An Assessment of Rural Water Supply Coverage using Geo-spatial Tools: A Case Study of Bahir Dar Zuria District in Amhara Region

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Abstract

The government of Ethiopia is committed in attaining safe drinking water coverage by the year 2015. However, the focus has been on provision of drinking water and spatial coverage rather than on safe and sustainable water point sources. The general objective of the study was to examine the rural water point sources coverage taking Bahir Dar Zuria district as a case. Five rural kebele administrations were randomly selected and a total of 124 households were selected using systematic sampling techniques for household survey. Water point data were collected for the entire district and a total of 523 water point sources were identified and mapped using GPS, DR Garmin and water point mapper. The results showed that hand dug pump (77.4%) and hand dug wells rope pump (11.9%) were the dominant water point sources in the study area. In terms of functionality, 16% of the water point sources were not functioning during the field survey because of lack of repair and maintenance, low yield and management problems. The study, through the use of GIS environment, revealed that the distribution of water point sources in the district were dispersed spatially. It was found out that there were dense concentrations of water point sources in the southern part of the study district, while in the northwestern part; the distributions were relatively thinner, especially that of hand dug well normal pumps. From the survey data, it can be inferred that community participation and strong institutional factors helped to enhance sustainability of water supply whereas theft, lack of spare parts, shortage of technical experts, faulty operation and lack of financial support for maintenance were identified as negative factors affecting the sustainability of water point sources in the study area. The study recommended that kebele officials have to create awareness in the community on sustainable use of the available water point sources.

Key words: Water points, Functionality, accessibility, Bahir Dar Zuria

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1. Introduction

Water is among the most important natural resources for sustenance for plants, animals and humans. It is also the basic requirement for the healthy functioning of the entire world's ecosystem (UNDP, 2011). Improved health, better living standards and economic developments are closely related to the availability and accessibility of adequate water supply (Hofkes & Visscher, 1986). However, about 800 million people do not use clean drinking water in 2011, in addition 185 million rely on surface water to meet their daily needs of drinking water, and about 3 billion people have limited accesses to adequate sanitation (UNDP, 2011). This means that unavailability of safe, adequate and affordable water seriously affects the social, economic and health conditions of a society. More specifically, children and women, who are directly involved in collecting water and managing activities at household level are more vulnerable to such problems (Tafesse, 2009). According to WHO and UNICEF (2013) report, at the end of 2012, 89% of the worlds' population could use clean drinking water, and 55% relished health benefits obtained from piped water supply. The paradox is that 83% of the populations in developing countries are living in rural areas without access to clean drinking water sources. The same report further added that Sub-Saharan Africa (SSA), including Ethiopia, has the lowest drinking-water coverage in the world. In contrast, several regions, including Northern Africa, Latin America and the Caribbean, and Western Asia, have achieved clean drinking water coverage close to 90% (WHO & UNICEF, 2013). UNICEF (2010) evidently stated that in developing countries like SSA countries, more people have mobile phones than improved access towater and toilet services.

Ethiopia is not exceptional to the problems mentioned. In 2011 for example, only about 50% of the total population of the country had access to drinking water services (WHO and UNICEF, 2011). The same report estimated that about 61% of the rural populations in Ethiopia had no access to potable water. The situation aggravated the infant mortality rate (150 per 1000), low economic productivity and low female enrolment ratio at school (Abebe *et al*., 2013). Habtamu (2012) added that many Ethiopian rural communities suffer from lack of safe drinking water for the reason that almost one-third or one-half of all drinking water point sources fail to give services after a few years of construction.

The Amhara region in its Growth and Transformation Plan (GTP) targeted to achieve drinking water coverage at about 87% for the entire region, in which urban coverage constitute 97.6% and rural coverage at about 86% in the year 2015 (Water, Sanitation and Hygiene (WASH), 2011). Nevertheless, in 2012, the drinking water coverage of the Amhara region had reached only 62%, with great variations between urban and rural, 61% and 71%, respectively (Office of Woreda Rural Development, 2012). This showed that drinking water supply coverage in the Amhara Region were not able to meet its intended targets. MoFED (2010) evidenced that rural potable water supply is a serious problem of the country in general and of the Amhara region in particular.

Few studies such as Zemenu (2012), Misgina (2006), Beshah (2012) and Abebe et al. (2013) have conducted researches on the issue of drinking water supply in some parts of Ethiopia. However, their works did not employ Geographic Information System and Remote Sensing Techniques in showing rural drinking water distribution. It is believed that using GIS and Remote Sensing Techniques could help to show the spatial and temporal variations of drinking water supply in certain areas. More importantly, as far as the researchers' knowledge is concerned, no study has been conducted in Bahir Dar Zuria Woreda in relation to rural drinking water supply using Geographic Information System and Remote sensing techniques. Hence, the present study tries to fill these gaps.

