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Rural households' access to water resources under climate impacts based on field evidence in Tigray Region, Ethiopia

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The climatic condition in Ethiopia is semi-arid and this has implications especially for rural communities in the country that are largely dependent on surface water. In water scarce areas across four districts in the Tigray region, a survey of 595 households was carried out, and two shared dialogue workshops was held. In this study, the following issues were examined: (i) Access to water in relation to sources, distances covered, gender and time taken; (ii) Local perceptions on current (2014-2017) and future (2018-2021) access to water, and (iii) The types of water conflicts encountered and their causes. Results indicate 50.8% of the surveyed households collected water from dugout ponds and 24% from rivers. Chi-square test showed a statistical significance at the 1 and 5% level, respectively for distance covered and time taken to water sources. Although gender was not significant statistically, females (*N*=440) were more involved than males (*N*=155) in fetching water. Immediate problems arise for householders and specifically women and girls that travelled more than 2 km to collect water. Climate change was mentioned as the key driver that reduced access to water resources whereas tanks with water brought in truck by the government was reported as reason for current increase in access to water. However, future access to water was perceived as unpredictable due to the impacts of climate change. At least 40% of households reported that a member had encountered conflict while accessing water, conflict that manifested itself as verbal accusation and physical fighting. The majority of such instances of conflict resulted from water shortage, followed by pollution from livestock droppings. Project interventions that promote watershed rehabilitation through different ecosystem-based adaptation approaches should be supported locally to restore nearby degraded water sources while improving the functionality of boreholes and existing taps to ensure access and sustainability of water infrastructures.

Key words: Water demand, vulnerability, dugout pond, water catchment, collaborative management, semi-arid.

INTRODUCTION

The Sustainable Development Goals (SDGs), Target 6.4, addresses issues related to water scarcity with the aim of ensuring sufficient water for the population, the economy and the environment by increasing water-use efficiency across all sectors in the society (Vanham et al., 2018). Specifically, the overall objective of this target is "*to substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity by 2030*" (UN, 2015a). Despite such an ambitious set of global goals, recorded progress, however, is slower than needed to meet these targets by 2030 (UN, 2017). To make matters worse, shortages in water supply, uncertain changes in replenishment rates for both surface and groundwater, and deterioration of quality with the potential to reduce both usability and health safety water-related issues are expected to soar in sub-Saharan Africa (Nkem et al., 2011).

Furthermore, it should be noted that Africa's demand and supply chains for fresh water are changing exponentially despite huge investments in water infrastructures (Nkem et al., 2011). Great efforts to improve access to water during the Millennium Development Goals' (MDG) mandate were oriented towards attaining coverage which resulted in a claim that 91% of the population worldwide in 2015 had access to improved water sources (UN, 2015b). Although such achievements are commendable, it leaves us with the impression that an additional 9% coverage could have solved the world's water crisis. This is far from being true because coverage does not translate to sustainability. Globally, populations that have no drinking water service at all and collect water directly from surface water sources such as rivers, lakes and irrigation canals face serious risks to their health and well-being. An achievement was reported in reducing this number when the population using surface water decreased from 4% in 2000 to 2% in 2015. However, of the 159 million using surface water in 2015, 147 million lived in rural areas, and over half lived in sub-Saharan Africa, where 10% of the population still drinks surface water (WHO and UNICEF, 2017: 38). In Ethiopia, this percentage is a little higher with over 12% of Ethiopians still relying on surface water in 2015 (WHO and UNICEF, 2017: 39).

In the most recent Joint Monitoring Programme Report, figures for 2015 show that 844 million people still lacked even a basic drinking water service. Furthermore, 263 million people spent over 30 minutes per round trip to collect water from an improved source (constituting a limited drinking water service) and 159 million people still collected drinking water directly from surface water sources, 58% of whom lived in sub-Saharan Africa (JMP, 2015). This compares unfavourably with the 2012 figures which state that at that time globally 750 million people lacked access to safe drinking water. This problem of access to safe clean water exacerbates, and is exacerbated by, the fact that in 2015, 2.3 billion people still lacked even a basic sanitation service (JMP, 2015). There is a small decrease in this figure from that recorded for 2012, wherein approximately 2.5 billion (1 in 3) did not have access to basic or improved sanitation, mainly as a result of poor water resourcing (WWDR, 2012).

Population growth, agricultural intensification, urbanization, industrial production and pollution, and climate change are beginning to overwhelm and undermine nature's ability to provide key functions and services according to the United Nations *Sustainable Development Goal 6 Synthesis Report 2018 on Water and Sanitation* (UN, 2018). A recent study indicated that climate change will increase the pace of the global hydrologic cycle with accompanied rise in temperature, variability and changes in precipitation patterns (Daniel, 2011). That is not to suggest that climate change is the only, or even the principal, pressure affecting rural livelihoods. Land degradation is considered a severe problem in Ethiopia due to the influence of its topography which affects both land qualities and water resources (Tadesse et al., 2017). Furthermore, Ethiopia loses about 1.9 billion metric tons of fertile soil from the highlands every year and the degradation of land through soil erosion is increasing at a high rate. The consequences of soil erosion and land degradation on crop yields have led to the expansion of farmlands by smallholders around watersheds in Eastern Tigray (Alemayehu et al., 2009).

