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Addressing the drinking Water Needs of hard to reach communities in rural and Peri-Urban areas of Sierra Leone – The spring box option

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ABSTRACT

Groundwater remains a viable option to surface water development if efforts are intensified to address the bacteriological quality which studies have shown has been compromised by high levels of faecal coliform bacteria found particularly in wells dug into the shallow aquifer. Evidences are emerging from recent studies which seem to suggest that the problem may be much more pervasive than expected. Springs appear to be much easier to manage if used for community water supply. In this study, the feasibility of spring sources in providing potable water for hard to reach communities in rural and peri-urban communities is assessed. Surface manifestations of groundwater were identified in 17 communities in five districts in Sierra Leone. The discharge of each spring was measured in the late dry season when flow was at its minimum. The potential of the spring sources in providing sustainable drinking water for the communities was assessed by comparing the per capita supply of the springs as against the per capita demand of the population. Population data for the target communities were obtained from the latest census data which were later validated on the ground with the local authorities. The study has revealed that 88% of the springs investigated are viable sources of drinking water, with per capita water supply meeting or exceeding per capita demand for a design period of 10 years. It is recommended that spring boxes are designed to capture and store as much water from the eyes of the springs. The water must of necessity be disinfected before use to destroy any pathogens that may have been present in the waters. The spring water option, it has been shown, provides a better alternative to unprotected dug wells, especially in rural settings where income levels are insufficient to meet the running costs of surface water development schemes.

KEYWORDS: Spring water option; potable water; discharge; per capita water demand; per capita water supply. viable sources

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I. INTRODUCTION

Access to potable water is a huge challenge in many parts of the world, not least, countries in sub-Saharan Africa, including Sierra Leone. A recent Multiple Indicator Cluster Survey conducted in Sierra Leone (Statistics Sierra Leone, 2017) estimates that only 52.5% of the rural population has access to improved sources of drinking water. Groundwater is the most important source of drinking water, accounting for about 80.8% of all sources in the country, and includes boreholes, protected and unprotected wells, and protected and unprotected springs (Statistics Sierra Leone, 2017).

In a bid to increase access to safe drinking water in rural and peri-urban communities, the Government of Sierra Leone commissioned a Rural Water Supply and Sanitation Project with funds from the African Development Bank, that will provide access to safe water for 625 000 people (47% women) including restoring access for 361 000, in rural communities in five districts in the country (African Development Bank, 2013). Some of the hard to reach areas that are challenged by poor road network but with viable spring sources were earmarked for the construction of spring boxes.

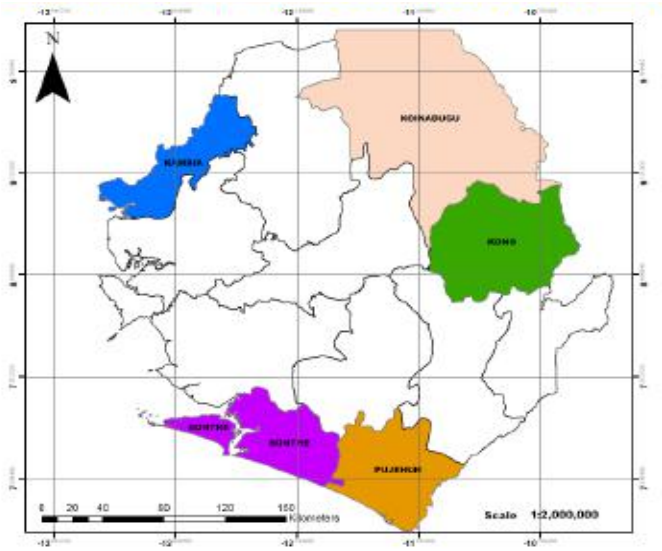
Five districts, including Bonthe, Kambia, Kono, Koidadugu, and Pujehun were targeted for the intervention. A preliminary study conducted by local authorities in the districts identified several spring sources which were deemed to be suitable for meeting the drinking water demands of sections of the population. This study assesses the potential of the spring sources in the target districts in providing sustainable drinking water, consistent with national and global drinking water standards. The result of the study will form the basis for designing spring boxes which would serve as collection basins for subsequent water storage, treatment, and use by the communities.

