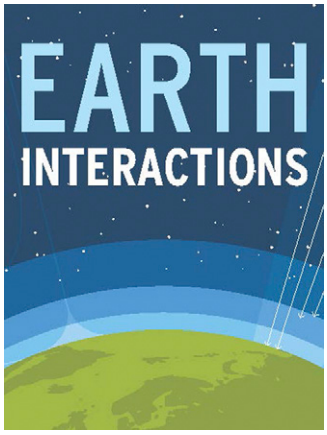

Coping with Household Water Scarcity in the Savannah Today: Implications for Health and Climate Change into the Future

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ABSTRACT: Even as millions live without reliable access to water, very little is known about how households cope with scarcity. The aims of this research were to 1) understand aspects of water scarcity in three rural villages in southwestern Uganda, 2) examine differences by demographics and type of source, 3) assess relationships between different factors related to water access,

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and 4) explore coping strategies used. Health implications and lessons learned that relate to future climate change are discussed.

Demographic data, water accessibility, and coping strategies used were recorded using a survey. Descriptive statistics were calculated, and Spearman's rank correlations were calculated between self-reported level of access, walking minutes to source, ranked ownership of source, and source accessibility during the last two weeks of April (16–30 April). Changes in water source type across seasons and demographic and access measures by coping strategies were examined.

Over half of the households relied on seasonal water sources. Of those accessing "permanent" sources, ~30% experienced inaccessibility within the last two weeks of April. Self-reported better access to water was correlated with minutes spent walking to source and to some degree with the source being more public or shared. Those without access to public sources tended to migrate as the primary coping strategy. Water sharing and reciprocity appears crucial between wealthy and poor households; however, those from outside ethnic groups appear to be partially excluded. Middle income households followed by the poorest had the largest reliance on purchasing water to cope. These findings underscore how access to water resources, particularly in times of insecurity, involves social networks.

KEYWORDS: Africa; Complex terrain; Watersheds

1. Introduction

The Millennium Development Goals (MDGs), developed in 1990, established a number of targets to be reached by the year 2015. Target 7c was to halve the number of people without reliable access to safe drinking water. Since the 1990s, much progress on this target has been made, particularly in urban areas (Mukungu 2000; United Nations 2014). From 1990 to 2010, access to "improved" water in rural sub-Saharan Africa increased from 36% to 49%, which means falling short of Target 10 by 30% in these areas (Bradley and Bartram 2013; WHO/UNICEF 2012).

The MDG target highlights two health-related dimensions of drinking water: quality and quantity. For MDG monitoring, an improved water source is defined as one "that, by the nature of its construction and when properly used, adequately protects the source from outside contamination, particularly faecal matter" (http://www.wssinfo.org/definitions-methods/watsan-categories/). However, there is a push to move beyond this paradigm to monitor access in more clear categories, by measuring (i) those using drinking water directly collected from surface water (e.g., ponds)—unimproved water sources; (ii) those using improved sources other than piped household connections; and (iii) those with household connections in a dwelling, plot, or yard (WHO/UNICEF 2012). These categories have implications for potential contamination but also for the quantity of water. Specifically, surface water sources are highly prone to fecal and other contamination (Howard et al. 1999, 2003; Pedley and Howard 1997) and evaporation (Reimann et al. 2003), whereas piped connections are typically drawn from groundwater sources, which tend to be more reliable (do not evaporate) and less contaminated (Pearson et al. 2008). Piped sources in dwellings or within plots also mean that households can more easily fetch water. Studies indicate that water-related diseases dramatically decrease when piped sources are located in a dwelling or on a plot (Bartram and Cairncross 2010).

