International Journal of Economics, Commerce and Management
United Kingdom Vol. II, Issue 8, 2014
http://ijecm.co.uk/ ISSN 2348 0386

FACTORS INFLUENCING PERFORMANCE OF SEWER SYSTEMS IN URBAN AREAS IN KENYA

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Abstract

This study examined factors influencing sewer system in urban areas with a focus to Isiolo town. These findings are of great benefit to the Isiolo water and Sewerage Company since it will find out the causes of its poor sewer performance in service delivery and thus review their sewer policies in order to improve their service delivery and performance. Improved access to water supply and appropriate sanitation is fundamental to the elimination of poverty and the achievement of millennium development Goals (MDGs). The Kenyan water sector underwent far-reaching reforms through the Water Act No. 8 of 2002. The Ministry of Water and Irrigation is in charge of policies for water supply and the Ministry of Public Health and Sanitation is in charge of policies. The study adopted descriptive research design employing ex- post facto technique. SPSS tool was used by the researcher to analyze data. Descriptive statistic such as mean, median and mode was used. On the basis of empirical findings it was recommended that the management should keep up keep up the good spirit of embracing modern technology that will enhance sewer performance. The management of Isiolo water and Sewerage Company should endeavor to maximize their staff capacity by training them and equipping them with technology skills for effective management of sewer performance.

Keywords: Infrastructures, Performance of sewer, Physical environment, Population, System technology

INTRODUCTION

According to Akinola (2002), Western countries have the lowest total water supply coverage of any region in the world. Currently about 300 million people in western countries do not have access to safe water and about 313 million have no access to proper sewer and sanitation facilities. This situation exacts a heavy toll on the health and economic progress of western countries. In Africa, millions of its population without water supply and access to sanitation is even worse than water supply. This situation is the cause of water related diseases, loss of valuable productive time and greatly contributes to perpetuate poverty on the continent. In line with its strategic plan for 2003 to 2007 and in response to the Africa Water Vision and the UN Millennium Development Goals on water supply and sanitation (WSS), the African Development Bank Group launched an Urban Water Supply and Sanitation Initiative (UWSSI) with the view to accelerating access to water supply and sanitation services in Urban Africa.

In Kenya, a sewer system was built in the late colonial period and the first wastewater treatment plant was completed at Kariobangi just east of the city in 1961, shortly before independence. A second wastewater treatment plant was commissioned in 1980 in Dandora further east and further downstream on the Nairobi River. In parallel, an effort was made to expand the sewerage system. With the new infrastructure the discharge of liquid waste in open drains declined considerably and for a period between 1987 and 1995 the water quality of the Nairobi River improved. However, the discharge of untreated wastewater in non-sewered areas continued. Because of inadequate garbage collection and poor maintenance sewers became clogged and overflowed, so that the benefits of the sewerage were less than expected. Furthermore, the Kariobangi plant was poorly maintained and stopped functioning. In Isiolo county, local communities have started developing their own water supplies and set up water committees. This has been necessitated by poor performance of the sewer company in Isiolo where sewer blockage is the order of the day. The county has experienced spilling and flooding of human waste along the sewer line and sometimes in town centre due to blockage of the system. The county government is helping the sewer company to address the issues in order to improve the falling performance and efficiency and the sanitation of the county.

Statement of the Problem

Improved access to water supply and appropriate sanitation is fundamental to the elimination of poverty and the achievement of millennium development Goals (MDGs).Yet, access to water for most urban and rural poor groups remain very poor in developing countries (UNDP, 2007). The provision of adequate water supplies is essential in order to meet basic human needs and to address poverty, and promote economic development, health and hygiene. Water supply has a long history in this respect, and the rationale for its improvement has always been the need to

protect public health, to reduce mortality and morbidity in the population, and to promote economic development, especially in the developing world.