The study area

The geographical locations of the five project districts are shown in Figure1. Koinadugu and Kono Districts are situated in mountainous areas in the northern and eastern regions of the country, respectively. Kambia District occurs in the north-western region where it shares a land border with the Republic of Guinea. Bonthe and Pujehun Districts are located in the coastal and interior plains which are so characteristic of the southern region. Most of the spring sources used in the investigation are located in Koinadugu and Kono Districts.

The springs emerge from the base of large boulders of Precambrian crystalline rock distributed throughout the districts. The sustainability of a spring source is predicated on the amount of rainfall which serves to replenish the source on an annual basis. Climate in the three districts reflect the seasonal rainfall pattern in the country with a rainy season that commences in May and ends in October, while dry conditions are experienced between the months of November and April (Statistics Sierra Leone, 2008).

Figure1. Map of Sierra Leone showing the study areas



Hydrogeological characteristics

Much of Sierra Leone is underlain by crystalline rocks varying in age from Archaean to Proterozoic (Williams, 1978; Wright et al., 1985). These rocks have been subjected to three phases of thermotectonic activities, namely, the Leonean (Ca. 2900 Ma.), the Liberian (Ca. 2700 Ma.), and the Rokellide (Ca. 550 Ma.). The rocks range in composition from quartz diorite to legitimate granites, with a predominance of granodiorite (MacFarlane et al., 1981). Although fractures are pervasive in the older rocks, they occur at relatively shallow levels except where they are of regional extent, such as faults.

The characteristics of crystalline basement aquifers have been exhaustively described (Acworth, 1987; Wright and Burgess, 1992; Taylor and Howard, 1994; Chilton and Foster, 1995; Butterworth et al., 1999). The source of the springs is groundwater moving through fractures in bedrock and emerging in areas where the component of flow is upward. The flow mechanism of groundwater within the shallow aquifer, comprising fractured crystalline basement, is described in Thomas (2019). Most of the spring sources are perceived to be fresh and used by local communities for drinking and other domestic purposes. Springs in the area are recharged annually by rainfall which lasts for about six months, commencing in May and ends in October. During the rainy season flow can be substantial, but is drastically curtailed during the long dry season.

II. MATERIALS AND METHODS

Prior to the field investigation the population size in the various communities were first determined from the most recent national census data (Statistics Sierra Leone, 2016). The annual average population growth rate is used to project the future demand for water in the communities based on the current census data. According to the 2015 census data for Sierra Leone (Statistics Sierra Leone, 2016), the average annual growth rate for the country is 3.2%. However, for the purpose of this study which targets communities in mainly rural areas where population growth is relatively low compared with urban communities, an assumed annual growth rate of 2% is applied. The geometric increase method is used to determine the future population, based on the current population and the average annual growth rate:

$$P_n = P_0 (1 + r/100)^n \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, P_n = projected population after "n" years
P_0 = current population
r = Assumed growth rate

The total quantity of water available for supply to the communities was determined by measuring the discharge, Q, of the spring (See Table1). However, for design purposes it is standard practice to measure the minimum discharge which is determined towards the end of the dry season when spring flow is at its minimum. The available water should be enough to cover the planned design period, taking into consideration the minimum flow available from the spring. A yearly growth rate of **2** per cent is considered for a design period of **10** years.

The minimum spring discharge Q_{min} is used in conjunction with the projected population to determine per capita supply (See Table2) which is given as:

$$Q_S = Q_{min} / P_{10} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where Q_S = Per capita supply (litres/capita/day)
Q_{min} = Average minimum discharge (litres/day)
P_{10} = Design population

In emergency situations, the Sphere Handbook (2018) recommends a minimum of 15 litres of water /person/day for drinking and domestic hygiene. The World Health Organisation recommends a higher quantity of about 20 litres/capita/day, which should take care of basic hygiene needs and basic food hygiene (World Health Organisation, 2013). For the purpose of this study the Author has used 20 litres/capita/day as the minimum water requirement or water demand.

The groundwater sources were first characterised as springs by determining the point of discharge from the subsurface. Springs in which the sources/origins could not be ascertained were excluded from the study. Measurements of spring discharge were undertaken in the late dry season when flow was at its minimum. A flow path for each spring was first established by clearing and decongesting the drainage channel.