The general objective of this study was to assess rural drinking water supply coverage using Geo-spatial Tools, in Bahir Dar Zuria Woreda, Amhara Region, Ethiopia. The specific objectives include: (i) to describe the types and coverage of water point sources in the study area; (ii) to identify the factors that affect the sustainable use of water point sources in the study area; (iii) to examine the role and power of women in decision making in planning and implementing water point sources in the study area.

2. Description of the Study Area

The study area, Bahir Dar Zuria district, is found in West Gojjam Zone of the Amhara Region, which is situated 560 kms far from Addis Ababa (Figure 1). The study area is located at an altitude ranging from 1700-2300 meters above sea level and has a total area of 151,119 ha. The area receives an average annual rainfall of about 1035 mm. The minimum and maximum temperatures lie at 10^0C and 32°C, respectively (BoFED, 2011). The Tis-Isat falls which is a tourist attraction site is located in this district which constitutes lots of monasteries and visit sitesCorn, sorghum, cotton, sesame and *teff* are the principal crops, while cattle, sheep, and goats are the dominant livestock.

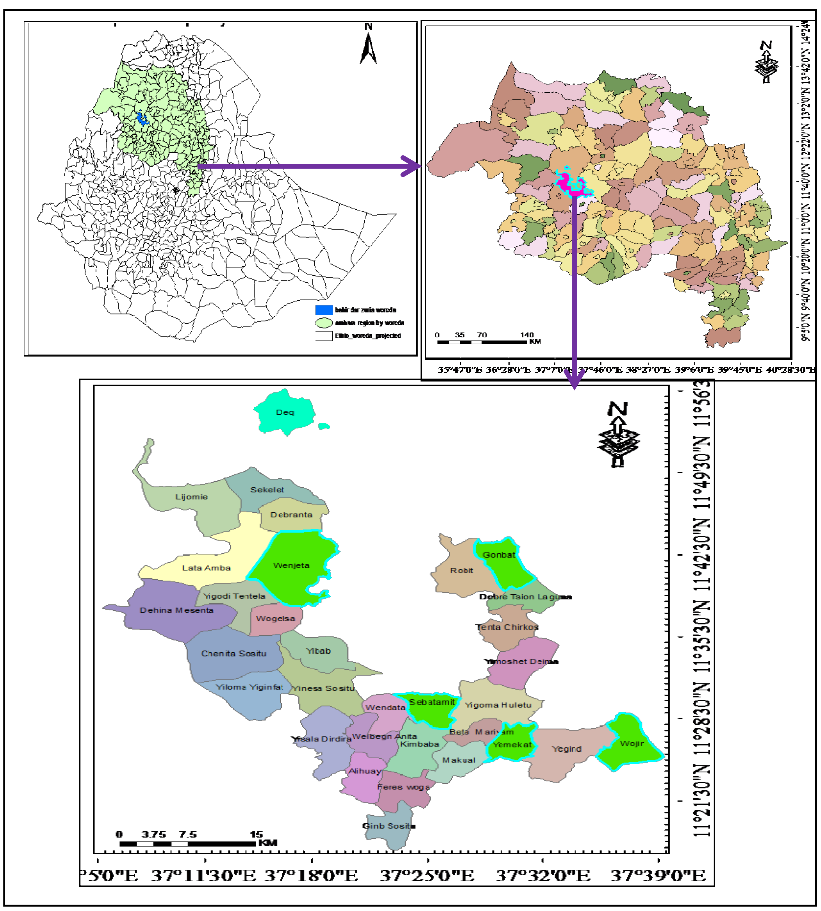

Figure 1. Location of the study area

3. Research Methodology

The research design for this study was mixed, composed of both quantitative and qualitative research methods. The study area was selected purposely for the reason that the issue raised is timely and due to the writers' familiarity to the area. Among the 32 rural *kebele* administrations (RKAs), five RKAs were selected using random sampling technique for household survey. As shown below, Kothari (2004) formula was used to determine the number of respondents to fill the questionnaire. Using this formula, a total of 124 households were chosen to fill the questionnaire.

$$n = \frac{z^2.P.Q.N}{e^2\ (N-1) + (Z^2\,P.Q)}$$

Where n = sample size; Z = values of standard variation at 95% confidence interval (1.96); P = sample proportion (0.03); q = 1 – p; e = the estimate should be within 3% of the true value; N = the total household population

In the identificationselection of key informants, purposive sampling techniques were employed composed of RKAs water committee, District Water Resource Development office, Water Resource Administration expert, Hygiene Water Supply Planner, Bureau of Water Resource Development and elderly and knowledgeable households in the selected *kebeles*.

