

An Assessment of Water Sourcing Technologies and Stakeholder Stratagems Applied in the Balikumbat Highland Community of Ndop Plain, Cameroon

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Authors' contributions

This work was carried out in collaboration of both authors. Author SAB designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript and managed the analyses of the study. Author ZNF managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

When a burgeoning population faces water supply scarcity dilemma, stakeholders and interests emerge to offer multivariate water harvesting systems to affected communities. Stakeholder provision of water resources have deployed varied indigenous and exogenous technologies for domestic uses from natural surface to ground water stores. Community technological prowess and stratagems are functions of relief and climatic traits within a socio-political setting and that is why this paper sets out to assess indigenous and exogenous technologies of stakeholder in community water harvesting systems. Qualitative and quantitative data were collected for water sources, water demands, stakeholders, harvesting systems, technologies of extraction and water management through field observations, questionnaires and interviews. Findings revealed that few inhabitants have exogenous water supply technology and greater proportions depend on low technologies which paradoxically proved to be more sustainable than the high technologies. Stakeholder involvement motifs self-pride and politically driven and so the dearth of village water committees accounting for very derisory participation rates in water sourcing and management. The development and rehabilitation of alternative water sources is vital for sustainable water resource management and not just reliance on technological knowhow in Balikumbat.

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1. INTRODUCTION

Clean water is undeniably crucial to life and health yet millions of people, the world over, are riddled by acute and structural water shortages and consequently whittle innovative techniques to get hold of this indispensable need. Where they fail, some hundreds and thousands of children perish annually from water-borne diseases that deprive them of this basic human right of minimum quantities of safe water estimated at 50 litres per person per day [1] triggering sanitation challenges of poverty and poor health. Unfortunately, the average water consumption in some 33 countries in Africa stands at just 35 litres per person per day, being 15 litres short in even luckier countries [1]. Cameroon, like many Sub-Saharan countries, has startling experiences that can be likened to the 16th Century trend where rural area cattle, pigs and goats compete for drinking water from the same stream with the ordinary, pregnant and farm battered indigenous woman that have trekked for kilometres just to fetch the little enough water for household use [2]. This is common place in the dry season months in the northern part of Cameroon and paradoxically gaining occurrence in the upland rural country of the high plains of Balikumbat that oversees the surrounding flood extension of the Upper Nun Valley of Ndop plain, North West Region of Cameroon.

It has been established that in rural areas water resources enhance ecosystem and making water and socio-economic developments to be mutually dependent. Lekunze [3] notes that water is valuable but vulnerable natural asset which when properly managed can be an instrument for poverty alleviation, economic recovery and economic growth. When water is poorly managed it can serve as a limiting factor in poverty alleviation with attendant replications as poor health, low productivity, insecurity and constrained economic development. This corroborates the predictions of World Bank's Vice President for Environmentally Sustainable Development that "Many of the wars in this century were about oil, but wars of the next century will be over water" (World Water Day, 2007). This is more than a clarion call to sturdily hunt for alternative options of averting water scarcity now and in future times to come. Such does not exempt this study area crisscrossed by winding streams, cascading hill slopes dissected

by fast flowing streams, numerous springs or aquifers into vast wetlands where wells and boreholes unsuccessfully rival to peter out the insufficient but reliable rainfall. This justifies the need for an analysis of the various technologies used in harvesting and sustainably managing this water resource in Balikumbat.

Under the auspices of the United Nations, most governments like that of Cameroon set up ambitious stratagems within the ambit of sustainable development goals to achieve an equitable access to safe and affordable drinking water for all people by 2030. In this bid, practitioners considered conventional and nonconventional portable water resources harvesting through both indigenous and exogenous technologies. Mindful of MDG 7c, decade 2010-2020 for Cameroon's Growth and Employment Strategy Paper (GESP), the strategy has been to reduce by half the proportion of people without access to safe drinking water. This study notes that it was ambitiously projected that 75% of the population will have access to safe drinking water by this year 2020 [4]. The failure has enabled the adoption of the Agenda 2030 under the canopy of Sustainable Development Goals (SDGs). The SDG6 strives to ensure the availability and sustainable management of water and sanitation for all. This would entail the putting in place of smart and sustainable water harvesting technologies so as to reduce the number of people who go without water and are unable to access and afford for portable water. Such would be Balikumbat local technologies for the efficient management and protection of wetlands and streams capable of educating people on the importance of avoiding water wastages.