Water supply and sanitation in Kenya is characterized by low levels of access, in particular in urban slums and in rural areas, as well as poor service quality in the form of intermittent water supply. Only 9 out of 55 water service providers in Kenya provide continuous water supply and proper sewer systems. Seasonal and regional water scarcity exacerbates the difficulty to improve sewer system. Water and sanitation sector in Kenya is characterized by institutional fragmentation that led to numerous inefficiencies and by subsequent attempts at reform. 95% of the excreta disposal facilities in Kenya urban areas are major use of sewer systems hence providing varied degrees of safety, hygiene and privacy. The government of Kenya has provided legal framework and entered into collaboration with donors such as JICA to ensure that the sewer systems in Kenya urban areas are functioning properly and sanitation is improved. Despite all the government efforts to modernize urban sewer system, there has seen complains that the urban sewer systems are not up to standards. This has been characterized by poor drainage of sewer system, blockage of pipe, spilling and flooding of wastes in towns. This can be exemplified by low delivery of services, lethargy, cronyism, slow implementation of government policies and programs leading to hue and cry from the stakeholders both internal and external.

Objectives of the Study

i. To determine extent to which population is a factor influencing performance of sewer system in urban areas.
ii. To establish how system infrastructure influences performance of sewer system in urban areas.
iii. To determine extent to which physical environment influences performance of sewer system in urban areas.
iv. To establish how System technology influences performance of sewer system in urban areas.

Delimitation of the study.

The study population included all sewer consumers of Isiolo water and Sewerage Company which includes commercial and domestic consumers. There is a total of 578 sewer consumers in Isiolo town. This is because for the researcher to come up with precise findings, recommendations and conclusion, all clients must be involved. The researcher would use the data gathered from the sewer consumers to generalize the finding.

LITERATURE REVIEW

Empirical Review

According to Renzetti & Dupont (2004), the diversity of the service sector makes it difficult to make useful generalization concerning the management of service organization. Water and sewerage services have certain special features not necessarily typical of other infrastructure services. They are exceptionally capital-intensive compared with other public services. The capital costs (including interest and depreciation) are often 65-75 percent of annual operating costs. The greatest share of capital costs by far is related to pipe and sewer networks. Contrary to common belief, adequate and modern wastewater treatment accounts for only 10-15 percent of annual operating costs (Megginson & Netter, 2001).Yet, the treatment processes are of utmost importance for health and environmental reasons.

The capital intensiveness is partly due to the low ratio of annual turnover to cost of assets. A second special feature of sewerage services operations is that fixed costs i.e. those that do not vary with the volume of production, except within very wide limits are about 80 percent of operating expenses. Yet, the revenue of many utilities depends mainly on the volume of water sold (Pickford, 2001). This has a profound effect on the structure of rates and charges. Consumers have to pay for the services, commonly through consumption related charges, sometimes by other means like taxation (Panda, 2007). Lack of proper cost recovery policy has been one of the key problems in many countries. The third, and maybe the most important, feature from the viewpoint of this study is that the Water and sewerage services infrastructure is a natural monopoly a concept first introduced by John Stuart Mill in 1848 (Perkins, 2008). In the case of services like water and sanitation it is feasible to construct only one system for one service area. General services and efficiency standards are commonly benchmarked, and finance efficiency is also tracked extensively (Pickford, 2001).

Population and performance of sewer system

According to a study conducted by UNDP (2007), on the rapid urban population increases found that during the nineteenth century, there was considerable urban population growth in the United States. In 1820, less than 5 percent of all Americans lived in urban areas (cities with a population larger than 8,000), but by 1860 the percentage increased to 16 percent and by 1880 had risen to 22.5 percent. From 1820 to 1880, most major cities in the United States experienced considerable growth. For example, during this time Boston's population increased eightfold, New York City's tenfold, Philadelphia's thirteen fold, and Washington, D.C.'s fivefold. As a result of this increased population density in urban areas, the decentralized privy vault-cesspool wastewater management systems became overtaxed. Mitigation measures included increasing the cleaning frequency and constructing additional privy vaults and cesspools. The

improvements, however, only slightly reduced the periodic overflows and development of nuisance conditions.

