Vol. 13(1), pp. 22-35, January 2019
DOI: 10.5897/AJEST2018.2587
Article Number: 0A4AA3059486
ISSN: 1996-0786

http://www.academicjournals.org/AJEST

ACADEMIC JOURNALS
expand your knowledge

African Journal of Environmental Science and Technology

Full Length Research Paper

Sustainability of Chiredzi town water supply and wastewater management in Zimbabwe

F. Homerai[1], A. W. Mayo[1*] and Z. Hoko[2]

[1]University of Dar es Salaam, Water Resources Engineering Department, P. O. Box 35131, Dar es Salaam, Tanzania.
[2]University of Zimbabwe, Civil Engineering Department, P. O. Box MP167, Mount Pleasant, Harare, Zimbabwe.

Received 26 September, 2018; Accepted 30 October, 2018

Urban water supply and sewage coverage in Zimbabwe is currently estimated at 78 and 73%, respectively with unserved population relying on boreholes and pit latrines. However, no study has been conducted to assess how small towns, such as Chiredzi, are sustaining their systems despite limited funding from the Government. A study was carried out to assess the sustainability of Chiredzi town water supply and wastewater management systems in Masvingo, Zimbabwe. The study assessed the level of service provision, level of users' participation and sustainability of water supply and wastewater systems. Data was collected through household questionnaires, key informant interviews, focus group discussions, desk study, water and wastewater analysis results, and field observations. A total of 150 households were interviewed and Statistical Package for Social Science, Microsoft Excel Spreadsheet, and De Carvalho Sustainability index were used as tools to analyse data. The service coverage was below the target of 100 and 80% for water supply and sewage coverage, respectively. The study revealed that 55.3% of the respondents were not satisfied with the level of services provided. Stakeholder participation was found to be done through contribution of ideas and reporting pipe burst with very few contributing money. The overall sustainability was found to be 6.5, a category of satisfactory progress towards sustainability. Finally, the findings showed that there is great need to improve on technical, social and financial aspect.

Key words: Level of service provision, stakeholders participation, sustainability index, water supply, wastewater management.

INTRODUCTION

Water supply and sanitation sectors are among the key aspects of human health and development of a country (Eid, 2015). In 2015, 193 member states of the United Nations adopted the 2030 Agenda for Sustainable Development, which comprises 17 Sustainable Development Goals (SDG) and 169 targets that seeks to end poverty, ensure prosperity for all people and protect the planet (United Nations, 2015). SDG target 6.1 seeks to achieve universal and equitable access to safe and affordable drinking water for all by year 2030 and SDG target 6.2 intends to achieve access to adequate and equitable sanitation and hygiene for all and by the end of

*Corresponding author. E-mail: aloyce.mayo@yahoo.com.

the same year. In accordance with WHO and UNICEF (2017), Sub-Saharan Africa, Zimbabwe inclusive, is lagging behind in as far as progress towards the achievement of SDG targets 6.1 and 6.2 are concerned. It is estimated that only 58% of population in Sub-Saharan Africa used at least a basic drinking water service in 2015, although the global average was 89% (WHO and UNICEF, 2017). In the same report, it was estimated that 28% of Sub-Saharan Africa population used at least basic sanitation services in 2015, which was much lower than the global average of 68%.

Zimbabwe had highest coverage of 97% levels in Africa, for both urban water supply and sewerage networks after independence (1980) up to 2000 (World Bank, 2009). WHO and UNICEF (2017) estimated that in 2015, 77% of Zimbabweans had improved water supply, but only 37% had improved sanitation facilities. An "improved" drinking-water source is the one that is constructed in a manner that adequately protects the source from any external contamination, particularly faeces. On the other hand, an "improved" sanitation facility is one that hygienically separates human beings from coming into contact with human excreta. Facilities that lack these qualities are considered "unimproved" (WHO and UNICEF, 2012).

The provision of improved water supply and sanitation facilities in urban areas have gradually deteriorated from 100% in 1990 to 97% in 2015 and 52% in 1990 to 49% in 2015, respectively (WHO and UNICEF, 2017). As a result, Zimbabwe recently suffered one of the worst cholera outbreaks recorded in sub-Saharan Africa (WHO and UNICEF, 2010). In accordance with Manzungu (2012), Zimbabwe cannot achieve targets for improved water supply and sanitation of reducing the number of people without access to water and sanitation by 50%. This is because of a number of factors including the growing demand from its growing population (Watson, 2009), melt-down of Zimbabwe's economy (Homerai, 2015), the willingness of foreign aid organization to avail funds to build and finance infrastructure projects (World Bank, 2009). Other challenges include implementation of low cost sewage treatment that at the same time permit selective reuse of treated effluents for agricultural and industrial use (Arth, 2012). Zimbabwe population has nearly doubled from 7.2 million people in 1980 to about 13 million in 2012 (Zimstat, 2012).

In accordance with UNICEF and USAID (2009), public works systems in the developing countries have long been recognized as complicated and disorganized. In Zimbabwe, most investments towards rehabilitation of infrastructure are focusing on large cities such as Harare, Bulawayo and Mutare, but according to UNICEF (2010) populations in the country's small towns have been growing rapidly. Consequently, this has placed a huge burden on the water supply and wastewater systems infrastructure in these small towns. Nhapi (2009) suggested that there are limited human and financial capacities in urban towns to provide efficient water services.

In Chiredzi town, about 65% of the residence have no access to safe water due to pipe bursts, failure of the water treatment plant and at times due to rationing and power cuts. As a result, frequent outbreak of cholera in Chiredzi town may be caused by the failure of the authorities to provide safe and reliable water to the public (Homerai, 2015). The government of Zimbabwe is now subsidizing water supply and sanitation services in large cities like Harare and Bulawayo, but small towns such as Chiredzi have not received similar attention. This study seeks to investigate the sustainability of water supply and wastewater management systems in Chiredzi town.

MATERIALS AND METHODS

Description of the study area

Chiredzi Town, which covers 128 km^2, is located in the south-east part of Zimbabwe in Masvingo Province at coordinates, 21°02′20″S and 31°40′40″E (Figure 1). In accordance with ZimStat (2012), the town's population was 30,594 people in 2012, and is estimated to have a current population of about 34,300 people in 6866 households with a yearly growth rate of 3.9%. Chiredzi town was established in 1957 as Crown Township for the sugar and citrus estates and granted town status in 2002 with 8 wards. The annual average temperature is 22°C and is characterized by low and erratic rainfall (Unganai, 2008). The town is small and has one major industry, Delta Chibuku Breweries, a Dairy board and is surrounded by sugar cane producing estates, which include Triangle, Hippo Valley, Mkwasine and smallholder farmers, which require large volumes of water for irrigation and domestic use.

