001). Using participant observation, interviews, and focus groups, researchers identify core themes in lived experiences of HWI, such as lack of funds or time to obtain water, forced trade-offs, constrained food and drink availability, poor hygiene, and health impacts. Researchers then develop and test survey items to assess household heads' reports on experiences of water insecurity. Using scaling methods, such as Guttman scaling or split-half reliability tests (Jepson et al. 2017a), these efforts have yielded a number of locally-adapted HWI scales for research in Kenya (Boateng et al. 2017), Uganda (Tsai et al. 2016), Ethiopia (Stevenson et al. 2016, 2012), Nepal (Aihara et al. 2015), the United States (Jepson 2014), and Bolivia (Hadley and Wutich 2009, Wutich and Ragsdale 2008). While these scales are well-suited for assessing within-group and longitudinal variation in HWI using statistical tests, future efforts should focus on developing scales and other methods suitable for cross-cultural and cross-site (e.g., urban/rural) comparisons (Jepson et al 2017a).

Water security research, to date, includes relatively little consideration of sacramental and symbolic meanings of water. Yet the wider literature on water and society demonstrates how important these considerations can be (Strang 2004). For instance, in Hindu societies, water, caste, and purity are inextricable, and as such caste inequality can be reproduced *through* water access or lack of access (O'Reilly and Dhanju 2014). Better understandings of water security can be supported through the valuation of water's symbolic qualities of purity, sustainer of life and livelihood, and representation of the gods (e.g., archaeological analyses in Scarborough 1998, Davis-Salazar 2003, Lucero 2006). These symbolic meanings may influence water source choices, and how households evaluate the quality of natural drinking water sources (e.g., Eichelberger 2017). In addition, peoples' material needs may be addressed by, or inflected through, non-material processes or phenomena such as the use of

water for symbolic purposes (Staddon and Everard 2017, Norman 2017). One example is the conspicuous consumption of water for landscaping, in which households dedicate enormous water expenditures toward supporting ornamental greenery as a marker of class and status (Larson et al. 2009, 2016, Feldman 2017). Some progress has been made in developing methods to explore cross-cultural disgust, shame, and stigma related to water and hygiene using focus groups and essays (Curtis and Biran 2011), behavioral observation, storytelling, and word elicitation (Curtis et al. 2009) and judgements of visual cues (Curtis et al. 2004); this work could be built upon to yield methods for exploring these dimensions of HWI. Yet sacramental and symbolic aspects of HWI are enormously complex, and research would require a range of contributions (foundational conceptual work, new analytic frameworks, new methods for description and measurement) to truly advance understandings of their role in household water insecurity.

Political Institutions and Processes

Political institutions and processes greatly influence the production and distribution of household water security across systems, cities and regions (e.g., Birkenholtz 2013, Meehan 2013). Water governance arrangements can create, sustain, overlook, exacerbate, and/or ameliorate structural injustices that underpin conditions of water insecurity. In most cases, the household is not the focus of research on political institutions and processes, though these processes are vital for understanding household water insecurity (Fam et al. 2015). In this section and in Table 3, we address methods to locate household water security within larger political institutions and processes.

Recent scholarship emphasizes that analyses of water governance regimes must span multiple scales, including the household-level, given the complex and dynamic social and ecological processes that influence water security (e.g., Romero-Lankao et al. 2016, Varady et al. 2016, de Grenade et al. 2016, Lemos et al. 2016). Important theoretical and conceptual work—conducted using participant-observation, semi-structured interviewing, critical discourse analysis, and other forms of qualitative analysis—has identified ways in which inequitable governance systems can produce household water insecurity (e.g., Norman and Cook 2015, Morinville and Harris 2014, Pearson and Muchunguzi 2011, Budds 2009, 2004), often deeply embedded in historical political processes. In future research, the use of semi-structured analytic approaches, such as causal loop diagramming (Butler et al. 2014) and framework method (Gale et al. 2013), may help develop cross-culturally comparable results from exploratory, qualitative, and community-based research. Beyond this, survey-based statistical analysis has been used to assess and track inequitable outcomes in water governance systems. For example, research in the United States has linked rates of drinking water contamination to the intersections of race, ethnicity, and socioeconomic status across municipal governments (Switzer and Teodoro 2017), and to governance of American Indian lands (Teodoro et al. 2016). These approaches can help provide an institutional context in which domestic water is provided to households; though they may aggregate household-level data, they are rarely used to disaggregate data at the household level. To advance our understanding of HWI, there is a need for such models to be interpretable at the household level and to examine how large-scale institutions foster or frustrate, and engage or alienate households, in the governance of their water. Q-Methodology is a relatively simple