The simple bucket method (Meuli and Wehrle, 2001) was employed to measure the flow of the springs. A 5-litre graduated bucket was used to collect water flowing from the springs. A digital stop watch was used to measure the time required to fill the bucket. For each spring, five readings were taken from which the average values are determined. The spring discharge, measured in litres per minute, is reported in litres/day, and defined here as the volume (litres) of water flowing past a particular point per day.

III. RESULTS

Table 1 shows the location of the spring sources and their respective discharge values measured on the dates shown. The data indicates that average dry season spring discharge ranges from 2 656 litres/day at Heremankono in Koinadugu District to 96 696 litres/day at Dewadu, in Kono District (Fig.2). The current population of Faada (101), located in Kono District, is almost thirty times that of Heremankono (3 000).

Per capita water supply is determined from equation (2). In Table 2 it is seen that all except two sources (Heremankono and Kasanikoro), both located in Koinadugu District, depict scenarios where per capita supply exceeds per capita demand, taking into consideration also, the minimum per capita demand for water in rural communities, which is 20 litres/capita/day. That is, the quantity of water available as against the population is enough to meet the drinking water demands of the communities for the next ten years, and adequate also, to compensate for all losses. The comparison is clearly portrayed in Figure3, where the red and blue columns represent total average per capita water supply and demand, respectively. Faada appears to have the greatest potential for providing sustainable drinking water for the community, with an amount of 489 litres available per person/day (Figure3).

Table1. Result of Spring Source Investigation in the Project Districts

DISTRICT	CHIEFDOM	COMMUNITY	COORDINATES	SURFACE ELEVATION (m)	POPULATION	MINIMUM SPRING DISCHARGE (liters/day)}	DATE OF MEASUREMENT
BONTHE	JONG	LUAWA	E 815883 N 842416	28	1200	43 200	12/04/17
KAMBIA	MASUNGBALA	GBONKOTALIA	E 0743366 N 1000105	63	300	13 305	26/03/17
	GBINLE DIXING	KALANGBA	E 0725426 N 1016435	30	500	14 400	27/03/17
KONO	TANKORO	DEWADU	E 288945 N 951071	418	500	96 696	23/03/17
	FIAMA	FAADA	E 288938 N 951082	456	101	60 183	23/03/17
	FIAMA	MEIDU	E 297866 N 949084	393	214	25 156	24/03/17
	SOA	TEIMA TOMBODU	E 321892 N 950875	400	350	93 468	24/03/17
	SOA	TEIMA FAAMA	E 321878 N 950856	377	200	80 407	24/03/17
	LEI	SOOMA	E 310250 N 974139	469	500	27 954	25/03/17
KOINADUGU	WARA WARA YAGALA	HEREMANKONO	E 215077 N 1051050	462	3 000	2 656	29/03/17
	KASUNKO	KASANIKORO	E 183965 N 1051050	462	1 220	10 865	29/03/17
	KASUNKO	MADINA GBONKORBOR	E 184484 N 1053089	302	985	71 069	29/03/17
	WARA WARA BAFODIA	KADANKA	E 203799 N 1062152	540	450	21 689	30/03/17
	NEINI	YORIA	E 241546 N 998407	442	778	85 476	31/03/17
	WARA WARA YAGALA	MANGO TREE	E 218493 N 1060176	461	800	43 200	02/05/17
	WARA WARA YAGALA	SULIMANIA	E 222431 N 1065870	396	2 500	86 400	19/05/17
PUJEHUN	KPAKA	BELEBU	E 204594 N 798653	28	150	8 048	27/03/17

Table2. Per capita demand and supply scenarios for spring sources in the districts