The raw water source, which is abstracted from Lake Mtirikwi, was completed in 1960 and pay Zimbabwe National Water Authority (ZINWA) for the bulk supply (Homerai, 2015). The lake also supports water schemes for several farmers and large sugar cane irrigation schemes in Triangle and Hippo Valley Estates. The town's treatment plant, which consists of coagulation, flocculation, sedimentation, filtration and chlorination, was commissioned in 1964 and its infrastructure has since deteriorated. The plant was designed to produce 10 ML/day, which has gone down to an average of 3.5 ML/day, which is only achievable when the plant is running for 24 h. Chitsanga Reservoir with a capacity of 1000 m^3 was also decommissioned due to a broken drain pipe that was causing leakages. Chiredzi town uses waste stabilisation ponds for its wastewater treatment. The first set of ponds was established at Khonami, which have been decommissioned due to town expansion paving way for a new set of ponds. Since then these ponds have not being desludged resulting in overloading. United Nations Children Education Fund (UNICEF) intervened to mitigate the epidemic by drilling 15 boreholes, but only 8 boreholes are still functioning. However, the groundwater has high mineral content such that the water is hard and difficult to drink (Homerai, 2015).

Study design and data collection

Information for water supply and wastewater management systems was collected from the institutions responsible for town water supply and sanitation and the stakeholders involved. Both quantitative and qualitative data was obtained from household survey, focus group discussion, key informant interviews and physical observation. Primary data was obtained from households, Chiredzi Town Council, Hippo Valley Estates officials and Environmental Health

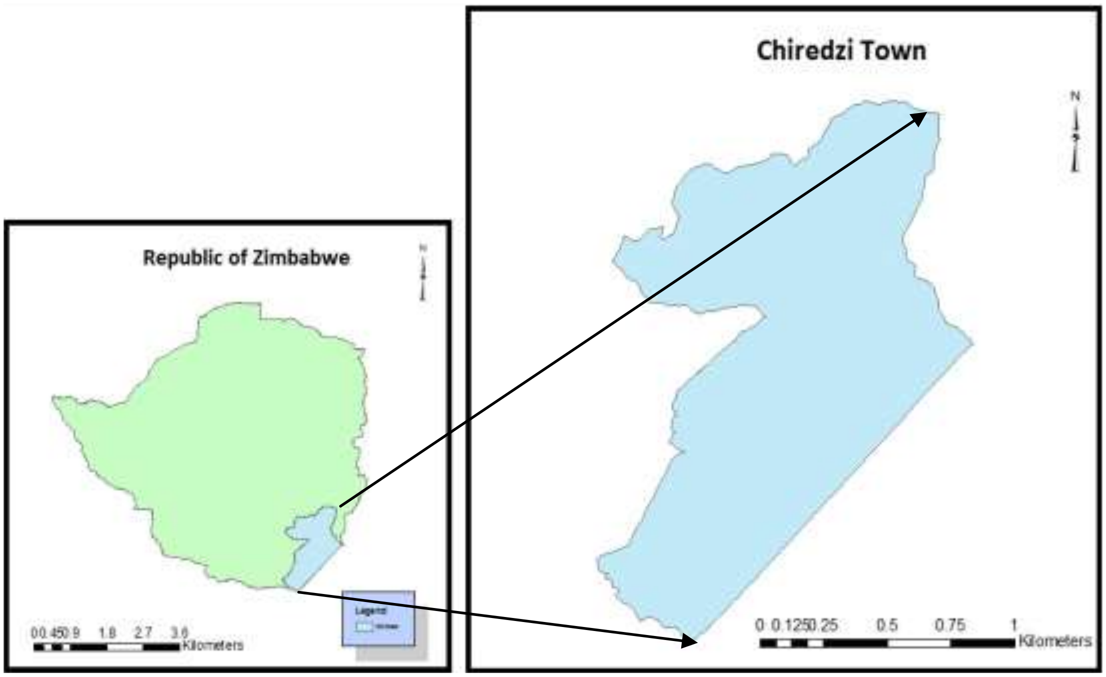

Figure 1. Location of study area in to Chiredzi town in Zimbabwe.

Technicians. Secondary data was obtained from annual reports and inventories.

Qualitative data were used to collect data based on facts from an individual point of view. Attitudes, perceptions and knowledge of stakeholders with regards to service delivery were assessed. Qualitative methods were conducted in a natural setting, without intentionally manipulating the environment. Probability and non-probability sampling techniques were employed to select study area and study sites. Purposive sampling was used to identify the areas in Chiredzi town under study. Systematic convenience sampling was used to select the households which were interviewed as suggested by Depoy and Gitlin (2005). Only households willing to participate in the research were interviewed. Purposive and systematic sampling techniques were employed to identify key informants and households to be interviewed, respectively.

Data on sustainability of water supply and wastewater management systems of Chiredzi town was obtained from desk study, personal observations, water and wastewater quality analysis, household surveys, key informant interviews and focus group discussions to collect both secondary and primary data. The information was compiled and analyzed on continuity or hours of water availability per day, population served, coverage of the utilities, water consumption and production and level of service provision.

Physical inspection was carried out on water supply and treatment plant along with wastewater stabilization ponds structures to determine the quality and physical condition of the facilities. Main aspects assessed under physical condition are the overall functionality of the water supply and treatment plant along with wastewater stabilization ponds. Other aspects such as easiness of operation, breakdown rate and the staff level of education, monitoring of water quality at different sites such as at water treatment plant, storage tanks and at the end user's tap will be observed.

Water samples were collected at taps, and were analyzed onsite for electrical conductivity and pH. Conductivity meter model WTW Cond7110 was used to analyze electrical conductivity (EC) whilst the Ecosan pH 5/6 mv/pH meter is to be used to measure pH. Samples of domestic wastewater were collected at the effluent.

Water supply and sanitation was assessed and evaluated from the maps of water supply and sanitation networks taking into consideration leak detection and response time, shortage of water, frequency of occurrence of faults and other options for both water and sanitation provisions while undergoing repairs. Sanitation facilities were visited and assessed in terms of their capacities considering population growth and the method used.

Interviews were conducted and the respondents are informed about the current problems and policies designed to solve the problem. Wherever opinion of the water users was required, the sample sizes for questionnaires were determined using Equation 1 in accordance with Krejcie and Morgan (1970).

$$n = \frac{\chi^2 \times p \times (1-p) \times N}{e^2(N-1) + Z^2 \times p \times (1-p)} \quad (1)$$

Where n is the required sample size, N is the population size, p is the population proportion, which is assumed to be 0.50 since this would provide the maximum sample size and χ^2 is the the table value of chi-square for 1 degree of freedom at the desired confidence level of 0.05. The degree of accuracy *e* of ± 5% was used hence a confidence level of 95%. Systematic convenience sampling was used to select households which were interviewed. A total of 150 questionnaires were administered on both high and low density wards.

Structured, semi-structured, and open-ended interview guidelines were developed and used to generate relevant data from the local authority offices, humanitarian organizations and Health Office. The local authority provided information on the roles of the department, water issues, factors affecting sustainability of water supply and treatment, along with wastewater management systems. The Environmental Health Technician from the Health Office provided information on safe disposal of wastewater and monitoring of water quality. Data on financial management, operation and maintenance, women participation, along with management of water supply and wastewater was obtained through interviews with local authority offices and water users.

Focus group discussions were held using discussion guide with women, men and water committee members comprising 12 people as recommended by Robinson (2002). The collected information included selection of water residence committees, decision-making on operation and maintenance, challenges facing the communities, women participation, availability of external support and coordination between the residents and services providers, trainings undertaken and their views on the solutions to water problems.