The specific objectives of this study were to determine the role of gender, distance covered, time taken and the impact of climate change on access to water. Considering the fact that these communities are heavily dependent on open sources such a dugout ponds, rivers and streams, the time spent in the queue is not relevant in this study. Therefore, three research questions are addressed in this study based on distance, gender and time to water sources used in Chi-Square tests of independence. The first H_o states that distance covered has no effect on water sources used by households, while the H_1 states that there is an effect. The second H_o states that there is no relationship between gender and water sources used by households, while the H_1 states that there is a relationship. The third H_o states that there is no association between time taken and water sources used by households, while the H_1 states that there is an association. These key questions will be considered in greater detail in the analysis together with other issues such as perceived impacts of climate change on access to water, the type and causes of water conflicts. Given that rainfall projections for Ethiopia are uncertain and climate variability is exacerbated by a number of existing risks such as drought (Calow et al., 2013), an insight into

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rural community's access to water is both timely and important. Such insights based on field evidence are invaluable especially for the SDG Target 6.4, which aims to address water scarcity and to substantially reduce the number of people suffering from water scarcity by 2030.

MATERIALS AND METHODS

Case study area in Ethiopia

Tigray is one of the regional states of Ethiopia located in the northern part of the country and lies between 12° 15′ N and 14° 50′ N and 36° 27′ E and 39° 59′ E with a total land area of 80,000 km². Administratively, it consists of five zones and 34 rural districts also known as 'Woreda', an Ethiopian local administrative unit that forms a district. It has a population of 4.3 million people of which 80.5% live in rural areas (Mekuria et al., 2007). Four districts were selected for this study by the WaterSPOUTT project; this project has as its objective to transform access to safe drinking water through the application of integrated social sciences, education, and solar technologies in vulnerable communities in Africa (Etongo et al., 2018: 4).

The case study sites were selected from the Eastern and Southern zones as follows: Serawat 10 km West of Mekelle, May Nebri 50 km South of Mekelle, Harena 15 km North of Mekelle, and Tsuwanet 55 km North of Mekelle (Figure 1). The rationale for their selection was based on locating communities surrounding ponds and streams that were in use as sources of domestic water supply, but where these unsafe water sources were being predominantly used at homes and in schools. Administrative units using local boundaries in the Tigray Bureau served as a guide in the selection of the four case study areas (Fagan et al., 2018). Three of the four case study districts are heavily dependent on surrounding dugout ponds and wells, while the fourth district relies on a stream closer to the community. Although the fourth district has tap water, it was not fully functional at the time of the survey that took place between June and September 2017. However, the dugout ponds and wells do not contain water all-year-round and these communities have to access water from distant rivers and/or functional boreholes from neighboring communities (Edossa, 2008).

The study area falls within the semi-arid agro-climatic zone having highly dissected and rugged terrain (Virgo and Munro, 1978). The region consists of central mountain highlands of uneven topography composed of peaks and plateaus dissected by gorges rising up to 3900 m a.s.l while the plains that are predominantly located in the north-western lowlands is as low as 500 m a.s.l. (Haregeweyn et al., 2006). Agro-ecologically, it is classified as a highland and midland area, with mean annual air temperature of 22.8°C and a maximum of 27.2°C. Annual precipitation ranges from 515 to 872 mm (Gebremedhin, 2004). This region has a bimodal rainfall pattern with smaller amounts of rainfall that occur between the months of November and March and the major rainy season of June and September, which is locally called "*Kiremti*" (Gebrehiwot and Van der Veen, 2013). The small rains are unreliable and insufficient for crop production. However, the regional climate is characterized by large spatial and temporal variations and frequent droughts. Especially of note is the one that occurred in 2015 a consequence of climate change due to variability in rainfall patterns.

The lithology of the study area is comprised of Mesozoic sedimentary rocks and Tertiary basalt (Nyssen et al., 2002). Soils of the study sites developed in calcium carbonate-rich parent material of the Agula Shale formation, which consist mainly of Marl and Limestone (Beyth, 1972). Agriculture is the main sector of the economy and constitutes nearly 45% of the total regional Gross Domestic Product. The importance of agriculture to the regional economy can be gauged by the fact that it directly supports about 80% of the population in terms of employment and livelihood. Agricultural systems are dominated by small-scale farmers with an average land holding of less than 1 hectare per family characterized by low input and output rain-fed mixed cropping with traditional irrigation technologies in place for centuries now (Solomon and Kitamura, 2006). The major crops cultivated in the study area include barley (*Hordeum vulgare*), wheat (*Triticum sativum*), teff (*Eragrostis teff*) and millet (*Eleusine coracana*). Rainfall in most of the arid and semi-arid regions of Ethiopia, and in Tigray in particular, is not sufficient to support rain-fed agriculture especially with prolonged periods of drought that are recurrent in the last three decades (Berhane et al., 2016).