The Joint Monitoring Programme (JMP), conducted through WHO and UNICEF, monitors and reports improved access to adequate water to assess progress in

meeting the MDGs and future targets. While these monitoring efforts have been critical to understanding changes in access over time, we still lack a realistic understanding of day-to-day access to adequate water for most of the world. What is clear is that an astounding 748 million people still lack access to improved water (WHO/UNICEF 2014). Even with such a large swathe of society living with unimproved access to water, very little is known about how households cope with poor quality and/or low quantities—or water scarcity. The dimensions of access to adequate water are the focus of the research here and can be usefully understood in relation to the notion of water security, which is a concept put forward as a focus for post-2015 sustainable development goals.

Water security has been defined as "...sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socioeconomic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability" (http://www.unwater.org/other-resources/for-the-media/allpressreleases/water-security/en/; United Nations 2012). This definition includes aspects of both quality and quantity and underscores several factors that influence water security, including the physical environment and political systems. The current WHO/UNICEF monitoring program does not account for or measure dimensions of water security including seasonal fluctuations in availability, maintenance and governance issues that affect the usability of or access to water sources, or the dynamic nature of changing levels of reliability in water source access.

One of the major global factors in changing water security is climate change. Climate change estimates for sub-Saharan Africa vary by region, with differing estimates of freshwater availability into the next decades. A recent review of climate change science states that in addition to the clear impacts of water for household hygiene and drinking, changes in water availability will likely impact crop yields and disease vectors, both of which will affect health in the region (Field et al. 2014). Still, both the uncertainty in climate change models and the inherent microclimatic conditions make it difficult to predict changes in precipitation and land temperature (which affect evaporation rates for surface water sources) (Boko et al. 2007). Even slight changes in precipitation in the arid and semiarid regions can lead to dramatic changes in runoff and resulting surface water availability (Fekete et al. 2004). Attributing water scarcity to climate change alone is myopic. In fact, a suite of issues act upon water availability including sedimentation and land-use practices, contamination of sources, governance, and population pressures. Even in the absence of climate change, current trends in population and water use indicate that before 2025 more African countries will exceed the limits of their land-based water resources (Ashton 2002). Climate change is expected to exacerbate scarcity, with estimates as high as 75–250 million people at risk by the 2020s (Bates et al. 2008).

The research here draws from the concept of water security to examine one dimension—water adequacy—and related coping strategies in the face of scarcity in rural communities in the semiarid savannah, which have undergone significant livelihood and water access changes as a result of national policy changes. Specifically, the aims of this research were to 1) understand aspects of water scarcity experienced in three rural villages in southwestern Uganda, 2) examine differences by demographic groups and type of source, 3) assess relationships between different

factors related to water access, and 4) explore the coping strategies used during times of scarcity by those of varying ethnicity or livelihood. In the subsequent discussion, health implications are then highlighted, and relevant lessons for the future between climate change and estimated exacerbation of water insecurity are discussed.

2. Methods

2.1. Ethical approval

Ethical approval was granted by the University of Washington (HSD 07–5209-J01), Mbarara University, and Uganda National Centre for Science and Technology prior to data collection.

2.2. Study site

Water adequacy is already an annual problem in arid and semiarid parts of the world. Arid regions of sub-Saharan Africa are often inhabited by nomadic pastoralists, who use migration to cope with water scarcity. National governments, international development agencies, and nature conservation groups have pushed for the settlement of nomadic people in Africa for decades (Bayer and Waters-Bayer 1994). The semiarid savannah of Uganda is one such location. The complex interplay between the physical environment, policies, and livelihoods make this part of Uganda a fruitful location for understanding current levels of water scarcity, coping strategies, and future implications in light of climate change.