Data analysis

The primary data collected from household survey through structured questionnaires were first checked for accuracy and data entries were coded. Thereafter, data were entered, edited and analyzed using statistical package for social science (SPSS) version16.0 software. Data were explored for frequency of responses, distribution trends and statistical relationships. Responses from the key informant interviews were used to validate the responses of the households. The level of services of the water and wastewater stabilization pond system were analyzed by assessing the services in terms of coverage, population served, water quality and quantity, wastewater characterization, and the capacity of utilities to serve the town. Laboratory analysis of water and wastewater was done. Water demand (present and future) for domestic, commercial, institutions, industries to be calculated and projected from 2015 to 2040 was analyzed using Excel. Water deficit was calculated from water production and demand data. SPSS was used to analyse field survey data on residence perception on service delivery.

Sustainability analysis

The use of sustainability indicators is recommended for evaluating the sustainability of water supply and wastewater management systems as it allows for a comprehensive evaluation of the environmental, economic and socio-cultural dimensions (UNEP, 2003). The indicators include physical conditions, operations and maintenance, consumer satisfaction, financial management (cost recovery) and willingness to sustain the services. Water demand and wastewater management aspect are selected based on population growth due to urbanization in developing countries, which has become a challenge to water supply and sanitation services (Watson, 2009). The sustainability index was obtained from sustainability aspect sub-indicators. For each sustainability aspect, sub-indictors were measured using series of questions assessed through semi-structured interviews, focus group discussion, measurements, observations and household surveys. Aggregated scores/100 was expressed for each sustainability indicator, which is technical, social, financial and environmental sorted fewer than four key factors of sustainability.

$$\text{Core-indicator} = \sum(\text{sub-indicator}_i * \text{Weight}_i) \quad (2)$$

Technical aspect scoring was based on a series of questions from 10 technical evaluation questions and also from information from the town council record books. The scores measure the level of service offered by service provider. A perfect technical score indicates that the water supply and wastewater systems are providing adequate services to the users and the systems are working perfectly, which means there is high service coverage, water production matches water consumption and water losses are minimum. The financial management scoring was based on 19 questions from key informant with the Financial Department of Chiredzi Town Council. The perfect score would indicate that the town council is able to cover costs incurred during operation as well as maintenance and services provision. It indicates also that there is savings for future repairs and system upgrading. It also reflects on high cost recovery and capacity of the users to pay for the services.

Environmental management scoring was based on 5 evaluation questions from the Department of Environmental Protection of Chiredzi Town Council. This measures the treatment efficiency of both water and wastewater and how the quality is monitored. It also measures the safe disposal of wastewater in natural waters, that is, the extent of pollution and also the extent of reuse. A perfect score would reflect high treatment efficiency of the systems, plus safe disposal of wastewater and desludged faecal matter into the environment.

Social aspect scoring was based on a series of 7 questions from the household questionnaires. The indicators measure the people's perception on level of services by the service provider, whether they are satisfied or not. A perfect score would reflect that the systems can provide adequate services to the users. This also reflects that there is high level of services, consumer satisfaction along with awareness and education.

The sustainability index for a particular city (SI_i) is the sum of all the weighted components (Equation 3). Indicators and sub-indicators are aggregated in the same manner as components. The standardized value of the respective component X_i, is multiplied by the attributed weight, w_{Xi}, to give a value on a scale of 0 – 10. De Carvalho (2007) equation was used to calculate sustainability index for Chiredzi Town.

$$SI_i = \frac{\sum_{i-1}^{N} w_{x,i} x_i}{\sum_{i=1}^{N} w_{x,i}} = \frac{w_S S + w_E E + w_F F + w_T T}{w_S + w_E + w_F + w_T} \quad (3)$$

Where W_S is the weight for social (S) aspect, W_E is the weight for environmental (E) aspect, W_F is the weight for financial (F) aspect and W_T is the weight for technical (T) aspect. The overall sustainability index of Chiredzi town is an average of the 4 indicators which was adjusted to a 10-score scale each with equal weight of 25%. The project is considered sustainable if the sustainability index is above 6.67, potentially sustainable if index is between 5 and 6.67 and unsustainable if index is below 5.

RESULTS AND DISCUSSION

Demographic characteristics of respondents

The interview involved 77 men (51.3%) and 73 women (48.7%). In terms of level of education, the survey showed that 98% of the respondents completed primary education with at least 12.7, 26.7 and 58.7% found to have attained primary, secondary and college education, respectively. Only 3 out of 150 respondents did not attend formal education. This made the household survey credible because most of the respondents were able to read the questions and give accurate information. With regards to age structure, 88.7% of the respondents were in economically active age group of 20-50 years. The major sources of income of the respondents was employment by either government or private sector (54.7%), informal business, which includes selling food and vending (31.3%), formal businesses (8%) and the least was small scale farming (6%). When respondents were asked about the monthly household income, most of them did not give exact answer due to lack of records and others were reluctant to expose their real income. Those who are into informal business gave estimations of what they sell to raise money for their household needs. Crops like maize and beans, and plantations were cited as their main sources of income to the farmers. From those who were able to state their incomes, the monthly income of the household ranged from USD100 to USD700. About 50.7% of the respondents have income below poverty datum line of USD 400 for a family of 6 and only 20% of the families have income exceeding USD 600.

Water supply services

About 5120 out of 6576 properties (77.9%) are connected to water supply network of Chiredzi town. This water supply services coverage is lower than the target coverage of 90% (Water Operators Partnership, 2009). The residents who are not connected to water supply system are depending on shallow wells for their water needs. However, it was noted that Chiredzi town is better than other urban areas in the region, such as Beira of Mozambique which has coverage of as low as 12%. However, other cities such as Walvis Bay of Namibia and South African urban areas have coverage of as high as between 90 to 100% (Water Operators Partnership, 2009).

With the population growth rate of 3.9%, Chiredzi town is expected to have a population of 50,000 people in 2025. In accordance with Chiredzi Council Report (2014) per capita water demand is estimated to be 200 L/day, which can be met with installed plant capacity of 10,000 m^3/day. The water demand projection shows that up to year 2025 there will be enough water supply, but thereafter the system would need upgrading to meet the demand. The growth for both commerce and institution was assumed to be 1% because of Zimbabwe's economic crisis. At the moment, the plant can produce 7,853 m^3/day against the estimated consumption of 6,863 m^3/day. A person in African cities requires 20-50 L of water to ensure basic needs of drinking, cooking and washing (Minghong and Pelin, 2012). Taking this into consideration, the utility is providing enough water to the users.

Response from residents and field observation shows that water is supplied by pumping directly to the consumers for 8 h/day because Chitsanga Reservoir was decommissioned. Water is also pumped to Chigarapasi Reservoirs for 6 h daily. Most South African and Walvis Bay of Namibia utilities provide water for 24 h daily. Availability of water, according to Nair (2010) is very essential in the provision of water for each person and must be sufficient and continuous for domestic and personal uses. Therefore, Chiredzi town water users are deprived of this human right by supplying water intermittently, which causes supply pressure losses, sewer system blockages and inequities in the distribution of water (WUP, 2001).