Primary and secondary data sources were employed for the study. Primary data were collected from survey responses, key informant interview, field observation and ground survey using GPS. According to Bahir Dar Zuria *woreda* water resource development office annual report (2014), there were 715 water supply schemes within 32 *kebeles* in the *woreda*. Ground reference data obtained from land survey with hand held GPS collected from 523 (above 70% of the total ground points in the study area) were the main data sources for this study. Secondary data sources included political administrative boundary maps obtained from Bureau of Finance and Economic Development of Amhara (BoFED) and GPS reading (192 WP). The Global Positioning System (GPS and DNR Garmin) were used in the mapping of water point sources accessibility and coverage assessment.

The collected data were analyzed using different techniques. The data obtained from the household survey were entered in to SPSS version 20 software and presented using frequencies, percentages and tables. Geographical Information systems were designed and developed for acquiring, compiling, analyzing and displaying topological interrelations of different spatial information, which were dependable with the works of Ekanayaki and Dayawansa (2003). Universal Transverse Mercator (UTM) system and ARC GIS10.1 software were used for data analysis. ARC GIS 10.1 was used for buffering, dissolving and clipping the water points and mapping the water supply coverage of the area. For analyzing proximity the Ethiopian Ministry of Water Resource and Energy (MoWRE) (2013) standards were employed. Global mappers 11 were used for Conversion of different image format; Water point Mapper were utilized for producing maps showing the status of water supply services and Google Earth production were employed to show the distribution of water supply schemes. Besides, Multi Criteria Evaluation Model (MCEM) was used to evaluate water supply coverage of the areas, which were computed on the basis of geo-spatial techniques since this model is widely used to handle suitability evaluation for water point sources.

Accessibilities Analysis of water supply schemes

Geographical Information Systems (GIS) were designed and developed enabling the acquiring, compiling, analyzing and displaying topological interrelations of different spatial information (Ekanayaki and Dayawansa, 2003). The required data for analysis was gathered with the help of GPS using the Universal Transverse Mercator (UTM) system and were given digits with ARC GIS10.1 software. For proximity analysis, Ethiopian Ministry of Water Resource and Energy (MoWRE) (2013) standards were used, and were scored the distance from the water supply schemes provided access to 15l/c/d water within 1.5km distance of the water points (Table 1).

Table 1. Accessibilities and distance from water supply sources.

Distance from the water supply source	Level of accessibilities
1 km	Highly accessible
1.5 km	Moderately accessible
2 km	Poorly accessible

Source: MoWRE (2013)

4. Results and Discussion

"To increase economic productivity and improve public health, there is an urgent need to immediately enhance access to safe and adequate drinking water to the community" (Sandhu, 2010: iii).

4.1. Demographic characteristics of respondents

The mean age of the sample respondents was about 39 years old and the majority of respondents (85%) were found to be married. About 22% of respondents were female-headed households. The average family size was seven with three the minimum and thirteen the maximum. Out of the total households, 19% were not able to read and write where as about 41% wereliterate. The survey result also showed that about 32% of the respondents had some form of formal education.

4.2. Factors Affecting Rural Drinking Water Point Sources/Supply

Physical and socio-economic factors were centralin influencing the water supply situations of the study area. Key informants' opinion and household survey results showed that access to water sources lie within 1.5 KM average distance. Time to fetch water from the sources, production capacity of water point sources, type of water sources and functionality of the water points were the major factors affecting the sustainability and use of rural drinking water supply in the study area. Besides, community participation, sense of ownership of the project, project management situations were institutional factors affecting the efficient use of rural drinking water points in the study area. Hence, the following discussions will focuson these issues.

4.2.1. Distance Traveled and Time Taken in Fetching Water

As shown in Table 1, more than 70% of the respondents traveled more than 1 km to fetch water. The mean distance was about 1.8 km. The average time for single round trip was about 43 minutes (Table 2). A study made by Arega (2013) indicated that on average women in *Kolla* zone of Lay Gayint district of the Amhara region traveled a round-trip of about four hours a day to fetch water, which was much higher than the present study. The focus group discussion results substantiated that queuing and waiting was more serious than the actual distance travelled to fetch water. The result obtained is still far from the recommended distance indicated by WHO and Ministry of Water Resources (universal access plan) which was 0.5 km to 1.5 km distance and 15 to 30 minutes of fetching water from the source to dwelling places (BoWRD, 2006).