COMMUNITY	Current Population	Projected population Pn (n = 10)	Minimum spring discharge (Q_{min}) litres/day	Per capita water Supply Q_{min}/Pn (litres/capita/day)	Per capita water demand litres/capita/day	Per capita supply as against per capita demand	Viability
Luawa	1 200	1 463	43 200	30	20	Supply > demand	Viable
Gbonkotalia	300	366	13 305	36	20	Supply > demand	Viable
Kalangba	500	610	14 400	24	20	Supply > demand	Viable
Dewadu	500	610	96 696	159	20	Supply > demand	Viable
Faada	101	123	60 183	489	20	Supply > demand	Viable
Meidu	214	261	25 156	96	20	Supply > demand	Viable
Teima Tombodu	350	427	93 468	219	20	Supply > demand	Viable
Teima Faama	200	244	80 407	330	20	Supply > demand	Viable
Sooma	500	610	27 954	46	20	Supply > demand	Viable
Heremankono	3 000	3 657	2 656	0.7	20	Demand > supply	Not viable
Kasanikoro	1 220	1 487	10 865	7	20	Demand > supply	Not viable
Madina Gbonkorbor	985	1 201	71 069	59	20	Supply > demand	Viable
Kadanka	450	549	21 689	40	20	Supply > demand	Viable
Yoria	778	948	85 476	90	20	Supply > demand	Viable
Mango Tree	800	976	43 200	44	20	Supply > demand	Viable
Sulimania	2 500	3 050	86 400	28	20	Supply > demand	Viable
Belebu	150	183	8 048	44	20	Supply > demand	Viable

Figure2. Bar graph showing minimum discharge of springs (X 10^2) in the various localities

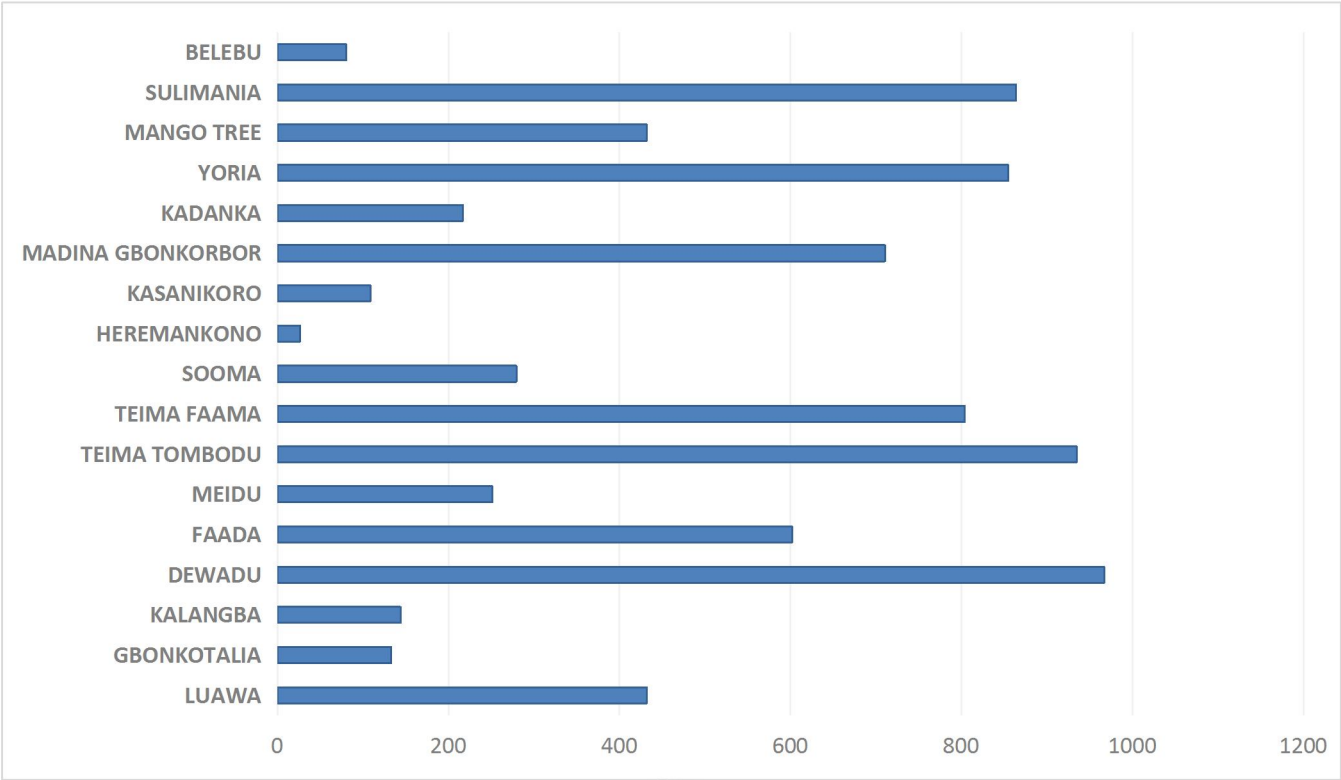


Figure3. Per capita supply (X 10^2) compared with per capita demand for water in the study area