Southwestern Uganda consists of semiarid savannah on a plateau surrounded by low-lying hills with an average elevation of 1800 m [Kiruhura District Local Government (KDLG) 2012]. This area experiences two annual dry seasons, with the extended dry season running from June to August. The area has an annual average rainfall of 1000 mm (KDLG 2012). For centuries, mobility has served as a key risk management strategy to manage water shortage (Loftsdottír 2001). However, throughout the 1980s and 1990s, land was privatized and Lake Mburo National Park (LMNP) was created, which contains a large, permanent drinking water source, Lake Mburo (Magunda and Tenywa 2001; Pearson and Muchunguzi 2011; Nkonya et al. 2005). Since then, migration involves trespass on privately held land. Access of livestock to Lake Mburo is restricted and is only granted by the government during extreme droughts (and is never granted for household use). For a detailed historical account of land use and resource management in the area, see Pearson and Muchunguzi (2011). As a result, households in this area predominantly rely on small, hand-dug ponds (called farm ponds) that have been found to be highly contaminated and susceptible to evaporation (Pearson et al. 2008). Other water sources available to the three villages include two boreholes (one each in Rwamhuku and Rwozi), a distant government-owned large pond, and Lake Kakyera (only reachable for some residents in Nyanga). Generally, households are very dispersed throughout undulating hills and valleys and only Rwamuhuku center can be reached by road. Within Kiruhura District, Nyabushozi County was selected as the study site because of its proximity to LMNP and to the region's severe water shortages from both climatic and political changes.

The area is predominantly occupied by pastoralists (Bahima) and cultivators (Bairu). Together, these two ethnic groups form the Banyankole people. The terms ''farmer'' (agriculturalist) and ''herder'' (pastoralist) characterize occupations but have historically been tied to ethnic and class identities throughout Africa (Turner 2004). These distinctions are often made by outside researchers but are complex and changing categories. Certainly, the relations between these social identities involve economic livelihood activities (and water usage), such as selling milk and maize, and personal relationships, such as marriage and friendship. The livelihoods of these two groups have certainly become blurred since resettlement. Many farmers now hold cattle as a store of wealth and many pastoralists now engage in agriculture. Still, a distinction exists in the prioritizing of activities, as found in other research in Africa (Turner 2004).

2.3. Study sample selection

From all villages within three subcounties directly bordering LMNP, three were randomly selected using a random number generator (Microsoft Excel Basic 2003, Redmond, Washington). Survey participants were then randomly selected from these three villages using proportional population sampling by village in 2008/09. With a goal of 100 households from all three communities, 18 households from Nyanga, 15 households from Rwozi, and 67 households from Rwamuhuku were recruited.

2.4. Survey

2.4.1. Demographic data

Demographic data were obtained using a survey administered by a trained field assistant speaking Runyankole. Demographic data were collected for each acting head of household, including age, sex, ethnicity, education, primary livelihood, and self-reported wealth (using a Likert-type scale). Acting head of household, in this study, was determined by the household and was defined as a leading adult family member who did not work and/or slept elsewhere for the majority of the study period.

2.4.2. Water scarcity and coping data

Data on type of water source for household consumption (e.g., borehole, small pond on personal land called a farm pond, and larger water body) in both the wet and dry seasons, water source ownership, seasonality of water availability, a self-reported measure of level of access, estimated minutes spent walking to access water (one way travel, not including waiting time at the source), whether the source was unusable (e.g., borehole pump malfunctioning, water source dry, owner banned shared use, etc.) at least once within the last two weeks of April were compiled using the survey. Note that the survey was conducted in the midpoint of the dry season. Type of water source was a categorical variable. Water source ownership was treated as both a categorical variable and as an ordinal variable, indicating the degree of

access based on ownership. Specifically, water sources that were more public were assigned high values (4 = public source), followed by somewhat public (shared = 3), personal source (2), and owned by boss (1). Self-reported level of access was also measured as an ordinal variable (where better access = 5 and poor access = 1). Minutes spent walking one way to the water source were divided into ordinal values (4 = <10 min, 3 = 11–29 min, 2 = 30–45 min, and 1 = 46+ min).

In addition, categorical data on primary coping strategies used during times of household water insecurity were recorded in the survey. The legality of such strategies was noted to compare tenuousness in coping options used by different subpopulations. Here, illegal migration includes trespass onto privately owned land and the national park. Legal migration includes movement onto distant land owned by friends or family or the respondents themselves. Sharing water included help from neighbors, friends, and family nearby.