Data collection and analysis

This current study began with a shared dialogue workshop (SDW) on water resources with opinion leaders and other stakeholders in the Tigray Region. Within the context of WaterSPOUTT, a SDW is a forum that brings academics as well as technicians, educators, politicians, practitioners, community leaders, and household members together at regular intervals (once every six-month-period) to identify challenges and obstacles to, and opportunities for, the uptake of solar technologies at the household, community, and regional level (Etongo et al., 2018). The Social Science Work Package of the project focuses on socio-cultural, institutional and governance issues around water during the SDWs. Therefore, the 3rd and 4th SDWs that occurred in November 2017 and May-June 2018 were specifically organized by WaterSPOUTT partners at Mekelle University to address issues around access to water.

Household surveys and field visits to the study sites complemented the data collection process. Given that the livelihood activities are similar across the case study sites, namely dependence on subsistence farming/livestock and the use of similar water sources (Fagan et al., 2018), a random sampling method was applied which resulted in the selection of 595 households. Questions asked in the household survey included what water sources were used; available water sources, distance covered by households to access water, household perceptions on their current (2014-2017) and future (2018-2021) access to water, types of water conflicts encountered and their causes. The collected data were mostly categorical and satisfy the following two assumptions for Chi-Square tests for independence. Assumption 1: datasets having at least two variables measured at an ordinal or nominal level (that is categorical data). Assumption 2: The two variables should consist of two or more categorical independent groups. Example of independent variables that meet these criteria include distance to main water source (4 groups: <500 m, 500-900 m, 1 km and >2 km), gender of household heads (2 groups: male and female), and time taken to water sources (5 groups: <10 min, 10-30 min, 30 min, 1 h, 1-2 h and >2 h).

The complementary qualitative data from the SDWs on issues around water was analyzed using verbatim transcription and Wordstat 7 (PROVALIS RESEARCH, Montreal, QC, Canada) content analysis software that enabled us to identify the key themes emanating from the discussion. The Wordstat 7 software was used because of its ability to find themes or relationships in verbatim responses, focus group transcripts, or other text sources. It involved four main steps as follows (Adam et al., 2015): (1) identification of the main themes; (2) attributing codes to the main themes; (3) classification of responses under the main themes; and (4) integration of themes and responses into narratives. Furthermore, descriptive methods using Chi-Square tests of independence were applied to test the three hypotheses. The results are presented in the form of pie charts and column graphs using the Statistical Package for Social Science (SPSS) version 23 (IBM Corp. Released 2015. IBM SPSS