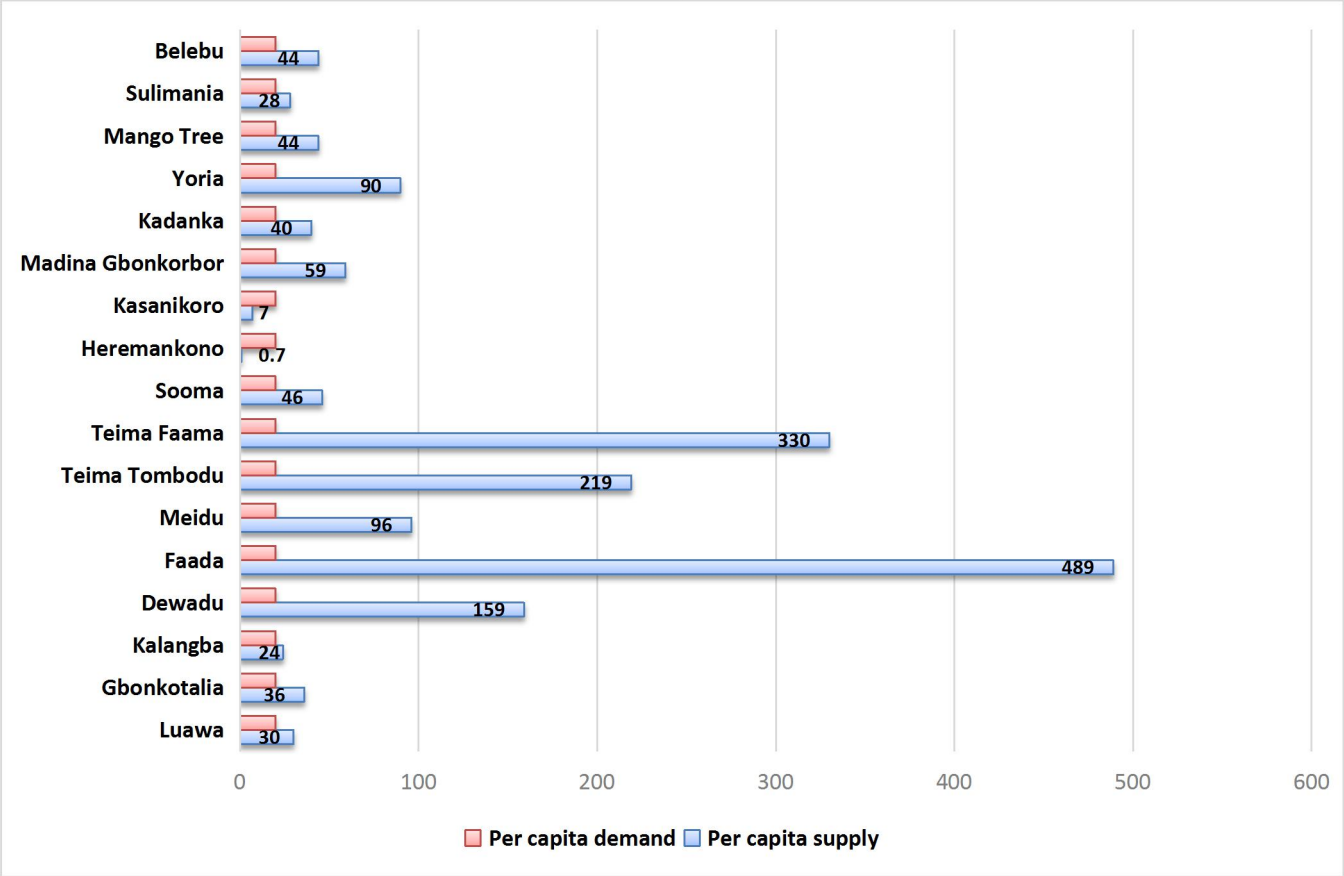