2.5. Analyses

Demographic data on households and data on primary water source type were compared between those accessing a permanent water source and those accessing a temporary one (which evaporates in the dry season or is no longer accessible because of migration for pasture, etc.). To assess relationships between different factors related to water security, Spearman's rank correlation was used in developing relationships between the following variables: self-reported level of access to water, minutes spent walking to source, ranked ownership of source, and whether the water source was inaccessible at least once during the last two weeks. Next, counts of households using various types of water sources as the primary source in the wet versus dry season were tabulated to understand differences in type of source used across seasons. Last, the demographic variables and some access/insecurity variables were compiled according to primary coping strategies employed during times of insecurity. All analyses were conducted using Stata version 13 (College Station, Texas).

3. Results

The survey was conducted in 92 households out of the original 100 enrolled in the three communities. Eight households were lost to follow-up due to relocation outside of the three study communities; there were no refusals. Most mothers and fathers in households did not attend any secondary school (Table 1). About half of the respondents reported that their primary livelihood was derived from agricultural activities (52%), followed by cattle, fishing, and other activities. The average age of the acting head of household was 45 years and most households self-reported their level of wealth as moderate or average (54%) followed by low to very low wealth (26%). Overall, 21% of households reported experiencing inaccessibility of their primary household water source in the last two weeks (during the midpoint of the dry season), and 61% report that this primary source is temporary or seasonal.

In comparing the household demographics and water source characteristics between those relying on a primary water source that is reported to be permanent

Table 1. Characteristics of survey respondents by seasonality of primary household water source.

Household and water source characteristics		Primary household source		Total
		Permanent $n = 36$	Temporary $n = 56$	$n = 92$
	Male acting head of household (%)	97	88	91
	Age acting head of household, mean (std dev)	41 (18)	47 (18)	45 (18)
Education (%)	Mother's education > primary school	10	24	19
	Father's education > primary school	6	33	23
Ethnicity (%)	Bahima	8	38	26
	Bairu	75	48	59
	Other	17	14	15
Main livelihood (%)	Cultivation	64	45	52
	Cattle	11	41	29
	Fishing	14	11	12
	Other	11	3	7
Self-reported wealth (%)	Very high to high	8	27	20
	Moderate	44	61	54
	Low to very low	47	13	26
Experienced water insecurity at least once in last two weeks (%)		29	16	21
Wet season water source type (%)	Borehole	81	2	33
	Farm pond	6	45	29
	Lake	11	0	4
	Rainwater	0	52	32
	Other	3	2	2

versus temporary (Table 1), most characteristics were similar between the two groups. However, households accessing temporary sources tended to have higher levels of at least primary education for the father (24% vs 10% for those accessing permanent sources) and mother (33% vs 6%), to be of Bahima ethnicity, to use cattle or agriculture as the primary livelihood, and rely on rainwater (52%) followed by farm pond (45%) as the type of water source. Surprisingly, those accessing permanent sources reported water inaccessibility within the last two weeks (29% vs 16%). As expected, those accessing permanent sources tended to use a borehole or the lake.

Assessment of the relationships between different factors related to water access, using Spearman's rank correlations (Table 2), indicated that self-reported level of better access to water was significantly correlated with fewer minutes spent walking to the water source (Spearman's rho = 0.585; 95% CI 0.432–0.705). The self-reported better access was weakly correlated with access to a more public or shared source, although at a marginal significance level (Spearman's rho = 0.203; $p = 0.0519$). Surprisingly, more public ownership was also weakly correlated with experiencing inaccessibility at least once in the last two weeks of April (Spearman's rho = 0.209; 95% CI 0.002–0.399). During the preceding two weeks, 40%

Table 2. Comparison of measures of water insecurity and access. The items in bold font significant at the $p < 0.05$ level.