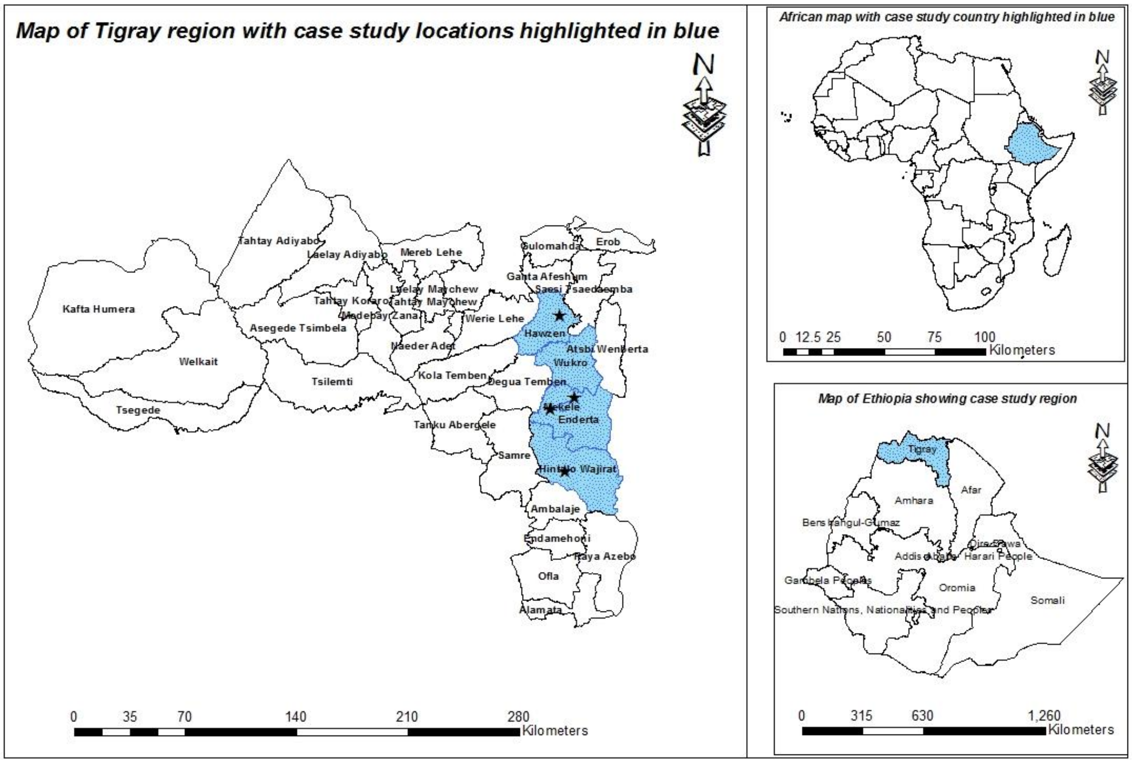

Figure 1. Case study location highlighted in blue.

Statistics for Windows, Version 23.0. Armonk, NY, USA).

RESULTS AND DISCUSSION

Access to available water sources

The majority of the surveyed households in the study area collected water from dugout ponds (50.8%). The use of rivers was reported by 24% while another 10.4% of the households collected water from dug wells (Figure 2). In Ethiopia the percentage of the rural population reported to have safely managed services and to have basic services is 4 and 26%, respectively. Water usage is determined by economic policy, population change, consumption patterns, technological infrastructure and water policy (Fagan et al., 2017). This is so because the installation of large-scale water treatment plants in rural Ethiopia is difficult due to the scarcity of resources and scattered settlement (Abatneh et al., 2014).

Additionally, a Chi-Square test was conducted to verify if the distance covered by households had an effect on the water sources used. The test result indicated that distance covered by households did have an impact on water sources used because the H_o was rejected in favour of the H_1 given that *p*< alpha (Table 1).

The relatively high percentage of households using dugout ponds relates to minimal resource requirement for construction where rainwater-harvesting ponds constitute an important feature on the Tigrayan landscape. Taps were found only at *May Nebri* and were undergoing rehabilitation at the time of the survey. According to a recent study conducted in the Tigray Region (Berhane, 2018), over 78,000 dugout ponds have been constructed since the year 2000 in order to increase access to rural water supply. Despite such efforts and investment by the government and Non-Governmental Organizations (NGOs), our research identified that most of the constructed ponds are not functional with overall poor performance levels and insufficient impacts to local communities was widely observed (Fagan et al., 2018, 2017). Some of the challenges that affect the performance of rainwater harvesting ponds based on field observations, key informants and from SDWs are inadequate site selection, absence of a biophysical survey during design and construction, leakage and evaporation losses, poor management of the ponds and the impacts of climate change (Berhane, 2018).

Furthermore, another statistical test was conducted with the H_o to find out that there is no relationship between gender and water sources used by households. The test result failed to reject the H_o given that *p* >alpha (Table 2). As such, water sources are not gender sensitive, but rather, accessibility is likely to be influenced by availability.

The problem will no doubt be further compounded

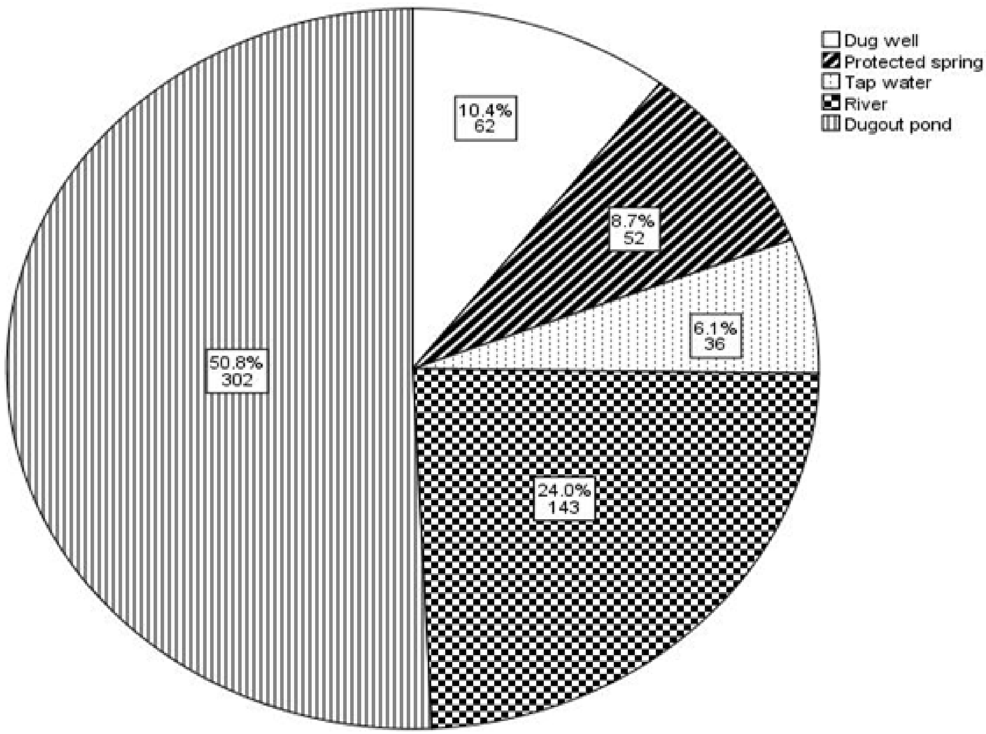

Figure 2. Primary sources of water used by households in the case study area.