Table 2. Distance traveled and time taken to collect water for the households

Distance (in meters)	Frequency	Percent	Time taken to fetch water
1 – 500m*	7	6	11 – 20 m
500 - 1000 m	27	22	21 - 30 m
1000 - 1500 m	31	25	31 - 40 m
1500 - 2000 m	20	16	41 - 50 m
2000 - 2500 m	26	21	51 - 60 m
2500 - 3000 m	13	10	61 - 90 m
Total	124	100	
Mean = 1759.677m, S = 611.515			

* m = meter

4.2.2. Construction of Water Point Sources

Key informants noted that construction of drinking water point sources increased the community's access to safe drinking water. However, it would have been sustained if the system remains functional after it had been constructed. The study identified that from the year 2010 to 2014 there was a progressive increase in construction of water point sources in the study area (Figure 2). Among the different water-point sources, normal hand dug well pump represented the largets share followed by hand dug rope pump though the difference in frequency between them is the highest as shown in the same figure. Protected spring and *Bonon* was the leastcompared to others. Consistent with this finding, a study made by USAID (2006) showed that rural households obtained much of their water from protected springs, protected dung well and communal water pipes. However, streams and rivers was the dominant water point sources accounting for 87%. The result is coherentto the work of Arega (2013). An interview with the Bahir Dar zuria district office-planner revealed that in the year 2012/2013, there was a plan to construct about 100 wells. This might be the reason that construction of water point sources abruptly increased in between 2010/11 and 2013/2014 in the study area. The same informant also revealed that the noticable increase of water point sources during the indicated time was the result of the government's universal access plan and that of supportive organizations.

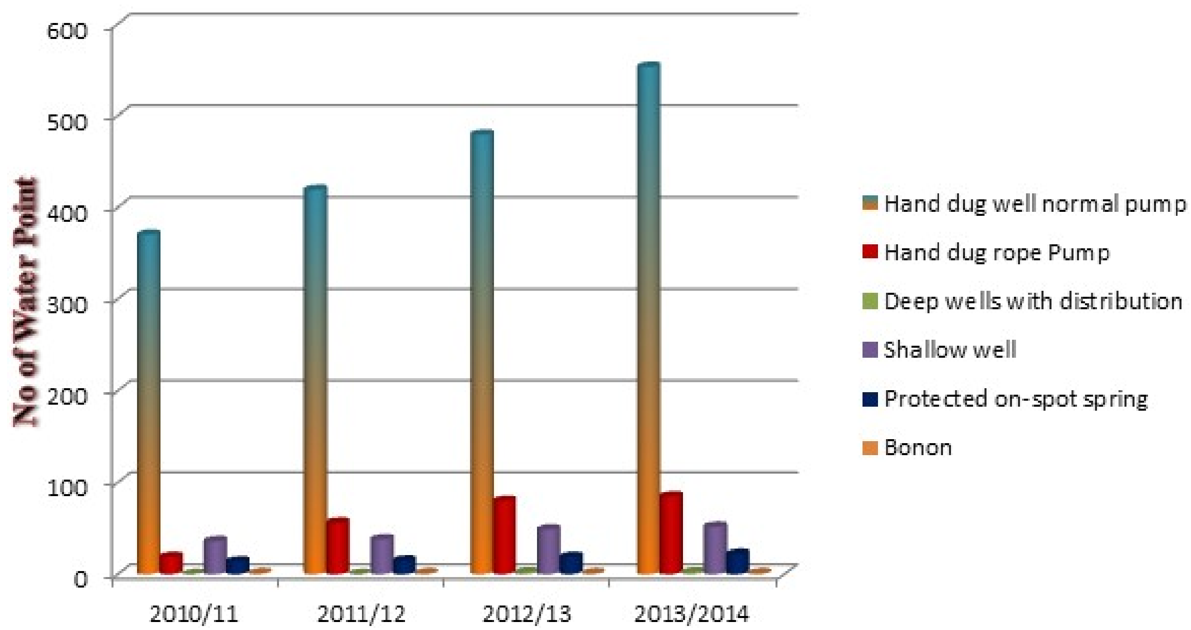

Figure 2. Yearly distributions of water point sources in the study area

4.2.3. Spatial Coverage of Water Point Sources

So far, discussions were made about the improvement and construction of water point sources in the study area through time. The situation demand showing the distribution of water point sources spatially using GIS environment for policy makers. This could help to meet the communities' demand for drinking water supply in the study area. As shown in Figure 3, hand dug well rope pumps were concentrated in the southern part, while they were relatively sparsely distributed in the northwestern part of the study area. Likewise, protected springs were concentrated in the southern part of the study area. However, during the field observation, there was scarcity of water point sources in the northwestern part of the study area, which necessitates the dunging of many wells to satisfy the needs of the communities. In this regard, key informants gave reasons for the uneven spatial distribution water points in the study area and they pointed out that in the north western part of the study area, the topography of the land is rugged and extracting underground water demands huge capital. This has limited the availability of ground water in the north western part which is markedly different to that of the southern part of the study area.