Spearman's rho (95% CI)	Self-reported level of access	Minutes walking to reach water source	Owner of water source	Insecurity at least once in the last two weeks of April
Self-reported level of access	1.000			
Minutes walking to reach water source	**0.585 (0.432–0.705)**	1.000		
Owner of water source	**0.203*** **(−0.002–0.392)**	−0.009 (−0.213–0.197)	1.000	
Insecurity at least once in the last two weeks of April	0.070 (−0.139–0.273)	0.048 (−0.161–0.253)	**0.209 (0.002–0.399)**	1.000

* $p = 0.0519$.

of those using boreholes experienced difficulty in accessing their primary source, indicating a maintenance issue with one of the two public boreholes and in the study area. In addition, 28% of households using rainwater experienced difficulty in accessing their primary source.

In the wet season, there was a fairly even split between reliance on boreholes, rainwater, or farm ponds (about 30% each). In the dry season, an increased number of households (50%) rely on boreholes, followed by lakes, farm ponds, and government-owned large ponds. Regardless of season, those accessing a borehole tend to use the source more consistently. In contrast, those accessing smaller surface water sources (farm ponds) in the wet season tend to shift to larger surface water sources in the dry season, such as lakes, rivers, and particularly government-owned large ponds. Those who use rainwater in the wet season rely predominantly on boreholes followed by lakes in the dry season.

To cope with water scarcity, Bahima, the relatively wealthy pastoralists, reported primarily relying on either legal migration (38%) or sharing (33%) (Table 3). This is because they typically have kinship and social networks with other pastoralists in other locations. Bairu, the agriculturalists, tend to rely on sharing (37%) and purchasing water (28%). Some Bairu also report illegal migration (7%). Although households of other ethnic groups are few in this study ($n = 14$ are nonnative to this region), these households reported reliance on legal migration (36%) and purchasing water (21%). This group also reported the highest percentage of no coping strategies used (29%). These groups may be less able to share with neighbors because of the lack of social connections.

Households reporting high wealth status tend to share water ($n = 18$) as do the poorest ($n = 24$), indicating that the wealthy may be sharing with the poorest households. This compares to slightly lower levels among the middle income group (30%). Households reporting low income reported the highest level of illegal migration (8%). The next highest was reported by wealthy households (6%), which may indicate that some poor households are more limited to tenuous coping strategies and that any fines or bribes are not a deterrent for the wealthy group. The middle income group had the highest reliance on purchasing water during times of scarcity (30%), followed by the poorest households (25%). It appears that

Table 3. Water access characteristics by primary coping strategy used during times of scarcity.

Household characteristic	*n*	Primary coping strategy: Illegal migration (%)	Legal migration (%)	Purchase water (%)	Share (%)	None (%)
Ethnicity						
Bahima	24	0	38	17	33	12
Bairu	54	7	22	28	37	6
Other	14	0	36	21	14	29
Self-reported level of wealth						
High	18	6	33	6	33	22
Medium	50	2	34	30	30	4
Low	24	8	13	25	38	17
Self-reported level of access						
Very high	11	9	37	0	27	27
High	17	0	35	6	41	18
Moderate	61	5	26	31	33	5
Low	2	0	0	50	0	50
Very low	1	0	0	100	0	0
Owner of home water source						
Boss	1	0	0	0	100	0
Personal	9	0	34	11	33	22
Shared by small group	25	0	48	28	24	0
Public	57	7	19	25	35	14

migration, whether legal or illegal, remains a well-used coping strategy in these communities, despite land privatization and the creation of Lake Mburo National Park.

Households with very high self-reported access to water relied on illegal migration as a coping strategy ($n = 11$). Those in the moderate access group utilize every coping strategy category, with a large proportion sharing (33%) followed by purchasing water (31%). Households reporting low ($n = 2$) and very low access ($n = 1$) were few. These households either report no coping strategies or sole reliance on purchasing water. The burden of paying for water may be the reason for reporting very low access to water for this household.