Among many factors that affect the quality of service delivery, is the reliability of the systems. About 98% of water consumers store water because water supply is intermittent. The users were also complaining of lack of information prior to interruption of the service. Data collected from the field over a period of two months indicates that the average period between the stopping of pumping and the resumption of pumping after breakdown, servicing the plant or back flashing, varies from 0.5 to 3.5 h with an average of 2 h daily. According to Hoko and Hertel (2006), the downtime for water utility should not be longer than 2 days.

Water management

Out of 6576 properties in Chiredzi town, about 6524 are metered, which is equivalent to 99% of meter coverage. However, field observations and key informant interviews have shown that only 25% of the meters are functioning at the time of the study. Therefore, about 75% of the customers are billed monthly based on estimation, which is potentially inaccurate. The information obtained from town council records and key informant interviews from technical department, shows that Chiredzi town water supply has non-revenue water losses of about 65%, which include 20% real losses through leakages during transmission and distribution. The apparent losses such as illegal connections, water theft and inaccuracies in meter reading are estimated to be 45%. Inaccuracy of meter reading was also evident as with the use of return valves at the plant, wrong figures were recorded at times due to reverse movement of water when the valve is faulty and the plant is not pumping. This information matched that of key informant interviews where it was highlighted that burst pipes take two days or more to repair. Mal-functioning meters also contributed to high percentage of non-revenue water.

Metering of users is considered to be good practice as it allows them to have confidence in the service provider and provides water utility tools and information for better management of the systems (Homerai, 2015). Metering helps in water conservation, leaks detection, and problem in the distribution process when conducting a system audit (AWWA, 2006; Hogas et al., 2016). In developing countries, non-revenue water should be kept below 23% according to Tyman and Kingdom (2002). This showed

Table 1. Water quality analysis.

Parameter	Units	Results	Zimbabwe standards
pH		7.97	8.5
Electrical conductivity	µS/cm	145	700
Calcium	mg/l Ca^{2+}	5.3	-
Magnesium	mg/l Ma^{2+}	2.1	70
Sodium	mg/l Na^{+}	14.4	100
Potassium	mg/l K^{+}	1.8	-
Manganese	mg/l Mn^{2+}	0.04	0.1
Copper	mg/l Cu^{2+}	0.01	0.1
Zinc	mg/l Zn^{2+}	0.01	1
Phosphate	mg/l PO_4^{3-}	3.6	-
Chloride	mg/l Cl^{-}	10.9	200
Total Nitrogen	mg/l N	4.2	-
Total suspended solids	mg/l TSS	10	-
Alkalinity	mg/l $CaCO_3$	30	-
Total hardness	mg/l $CaCO_3$	24.2	20-300
Nitrates	mg/l NO_3^{-}	0.87	10
Lead	mg/l Pb^{2+}	<0.01	0.05
Feacal coliforms	number/100ml	0	0

that the council is billing less water than is produced, which suggests that the Council must fix mal-functioning meters and attend to the leakages and theft in time to reduce non-revenue water losses.

Water quality monitoring

The results of water analysis of the measured parameters are within Association of Zimbabwe Standards SAZS 560-1997 limits and WHO guidelines because water was free from disease causing micro-organisms and chemicals substances that are a threat to human health (Table 1). According to David (2005), water quality and quantity are considered important factors in rating the performance of a water supply system. Records from the water treatment plant indicates that a thorough monitoring system of the water quality is practiced once a month from domestic points and after every 2 h for pH, temperature and residual chlorine in the treatment plant. Residential taps are randomly selected for water quality analysis. About 80% of the respondents were satisfied with the quality of water.

Wastewater management

It was observed that 4779 out of 6579 properties (72.6%) were connected to sewage network. Other common sanitary facilities include VIPs and pit latrines (21.4%) as well as septic tanks and soakage pits (6.0%). From the survey, 27.4% households use on-site sanitary facilities and this constitutes the low density suburbs and illegal settlement properties. This reflects that the town is lagging behind in terms of sewage services coverage which was targeted to reach 82% by year 2015 (Water Operators Partnership, 2009). It was noted that Southern region have the highest coverage for sewerage, with Walvis Bay of Namibia having 100% coverage. In the Eastern region it was found that Moshi of Tanzania has coverage of 44%. This reflects that even Chiredzi town is lagging behind its set target to achieve 100% sewerage coverage as compared to Lusaka (Zambia) with 11% coverage. With the assumed population growth rate of 3.9%, the current population would be 34,315; implying that daily waste generated is 2,607 m^3/day, which suggests that the design can sustain influent loading over the next 25 years.

Wastewater analysis results show that the measured parameters are within Environmental Management (Effluent and Solid waste Disposal) Regulation, 2007 limits (Table 2). Arth (2012) emphasized the need for effluent quality to be of World Health Organization Standards to prevent environmental pollution and spread of diseases. Reports from the authorities show that examination of domestic wastewater is done for all parameters on monthly basis (Figure 2).

Customer care and consumer perceptions on service delivery

Respondents submit their complaints to water utility management. Others make use of resident association,

Table 2. Effluent wastewater quality analyses.

Parameter	Units	Effluent	Zimbabwe Standards
pH	-	7.45	6-9
Electrical conductivity	µS/cm	618	<2000
Sodium	mg/l Na^{+}	27.78	<300
Potassium	mg/l K^{+}	13.78	<500
Iron	mg/l Fe^{2+}	0.48	<8
Manganese	mg/l Mn^{2+}	<0.01	<0.3
Zinc	mg/l Zn^{2+}	<0.01	<4
Biological oxygen demand	mg/l	15	<50
Dissolved oxygen	% saturation	50	>75
Total Hardness	mg/l $CaCO_3$	60	-
Total Suspended Solids	mg/l TSS	100	<50
Total Dissolved Solids	mg/l	171	<1500
Sulphate	mg/l SO_4^{2-}	117	<300
Phosphorous	mg/l PO_4^{3-}	1	< 5
Chlorine	mg/l Cl	31	<250
Total Nitrogen	mg/l N	8.6	<10
Faecal coliforms	Number/100 ml	800	<1000

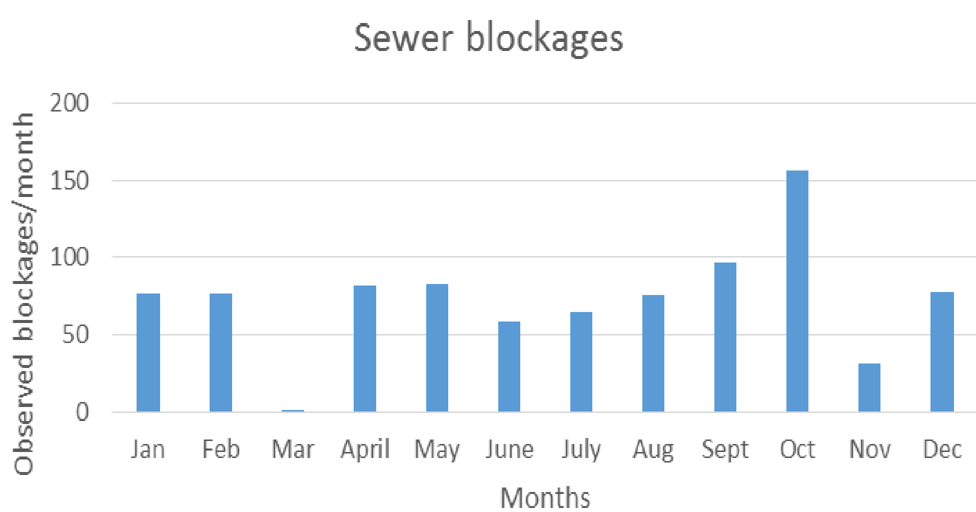

Figure 2. Monthly sewer blockages.