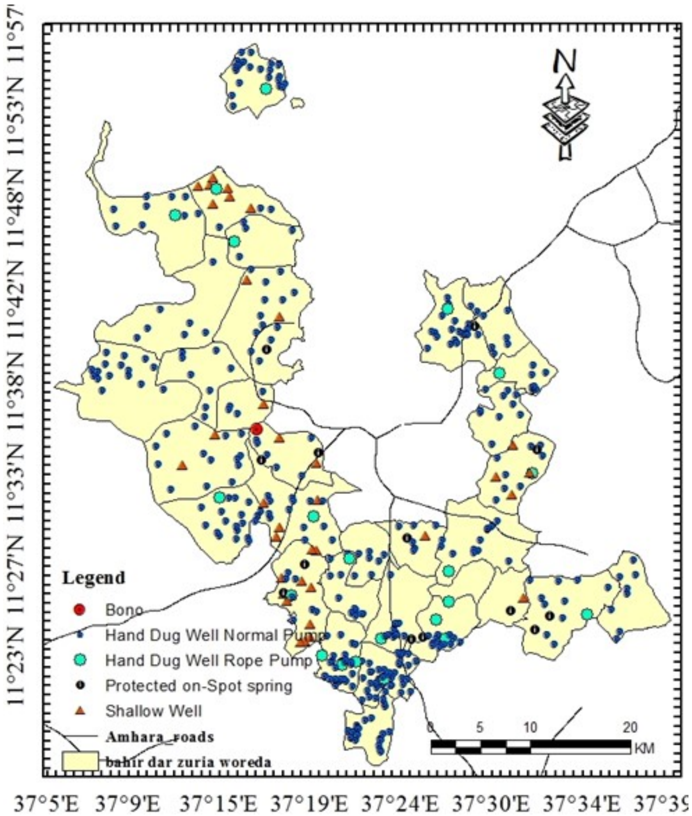

Figure 3. Water Point Coverage in the study area between 2010/11

With the objectives to show the improvement of water point sources in the study district another map was prepared (Figure 4). As shown in the same figure, hand dug well normal pump and hand dug well rope pump have tremendously increased throughout in the entire district with higher concentration in the southern and northeastern part of the study area. Though *bono* and protected on-spot spring were fairly distributed, the overall coverage seems promising. This is due to the government's quest to extend water point sources with the objectives to achieve the millennium development goals (MDGs).