Households using public water sources ($n = 57$) tended to share (35%) or purchase water (25%). This group was also the only group to report illegal migration (7%). Those using a shared ($n = 25$) or public ($n = 9$) source tended to rely on legal migration during scarcity. Those using a personal source reported the highest percentage of no coping strategies (22%), followed by migration (34%) and sharing (33%).

4. Discussion

In this study, almost half of the participating households located in southwestern Uganda access a household water source that becomes unusable in the dry season because of evaporation. Of those accessing ‘‘permanent’’ sources, about 30% experienced inaccessibility of their primary household water source within the last two weeks of April (during the midpoint of the dry season). This inaccessibility of

Table 4. Numbers of households using various water source types in wet vs dry season. Boldface italic numbers indicate a change in source type across seasons. Regular-font numbers on the diagonal indicate the same source type across seasons. Here, GB pond indicates government big pond.

	Dry season water							
	Borehole	F pond	Lake	GB pond	River	Rain	Other	Wet season sum
Wet season water								
Borehole	24	***6***	0	0	0	0	0	30
Farm pond	***4***	6	***2***	***10***	***2***	***0***	***3***	27
Lake	0	0	4	0	0	0	0	4
GB pond	0	0	0	0	0	0	0	0
River	0	0	0	0	0	0	0	0
Rain	***16***	***1***	***9***	***1***	0	0	***2***	29
Other	***2***	0	0	0	0	0	0	2
Dry season sum	46	13	15	11	2	0	5	92

a permanent water source was because of a malfunctioning borehole in one community, as observed during the process of data collection. Access to other sources considered permanent, such as the lake, were more reliable over the preceding two weeks; however, surface water sources have previously been shown to be highly contaminated in this area (Pearson et al. 2008). These findings suggest separate long- and short-term causes of insecurity. A short-term cause of insecurity is the lack of maintenance or proper management of water sources by the water management committee. Two long-term sources of insecurity that are evident include the lack of government provision of sustainable water supplies (e.g., boreholes) and the inherent annual water scarcity related to living in the semiarid savannah.

Table 4 illustrates the seasonal diversity of water sources utilized by households. The most likely sources of relatively safe water are boreholes, and it is interesting that, in this environment, during the dry season borehole water is used by 50% of households (46 of 92), whereas borehole use falls to 32% in the wet season. Meta-analyses of coliform counts on diverse water sources (Bain et al. 2014) suggest that harvested rainwater is often contaminated, and our data show that farm ponds in the area have marked coliform contamination (Pearson et al. 2008), so that, contrary to what might have been expected, use of polluted sources appears to rise in the rainy season. The data on seasonal use of sources point to a need for education on choosing safe sources in the wet season and the need for more studies of harvested rainwater quality in the study area.

For households, self-reported better access to water was associated with proximity to the source and, to a lesser degree, with using more public or shared sources. Those without access to public sources tended to utilize migration as the primary coping strategy. There was also a subset of wealthy Bairu with access to public sources. When those sources became inaccessible, the wealthier resorted to illegal migration to cope. This study also identified a high level of water sharing and reciprocity (although at much lower levels for outside ethnic groups) between wealthy and poor alike. This most likely indicates a strong reliance on social capital bridging between the wealthy and poor for coping (Bisung and Elliott 2014) as wealthy households tended to have larger water sources (because of having

larger plots of land) that persisted longer into the dry season. Because outside ethnic groups appear partially excluded from this coping mechanism, with higher reliance on migration and purchasing water, this suggests that there may be aspects of strong social capital, which are beneficial for Bahima and Bairu but may negatively impact outsiders. For example, social norms defined by these ethnic groups may make it difficult for other ethnic groups to assimilate, to participate, and to form social bonds that are used to cope in times of water scarcity, as suggested elsewhere (Bisung and Elliott 2014). The observed social aspects of water access and coping strategies are entrenched in a much longer history of resource access and ethnic privilege, which existed prior to colonialism but was exacerbated by a series of geopolitical processes over the past 150 years [for a historical account, see Pearson and Muchunguzi (2011)]. Whereas historical power struggles existed between the Bairu and Bahima, these may have diminished in comparison with the exclusion of those from outside ethnic groups.