United Chiredzi Residents and Rate Payers Association (UCHIRRA), which has committee members in each of the 9 Wards of the town. It was noted that the UCHIRRA committee members meet councilors every month to report on the service delivery issues to councilors of respective wards. In accordance with the Department of Customer Care Services, 75% of customer complaints are attended within 24 h for both water supply and wastewater systems. However, feedback from 80% of the consumers indicates that it took more than two days to attend to the complaints. The consumers were also not satisfied with reliability of water supply because of the intermittent flow. As a result, 55.3% of the respondents reported that they were not satisfied with the performance of water utility. Notification of service interruptions is of paramount importance as a customer care factor, which affects users' perception on service delivery of utilities. It was observed that only 2.7% of the respondents from the sampled households received notification prior to service interruption. It was also noted that 77.3% of the respondents mentioned that when paying bills the service personnel are helpful and friendly. However, the respondents prefer to pay their water bills through bank instead of travelling to water utility offices, which saves time and transport cost to water utility.

Roles and responsibilities of UCHIRRA

The main responsibilities of UCHIRRA are to monitor the quality of service delivery especially on water availability, the performance of sewerage system, calling for meeting of water users when need arises, and meeting with councilors to discuss issues of service delivery. They also educate and create awareness to water users on the importance of timely payment of bills. These duties are vital to the water supply and wastewater management systems since they promote sustainable use of resources and efficient operations of the systems in as far as service delivery is concerned. According to the chairperson, the meetings were meant to assist the councilors and management of council by giving a feedback on service delivery with respect to each ward, concerning mobilizing users to pay for the bills, protection of the piping system for both water supply and sewer system to minimize bursts. It was noted that user association committees, comprising 9 members of whom 4 were women and 5 men were established in every ward. However, while the gender aspect was taken into consideration, the position of chairpersons in all 9 wards was held by men, whilst women are secretaries. Similar observations were made in Tanzania where Mayo and Nkiwane (2013) reported that 78% of leadership positions were occupied by men.

Participatory approaches are recommended when implementing water project activities because they are instrumental for sustainability of water supply projects (Dube, 2012; Kamruzzaman et al., 2013; Kwangware et al., 2014). In Chiredzi town it was observed that users participate by contributing ideas (55.3%) and cash (16.7%), but 28.0% did not participate in any way. The results matched those of Mayo and Nkiwane (2013) who found out that reporting of leakages to management help minimize water losses and improves sustainability of the water utility. According to some of the respondents, timely payment of their bills was considered a great contribution to the sustainable management of the utilities. The need to have continuous supply of water and avoiding disease outbreaks such as cholera by the households was the driving force for users to participate in the services provision, which benefits the users socially and health wise.

Focus group discussions and household questionnaire were used to assess the involvement of women in water supply and sanitation management systems. From the sampled households, 75% of the respondents agreed that women are involved although they are marginalized, particularly in leadership positions such as councilors, chairpersons and treasuries. In as far as National Gender Policies are concerned Zimbabwe is ranked 107 on related global related development index (WEDC, 2007). This reflects the low status given to gender with respect to access, control and ownership of economic resources and decision-making positions. Therefore, there is need to address the imbalance between men and women. The Zimbabwe gender policy gives comprehensive strategies for water supply, but not for sanitation. However, water and sanitation issues are combined and guided by water and sanitation policies, but sanitation is given less attention.

Stakeholder participation in project activities is considered as very important because it builds a sense of ownership and commitment among the local people (IRC, 2003). About 54% of the respondents have participated in association meeting and about 61.3% of the respondents have contributed to the provision of services through reporting pipe bursts and sewer blockages. From the demographic information, it was found that the general meeting, which involves all members is held once annually whereas water users’ committee members hold meetings once every month. The meetings were meant to discuss the quality of service delivery in each ward and propose solutions to the identified problems. From focus group discussions it was found that water users committee meet once every month with councilors to fill in the score cards on service delivery.

Tariff setting, revenue collection and willingness to pay

From the sampled households, only 18% of the consumers were aware and involved in tariff setting, the majority of whom was council employees. This is because water tariffs are set by the government although procedural consultations were made through stakeholder meetings as confirmed by 56% of the respondents. However, it was noted that 67% of the respondents were satisfied with the set tariffs. In principle, setting of tariffs should involve participatory approach whereby stakeholders, particularly consumers are actively involved in order to positively influence willingness to pay and revenue collection (Stenekes, 2006; Murinda, 2010). Chiredzi town water utility utilizes volumetric tariff system and charges 0.30, 0.35 and 1.00 USD/m^3 for domestic, institutional and commercial customers, respectively. Unfortunately, only about 25% of the meters are functioning, which means bills are largely estimated. While water tariffs for water services are depending on the location and production costs (Kaercher et al., 2004), there was no evidence that the gazetted tariff for Chiredzi town considered actual cost of development and maintaining the utility. In African small towns, government determines the charges regardless of consideration of actual cost of supplying water.

It was further observed that only about 65% of users pay their water bills, which are required to be paid within 60 days, but are rarely disconnected for failure to pay for the services. It is known that the town council uses fines and disconnection from service as methods to enforce payments. From this study, 93.3% of the respondents were willing to pay for the services, but 35% of the consumers had not paid their bills because of various reasons including affordability of the services, poor service provision and complaints on estimated bills in the absence of metered bills. The reconnection fines of USD 15 and USD 30 for residential and commercial, respectively are charged by the council. However, due to corrupt staff responsible for disconnection, users continue to use the service after bribing them. It was also noted that urban services are used for political gains, where the government can intervene and allow defaulters to use water services.

Chiredzi Council is operating under the Urban Council's Act and complimenting it with the ZINWA Water Act of 1998. Urban Councils Act Chapter 29:15 governs the management of urban areas in Zimbabwe. It was noted that Part XIII: 83 of Urban Councils Act apply to water supply services with the exclusion of sanitation. It specifies the responsibilities of the council concerning the provision and maintenance of water supply within and outside council areas. The Acts' weakness is that it does not give enough guidance for management of urban water supply services. Issues of tariff settings, punishment of defaulters and who should regulate water management in the urban areas are not addressed in the Act. Also worth noting is that Zimbabwe has no policy on urban water and wastewater services. In Southern African countries, only South Africa and Zambia have Urban Water and Sanitation Acts, which are specific to water supply and sanitation in urban areas (Murinda, 2010). The Acts clearly elaborates on the institutional arrangements, which exist in the urban areas and their roles in the management of water supply, wastewater and solid waste services.