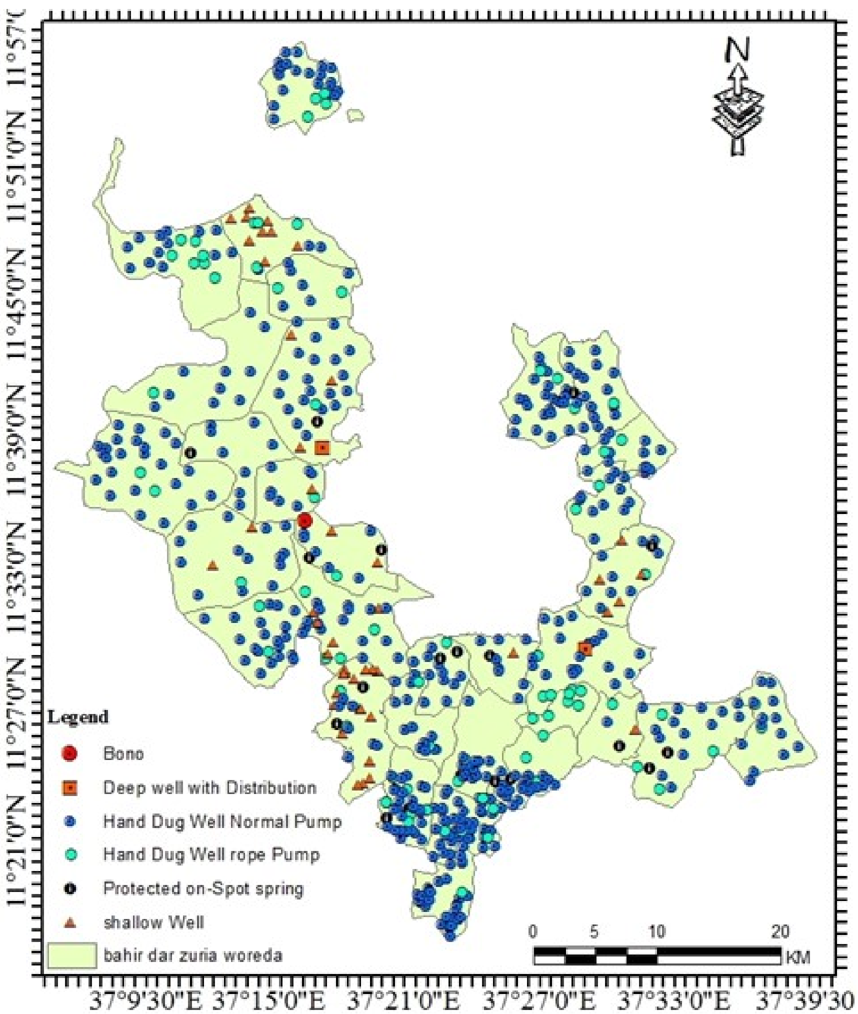

Figure 4. Water Point Coverage in the study area between 2012/13

4.2.4. Functionality of Water Point Sources

The study found out that, of the total 523 water point sources identified only 85 (12%) water point sources were non-functional (Figure 5). The result was much higher thanAhmed's (2013) finding that putthe mean non-functional water points in four districts of the Amhara region at 1.4%. Out of the non-functional water point sources, about 50% were identified to have broken handles caused by exerting high-pressure or continuous pumping (about 30 minutes), and solving this problem was beyond the capacityof the community. In addition to this, management and/or financial problems contributedabout 20% for its non-functionality.

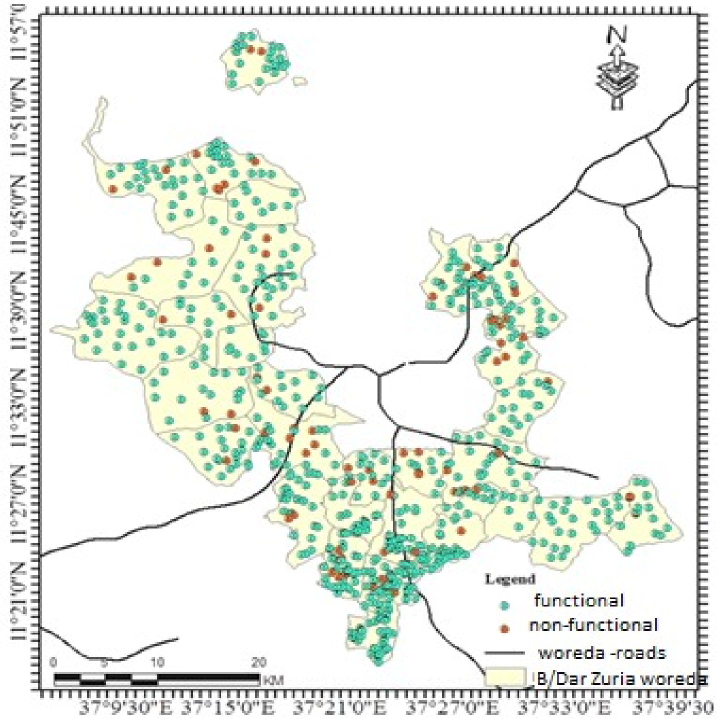

Figure 5. Functionality and non-functionality of water point sources in the study area

Lack of finance for operation and maintenance, shortage of spare parts and technical experts were additional factors contributing for the non-functioning of water point sources in the study area. In general, as shown in Figure 5**,** non-functional water point sources were uniformly distributed across the district.

4.2.5. Accessibility Analysis of Water Supply Schemes

Based on Joint Monitoring Programme for Water Supply and Sanitation of WHO and UNICEF(2001) and Universal Access Programme (2010), classification of rural drinking water schemes access was estimated as follows: 1km as highly accessible, 1.5km as moderately accessible and 2km poorly accessible. These were used as a tool for measuring rural drinking water accessibility. Accordingly, the buffer zones derived from the boundaries of the study area were based on the "reclassification" systems of GIs environment as shown in Figure 6. The same figure revealedthat water supply schemes were most accessible in the southern part and poorly accessible in the northwestern part.