The Cameroon government statutory water technologies are the exclusive preserve of the Ministry of Water and Energy Resources and the Rural Engineering Department or the Community Development Department (CDD). Both high and low technologies are used in the extraction of portable water and the sustainable management of water resources by the government through its specialised agencies, NGOs, the missionaries, elites and the community. The objective of this paper will be to evaluate the relative importance of the various high and low water harvesting technologies adopted in different areas by partners of community water management in Balikumbat.

2. METHODOLOGY

2.1 The Study Area

Balikumbat is a Subdivision of Ngoketunjia Division in the North West Region of Cameroon (Fig. 1), created by Decree No. 92/187 of 1st September 1992 to the western part of the Upper Nun Valley of Ndop. The population was 58,374 inhabitants in 2005 (National Census 2005) unequally spread on an area of 973 km² with major human concentration on the Balikumbat tableland which rises abruptly from the Ndop plain average of 1,100 to 1,500m thereby having the Lamissang escarpment in the east. The tableland serves as the internal watershed for the five sub divisional villages of Balikumbat,

Bamunkumbit, Bafanji, Baligashu and Baligansin that lie between latitude 05°50' to 5°95' North and longitudes 10°20' to 10°30' East. Balikumbat is bounded in the north by Tubah that is the extension of the Western High Lava Plateau, in the east by Ndop flooded plain, in the south by Galim and in the west by Santa which are all extensions of the lava plateau.

2.2 Techniques of Data Collection and Analysis

Varied methods were used in the acquisition, analysing and presentation of data collected for water harvesting technologies and stakeholder's involvement in the management of water resources in Balikumbat. A set of indicators were