Panda (2007), argues that domestic water, regarded as an always present and constant commodity, is used as a produce and laundry cleaner, a carrier for garbage disposal grist, and a necessity for human metabolic functions. Each process excretes the utilized water with its own type of pollutant yet all converge at the same location, the local sewage treatment plant. Too often the municipal treatment plant designed for a particular capacity and type of sewage cannot keep up with demand and allows the outflow of non-treated or only partially treated wastewaters. The eutrophic problem of receiving waters caused by the release of municipal wastewater effluents was one of the prime reasons for implementation of Public Law 92-500.

System Infrastructure and performance of sewer system

The role of infrastructure such as safe drinking water in societal welfare and development has long been recognized. Infrastructure is regarded as the systemic framework which underpins community's ability to fulfill its mission of providing a base for its citizens to be productive and to nurture social equit (Davis, 2005). It is a kind of public trust of commonwealth upon which every citizen relies and draws for prospect and day to day socio-economic opportunities. When it functions efficiently the whole society benefits and the resultant effect is manifested on the growth and development of the community, when it functions below expectation, everybody pays in kind and cash (Akinola, 2002).

Sewer supply like energy, capital and communications is a very important infrastructural prerequisite for sustainable development. Apart from its primary role in enhancing human health and wellbeing, it is equally important for industrialization and commercial developments (Pickford,2001). Adequate water is absolutely necessary to support the population and economic life of a city. Critical shortages of water not only inhibit or stop economic development but also directly damage the health of the city's people.

(Pickford 2001) contends that without water, there is no life; he cautioned that bad water could be almost as harmful as no water at all. The recognition of the significant role of water resources to support life in a city and its use for urban development has instigated interest on it at the global level and its inclusion on the subject of sustainable development and environmental sustainability.

Buller (2006) argues that decentralized systems are also better at coping with the need to expand services. In the area of storm water drainage, there is also a growing use of "source control" technologies that handle storm water near the point of generation, i.e. locally, also providing opportunities for direct use for, e.g., toilet flushing.

Physical environment and performance of sewer system

According to Pickford, (2001), there are two basic physical environment reasons why the implementation of centralized water-carriage sewer systems was favored over decentralized privy vault-cesspool systems. Water-carriage sewer systems were believed to be more cost effective over the long term. Experience in England showed that physical environment of a water supply and water-carriage sewer system cost with interest, divided over a period of thirty years would be less than the cost of keeping privy vaults and cesspools clean. Similarly in the United States, proper physical environment a of centralized sewer system advocates pointed out that the capital and maintenance costs of sewer systems would represent a saving over the annual cost of collection and cleaning with the privy vault-cesspool system. Based on this economic reasoning, city councils, sanitary engineers, and health groups almost unanimously agreed that water-carriage sewer systems provided the most benefits and the lowest long-term costs compared to other disposal options, as was the case for New York City.

System technology (ICT) and performance of sewer

Automation and ICT were adopted in sewer supply facilities and networks since the early fifties. Most of modern sewer supply plants in the developed countries are nowadays fully automated, utilizing ICT for synchronization of water supply with demand, regulation of pumps operation for energy savings, coordination of withdrawal from different sources and reservoirs and control of purification processes in sewerage reclamation facilities (Davis, Bagozzi & Warshaw, 2001). The introduction of variable speed pumps, incorporating frequency adjustment drives, facilitates high-level regulation of discharge and pressure regime for savings of energy and water. The use of this advanced technology was boosted by the increase in oil price during the last decade. The anticipated oil price hike in the future increases the incentive for more extensive adoption of ICT in water supply facilities. Energy savings by installed appliances, amount to 20% - 30% by increasing the efficiency of pumping units, balancing withdrawals and eliminating pressure surges and fluctuations (Tjandraatmadja & Burn, 2005).