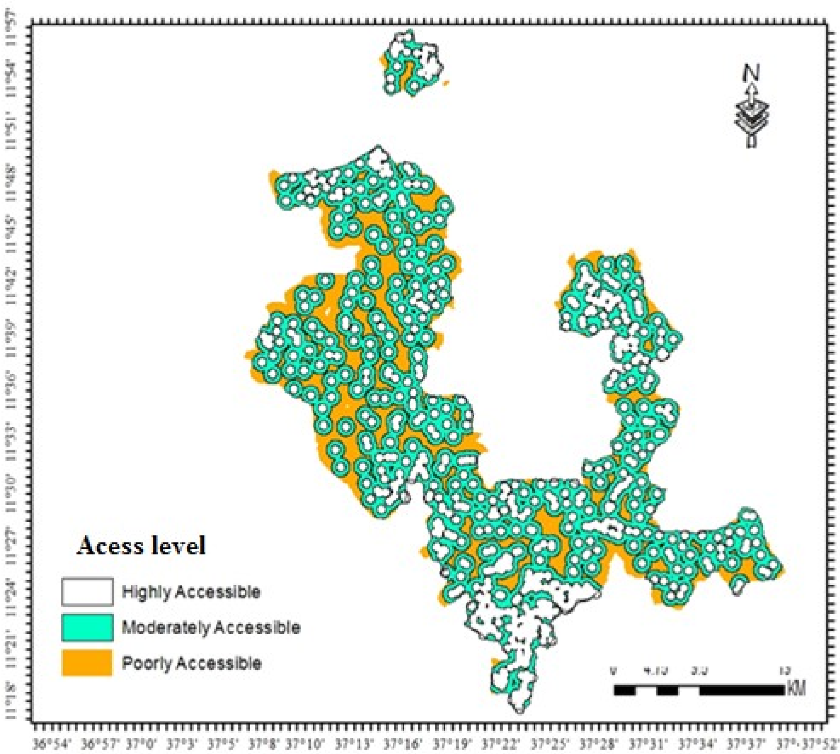

Figure 6. Accessibility of water sources in the study area

4.3. Problems Associated with Sustainable Use of Water Points

Key informants from different sectors pointed out that the main problem of rural water supply schemes was weak coordination between different services delivery systems such as government bodies, local NGOs and water committee. The informants added that weak financial capacity, lack of logistics and human power, inappropriate technology and operational incapability of water committees were considered as the major constraints for the sustainability use of water sources.

According to key informants', technical issues related to design and construction of quality schemes, technical skills needed for operations and maintenances, selection of appropriate technology, availability, accessibility and affordability of spare parts were important determinants to the sustainability of water points. The survey result showed that about 17% of the respondents identified poor construction, 21.2% poor technology and 31% lack of qualified local technicians as the main causes of non-sustainability of drinking water supply in the study area.

Specifically, non-availability of spare parts and tools was the major factor that contributes to the non-sustainability of rural water supply schemes. With regard to this, Hayson (2006) stated that without a reliable supply of spare parts and some qualified persons to repair and maintain the water supply schemes, the use of water points will not be sustainable. Ahmed (2013), from a different point of view, noted that the prices of spare parts are increasing from time to time due to inflation, a common incident in Ethiopia. In assessing whether the local technicians were equipped with necessary toolkits to carryout repairs or not, 21.8% of the respondents revealed that the villagers were unequippedfor such tasks. This might be the reason that some water point sources were non-functional during the field survey (Figure 7).

Some of the factors affecting the sustainability of the water points were identified as contamination by livestock, flooding, and high pressure in the use of the water points.

Figure 7. Non-functional and semi-functional water supply schemes in Sebatamit and Gombat *kebeles*

The other serious problem identified was the communities' low sense of ownership of the existing water points which is directly or indirectly related to lack of awareness . In relation to this, Ahmed (2013) indicated that real ownership feeling means the feeling that one senses property as his own asset or property. The development of sense of ownership calls for community training that could help for the sustainability of the projectas trainings provide the beneficiaries with the skills they need to operate and to maintain the system for the coming consecutive years. However, the study found out that no community based training has been given to develop sense of ownership of these water points. This result was also evidenced by Habtamu (2012). Key informants, on the other hand, stated that strong institutional factors have paramount impact on the sustainable development of water points. Further, they indicated that government experts are concerned about protecting and sustaining the water projects. However, the work done so far in creating awareness and continuous follow up in sustaining the project was insignificant.

As can be seen in Table 3, poor construction schemes and lack of community participation were othermajor problems identified by the respondents. Nonetheless, insufficient water sources and lack of finance for operational activities were least identifiedby the participants as shown in the same table.