given that climate models have predicted temperatures in Ethiopia will rise over the coming years, increasing by 2.1°C in 2050 and 3.4°C by 2080 (FDRE, 2007). On the other hand, rainfall has witnessed a high degree of variability during the last five decades and is expected to continue and to be accompanied by frequent and severe droughts, thereby increasing the burden on water (Deressa et al., 2011). Immediate problems arise for householders and specifically women and girls then in that our study revealed that female were more dominant than males in accessing water from the different sources (Table 2). Furthermore, our result indicated that distance had an effect on access to water (Table 1) of which some of the surveyed households travelled more than 2 km to collect water. The main reasons provided to us during a field visit in the area in July 2017 was that nearby sources such as dugout ponds and wells easily dry-up (Figure 3) while the few available water sources also suffer from constant pollution from livestock droppings.

The test result between water sources used by households versus time taken to arrive at these sources showed a 5% level ($p \leq 0.05$) statistical significant (Table 3). Information gathered from SDWs and during a field visit to the study sites further reaffirm our findings of householders using rivers at distant location as reliable water sources. Travelling for longer distances to access water is not a surprise in rural Ethiopia as corroborated by an earlier study in which approximately 60% of those residing in rural areas travel more than 1 h and up to 5 h daily to collect water. This burden falls disproportionately on women who are solely responsible for collecting water and with such time demands, it is not surprising that per capita water use especially in rural areas in Ethiopia is low (Calow et al., 2015).

Water and climate change: Local perceptions and field evidence

Most households in this study perceived a decline concerning their current access (2014-2017) to water. The explanation provided by one of the households in *May Nebri* is that their “family has been living here for more than 50 years and several nearby streams have disappeared and water in ponds gets evaporated easily compared to five decades ago” (MN27). Another household said, “we have not experienced the kind of drought we had in 2015 in the last thirty years. Not only did we lose our livestock, but all surface water except for a river which 2 hours from our community completely dried-up” (S45). It is evident that water resources are vulnerable to the impacts of climate change and the main environmental challenge, in addition to land degradation, that Ethiopia and neighbouring countries are facing today is water scarcity (Mekonnen et al., 2015a, 2015b). Other reasons for water scarcity mentioned by key informants in the Tigray Region include poor management of water points, lack of adequate water infrastructures, and

Table 1. A cross-tabulation between water sources versus distance covered.

Main water source versus distance covered			Distance to main water source from home				Total
			<500 m	500-900 m	1 km	>2 km	
Main water source	Dug well	Count	17	18	16	11	62
		Expected count	3.5	11.8	9.3	37.4	62.0
	Protected spring	Count	3	7	18	24	52
		Expected count	3.0	9.9	7.8	31.4	52.0
	Tap water	Count	1	13	6	16	36
		Expected count	2.1	6.8	5.4	21.7	36.0
	River	Count	11	21	12	99	143
		Expected count	8.2	27.2	21.4	86.3	143.0
	Dugout pond	Count	2	54	37	209	302
		Expected count	17.3	57.4	45.2	182.2	302.0
Total			34	113	89	359	595

Chi-square tests	**Value**	**df**	**Asymp. Sig. (2-sided)**
Pearson chi-square	129,082[a]	12	0.000
Likelihood ration	115,012	12	0.000
Linear-by-linear association	70,855	1	0.000
Number of valid cases	595	-	-

Symmetric measures		**Value**	**Approximate significance**
Nominal by nominal	Phi	0.466	0.000
	Cramer's V	0.269	0.000
Number of valid cases		595	

(a) 3 cells (15.0%) have expected count less than 5. The minimum expected count is 2.06. Not assuming the null hypothesis. (b) Using the asymptotic standard error assuming the null hypothesis.

increasing demand for irrigation and livestock watering.

However, some of the households perceived their current access to water has stayed the same while others were of the opinion that it has increased during the said period. Next most mentioned reason for the increase in current access to water was the provision of water tanks that were installed at schools and health centres (Figure 4). Over 70% of the surveyed households mentioned the role of the government in bringing water in trucks from distant locations to fill-in the tanks especially during the dry season.