Other studies evaluating coping strategies and adaptation in arid lands tend to focus on livelihood adaptation of pastoralists (Huho et al. 2011) or agricultural and food strategies (Rufino et al. 2013) rather than explicitly focus on strategies used to access household water. However, an exception is a study in Nigeria that identified that households tended to ''close'' sources to outsiders during times of scarcity and, echoing our study's findings, there was thus a reliance on purchasing water (Adeniji-Oloukoi et al. 2013). Notable differences between the present study and the Nigerian study are that the sample in Nigeria primarily relied on wells and boreholes that are less prone to evaporation and contamination. Migration was not an identified coping strategy (presumably because of the lack of pastoral participants), and a series of behavioral coping strategies used to conserve water were highlighted. These differences highlight important considerations for future water insecurity research and potential policy implications.

First, the lack of behavioral water conservation strategies in this study indicates that households tend to minimize water usage and inhabit a water insecure environment. This is indicated by the reliance on surface water sources and a high level of recent experienced insecurity. This means that households must find alternative sources rather than alter water usage activities to cope. Locating alternative sources involves sharing, migration (both legal and illegal), and/or purchasing water. Because of the historical reliance on migration in this region, this remains a primary coping strategy for many households, despite government efforts to promote sedentarism (Cook 1994). However, it is unknown whether the driving force behind migration is the needs of livestock or humans but it is likely to be both.

Second, the continued reliance on migration (including illicit migration) suggests the need for local or national government consideration of water needs for both household and livestock consumption. Allocation of large surface water sources on public land may be a reasonable action to reduce illicit migration (particularly for those with herds of cattle and if grazing is permitted on such land). District-level government could also prioritize allocation of geologic and hydrologic surveying, with the subsequent provision of groundwater drinking water sources to reduce the reliance on surface water sources for household consumption. Actions such as these may reduce migration and also potentially high levels of contamination associated with surface water sources in the area (Pearson et al.

2008). Policies that integrate the importance of adequate water for households and for livestock may be more effective and sustainable.

This study has limitations: First, water used to support livelihoods (e.g., livestock or crops) was not assessed. The focus of this research was household water. However, without access to water for food or marketable goods, households still experience water scarcity (and food insecurity), with severe health implications. Often, water sources are shared between humans and livestock (Pearson et al. 2008) and thus water availability in one domain affects the other. Any policy or intervention to address household water must also consider the water needed for livelihoods in order to sustainably address water availability. Second, the self-reported data inherently involve potential bias in recall and reporting bias. This is particularly salient in terms of reporting illegal migration. Participants may have been concerned about the consequences of reporting this coping strategy and thus there is likely an under-reporting here. Third, households may rely on more than one source type in each season. This study reported only the primary source type for wet and dry seasons. Last, the cross-sectional nature of this study means that comparison of recent scarcity in the wet and dry seasons was not possible. Future studies could benefit from collecting objective data on water-use quantities, water access for livelihoods, and longitudinal data on experiences of scarcity or inaccessibility of water.

5. Conclusions

This study underscores how access to water resources, particularly in times of scarcity, involves social systems and governance. The absence of diversity in coping strategies (or the uniformity of coping strategies) by the poorest households and reliance on purchasing water among the middle income group have the potential to exacerbate socioeconomic health inequalities. The lack of adequate water for drinking and hygiene has been associated with a suite of infectious diseases (Pruss et al. 2002). With changing water availability expected across the planet, water scarcity will be a new phenomenon in some locations and exacerbated in others. The identified long- and short-term causes of scarcity in this study could partially be mediated by proper maintenance and governance of water provision. Any policies or actions to diminish water insecurity must foster such trust and reciprocity upon which many households already rely. Specific interventions or policies must also be considered for migrants and the poorest households (both economically poor and poor in social capital).

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