Table 3. Respondents' opinions on the causes of unsustainability of water point sources

Alternatives	Respondents Frequency	Respondents Percent
Insufficient water sources	70	58.0
Poor construction of schemes	102	82.0
Lack of communities participation in the water points management	120	97.0
Lack of provisions of spare parts	90	73.0
Lack of qualified local technicians in maintaining project	101	81.5
Lack of finances for operational activities	20	16.0
Pressure in the use of water points	80	64.5
Poor quality of technologies installed	100	81.0

Note: the total is not 100% because of multiple responses

4.4. Community participation

Community participation in all aspects of the project starting from planning to implementation is key to the sustainability of the project. The study found out that community participation in the study area was weak due to lack of awareness in the sustainable use of the project and poor institutional arrangement. This is evidenced by the survey result of which the majority of the respondents (90%) indicated that the technology was prescribed by the government experts. In relation to this, Awoke (2012) pointed out that community participation in all aspects before and after the project implementation, is an indication of sustainability in the use of water points. However, according to the same report, there was limitation in site selection and choice of technology. Abebe et al. (2013) had made an extensive focus group discussion and the results indicated that the rate of community participation in planning and implementation was encouraging while community participation in monitoring mechanism of operation and management as well as on choice of technology was extremely poor. Likewise, Musonda (2004) pointed out that communities should have a say and participate in technology option for sustainable development.

4.4.1. Women's participation in planning rural drinking water supply

As shown in Figure 8, children and women were responsible for fetching water for householdsusing clay pot and plastic *Jarricans*. The study noted that more than 90% of water consumed in the house is collected by women and girls. Likewise, Beshah (2012) indicated that children spent their time in fetching water and stay away from school – thus the futureof the children and their need for education remain unattainable. Likewise, key informants in this study indicated that girls were tasked to fetch water and collect fuel wood after school jeopardizing their education. Tafesse (2009) added that children and mothers are the main water collectors who spend much of their time in doing this work. There are indications of such heavy workload on children and women in the study area.

Figure 8. Woman fetching water (Photo taken with consent)

As a key woman informant pointed, experts in the district overlooked women's participation in project planning and implementation which testifies the negligible role and decision-making power women have in water point management (protection) . During the field survey, it was observed that the representation of women in water committee was insignificant. For example, the present study found out that the representation of women in each water committeewas less than three.Similarly, Habtamu (2012) noted that from functional schemes only one committee has three female members, three committees have two female members, two committees have one female member, and two committees have no female members at all. The same author pointed out that about 38% and 74% women were not participating in the functional and non-functional water schemes, respectively. However, it is women who are the highest beneficiaries from the sustainability of the project and the major contributors for the sanitation and hygiene of the water points. This result is consistent to the work of Ahmed (2013). Awoke (2012) added that women are the one who suffer most from lack of safe water supply in the house. This is due to the fact that women and children are responsible to fetch water from distance and unsafe water points. Likewise, Abebe et al. (2013) indicated that increased access to safe drinking water would mean much for women and their children in terms of health, productivity and income. This is also evidenced by women key informants in this study.

5. Conclusions and Recommendations

This study was initiated with the aim of assessing the problems of rural drinking water supply in Bahir Dar Zuria district of the Amhara region. The issues raised were community participation in maintaining water points, spatial coverage of water points, problems associated with the use of water points, protection of water supply schemes, and women's participation in planning and implementation of water point sources. The study revealed that on average women traveled a round-trip of about 43 minutes a day to fetch water. Like in other parts in the region, women and children were the main sources of labor to fetch water in the house. The study also identified that socio-economic factors such as lack of trained local technicians, unavailability of spare parts and poor construction of water points, lack sense of ownership and poor participation of the communities in maintenance and development of water points were the major constraints in the efficient use of water sources in the study area.

The distribution of water point sources in the district was displayed spatially using GIS environment. It was found out that there were dense concentrations of water point sources in the southern part of the study district, while in the northwestern part; the distributions were relatively thinner especially that of hand dug well normal pumps. As observed in the field, communities' motivation in the contribution of finance, labor and local materials were encouraging. However, the major problem identified was communities' low participation in planning and site selection. Besides, low involvement of women in decision-making process, low capacity of water committee and low sense of ownership by the beneficiaries were vital factors influencing in the sustainable use of water sources in the study area. Scattered settlement patterns (commonly practiced in the northern parts of Ethiopia) and inaccessible topography were some of the barriers in delivering services to the community. This study recommendsthat the local administrators have to create awareness in the community on protecting the water points and develop sense of ownership to the beneficiaries for the sustainable use of the existing sources. These demand greater attention, such as better planning and follow-ups, better operation, maintenance and management of resources. Involvement of women has to be maximized in terms of planning, implementation and management. More importantly, providing training for capacity building has paramount importance in order to scale up the capacity of the water committees to protect and manage the project. Government bodies should develop and monitore traditional springs, hand pumps and ponds through the dissemination of efficient technologies. Finally, there is an urgent demand for succinctly adequate and safe drinking water supply from the rural communities in the study area.

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