The climatic condition in Tigray is semi-arid and according to the Climate Change Vulnerability Index, Ethiopia is ranked seventh among countries at risk from the impacts of climate change (Maplecroft, 2015). This has implications for water resources for various uses such as domestic, livestock watering and even for the traditional irrigation systems used by smallholder farmers which have been practiced for centuries. To make matters worse, it has been estimated that two-thirds of the world population will be living in areas facing water-stressed conditions by the year 2025 (Ahmad, 2002). Adequate and accessible water supply is a prerequisite for socio-economic development (IFAD, 2012; Hunter et al., 2010), and it is clear that water resourcing still remains a major health and livelihood challenge in Ethiopia in general, and in Tigray in particular.

In relation to their hopes for improving future access to water, many of the surveyed households were of the opinion that it is unpredictable. One household explained that, "one of our neighbouring community use to have similar problem on water but now they have a functional borehole, but for us, we cannot tell what will happen in the future concerning access to water" (H22). It is not a surprise that the majority of the households surveyed are not certain concerning their future access to water

Table 2. A cross-tabulation between gender and water sources used.

Gender versus water sources used			Gender		Total
			Female	Male	
Water source used	Dug well	Count	43	19	62
		Expected count	45.8	16.2	62.0
	Protected spring	Count	39	13	52
		Expected count	38.5	13.5	52.0
	Tap water	Count	28	8	36
		Expected count	26.6	9.4	36.0
	River	Count	111	32	143
		Expected count	105.7	37.3	143.0
	Dugout pond	Count	219	83	302
		Expected count	223.3	78.7	302.0
Total			440	155	595

Chi-square tests	Value	df	Asymptotic significance
Pearson Chi-Square	2,306[a]	4	0.680
Likelihood Ration	2,322	4	0.677
Linear-by-Linear Association	0.072	1	0.789
N.of Valid Cases	595		

Symmetric measures		Value	Approximate significance
Nominal by nominal	Phi	0.062	0.680
	Cramer's V	0.062	0.680
Number of valid cases			595

(a) 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.38. Not assuming the null hypothesis. (b) Using the asymptotic standard error assuming the null hypothesis.

especially with the high dependence on water sources that are highly vulnerable to the impacts of climate change. One of the case study communities, *May Nebri,* have taps that were expected to be functional a month after our survey. Households in this community were convinced that their water problems will be solved by tap water being provided, but worried about the functionality of the taps given the pervious very long period of breakdown. Therefore, both current and future access to water, especially under a changing climate, would require water technologies that are functional and can be easily maintained.

Conflicts over access to water

Out of the 595 surveyed households across the four case study communities, a total of 40.7% (*N*=242) had encountered at least one type of conflict. These conflicts occurred across different stakeholders, and manifested as verbal accusation and physical fighting as reported by 43.8 and 31.8% of surveyed households respectively (Figure 5). Additionally, disputes were also reported to have occurred with the water user committees (WUCs), and also with government representatives at the regional level especially with the Tigray Regional Health Bureau and Tigray Bureau of Agriculture and Rural Development. Both Bureaus have the mandate (especially the former) to improve community access to water.

Shortage of water is the predominant cause of conflicts in the case study community as reported by 69.4% of the surveyed households. Pollution from livestock droppings (22.3%) and the breakdown of dug wells (8.3%) (Figure 6) were also mentioned. Excessive demand on water resources for agricultural, domestic, and industrial activities combined with a growing population contribute

Figure 3. Rainwater harvesting pond at *Serawat* with water at full capacity as seen in the month of October 2016 (Figure 3a) while in July 2017, the same pond is completely dry (Figure 3b).

Table 3. Water sources used versus time taken to arrive at these sources.

Water sources versus time to access these sources			Time taken to arrive at water source					Total
			Below 10 min	**10-30 min**	**30 min-1 h**	**1-2 h**	**Above 2 h**	
Main water sources	Dug well	Count	0	5	9	5	43	62
		Expected Count	0.3	5.1	6.5	9.3	40.8	62.0
	Protected spring	Count	0	3	9	5	35	52
		Expected Count	0.3	4.3	5.4	7.8	34.3	52.0
	Tap water	Count	0	2	4	10	20	36
		Expected Count	0.2	3.0	3.8	5.4	23.7	36.0
	River	Count	0	21	18	18	86	143
		Expected Count	0.7	11.8	14.9	21.4	94.2	143.0
	Dugout pond	Count	3	18	22	51	208	302
		Expected Count	1.5	24.9	31.5	45.2	199.0	302.0
Total		Count	3	49	62	89	392	595
Chi-square tests			**Value**	**df**		**Assymptotic significance**		
Pearson chi-square			29,653[a]	16		0.020		
Likelihood ration			29,302	16		0.022		
Linear-by-linear association			0.418	1		0.518		
Number of valid cases			595					

Table 3. Contd.

Symmetric measures		Value	Approximate significance
Nominal by nominal	Phi	0.223	0.020
	Cramer's V	0.112	0.020
Number of valid cases		595	

(a) 8 cells (32.0%) have expected count less than 5. The minimum expected count is 18. Not assuming the null hypothesis. (b) Using the asymptotic standard error assuming the null hypothesis.