The public sector, particularly government facilities, sewer supply is lagging behind the in controlling the supply and consumption. According to Karanja and Nyambura (2014), system technology will always lead to improved performance especially if its adoption is fully supported by management and the end users. Most government facilities consumers in the world do not pay for sewer according to consumption. Many of them do not pay at all for the sewer consumed (Renzetti & Dupont. 2004). Only in limited number of countries, like Israel, each consumer's sewer outlet is equipped with a sewer meter. But, due to increasing worldwide sewer facilities shortages, interest is growing in measuring government and household sewer consumption and invoicing the users according to the actual amount of sewer consumed.

Theoretical Framework

This study shall be based on two theories: Technology acceptance Model and the Brett frischmanns economic theory of infrastructure. A theory as defined by (Mugenda and Mugenda 2003) is a set of concepts and interrelations that are presumed to exist among concepts. Theoretical framework is a collection of interrelated ideas based on theories –a reasoned set of prepositions which are derived from and supported by data or evidence (Kombo and Tromp, 2006).The two theories will complement each other for the purpose of this study.

Technology Acceptance Model

One of the well-known models related to technology acceptance and use is the technology acceptance model (TAM), originally proposed by Davis in 1986. TAM provides a basis with which one traces how external variables influence belief, attitude, and intention to use. Two cognitive beliefs are posited by TAM: perceived usefulness and perceived ease of use. According to TAM, one's actual use of a technology system is influenced directly or indirectly by the user's behavioral intentions, attitude, perceived usefulness of the system, and perceived ease of the system. The study adopted this model to explain the role of information in enhancing efficiency in the provision of sewer services.

Brett Frischmann's economic theory of infrastructure

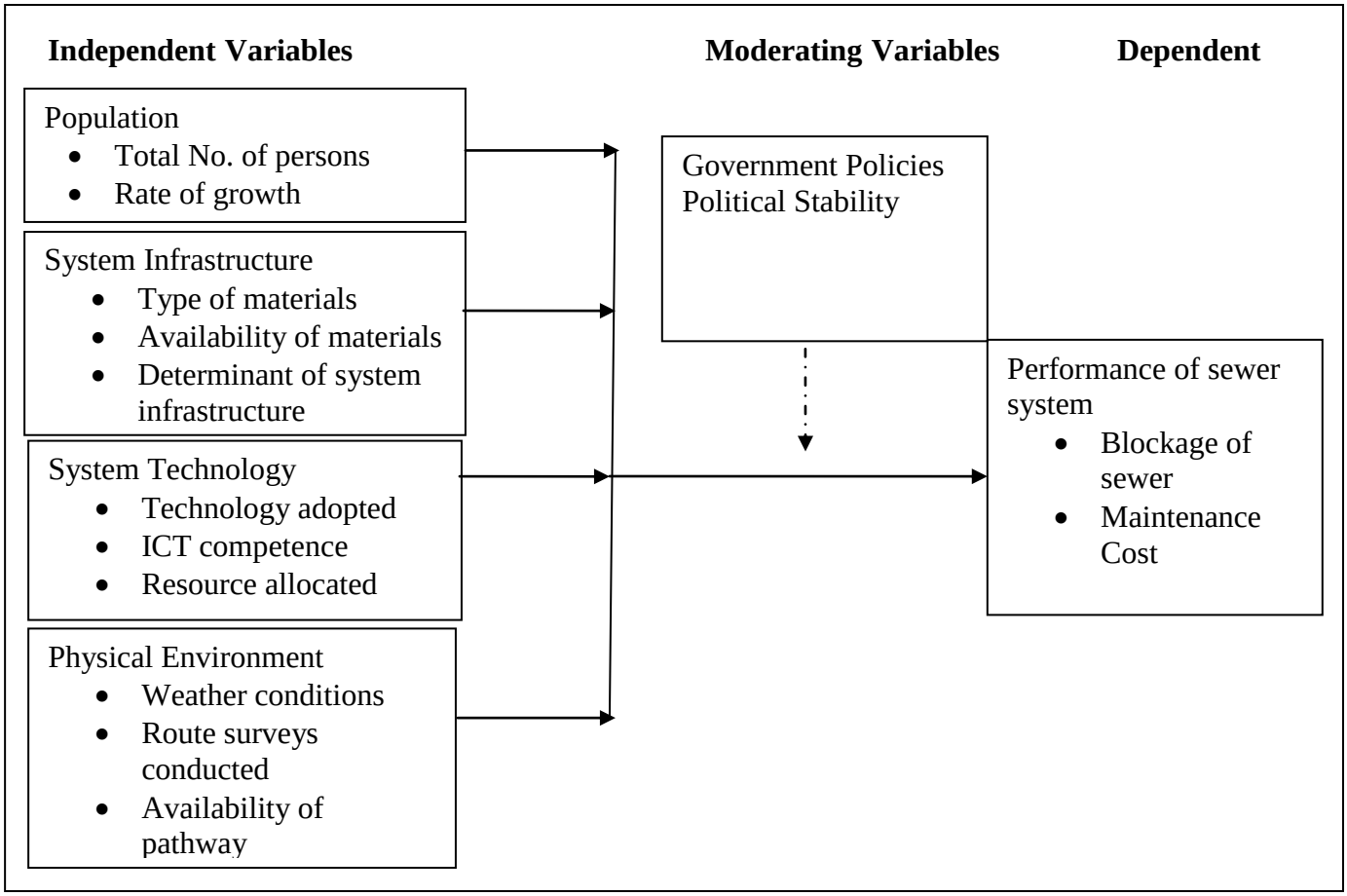
Brett Frischmann's economic theory of infrastructure and commons management offer a comprehensive new proposal about managing certain types of resources by providing public access to them on an obligatory and nondiscriminatory basis. It critiques any systematic right to exclude as inappropriate—a right that would be an integral part of a typical resource management scheme based on private property. For many resources that are broadly shared and reusable, Frischmann argues, open access will be more conducive to maximizing the production of public and nonmarket goods on an ongoing basis. The beneficial processes of shared use and reuse, with their many positive spillover effects, would be impeded by granting a property right to an owner who then could exclude potential downstream users, based on inadequate signals about demand. Frischmann concludes that fundamental infrastructure should instead be shared. His theory is important and helpful in addressing current issues of management, organization structure and information.