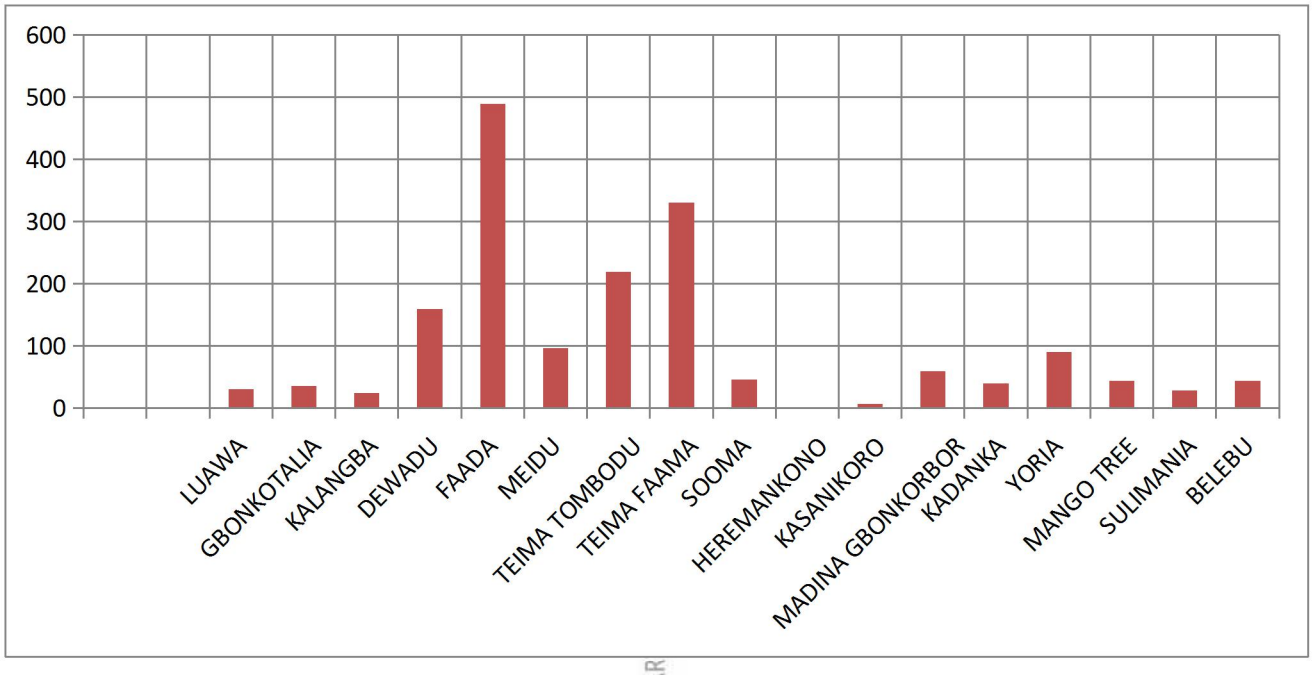