Figure 4. A hand-dug well close to a primary school in *Tsuwanet* with walls that easily collapse and also visible is a rainwater tank and a white storage tank close to the school building (Figure 4a). With financial support from World Vision International, a stone wall was constructed in May 2017 to protect walls from collapsing and also from livestock (Figure 4b).

to water shortage and conflicts. In three of the study areas, with the exception of *Tsuwanet*, water sources were accessed by humans and livestock together. It is clear that as reported in the present results (Figure 6) from information gathered from visits to the study sites (Figure 7) and the discussions at SDWs, that conflicts arose because of livestock droppings in water sources making it unfit for some domestic uses showing agricultural and domestic needs clashing.

Limitations of the study

This study faces a number of limitations. First, it could have been much better to have a dichotomous group: improved access and unimproved access to water. With these two categories, the factors that affect water users in both groups could be identified easily. But this was not the case because these communities are highly dependent on untreated water sources and *May Nebri* had taps that were not functional at the time of the survey. To overcome this limitation, water sources used by the surveyed households were considered.

Next, self-reported assessment by households can be biased, especially if the issue under investigation is considered sensitive. This was the case with the question that focuses on the type of water conflicts encountered by household members. Although issues concerning rape are mentioned during SDWs, households that have a member who is a victim of rape, are not willing to share such information.

CONCLUSIONS AND POLICY RECOMMENDATIONS

Despite the progress recorded during the mandate of the

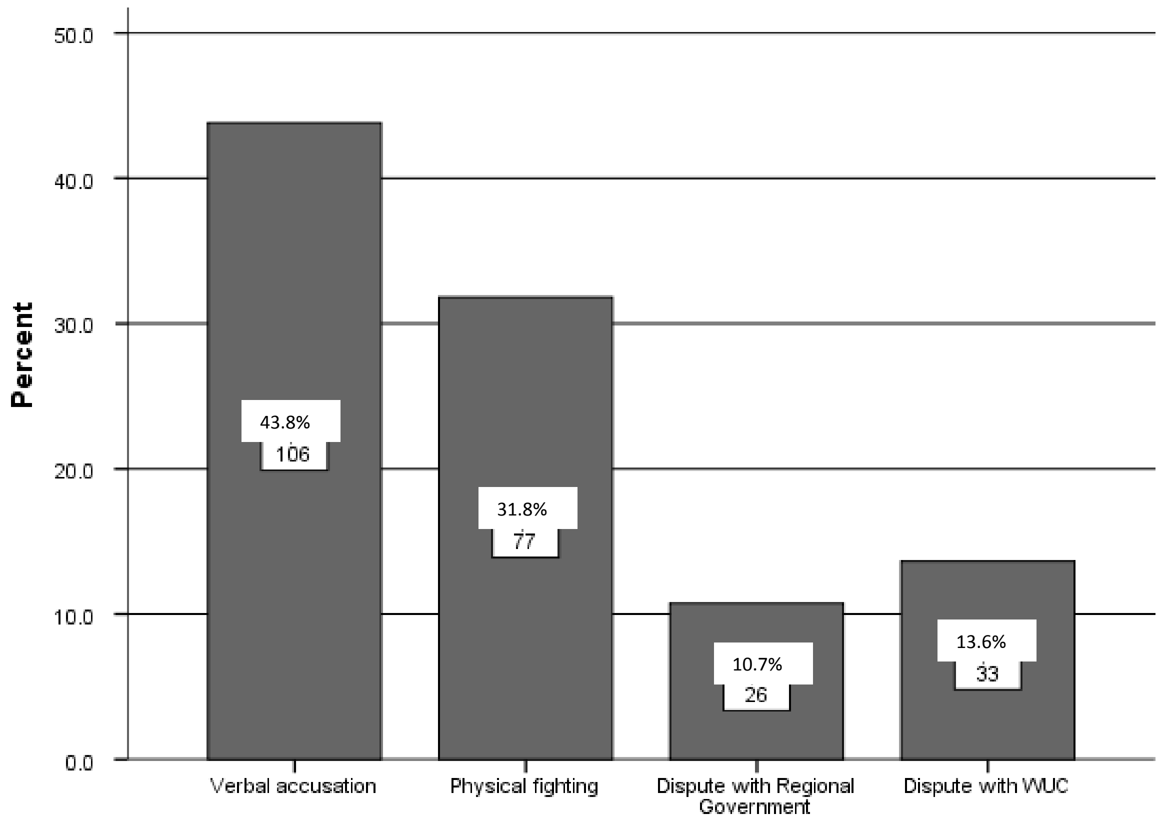

Figure 5. Type of conflicts encountered by surveyed households while accessing water.