Conceptual framework

The conceptual framework below explains that the performance of sewer systems is dependent on population the system infrastructures and at other stages the system technology and the

physical environment. Moderating variables that equally play a role in the performance of sewer is the government policies and political stability.

Figure 1 Conceptual framework



METHODOLOGY

Research Design

A research design is a conceptual structure within which research is conducted. It constitutes the blue print for the collection, measurement and analysis of data. The study adopted descriptive research design employing ex- post facto technique. According to Kothari (2009), this design will help the researcher to report what has already happened in the ground or what is happening since the problem has been well designed .It involves fact finding and enquiries of different types. This is the research design that was used to establish factors influencing performance of sewer system in urban areas.

Target Population

The study population included all the 15 management employees of Isiolo water and Sewerage Company and the sewer consumers in Isiolo town. The sewer consumer population included the

commercial and domestic consumers. There are 578 sewer consumers who comprise of both commercial and domestic. The researcher liased with Isiolo water and Sewerage Company to provide with contacts and physical address of the respondents who formed the target population. This is because for the researcher to come up with precise findings, recommendations and conclusion, all clients must be involved.

Table 1 Target Population

	Frequency	Percent
Management IWASCO	15	3
Commercial	63	11
Domestic	500	86
Total	**578**	**100.0**

Sampling Procedure

Cooper and Schindler (2003) explains that the whole idea of sampling is selecting some of the elements in a population, so the same conclusions can be drawn about the entire population. 10- 30% is a good representation of the target population.