Generally, the service level of Chiredzi town is poor because of the failure of council to rehabilitate, expand and upgrade the old and worn out infrastructure. Thus the town is lagging behind in terms of service coverage, with 77.9 and 72% for water and sewerage systems, respectively. Willingness to pay is affected by many factors especially the level of service delivery, which can increase or decrease willingness to pay for the improved services. The reliability of the service is of importance to users as this also determines the level of willingness to pay by the users. These results supported those of Bhandari and Grant (2007) who mentioned that reliability of water supply systems is among the factors which influence the willingness of users to pay for the services. In another study in Kenya, Spaling et al. (2014) reported that water supply, regulatory policy and local management are among the factors affecting the sustainability of a community water supply project. Revenue collection was affected by poor billing system, high level of malfunctioning meters, high rate of non-revenue water and low confidence of customers with their service provider.

Costs for operation and maintenance (O&M) and revenue collection

O&M and revenue collection for water supply

At the time of the study, Chiredzi town council was facing financial problems, especially for upgrading the system. For example, water supply system cannot supply water to the users for 24 h because their storage tanks need upgrading to meet the daily requirement. The council was also unable to pay its staff because of financial problems, which is de-motivating them. Table 3 shows that total O&M costs for water supply declined from USD 455,469 in 2010 to USD 322,621 per annum in 2014. The decrease in costs was caused by retrenchment, which started in 2012 up to 2013. However, it was noted that although there was a decline in costs, the costs were higher than the revenue collected from 2010 up to 2013. The study found out that only in year 2014 the collected revenue was higher than the costs incurred for that year. It was worth noting that in 2010 there was an outbreak of cholera and high costs (USD 455,469) were incurred for purchasing water treatment chemicals. The average collection ratio was found to be 46% meaning that the revenue collected was less than the expected in general, except for 2014. The scheme was not operating viably from 2010 up to 2013, and in 2014 it started to accrue marginal surplus that could be used for system upgrading and contingency measures such as breakdowns.

Table 3 shows that the O&M cost for wastewater management were higher than collected revenue as from 2010 up to 2011 and thereafter the collected revenue were higher than the cost incurred. The major O&M activities were noted to be regular staff, repairs/ maintenance costs and other costs. It was noted that although the costs were less than revenue collected, their differences were marginal, especially in the year 2012 where the costs were USD 100,153 compared to USD 110,765 revenue collected. The study findings revealed that as from 2010 to 2014 the expected revenue ranged from USD 240,567 to USD 295,047 per annum. The collection ratio was found to be 47%, and this reflects that the revenue collected for the given period was less than the expected revenue.

It was observed that amount of revenue collected by the service provider was lower than the costs incurred from years 2010 to 2012. This reflects that the council had no surplus funds for expansion and maintenance, meaning that the systems were run unsustainably. From the key informant interview with the financial department, the losses which the council suffered from 2010 up to 2012 were attributed to the cholera outbreak of 2010 and political campaigns of 2011/12 elections. Minister of

Table 3. Water supply financial requirement for O&M and revenue collected.

Financial year	2010	2011	2012	2013	2014
Expenditure component			**A: Water**		
Total O&M cost (USD)	455,469	444,730	424,598	317,221	322,621
Revenue collected (USD)	325,069	420,789	300,290	311,151	478,693
Expected revenue	675,567	738,330	738,330	850,678	982,047
			B: Wastewater		
Total O&M cost (USD)	109,613	106,648	100,153	101,715	103,485
Revenue collected (USD)	90,450	102,679	110,765	174,687	154,584
Expected revenue (USD)	240,567	240,567	245,373	295,047	295,047
			C: Water and wastewater		
Total revenue collected (USD)	415,519	505,468	411,055	485,838	633,277
Total O&M cost (USD)	565,082	551,378	524,751	418,936	426,106
Surplus/Shortfall (USD)	(149,563)	(45,910)	(113,696)	66,907	207,117

O&M and Revenue collection for wastewater management

National Housing announced the right-off of all urban tariffs arrears for water supply and sanitation. This impacted negatively on the general performance of small towns, which had already had small savings from the tariffs collected. From 2013 to 2014, it was noted that the revenue collected was higher than the costs incurred, meaning that currently council is operating viably and the surplus can be used for system upgrading and contingency measures such as breakdowns. This is the basis for sustainability of water supply schemes.

Sustainability index for water and wastewater systems

Sustainability of water and wastewater systems depend on numerous factors including legal, policies and institutional framework, community participation and social aspects, economic factors, financing and cost recovery, technical aspects, capacity building and natural environment (Mays, 2006; Gowda and Doddaswamy, 2011; Juwana et al., 2012). Various researches done in sub-Saharan Africa on sustainability of community water projects have studied at least two of these factors (Marcus and Onjala, 2008; Spaling et al., 2014; Kwangware et al., 2014). However, Peter and Nkambule (2012) concluded that technical and social factors were more important than other factors. Others have measured key determinants of sustainability such as technical, financial, social and environmental factors (De Carvalho, 2007; Spaling et al., 2014), an approach that was adopted in this study.

Technical aspect

Table 4 showed that the overall average score for the technical determinant was 6.2 meaning that it is performing at 62% which is quite satisfactory. Under technical, the indicator that scored the highest was that for water production and consumption which had an average score of 10, followed by service coverage which had 7.8. The lowest score was for the water loss indicator. This reflects that there is poor metering level (20%) and the unaccounted for water is very high (65%). This showed that town council is lagging behind in terms of ensuring 100% metering. This compromises revenue collection level which is about 10%. Water losses can be minimized by replacing faulty meters, leaking pipes and conducting water audit.

Financial aspect

The results indicated that the financial determinant had an average score of 5.8 and was the second last among the sustainability determinants studied (Table 5). The indicator, capacity to pay for the services scored the lowest of 5.25. This was mostly affected by the variable collection efficiency which had a score of 1. It was worth noting that collection efficiency of sufficient revenue was greatly dependent on the consumer's satisfaction level to the quality of services they receive as mentioned by Bhandari and Grant (2007). A household questionnaire was used to assess the willingness to pay and 93% of the respondents were willing to pay, but only 65% paid their bills. From this study, it was observed that the town council should improve on tariff collection efficiency by improving the quality of service delivery. It was also noted that 45% of the respondents are not employed, but they depend on informal business, thus their incomes are low and irregulars, meaning that they cannot afford to pay for the bills when due. Their incomes range from 100USD to 200USD which is far below poverty datum line of 450

Table 4. Technical aspect sustainability scores (Aspect weight = 25%).

No.	Indicators	Variable	Score
1		Population served	7.8
2	Service coverage	Water supply coverage	7.8
3		Sewage network coverage	7.3
4	Water production and consumption	Quantity produced/d	7.2
5		Per capita requirement/d	10
6		Metering level	2.0
7	Water losses	Unaccounted for water	4.0
8		Leakage detection system	2.0
		Total average score	6.2

Table 5. Financial aspect sustainability score (Aspect weight = 25%).