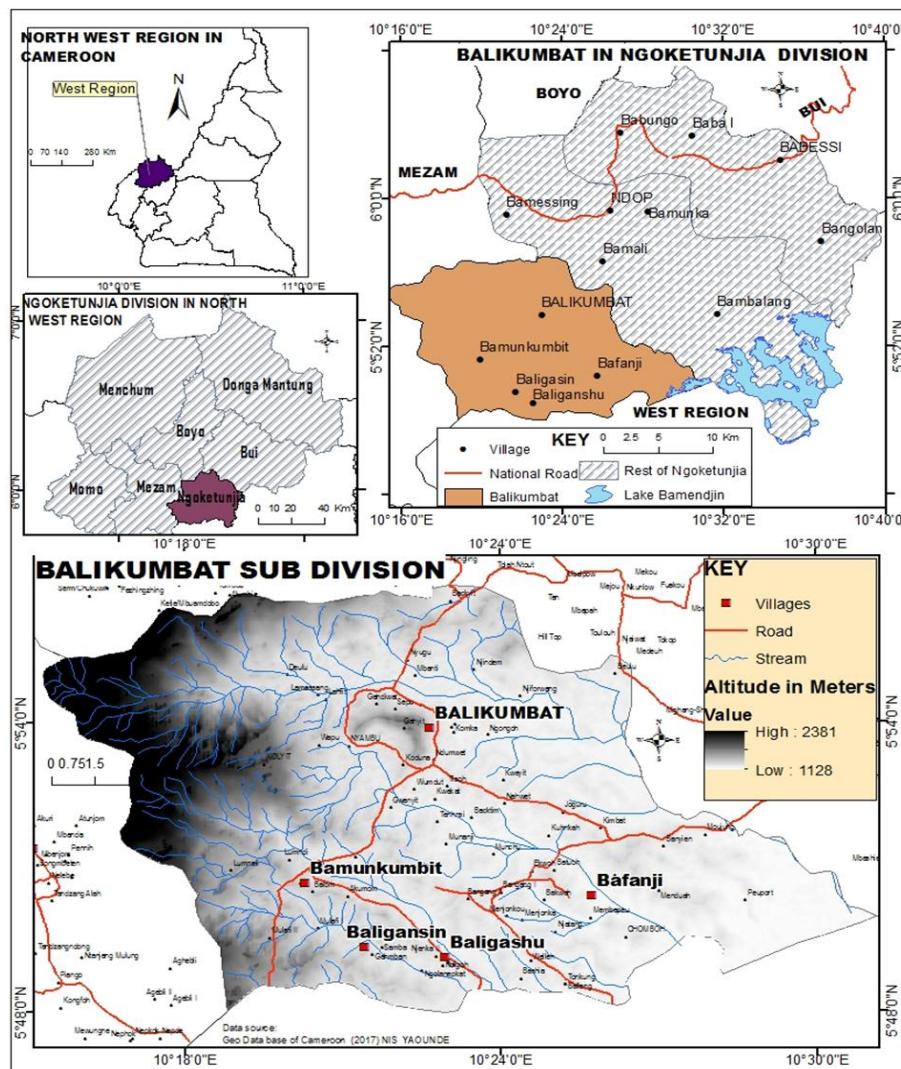


Fig. 1. Physiographic outlay of Balikumbat

designed to define the main socio-economic characteristics of the local community and look into different water aspects. A descriptive and analytical approach was used to analyze the data and obtain the results of the study. Both qualitative and quantitative data through experiences from the community, beliefs, tradition and cultural perspectives on water resources, its uses, regulation and management strategies by field observations and on-the-spot appraisal were employed. Secondary data were collected from reviews, research publications, policies and frameworks on water harvesting systems in Cameroon. To figure out the population sample, some 30 percent of the total of the 567 households [5] were consulted. Thus, $30 \text{ percent} \times 567 = 170$ questionnaires administered in randomly selected and spatially representative major quarters within each village in Balikumbat Subdivision. This was closely complemented using the Global Position System in the mapping of watersheds, streams, rivers, springs, wells and stand taps. Stream discharge trends over time were determined from interviews made with aged persons living in the streams areas. Quantifiable hydrographic data were also taken to compare and contrast with the qualitative data provided for in the questionnaires and assessed in percentages of observed frequencies of water harvesting systems and technologies. Microsoft Excel statistical options permitted and ease the study to establish the degree of variance between indigenous and exogenous technologies of water harvesting systems in the high plains of Balikumbat Subdivision.

3. RESULTS AND DISCUSSION

The Cameroon government through its decentralised organs had been participating in the realisation and management of many water schemes in the area using diverse technologies. The population of Balikumbat has equally benefitted from financial assistance, material contributions and policy frameworks towards achieving a sustainable water supply schemes. The rural communities (Village Development Organisations) and wealthy elites and the political class are encouraged to develop and manage their individual water systems. The State has equally encouraged foreign organisations (NGOs) to help provide the rural communities of Balikumbat Subdivision with portable water schemes with sustainable motives. Stakeholders had employed varied indigenous (low) and exogenous (high)

technologies to attain the goals of achieving portable and sustained water supply schemes in Balikumbat (Table 1).

From Table 1, some 111 households (69.38 percent) used indigenous or low technologically developed water sources and 49 (30.62 percent) acknowledged that they use exogenous or high technology. Field observations showed that the communities of Balikumbat depend largely on low technological strategies of water harvesting. In the survey of sources of portable water (Table 1) some 69.38 percent of the respondents indicated they depend on low or indigenous technologically tapped water resource and 30.62 percent depended on high or exogenous technology. Varied technologies are put in place by the different stakeholders involved in the provision and harvesting of portable water and its management in Balikumbat. Water scarcity for both sources and technology is imminent during the peak of the dry season. This has led to poor health, long distance trek to far off sources and a greater waste of human labour and productive time.

3.1 Ground Water Harvesting Techniques

Scarcity of piped water has made the communities of Balikumbat to find alternative water sources. Groundwater sources became a ready source for livelihood as a palliative for the lack of supply of pipe-borne water in the high plains. In this perspective, many households have dug wells around the home. Most inhabitants of the area rely on wells, springs and streams for their livelihood and daily household chores. These sources of water had been developed in various ways using indigenous technical know-how by some 56 percent of the population of the inhabitants in the form of uncovered and not treated wells. Wells have been developed locally by various stakeholders of the water sector in the area (Fig. 2)

Field survey revealed that 57.11 percent of the inhabitants of the study area depend on well sources for their daily water needs. Wells are a common groundwater source readily explored to meet community water requirements or address shortfalls [6]. Such hand dug wells depths ranging between 8 to 15 metres and diameter ranging between 55 to 60 centimetres. Some are covered with a metallic cylinder lid (C), few are left open and some covered with flat surface woods (B, A) while others are sealed with cement materials and locally fabricated hand

pumps are fitted for it to function properly (D). Fieldwork in December 2019 identified 153 wells some of which were permanently functional while others are ephemeral or dysfunctional in the Balikumbat, Bafanji, Bamunkumbit, Baligashu and Baligansin villages. Some 140 of the wells were protected while 33 are locally developed with hand pumps to cater for their sustainability. Some wells user claimed they usually treat the wells with Carmel water (*la croix*) and salt before using the water.