quantitative technique (a factor analysis of interview data) that enables researchers to systematically determine different perspectives among key actors involved in water and natural resource management (Eden et al. 2005, Vugteveen et al. 2010, Lynch et al. 2014), and may help elucidate the links between larger institutions and household-level impacts.

Because water security is, in many ways, tied to the idea of a “right to water” (Cook and Bakker 2012, Sultana and Loftus 2013), legal analysis plays an important role in understanding how water security is defined, and how this plays out at the household level (Wouters 2005, Bluemel 2005, Gerlak and Wilder 2012). In addition, a large body of research aligned with the Institutional Analysis and Development Framework has developed methods for identifying the rules and norms that govern rights to environmental resources, often as they pertain to water, in the context of irrigation systems, and at the household level (Ostrom 2005, Poteete et al. 2010). In this context, agent-based modeling has emerged as a potentially fruitful method for understanding how ecological contexts, institutional rules and individual decision-making can produce household water insecurity (Srinivasan et al. 2017). Cultural consensus analysis, a factor analysis of shared agreement on cultural knowledge and norms, is another emerging method that can be applied to HWI analyses. This method can measure the strength of agreement about how norms impact household and individual outcomes (Weller 2007). Cultural consensus analysis has been applied to water institutions at higher levels of analysis (e.g., Stone-Jovicich et al. 2011) but has not yet been applied in HWI research.

Beyond legal protections and institutional norms, informal processes can play an important role in shaping household water insecurity. Ethnographic research and interpretative analysis are common in the study of intermediaries in the water system, who are positioned in-between other actors, institutions, processes, or interests in the waterscape (Björkman 2015). For example, ethnographic study of intermediaries dominates research on informal or alternative water providers, as the coexistence of different socio-technical water provisioning systems is often more efficient at satisfying demand than planners or policymakers admit (e.g., Meehan 2014). Critical, historical approaches to the study of water (and land) governance often employ interpretive or narrative analyses based on qualitative data such as semi-structured interviews, oral histories or policy documents (Pearson and Muchunguzi 2011). Participatory methodologies allow researchers to tease out complex dynamics of water governance regimes and implications for domestic water service provision that are not readily captured in conventional, aggregate measures or indicators. More importantly, participatory research offers alternative modes to study domestic water service from the perspective of water users (Sultana 2007, Margerum and Robinson 2015). Ethnographic and participatory research methods extend to household and water user participation and inform our understanding of household water insecurity, notions of citizenship, and water users as political agents (O’Reilly and Dhanju 2012, Morinville and Harris 2014, Loftus 2011, Vandewalle and Jepson 2016). Social network analysis can leverage structured data (survey, observational, or archival) to analyze informal water governance networks (Cutts et al. 2015) as well as informal flows of resources, influence, and knowledge (Borgatti et al. 2016). The application of social network analysis could improve precision and prediction in the analysis of political processes, non-monetary negotiations, and intermediaries that impact household water insecurity.

Discussion

HWI methods are currently dominated by measures of water quality, quantity, sources, and affordability with conventional modes of operationalization. We need not abandon such methods, as they make important contributions to understanding HWI due to their relative simplicity and comparability, and new research is constantly improving the operationalization of these measures. Yet, scholars widely agree that there is a mismatch between concept and measurement in HWI research, and that these conventional methods are generally unable to capture important dimensions of HWI related to economic, socio-cultural, and political dynamics. We thus provide guidance on further methodological developments needed to advance a broader and more holistic definition of household water insecurity. After reviewing methods currently used to research the economic, socio-cultural, and political dimensions of HWI, we proposed nine ways that future research could advance methods for understanding household water insecurity. We also address the extent to which these new methods and measures could be used to facilitate systematic, cross-cultural and cross-site comparative analysis. Our paper raises some questions that we were unable to fully address, and we turn to a brief consideration of these issues here.