No.	Indicator	Sub-indicator	Score
1		% users paying for water and sewage	6.5
2	Cost recovery	% Non-Revenue Water (NRW)	3.8
3		% willingness to pay	9.3
4		Average Income levels	5.5
5	Capacity to pay for the services	Unemployment rate	4.5
6		Collection efficiency	1.0
7		Average tariffs level	10.0
		Total average score	5.8

USD (Zimstat, 2012). Non-revenue water was 65%, reflecting that only 35% of the generated water was billed. It was noted that high level of unaccounted for water was impacting negatively on the financial status of the service provider.

Financial aspect have low index of 5.8 indicating slow progress towards sustainability. It was observed that %NRW, collection efficiency and unemployment rate with scores of 3.8, 1.0 and 4.5, respectively were the major sub-indicators, which brings down the financial aspect index. These indicators had a huge impact on cost recovery and capacity of users to pay for services. It is worth noting that cost recovery is linked to technical aspect sub-indicators such as metering level, unaccounted for water and leakage detection system. Therefore, by improving on leakages detection, sorting out malfunctioning meters and reduction of unaccounted for water, cost recovery is improved.

Stakeholder participation is generally low, which has led to low percentage of users actually paying for the services, thus poor sustainability of water supply and wastewater systems. There is poor dissemination of information from management to stakeholders as evidenced by no interruption notification for services. The water users association was also found to be effective in terms of improving service delivery and if sustainable management of water supply and wastewater systems is to be achieved. This is because water users association gives the insight of services delivery levels that are on ground.

Social aspect

Among the social sustainability indices, the level of information dissemination had the lowest score of 0.4. A household questionnaire was used to assess the level of information dissemination and 96% of the respondents mentioned that they have never been informed of interruptions or development of services systems. Thus, users need to be informed of interruptions and any activities involving the development of services systems. It was also noted that the level of stakeholder participation (56%) is very low. This findings showed that the service provider is not involving users in the development and activities of water supply and sanitation systems. About 78% of the respondents were satisfied by water quality and service tariffs. High consumer

Table 6. Social sustainability score (Aspect weight = 25%).

No.	Indicator	Sub-indicators	Score
1	Level of services	Continuity of water supply	3.3
2		Response time to complaints	3.0
3		Efficiency in addressing complaints	7.5
4	Consumer satisfaction	Perception on water quality	7.8
5		Perception on services tariffs	7.6
6	Awareness and education	Level of education	9.8
7		Level of information dissemination	0.4
8		Level of stakeholder participation	5.6
		Total average score	5.6

satisfaction is a good indicator of sustainability management for both water supply and sanitation systems. The results agreed with those of Kwangware et al. (2014) who mentioned that the level of consumer satisfaction is one of the factors that influence their willingness to pay for the services. Table 6 shows that the overall average social score was 5.6. From the results, level of information dissemination, response time to complaints and continuity of water supply which had scores of 0.4, 3.3 and 3, respectively were the sub-indicators which brings down the social index. These three sub-indicators can be improved through education and awareness and upgrading the system to meet daily demands.

Environmental aspect

Sub-indicators of environmental sustainability include the quality of wastewater effluent, management of faecal sludge and compliance of wastewater treatment with Environmental Management Authority (EMA) policy. Others include water quality monitoring and reuse of domestic water after consumption. From the key informant interview and water and wastewater analysis, it was observed that the service provider complied with National Environmental Protection standards of 2007. It was noted, during physical inspection of the systems that faecal sludge matter was composed for 6 months before using it as manure. Sludge from the settling tanks was disposed in drying beds and water was allowed to drain through the unearthed channel to Mteri Dam where it is used for sugarcane irrigation. From field observation, effluent reuse is only practiced by the residents who have gardens around the stabilizing ponds for irrigation of tomatoes, vegetables, sesame, okra and maize, but root crops such as carrots have been avoided. For those who are into informal business, they sell these crops to raise household income. The council is not recycling water at all; instead it leaves the wastewater to flow to Chiredzi River. The overall average environmental score of 7.3 was the highest of all the four determinants under study, which reflects high sustainability (Table 7). However, sustainability index of environmental aspects can be raised by implementing water reuse for irrigation and aquaculture. It is worth mentioning that in emerging rapidly urbanising developing countries, sharp increase in demand for water is expected due to demands for irrigation and industry. The expansion of irrigated crop areas using recycled water may be a feasible option because of competition for water between economic sectors (Jägermeyr et al., 2016).

Overall sustainability index

Each of the determining factors, namely technical, financial, social and environmental aspects contributed 25% to the overall sustainability index. The environmental determinant had the highest sustainability index of 7.3, followed by technical, financial and social aspects with scores of 6.2, 5.8 and 5.6, respectively. The composite sustainability index was found to be 6.2 on a 10-point scale. This indicates that the performance of water supply and wastewater management is considered to be satisfactory progress towards sustainability in accordance with De Carvalho (2007). However, there is a need for improvement on financial, technical and social aspect. Other areas of improvement include reuse of water and wastewater, water metering and auditing should be implemented to minimize water losses.

CONCLUSIONS AND RECOMMENDATIONS

From the results of this study, it can be concluded that Chiredzi town is lagging behind in terms of service coverage, with 77.9 and 72% for water and sewerage systems, respectively. This was contributed by the failure of council to expand and upgrade the old and worn out

Table 7. Environmental sustainability score (Aspect weight = 25%).

No.	Indicator	Sub-indicators	Score
1		Effluent quality	8.3
2	Wastewater management	Disposal of faecal sludge	8.9
3		Compliance with EMA policy	8.8
4		Water quality monitoring	8.5
5	Domestic water management	Water reuse	0
6		Sludge disposal	9.1
		Total average score	7.3

infrastructure. It was further observed that issues of tariff settings, punishment of defaulters and institutional arrangement for regulation of water management in the urban areas are not adequately addressed in the Water Policies and Acts of Zimbabwe. In absence of proper institutional arrangement, Chiredzi town has failed to raise funds for rehabilitation, expansion and upgrading of water supply and wastewater system. A composite sustainability index of 6.2 out of 10, suggests that sustainability of Chiredzi town water supply and wastewater system was satisfactory progress towards sustainability. However, improvements are required in some areas including reuse of wastewater, increasing operating water meters and minimization of water losses, which are currently 20 and 65%, respectively. In general, the stakeholder participation is generally low and this has consequently contributed to low percentage of users actually paying for the services, thus poor sustainability of water supply and wastewater systems. To improve on water supply and sanitation service delivery, the Government of Zimbabwe has to ensure the budget for Urban Councils includes small town such as Chiredzi, so that they keep on operating despite revenue collection being low. To improve on the sustainability index, service providers must increase revenue collection, ensure reduction of non-revenue water, recycle and reuse treated wastewater, reduce service interruptions and improve stakeholder participation through awareness and sensitization programs to users.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

This paper presents part of the dissertation research work by Mr. F. Homerai at the University of Dar es Salaam under a WaterNet fellowship. The authors wish to express their gratitude to WaterNet for the financial support they extended to the first author.

REFERENCES

Arth G (2012). Urban Wastewater. Available online at http://greenarth.com/urbanwastewater.html. Retrieved on 22nd October 2018.

American Water Works Association (2006). Committee Report: Accelerated Testing of Water Meters. Journal-American Water Works Association 98(6):127-130.

Bhandari B, Grant M (2007). User satisfaction and sustainability of drinking water schemes in rural communities of Nepal. Sustainability: Science, Practice, and Policy 3(1):12-20.