Indigenous technologies of water management are equally used to improve on the state of the wells so that sustainability and quality of water can be safeguarded. Photo B, C and D, in Fig. 1 shows recent indigenous technologies used by

the people in water resource management. Local wells are protected from external or surface contaminants with the use of a metal cylinder with a cover that protects the inlet. Others used locally fabricated wheels or rollers on which a rope is attached and a handle to rotate the pulley which in turn pumps out water through a pipe connected into the covered well (Photo C and D of Fig. 1).

The reliability of these ground water extraction systems to sustainable water supply and management is doubtful. The system most often fails to supply water. During the dry season, there is extreme scarcity of water for drinking and other domestic purposes, due to the lowering of water table resulting in water drying up

Table 1. Typology of water harvesting technologies and level of household usage

Type	Water sources	Households involved
LOW	Uncovered dug wells	20
	Springs piped with Indian bamboos	04
	Unprotected open springs	29
	Surface stream	32
	Ponds	25
	Rain water	01
	Total	111
HIGH	Piped spring harnessed with stand tap technology	17
	Boreholes well equipped with hand pumps	12
	Dug wells, covered and having hand pumps	07
	Dug wells, covered and having solar energy pumps	05
	Dug wells, covered and having electrical energy pumps	08
	Total	49
TOTAL		160

Source: Fieldwork, October 2019



Fig. 2. Types of wells as indigenous strategies for water harvesting in Balikumbat

Source: Fieldwork, December 2019

water table resulting in water drying up in wells [7]. These result in inadequate access to sufficient water supply to meet societal needs, and the users often walk several kilometres to obtain water from streams and rivers. The rope spinning the water through the pipes by an attached plastic fan for a hand pumped well usually and often cuts off. It sometimes detaches itself from the pulley and drop down into the well. The people find it difficult and costly to get into the wells for repairs. This situation places the sustainability concept of these technologies in water management at stake. The open wells are exposed to surface contaminants as runoffs, plastic bags, insects and creeping animals that drop in them. The open wells were observed to be dead traps for domestic birds, animals and sometimes humans. As [8] observed, the wells that have no cover lids are dirty and unkempt, thus making the water susceptible to infection. Hence, there is insufficient good quality water for drinking, due to high pollution rates of groundwater sources [7].

Driven and drilled wells commonly known as boreholes were discovered as a major technological strategy to sustainable water resource management in the study area within recent years. It is a vertical capture engineered structure used to exploit water from a water table held in the interstices or in the cracks in a rock in the subsoil known as aquifer. They are drilled to such depths below the shallow water table aquifers and deep into the first potential confined/semi confined aquifer or aquifers. The boreholes are located at places that cannot get

flooded in the rainy season and are away from marshy or flood plain in the locality. The boreholes are sited at least 20 meters away from pit toilets and other sources of pollution like stagnant pools of dirty water or animal pens. The drilling devices are often mounted on large well equipped lorry or a make shift iron bar stands. They use rotary drilling tools that chew or break the rocks at greater depths. The boreholes are several tens of metres deep, though it varies from one spot to the other due to the relief or landscape. Fig. 3 showing boreholes in the study area executed by using heavy drilling machineries that can reach great depths. Most of the boreholes in Balikumbat range from 35 to 45m deep fitted with a pipe having a diameter of 20cm. When drilling is over a pump with a non-return valve is installed at the bottom to pump the water up to the surface.

The water is raised to ground level by using a manual or motor driven pump. Boreholes vary tremendously from wells, be it in depth, the volume of water, the cost or the purity of the water. The openings are narrow given the tools used and the huge depth reached. Whether or not, the borehole requires regular treatment before consumption and must be checked regularly as far as the structures are concerned to guarantee its sustainability. Few boreholes constructed in the area had failed due to technical reasons, over extraction and perhaps poor quality of the ground water. This as result of technical reasons involved in the installation of boreholes at sites having unsuitable hydrogeological conditions are the cause.