Figure4. Bar graph showing amount of water available for use (litres/person/day), determined as the difference between per capita supply and per capita demand



IV. DISCUSSION

From the data presented it is very clear that most (88%) of the springs that were investigated are shown to be viable sources of drinking water. That is, per capita supply exceeds per capita demand, taking into cognizance also the physico-chemical and bacteriological imperatives. Faada, located in Kono District appears to hold the greatest promise in terms of sustainability (see Fig. 4.). Although the population is projected to increase to 123 in the next ten years, there is sufficient amount of water available to meet the demands of the population. Heremankono, in Koinadugu District, has a current population of 3 000 which is projected to increase to 3 657 in the next ten years. It is clear from the data presented that per capita demand for water in this case exceeds per capita supply. In this case, only a fraction of the population will be served, which might lead to scarcity.

In the rainy season spring flow is expected to increase by three orders of magnitude. Due to the decreased demand for water in the rainy season, much of this surplus will be allowed to runoff and used for ecosystem development. It is recommended that "boxes" are constructed around the 'eyes' of the springs to capture and store as much water as possible. Springs, by their very nature are highly susceptible to contamination due to their interaction with surface water. Consequently, most springs will require some treatment before the water is considered a safe source of drinking water.

It is recommended, therefore, that physico-chemical and bacteriological tests are conducted on the springs to ascertain their suitability for drinking and other domestic use. The testing will help to determine exactly how much treatment will be necessary and may help determine if other sources of water would be more economical.

V. CONCLUSION

The study has shown that the overwhelming majority of the springs are viable sources of domestic water supply, at least, for the next ten years. It is clear from the results that the spring water option have the potential of addressing the drinking water needs of communities with poor road access in rural and peri-urban settings. The results indicate that at the peak of the dry season daily per capita supply of water by the springs exceed per capita demand in 15 out of 17 sources. Physico-chemical and bacteriological tests are required to ascertain the suitability of the springs for drinking and other domestic purposes.

VI. ACKNOWLEDGEMENTS

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VII. REFERENCES

[1] **Acworth, R.I. 1987.** The development of crystalline basement aquifers in a tropical environment. *Quarterly Journal of Engineering Grology, 20, 265-272*
.

[2] **African Development Bank. 2013.** Rural Water Supply and Sanitation Project- Project Appraisal Report. *Sierra Leone Water Company.*

[3] **Butterworth, J.A., Macdonald, D.M.J., Bromley, J., Simmonds, L.P., Lovell, C.J., and Mugabe, F. 1999.** Hydrological processes and water resources management in a dryland environment III: Groundwater recharge and recession in a shallow weathered aquifer. *Hydrology and Earth System Sciences, 3(3), 345-352.*

[4] **Chilton, P.J. and Foster, S.S.D. 1995.** hydrogeological characteristics and water-supply potential of basement aquifers in tropical Africa. *Hydrogeology Journal, Vol. 3(1), 33-49.*

[5] **MacFarlane, A., Crow, M.H., Arthurs, J.W. & Wilkinson, A.F. 1981.** The geology and mineral resources of northern Sierra Leone. *Inst. Geol. Sci. Overseas Memoir. 7., 1-103.*

[6] **Meuli, C. & Wehrle, K. 2001.** Spring Catchment. *Series of manuals on drinking water supply. Vol.4. Swiss Centre for Development Cooperation in Technology and Management.*

[7] **Statistics Sierra Leone. 2016.** National population and housing census 2015. *Government of Sierra Leone. 51pp.*

[8] **Statistics Sierra Leone. 2017.** Sierra Leone Multiple Indicator Cluster Survey. *Government of Sierra Leone.*

[9] **Statistics Sierra Leone. 2008.** Annual Statistical Digest. *Government of Sierra* Leone.

[10] **Taylor, R.G. and Howard, K.W.F. 1994.** Groundwater quality in rural Uganda: hydrochemical considerations for the development of aquifers within the basement complex of Africa, In: Groundwater Quality, eds.: Nash, H. and McCall, G.J.H. *Chapman & Hall, London.*

[11] **The Sphere Handbook. 2018.** Humanitarian Charter and Minimum Standards in Humanitarian Response. *Fourth edition, Geneva, Switzerland. www.spherestandards.org/handbook. 406pp.*

[12] **Thomas, M.O. 2019.** Groundwater flow mechanism at a proposed mining site in South-western Sierra Leone. *Advance Research Journal of Multidisciplinary Discoveries; 35(4) pp. 20-25*

[13] **World Health Organisation. 2013.** Technical notes on drinking-water, sanitation and hygiene in emergencies. *World Health Organisation. Geneva, Switzerland.*

[14] **Williams, H.R. 1978.** The Archaean geology of Sierra Leone. *Precambrian Res. 6: 251-268.*

[15] **Wright, E. P. & Burgess, W. G. (eds), 1992.** Hydrogeology of Crystalline Basement Aquifers in Africa. *Geological Society Special Publication No 66, pp 1-27.*

[16] **Wright, J.B., Hastings, D.A., Jones, W.B., and Williams, H.R. 1985.** Geology and Minerals Resources of West Africa. *George Allen and Unwin. 187 pp.*

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