Chiredzi Town Council (2015). Water Treatment Plant Design. Cartographic Department, Chiredzi, Zimbabwe.

David H (2005). Water Privatization in Africa. Public Services International Research Unit, University of Greenwich, UK.

De Carvalho S (2007). Sustainability Index for Integrated Urban Water Management (IUWM) in southern African Cities: A case study application-Greater Hermanus region and Maputo Cities. MSc Thesis, Department of Civil Engineering, University of Cape Town, South Africa.

Depoy F, Gitlin LN (2005). Introduction to Research: Understanding and applying multiple strategies, 3rd Edition, Elsevier Mosby.

Dube T (2012). Emerging Issues on the Sustainability of the Community Based Rural Water Resources Management Approach in Zimbabwe: A Case Study of Gwanda District. International Journal of Development and Sustainability 1(3):644-655.

Eid U (2015). The importance of water, sanitation, and hygiene as keys to national development. Johns Hopkins Water Magazine. Finan R. (Ed.). Available online at http://water.jhu.edu/index.php/magazine/climate-change-and-health-why-the-link-to-water-is-critical.

Environmental Management Regulations (2007). Effluent and solid waste disposal.

Gowda K, Doddaswamy R (2011). Sustainable Water Supply Systems in India- The role of Financial Institutions and Ethical Perspective. SPATIUM International Review, UDC 628.1, 540(24):16-20.

Hagos M, Jung D, Lansey KE (2016).Optimal meter placement for pipe burst detection in water distribution systems. Journal of Hydroinformatics jh2016170.

Hoko Z, Hertle J (2006). An Evaluation of Sustainability of Rural water rehabilitation project in Zimbabwe, The case of Mwenezi, Gwanda, Bulilima and Mangwe. Journal of Physics and Chemistry of the Earth 31(15-16):699-706.

Homerai F (2015). Sustainability of Chiredzi Town water supply and wastewater management in Masvingo Province, Zimbabwe. Masters in Integrated Water Resources Management, Department of Water Resources Engineering, University of Dar es Salaam.

IRC (2003). Community water supply management: About community management. Available online at http://www2.irc.nl/manage/whatisit/index.html. Retrieved on 25th February 2015.

Jägermeyr J, Gerten D, Schaphoff S, Heinke J, Lucht W, Rockström J (2016). Integrated crop water management might sustainably halve the global food gap. Environmental Research Letters 11:025002.

Juwana I, Muttil N, Perera BJC (2012). Indicator-based Water Sustainability Assessment - A Review. Science of the Total Environment 438:357-371.

Kamruzzaman AKM, Said I, Osman O (2013). Overview of Management Patterns in Community, Private and Hybrid Management in Rural Water Supply. Journal of Sustainable Development 6(5):26-36.

Krejcie RV, Morgan DW (1970). Determining Sample Size for Research Activities. Education and Psychological Measurement 30:607-610.

Kwangware J, Mayo AW, Hoko Z (2014). Sustainability of donor-funded rural water supply and sanitation projects in Mbire District, Zimbabwe. Journal of Physics and Chemistry of the Earth (76-78):134-139.

Marcus RR, Onjala J (2008). Exit the State: Decentralization and the Need for Local Social, Political, and Economic Considerations in Water Resource Allocation in Madagascar and Kenya. Journal of Human Development and Capabilities 9(1):23-45.

Mayo AW, Nkiwane L (2013). The role of community participation on cost recovery and sustainability of rural water supply project in Hai District in Tanzania. Journal of Environmental Science and Water Resources 2(11):388-395.

Mays L (2006). Water Resources Sustainability. New York: McGraw-Hill.

Minghong T, Pelin W (2012). Challenges for sustainable urbanization: a case study of water shortage and environment changes in Shandog China. Procedia Environment Sciences 13:919-927.

Murinda S (2010). Comparative Assessment of performance of urban water supply systems in small towns of Zimbabwe. Masters of integrated water resources management Thesis. Department of Civil Engineering, University of Zimbabwe.

Nair KS (2010). Socio-economic and environmental issues associated with urban water management in India. International Symposium on New Directions in Urban Water Management, UNESCO Paris.

Nhapi I (2009). The water situation in Harare, Zimbabwe: A policy and management problem. Journal of Water Policy 11:221-235.

Peter G, Nkambule SE (2012). Factors Affecting Sustainability of Rural Water Schemes in Swaziland. Physics and Chemistry of the Earth, Parts A/B/C 50-52:196-204.

Robinson P (2002). Upgraded Family Wells in Zimbabwe. Household level water supplies for Multiple Uses: Water and Sanitation Program-Africa Region (WSPAF), The World Bank, Nairobi, Kenya.

Spaling H, Brouwer G, Njoka J (2014). Factors affecting the sustainability of a community water supply project in Kenya. Journal of Development in Practice 24(7):797-811.

Stenekes N (2006). Risk governance in water recycling: Public acceptance revised. Science Technology and Human Values 31(2):107-134.

Tyman N, Kingdom W (2002). A water scorecard: setting performance targets for water utilities. Public Policy for the Private Sector, Note No. 242, World Bank.

United Nations (2015). Transforming our world: The 2030 Agenda for sustainable development. A/RES/70/1, United Nations. Available online at https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf. Retrieved on 1st June 2018.

UNICEF (2010). Water Sanitation and Hygiene. Available online at http://www.unicef.org.wash. Retrieved on 20th October 2018.

UNICEF and USAID (2009). Assessment of Water and Sanitation facilities in Four Urban towns. Chipinge Assessment report.

United Nations Children's Fund (UNICEF) and World Health Organization (WHO) Joint Monitoring Programme (JMP) for water supply and sanitation (2017). Progress on drinking water and sanitation and hygiene 2017, Updates and SDGs baselines, New York, USA.

Unganai L (2008). Climate change scenarios for the Save catchment of Zimbabwe with special reference to Chiredzi, Synthesis report for GoZ-UNDP/GEF Coping with drought and climate change project c/o Environmental Management Agency (EMA). Available online at cwd@ecoweb.co.zw. Retrieved on 20th October 2018.

Water Operation Partnership (2009). Africa Utility Performance Assessment. Final report.

Watson V (2009). Seeing from the South: refocusing urban planning on the globe's central urban issue. Journal of Urban Studies 46:2229-2275.

WEDC (2007). Community and Management. A WEDC Postgraduate Module: WEDC, Loughborough University, UK.

WUP, World Bank (2001). Final Report of Performance Indicators: African Water Supply and Sanitation Supply systems. Water Supply systems Partnership, Abidjan, Cote d'Ivoire.

WHO and UNICEF (2017). Progress on Drinking Water, Sanitation and Hygiene, 2017 Update and SDG Baselines, Joint Monitoring Program, Launch version July 12 Main report, Geneva, Switzerland.

World Bank (2009). African Infrastructure country diagnostic: Africa's infrastructure: Time for transformation. Overview, World Bank, Washington D.C.

Zimbabwe National Statistics Agency (ZimStat) (2012). Census 2012 Preliminary Report, Government of Zimbabwe, Harare, Zimbabwe.