Fig. 3. A- Borehole donated by an NGO, B- Borehole donated through PIB 2017

Source: Fieldwork, September-October 2019

Fig. 3 shows variation in borehole types built in Balikumbat. Photo A shows a borehole donated by the Nahkah Foundation, an NGO based in the United State of America and Photo B is

donated by the government of Cameroon through the Public Investment Budget for 2017 to the communities of Balikumbat Subdivision.

Field observations showed that some well-to-do elites of the study area had developed private wells fitted with concrete rings throughout its depth to pre-empt or protect eventual collapse of the walls. The wells are developed, covered and well treated for use. Some of them use manual hand pumps while others have an inbuilt electric powered system that pulls water from the well to plastic tanks mounted on concrete towers built four to six metres high. Others use solar panels that produce energy capable of pulling water from the depth of boreholes to a collection chamber erected to an appreciable height. The collection tanks thus supply portable water to the population of the area. Fig. 4 shows the solar power system in Bafanji. Solar energy is absorbed by the panels (Photo A) and the energy generates the pump built in the power house (Photo B). The pump pulls water from the catchment through laid pipes into a storage tank located far off at an altitude (Photo C) where the Presbyterian Health Centre is built. The storage tank supplies water to the health centre and its neighbourhoods. Interviews conducted revealed that most of them were not sustainable. During the dry season when the water table falls or

drops the local mechanisms or technologies fails leaving the population still with their aged old problem of water scarcity. This therefore, puts the indigenous technologies of water management in a questionable state. It was also found out that most of the wells used were unsustainably managed. They were neither treated with chlorine nor *La Croix* before use.

3.2 Surface Water Harvesting Technologies

Less than half (43.76 percent) of the population of Balikumbat depends on unprotected springs and tap water which is presumed to be the only source of good water in the area. The springs are poorly recharge and not sufficiently protected. Grazing animals use the sources and compete with humans for their livelihood. The rivers and streams are not sustainably managed for the fact that its sources are on the rangeland of the study area and their courses are through farmlands where chemical inputs leak into the streams. At the upper part of the middle course of streams Wetgwa, Ntam-Ntam and Mombe pit toilets are