Kothari (2009), highlights the formula of sample size as $nf = \frac{n}{(1+n)}$

nf= the desired sample size

N= the estimate of population size N

The study used stratified sampling method, where each institution was treated as a stratum. Since the population is not large for the IWASCO management and commercial consumers, and there are well organized structures where the respondents can be found easily, the researcher conducted a census. According to Kothari (2009), a complete enumeration of all items in the population is known as a census inquiry. It can be presumed that in such an inquiry, when all items are covered, no element of chance is left and highest accuracy is obtained and especially when the population is small hence no need for further sampling.

For the domestic consumers who are landlords, the researcher used a simple random method where 10% of all the respondents was selected. A list of all the domestic consumers was drawn from the sewer service provider. The researcher assigned numbers and every 10^{th} consumer was picked as a respondents hence a total of 50 respondents from domestic consumers was used. A total sample of 128 respondents was used for the study.

Methods of Data collection

The questionnaire was used to collect the data from the sample. The researcher administered the questionnaire to the respondents and gave them 2 days to complete, and then picked them after the 2 days.

Methods of data Analysis

Data analysis process included data sorting, editing, coding, or variable generation, data entry, cleaning, processing and interpretation of results. The SPSS tool was used by the researcher to analyze data. Descriptive statistic was used. Quantitative data was represented using tables while qualitative data was presented in narrative form.

ANALYSIS

Population influence on the performance of sewer system in urban areas

The study established with 73% of the respondents that there is high growth rate of population in Isiolo town, 12% strongly agreed that there is high growth rate of population in Isiolo town. However, this was followed by an agreement of 67.5% and 24.8%, of the respondents strongly agreeing that there is high population connected to the sewer system, agreed that there is high population connected to the sewer system. Most of the respondents (72.7%) indicated that there is inefficiency of system to cater for huge population. Majority of the respondents (59.2%) strongly agreed that there is poor usage of sewer system by the population. it was always noted from (44% and 29%) of the respondents that there is no occupation of areas kept a side for sewer expansion by individuals.

System technology influence on performance of sewer system in urban areas

The study established that (50.3% and 15.3%) of the respondents indicated that there is lack of modern sewer equipment's. it was also established from the study with 61% of the respondents that the staff are trained to handle and how to operate the sewer systems. However, it was found with 31.2% of the respondents that there is there is poor investment on sewer system technology,

It was also noted from the study with 47.1% of the respondents indicating that that there no sufficient competent staff who can handle sewer performance in Isiolo. The study also established with 40.8% of the respondents indicating that there is no ICT systems to monitor sewer operations,

It was also established from the study with 75% of the respondents indicating that the members of staff in IWASECO does not have appropriate technology to manage the system while. This was attributed to have caused the sewer problems in the in Isiolo town.

System Infrastructure influence on performance of sewer system in urban areas

The study established with 28.7% and 18.5% that there is no adequate infrastructure funding to enhance the sewer performance in Isiolo town. It was also established with 45% and 22.7% of the respondents that there is availability of sewer treatment facilities. However, the study also established that the swere systems are not poor constructed and they are in good condition which was indicated by (31.8% and 7.6%). It was also found that there is availability of electricity in Isiolo town with 28% and 15.3% which should have enhanced the performance of sewer systems.

The study established that infrastructural facilities in managing the performance of sewer systems is very important element which was indicated by (42.7%) of the respondents

Physical environment influence on performance of sewer system in urban areas

The study established that from (86%) of the respondents that the weather conditions is not reliable to enhance sewer performance. It was also found (66.9%) of the respondents indicating that route surveys are well conducted when laying down sewer line and this should enhance the performance of sewer in Isiolo town. It was also indicated by (71.3%) of the respondents that there is no available pathways for the new sewer lines and this is a challenge especially when expanding the existing sewer lines. The respondents suggested that management should endeavor to ensure that should be adequate survey of sewer lines conduct seminars more frequently to train the Isiolo residents on methods maintaining sewer physical environment and that IWASCO Company should come up with ways of getting alternative route paths for sewer flow in Isiolo town.