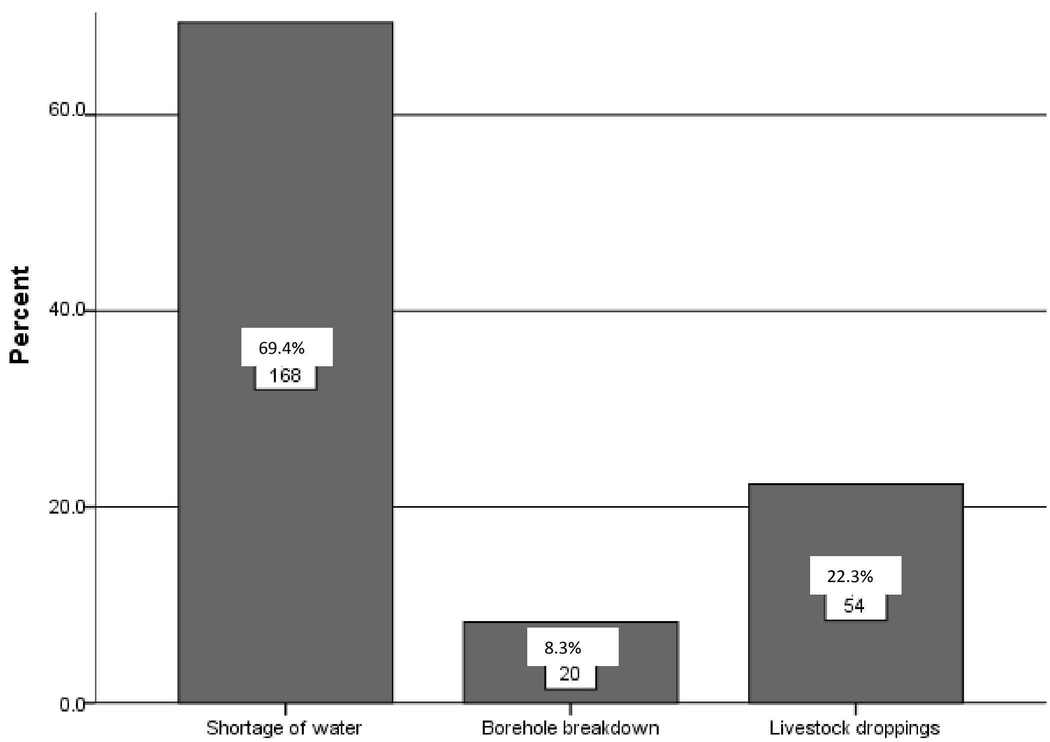

Figure 6. Causes of conflicts encountered by households.

Figure 7. Water sources predominantly used across the four study communities with visible signs of cattle sharing three of the four sources with human.

MDGs, the majority of households in rural areas in the Tigray Region in particular still lack access to safe and reliable sources of water. The Chi-square test results showed a statistical significance at the 1 and 5% level, respectively for distance covered and time taken to water sources. Immediate problems arise for householders and specifically women and girls that travelled more than 2 km to collect water. Although gender was not significant statistically, females (*N*=440) dominated males (*N*=155) in collecting water. Some of the challenges that affected the performance of rainwater harvesting ponds aside from the impacts of climate change based on field observations, key informants and from SDWs included inadequate site selection, absence of a biophysical survey during design and construction and poor management. Despite the occasional provision of water by the government by bring water in trucks, climate change was highly perceived to have reduced current access to water while future access was highly unpredictable.

Furthermore, at least 40% of households reported that a member had encountered conflict while accessing water, conflict that manifested itself as verbal accusation and physical fighting. The majority of such instances of conflict resulted from water shortage, followed by pollution from livestock droppings. The government have responded to the scarcity of water by bringing in water tanks with truckloads of water especially to some primary schools and health centres in the case study areas. However, the majority of the surveyed households perceived their future access to water as unpredictable given that some springs, hand-dug wells and rainwater harvesting ponds are completely dried-up during certain period of the year. The consequences therefore are that longer distances are covered to access water from relatively more reliable sources such as rivers or from neighbouring communities with boreholes and water pumps that are functional. Generally, per capita water use in the case study locations and the rural areas in Ethiopia is low given that most household members travel more than 2 hours to collect water, the majority of whom are women and female children.

Aside from the low per capita water use, different types of conflicts were recorded such as verbal accusation and physical fighting in addition to disputes between stakeholders. It is clear that as reported in the results from information gathered during a visit to the study sites and the discussions at SDWs, that conflicts arose because of livestock droppings in water sources making it unfit for some domestic uses showing agricultural and domestic needs clashing. Project interventions that promote watershed rehabilitation through different ecosystem-based adaptation approaches should be supported locally to restore nearby degraded water sources while improving the functionality of boreholes and existing taps to ensure access and sustainability of water infrastructures. Water allocation is also important to avoid waste and conflicts. For example, water from ponds should be allocated for other domestic purposes such as washing, cleaning to avoid the waste of water. Such sources should also be used for small-scale irrigation and for the watering of livestock.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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