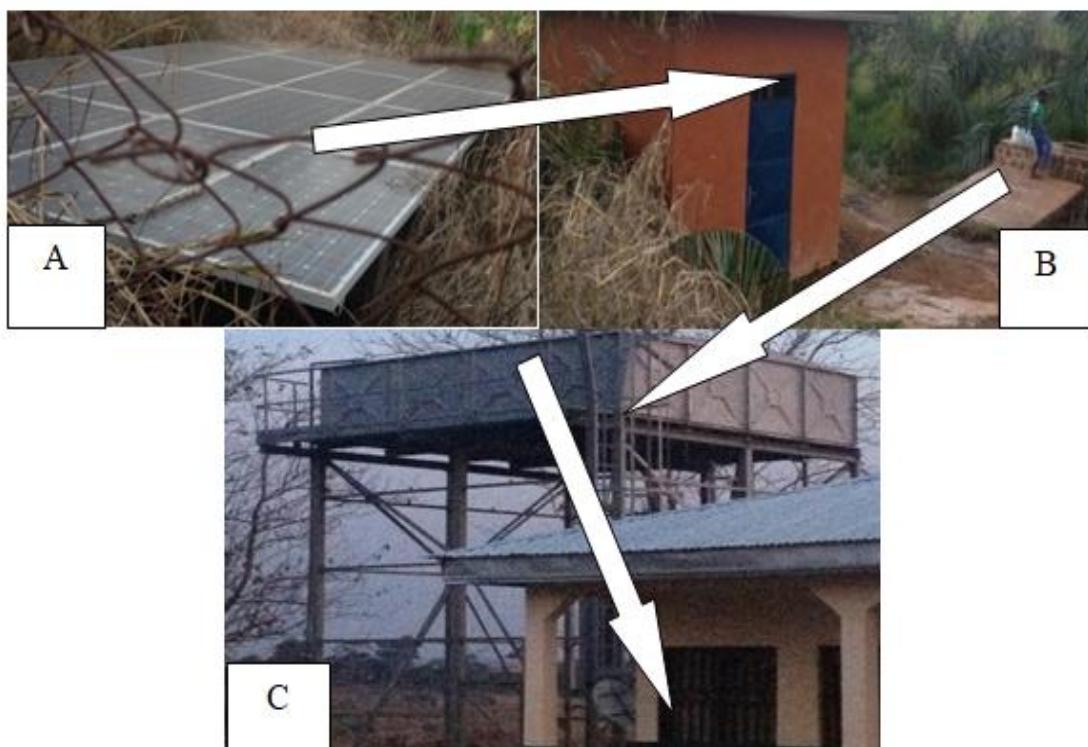


Fig. 4. Solar power water supply system

Source: Fieldwork, November 2019



Fig. 5. Abandoned storage tank and stand tap
Source: Fieldwork, September 2019

dug closed to the banks and some few metres away the people use the water as a portable source. Field observation shows that many stand taps built from these spring sources were dysfunctional. This portrays the poor and unsustainable management techniques in surface water resources by the stakeholders. Many dysfunctional stand taps were found abandoned to nature in the villages of Balikumbat, Baligansin and Bafanji. The defunct SCANWATER and CIACC installations in Balikumbat and Bafanji respectively left the people with only a visible water technology but no drop for consumption (Fig. 5).

It was noted that the spring and stream projects were conceived and funded on a top-down development approach that did not take into consideration the bottom-up development policies where the community plays a pivotal role. The projects were designed and executed without the notion of economic, social and ecological sustainability parameters in water management. This explains why this giant project faced a collapse or doom few weeks after its completion.

In some areas of the high plains of Balikumbat, ponds and streams are accessible sources of domestic water, but are prone to water-borne infections. About 54.37 percent (Fieldwork estimates, November 2019) of the population is dependent on ponds, rivers, streams and rainwater. This is an indication that almost half of the population in Balikumbat depends on natural and unimproved water sources for their health and household chores. Most of the ponds are exposed to refuse dumps, close to pit latrines and open dumps. Generally, around the ponds, common environmental sanitation is poor. Most of the ponds are exposed to direct solar energy

that encourages the proliferation of alga blooms. Some are found in dampen area surrounded by vegetation leading to decay of dead tissues. The ponds are exposed to runoff that carries debris of varying origins and dump into them. These lead to poor water quality and its negative health impacts on human life. The inhabitants suffer mainly from diarrhoea, gastro-enteritis, malaria, measles, tuberculosis, cholera and typhoid. Most of the ponds are infested with guinea worm, schistomiasis and other [9] thus, water-borne diseases are prevalent, including cholera, typhoid, bacillary dysentery, paratyphoid, amoebic dysentery, gastroenteritis and infective hepatitis [10,11,12]. The prevalence rate of these diseases varies with seasons in the study area. There is a seasonal pattern of water borne diseases, with ~50% occurring between July and September [12]. This has rendered the healthy and sustainable management of these sources impracticable by the community of Balikumbat Subdivision and they people turn to local protective measures using sticks and bamboo fence. This prevents stray animals like pigs, goats and ducks to meddle with water quality during periods of water shortages especially in the months of November through to April (dry season period). This indigenous method of water management is applied by most of the communities in Balikumbat Subdivision in varied ways. Others used palm fronds to protect the water sources while some uses thorny branches of trees placed close to the ponds. This entails the active participation of indigenous people in the sustainable management of water resources in Balikumbat Subdivision.

3.3 Atmospheric Water Harvesting Technology

Rainwater harvesting is important for sustainable development and has no adverse environmental

impacts. Rain water harvesting is a technology used for collecting and storing rainwater from rooftops, land surfaces or rock catchments using simple storage utensils, such as pots, tanks and cisterns and more complex options, such as underground check dams [13,14,15]. It also provides convenience in terms of decreased distance to sources of supply and is less time consuming than surface and groundwater sources. The technology acts as a tool for poverty eradication, for improving women's livelihood as they are directly involved in water provision for households. It is principally as a supplementary source of water harvesting in the high plain of Balikumbat Subdivision (Fig. 6). The technology has been introduced as part of an integrated water supply system where local water sources dry up for a part of the year. This option was equally observed by [14], when he expressed the view that Rain Water Harvesting is an option where conventional water supply systems have failed to satisfy the community's demand.