The first question concerns what it means to conduct household-level water insecurity research. Households comprise diverse individuals, and are nested within communities and societies. The implications of this are, we believe, that the ‘household’ is not necessarily a unit at which analysis should remain fixed. A more granular analysis of intra-household differences is needed to understand how household members’ differential social positions, roles and responsibilities, and biocultural needs and vulnerabilities contribute to experiences of household water insecurity. Broader structural analyses of the factors that shape household differentiation and experiences of water insecurity remain central to ‘household’ level analysis of water insecurity. Households are governed by societal norms and state policies and located within broader ecological processes. Water maintenance, upgrades, water quality monitoring schemes, and infrastructure may relate to levels of political freedom and engagement, as well as the self-determination of individuals, households and wider communities. These societal features and governance structures often reflect existing socioeconomic, ethnic, and gender inequalities whereby some groups are advantaged while others are excluded. Thus, any holistic HWI analysis implies a relational consideration of multi-scalar processes. To address this, we recommend that future research strive to locate the household within a multi-scalar approach, employing methods that facilitate attending to the subjectivities, experiences, culture, and wider politics and governance that shape water access–factors central to research into the causes and effects of water insecurity that manifest at the household level.

The second question concerns the extent to which it is appropriate and feasible to include ecological processes in our understanding of household water insecurity. For example, we believe that the relational HWI approach enables us to resituate thinking about environmental change. The relational approach suggests that what really matters is the adaptability of social, political, cultural and economic sub-systems that govern a changing physical resource, as opposed to viewing environmental change as an ineluctable and entirely physical backdrop to social process. Recent scholarship has made important

progress in advancing our understanding of water insecurity as emerging from multi-scalar ecological and political-economic processes (e.g. Romero-Lankao et al. 2016, Varady et al. 2016, de Grenade et al. 2016, Lemos et al. 2016). Scholars have described how climate change and seasonal environmental factors affect household water security, as well as related coping mechanisms and cultural dimensions (Eichelberger 2017; Pearson, Mayer, and Bradley 2015; Pearson, Zwickle et al. 2016; Hadley and Wutich 2009). There has been limited conceptual work to unpack ecological dynamics as a component of household water insecurity. Future studies could enable researchers to develop methods that are capable of assessing ecological dynamics of water security at the household level. Well-known theoretical framings such as coupled social-ecological systems (Liu et al, 2007) and sociohydrology (Srinivasan et al. 2017) may not go far enough in deconstructing the nature/culture dualism at the heart of much current work. Newer conceptual frameworks that encompass complex, multiscalar socio-ecological dynamics, such as the hydrosocial “cycle” (Linton and Budds 2014) or “transition” (Staddon, Sarkozi and Langberg 2016), may offer the best ways forward.

A major future challenge will be to develop new methods and metrics that can be widely adopted across cultural, geographic, and demographic contexts on complex, multi-scalar socio-ecological dynamics. This kind of research complements the rich theoretical and ethnographic analyses that dominate current household water insecurity research by allowing us to identify empirically trends across culture, space, and time. Such research has been a goal since the early days of political ecology, but recent developments such as increased data capture and computing capacities, broader receptivity to multi-method and inter-disciplinary research, and the increasing urgency of environmental crises beckon more rapid progress. The methodological recommendations in this paper will help us to make important steps toward achieving this goal.

Conclusion

The challenges of defining and measuring HWI in a contextualized yet cross-culturally relevant way remain substantial. We aim to meet this challenge with multidisciplinary debate and a broad perspective, as divergent operational concepts and measures may impede cross-study comparisons. Conventional, established measures and metrics do not fully reflect the unique hydrosocial conditions or historical marginalization that produce water insecurity. However, we argue that adopting a more holistic conceptualization of water security, accompanied by an expanded toolbox of methods that includes a wider array of qualitative and quantitative methods, will enable researchers to advance methods for assessing and measuring the drivers, nature, and impacts of household water insecurity.