SUMMARY & DISCUSSION

Influence of population on the performance of sewer system in urban areas

During the study, the respondents were asked to think of population and to express their level of agreement by placing a tick in an appropriate column that expresses what you feel. Majority of the respondents agreed that there is high growth rate of population in Isiolo town which is connected to the sewer system and the system are not able to cater for the huge population. This agrees with the UNDP (2007) study, on the rapid urban population increases which found that during the nineteenth century, there was considerable urban population growth in the United States which as a result of this increased population density in urban areas, the decentralized privy vault-cesspool wastewater management systems became overtaxed. Mitigation measures included increasing the cleaning frequency and constructing additional privy vaults and cesspools. The improvements, however, only slightly reduced the periodic overflows and development of nuisance conditions.

System infrastructure influence on performance of sewer system in urban areas

Data collected from the respondents indicated that majority of the respondents agreed that there is lack of modern sewer equipment's. This is agreeing with the study conducted by Pickford, (2001), that sewer supply like energy, capital and communications is a very important infrastructural prerequisite for sustainable development. Apart from its primary role in enhancing human health and wellbeing, it is equally important for industrialization and commercial developments and if the infrastructures are not improved there will be critical shortages of water not only inhibit or stop economic development but also directly damage the health of the urban people. These findings also agrees with a study by Davis, (2005) where he argued that infrastructure is s the systemic framework which underpins community's ability to fulfill its mission of providing a base for its citizens to be productive and to nurture social equity especially in sewer performance.

Influence of physical environment performance of sewer system in urban areas

The respondents were asked to describe the influence of sewer physical environment on the performance of sewer in Isiolo town. The respondents indicated that they could not describe the weather conditions are not reliable to enhance sewer performance. However, respondents argued that there are no available pathways for the sewer lines. Majority of the respondents were highly dissatisfied with the sewer physical environment in Isiolo town. This agrees with findings of a study by WHO & UNICEF (2007), where pipeline excavation is difficult because of rock or there is limited topographic relief (i.e., due to flat terrain), gravity collection systems may not be practical and the sewage must be pumped through a pipeline to the treatment plant. This also corresponds with the study by Pickford, (2001), that there are two basic physical environment reasons why the implementation of centralized water-carriage sewer systems was favored over decentralized privy vault-cesspool systems. Water-carriage sewer systems were believed to be more cost effective over the long term. In low-lying communities, wastewater may be conveyed by vacuum.

Influence of system technology on performance of sewer system in urban areas

The study noted that there are no ICT systems to monitor sewer operations. Majority of the respondents indicated that the member of staff in IWASCO does not have appropriate technology to manage the system. This was highlighted as to what has led poor management of the sewer system in Isiolo town. this study agrees with the findings of Karanja & Nyambura (2014), that the public sector, particularly government facilities, sewer supply is lagging behind the in technology adoption controlling the supply and consumption which would lead to improved performance especially if its adoption is fully supported by management and the end

users. These findings correspondences with those of Bagozzi & Warshaw, (2001), where they argues that automation and ICT were adopted in sewer supply facilities and networks since the early fifties.

CONCLUSIONS AND RECOMMENDATIONS

From the literature review it was established that the performance of sewer systems in the urban areas both globally and locally throughout the history has experienced challenges. With the poor sewer performance by IWASCO in Isiolo town it has been noted that very high population that have settled in Isiolo town has contributed to poor performance of sewer systems. There have been notable reforms in the sewer management but the use of technology has not been adopted well in the sewer management. Sewer infrastructures which has been introduced by IWASCO, has not able to bring improvement in the sewer management. However, despite the much envisaged reforms in the sewer company, it was noted that consumers are still highly dissatisfied level of physical environment and this have affected the sewer performance in Isiolo town.

It was recommended that the management of IWASCO should endeavor to improve the sewer system by either building enough sewer manholes to accommodate the increasing population growth. It was also recommended that the management should keep up the good spirit of embracing modern technology that will enhance sewer performance. The management of IWASCO should endeavor to maximize their staff capacity by training them and equipping them with technology skills for effective management of sewer performance.

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