The catchment surface is mostly rooftops where roof gutters and down pipe are used as conveyance system for transporting water from catchment surfaces to storage tanks slightly elevated from the surface. It was observed that only few households had established giant underground or above ground tanks storage system for storing water until needed as the case of the Catholic Mission Presbytery. Few

households practice rain water harvesting so find it difficult to meet up with their water needs throughout the year and consequently. They must therefore resort to other sources of portable water supply such as the ponds, rivers and wells especially during the dry season as confirmed by [16] who observed that rooftop roof water harvesting is a dominant practice of most households in Otukpa community - Nigeria, and its supply is inadequate for sustenance through the dry season.

Rain water harvesting on roof catchments is generally practiced to obtain relatively clean drinking water as well as water for domestic purposes. This is done on the roof of individuals houses, with gutters and pipes to guide the water into a tank on the ground or slightly suspended from the surface. Mbilinyi et al. [17] noted that in communities where such technology of water harvesting is used, a tap is attached to the tank for individuals to access this water. In the high plains of Balikumbat there is concern over whether or not the water is clean enough for drinking, as pollutants in the atmosphere have been known to be present in rainfall. Olaoye and Olaniyan [18] making an analysis of rainwater samples within Ogbomosho, Oyo State in Nigeria suggested that boiled harvested water could be used for domestic purposes, if gutters and catchment areas were cleaned regularly to remove animal droppings and leaves from overhanging trees.

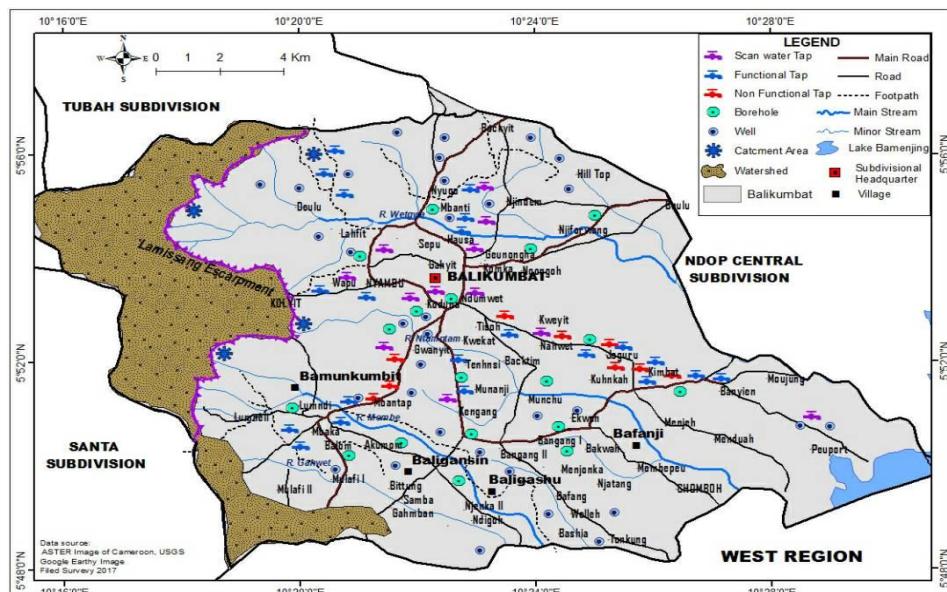


Fig. 6. Distribution of water resource technologies in Balikumbat villages

Source: ASTER Images of Cameroon USGS, December 2017

The rugged nature of the landscape has greatly influenced the distribution of exogenous or high technology water schemes in Balikumbat. The population are sparsely distributed at various lowlands distant thereby excluding some the habitats from the benefits of exogenous water technology schemes. Some other people are deprived by the natural barriers making less than three quarters (69.38 percent) of the population to depend on indigenous sources of water supply.