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- Existing approaches have many advantages, but underestimate household water insecurity
- A broader definition of household water insecurity should include entitlements and human capabilities, socio-cultural dynamics, and political institutions and processes
- We discuss qualitative and quantitative methods that can assess hard-to-measure dimensions of household water insecurity

Table 1

Advancing methods for assessing entitlements and capabilities as dimensions of household water insecurity

HWI Concept	Market-based Entitlements	Non-market Entitlements	Human capabilities
Common methods	Economic methods, such as those discussed in "Water Affordability" section	Acquisition data, recorded using observational & interview methods; Descriptive and statistical analysis	Measures of HWI impacts on health and basic goods; education and literacy; mental and physical capabilities
Purpose or use of common methods	Widely used, though data limitations often lead to measurement at higher levels of aggregation	Describes and quantifies non-market water acquisition (e.g., reciprocal exchange & common-pool institutions)	Quantifies 3 aspects of capabilities (health, education, mental/physical) in cross-cultural context
Is the household (HH) typically the unit of analysis?	Yes. Also common at higher levels.	Yes, typically the household head reports on HH data.	Individual or household. Data can be aggregated to HH.
Recommended HWI approaches & methods that need further development	Broader assessments of the monetary cost of water, including opportunity costs and physical risks	Better conceptual definition of the range of non-market exchanges used to acquire water	Conceptual definition & measures to assess less-documented and poorly-understood dimensions of HWI impacts on capabilities
Why new approaches or methods are needed	To estimate more accurately the economic cost of water and how it contributes to HWI	To develop a valid & comprehensive framework for categorizing or quantifying non-market water entitlements	To assess the other dimensions of HWI & capabilities in ways that are valid for cross-cultural contexts & comparisons

Table 2

Advancing methods for assessing socio-cultural dynamics as dimensions of household water insecurity

HWI Concept	Social Structure	Lived Experience	Symbolic/Sacramental
Common methods	Archives, Interviews, Participant and Direct Observation	Ethnography, Interviews, Surveys	Interviews, Visual Methods, Material Culture, Historical & Secondary Data
Purpose or use of common methods	Identify key social structures, assess how they impact people and societies	Describe, assess, quantify lived experiences of HWI, including health concerns and outcomes	Describe symbolic and sacramental uses of water; Interpret their role in HWI
Is the household (HH) typically the unit of analysis?	No, but HH level effects can be tracked with a variety of methods.	Yes, typically the household head reports on HH data.	No. Data is typically thematic or cultural. Need new methods to disaggregate to HH.
Recommended HWI approaches & methods that need further development	Need clearer methods for research on HWI within hydro-social cycle approach; May be possible to do this by refocusing existing methods	Need more foundational research; Need development & testing of cross-cultural scale(s)	New HWI concepts to include symbolic & sacramental values; Refocus existing methods for cross-cultural description & comparison
Why new methods are needed	To improve inquiry into temporal, spatial, and socio-ecological dynamics	To describe & assess lived experiences of HWI in ways that are valid in cross-cultural contexts & comparisons	To develop analytic frameworks & research methods to link HWI to symbolic and sacramental uses

Table 3

Advancing methods for assessing political institutions and processes as dimensions of household water insecurity

HWI Concept	Water governance	Laws & Institutions	Informal Processes
Common methods	Participant-observation, Interviews, Critical discourse analysis, Text analysis, Surveys, Oral histories, Statistical analysis	Methods aligned with Institutional Analysis & Development Framework; Legal & institutional analysis	Ethnography, Archives, Interviews; Narrative, Interpretive & Critical Analysis; Participatory methods
Purpose or use of common methods	Discover how water governance produces water insecurity; Examine inequalities; Compare impacts of different governance regimes on HH	Determine how formal laws & institutions contribute to or mitigate HWI	Determine how informal rules or intermediaries contribute to or mitigate HWI
Is the household (HH) typically the unit of analysis?	No. Data is typically at higher scales. Some methods can disaggregate to HH	No, but HH level effects can be tracked with a variety of methods	No, but HH effects can be assessed; May need new methods to improve HH measures
Recommended HWI approaches & methods that need further development Why new approaches or methods are needed	Causal loop diagramming, Framework method, Q-Methodology To systematically track perspectives among key actors; Facilitate cross-site comparisons; Disaggregate to HH level	Agent-based modeling, Cultural Consensus Analysis To produce data on hard-to-document norms and shared knowledge; Need to disaggregate to HH level	Social Network Analysis To improve precision on analysis of informal flows of resources, influence & knowledge; Need to disaggregate at HH level