4. CONCLUSION

Diverse forms of indigenous and exogenous water harvesting techniques (extraction of groundwater, surface and atmospheric water) are variedly practised by a plethora of stakeholders in the high plain of Balikumbat. The daunting challenge facing these complementary technologies in community water supply harvesting systems is the lack of communication between the stakeholders in water management and the users. There are apparent gaps in sustainable water management skills and knowledge transmission between one stakeholder and another that may continue from one generation to another. Indigenous knowledge technologies need to be published for it to be integrated into water management plans in the Subdivision so as to guarantee the drive to attaining SDG6 at least at local community level in the next decade come 2030. Strengthening institutions and policy makers for the use and management of natural capital such as water is vital in enhancing economic development and alleviating poverty. As such the community and other stakeholders in Balikumbat should fine-tune and embrace water resource management strategies that give pre-eminence to ideologies and paradigms of good governance.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. WHO. Regional and Global Costs of attaining the water supply and sanitation target (Target 10) of the Millennium Development Goals; 2008.
2. Ako Ako A. et al. Water Resources Management and Integrated Water Resources Management (IWRM) in Cameroon. *Water Resources Management*. 2009;24:871-888.
3. Lekunze RN. (Assessing stakeholders' participation in Integrated Water Resource management. The role of Youths in Cameroon Water Management Projects in Cameroon, Master's Thesis, Lund University, Sweden; 2001.
4. African Ministers' Council on Water-AMCOW: An AMCOW Country Status Overview. Water Supply and Sanitation in Cameroon, Turning Finances into Services for 2015 and Beyond. 2010;32.
5. Balikumbat Council Development Plan: Revised edition; 2017.
6. Adelekan BA. Water quality of domestic wells in typical African communities: Case studies from Nigeria. *International Journal of Water Resources and Environmental Engineering*. 2010;2(6):137-147.
7. Lade OO, Coker AO, Sridhar MKC. Sustainable water supply for domestic use: Application of roof- harvested water for groundwater recharge. *Journal of Environmental Science and Engineering A*. 2012;1(5):581-588.
8. Onunkwo A, Uzoije AP. (Exploratory survey of geochemical aspects of underground water in Ehime Mbano Area, Southeast Nigeria. *Global Journal of Research in Engineering*. 2011;11:14-22.
9. Oloruntoba EO, Sridhar MKC. Bacteriological quality of drinking water from source to household in Ibadan, Nigeria. *African Journal of Medicine and Medical Sciences*. 2007;36:169-175.
10. Ogunteke O, Aboderin OJ, Bankole AM. Association of water-borne diseases morbidity pattern and water quality in parts of Ibadan City, Nigeria. *Tanzania. Journal of Health Research*. 2009;11(4):189-195.
11. Oloruntoba EO, Agbede OA, Sridhar MKC. Seasonal variation in physicochemical quality of household drinking water in Ibadan, Nigeria, ASSET- An International Journal Series B. 2006;5(1):70-81.
12. USAID. USAID Health: Environmental Health, Overview. Online; 2005. Available:<http://www.culturalpractice.com/site/wp-content/downloads/5-2005-8.pdf> [Accessed 1 August 2013].

13. Lekwot VE, Samuel IO, Ifeanyi E, Olisaemeka O. Evaluating the potential of rainwater harvesting as a supplementary source of water supply in the Kanai (Mali) and the district of Zangon-Kataf local government area of Kaduna State, Nigeria. *Global Advanced Research Journal Environmental Science and Toxicology.* 2012;1(3):38-45.
14. Alam MA. Technical and social assessment of alternative water supply options in Arsenic affected areas, M.Sc (Civil Engineering of Bangladesh University of Engineering and Technology (BUE 1); 2006.
15. Zhu K, Zhang L, Hart W, Liu M, Chen H. Quality issues in harvested rainwater in arid and semi-arid Loess Plateau of Northern China. *Journal of Arid Environments.* 2004;57:487-507.
16. Onoja SB, Ocheja IE, Isikwe MO. Rainwater harvesting practices and design of rainwater harvesting system for Otukpa Community, Benue State, Nigeria. CTA Seminar. Department of Agricultural and Environmental Engineering, University of Agriculture Makurdi, Nigeria; 2010.
17. Mbilinyi BP, Tumbo SD, Mahoo HF, Senkondo EM, Hatibu N. Indigenous knowledge as a decision support tool in rainwater harvesting. *Physics and Chemistry of the Earth. Parts A/B/C* 30. 2005;11-16:792-798.
18. Olaoye RA, Olaniyan OS. Quality of rainwater from different roof material. *International Journal of Engineering and Technology.* 2012;2(8):1413-1420.

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