

literal rudiments, sustainability refers to the capacity to maintain some entity, outcome or process over time. Water as a resource may be deemed sustainable if and when various activities do not exhaust the material resources on which it depends [22]. In its increasingly common use, the concept of sustainability frames the ways in which environmental problems imperil the conditions of healthy economic, ecological and social systems.

On a global perspective, the environmental challenge of sustainability raises a set of basic problems and comprehensive goals. By focusing on the ecological dependency of economic and social systems, sustainability illuminates the mutual effects between environmental degradation caused by human activities and the perils to human systems presented by global environmental problems [13]. The scholar further asserts that the theory of sustainability raises a starkly basic question on whether or not human activity successfully maintains itself and its goals without exhausting the resources on which it depends. This question directs attention towards the planetary impact of human activity and its durability over time. Therefore, it provokes reflection on the manner and purposes of global human society.

Problems like biodiversity loss and climate change point to the global reach of human's powers and the scale of its risk. Mitigating their impact and risks, is also noted [5] that it seems to require reform across many human systems (financial, political, production, energy, transportation, communication and indeed education. Yet, those reforms could compromise other community goals such as overcoming poverty. The mutual relations that sustainability brings into focus reflect the dependency of the aforementioned goals on ecological conditions. In the same light, it is reasoned that poverty, for instance, cannot, over the long run, stand in competition with protecting sufficient biodiversity. The practical challenge of sustainability [22] is to find specific ways to pursue those distinct goals that conform to their mutual relation. Therein, lies the possibility of maintaining or developing over time a decent quality of human life for all. Sustainability theory, thus, confronts societies and/or communities with the moral questions: what must be sustained? What goods may be imperilled by the dramatic expansion of human systems? Which goods must be protected? Which goals must be pursued? And, what is the shared foundation for doing so? Sustainability is employed to argue for and against climate treaties, for and against social spending, and for and against environmental preservation. Any appeal to sustainability proposes to somehow integrate responses to social and ecological problems, taking account of feedback between human and biophysical systems and assuming that there are limiting conditions to those systems. By focusing on the ecological embeddedness of human social systems, concepts of sustainability mitigate perceived tensions between humanist and environmental goals. Indeed, there are assertions that properly conceived the interests of human systems and ecological systems harmonize. Noting that global environmental problems threaten prospects for the human future, it is suggested that the question of sustainability essentially amounts to a question about future generations [22]. Water sustainability is very crucial for future

generations. Not only does it mitigate on water losses through, for instance, unaccounted-for water, but water sustainability also minimizes economic losses associated with water resources depletion.

In the context of this study, sustainability is on the environmental preservation since the general objective of the study is on sustainability of water supply schemes. The theory of sustainability is very fundamental in this study because in all water supply schemes including the one under study, the aspect of their sustainability determines their success in meeting the expectations and demands of the local communities. The sustainability of water supply schemes is pegged on among others, financial and political considerations [5].

6.1.2 Theory of Community-Based Natural Resource Management

The theory behind community-based natural resource management (CBNRM) argues that the best way to manage natural resources is for local people to employ their local knowledge and techniques. Nevertheless, research argues that this theory is not reflected in practice and most CBNRM schemes fail. CBNRM objects to achieve both sustainable environmental management and community development. There are a number of key arguments put across by this theory. It is said to contribute to poverty reduction by using the local labour and investment; it is also said to promote the use of local knowledge and local technologies, which helps to reserve them (local knowledge and technology); more so, local management is argued to imply that the local people have power and make decisions, thus creating accountable and democratic local institutions; the use of resources is further enforced locally by people who have a stake in its protection which is more effective than, say, government enforcement; finally CBNRM is seen as a better solution to conservation than fencing off natural resources and excluding people from them.

CBNRM theory is referred as a process by which landholders gain access and use rights to, or ownership of, natural resources; collaboratively and transparently plan and participate in the management of resource use; and achieve financial and other benefits from stewardship [7]. Community-based conservation which is annexed to this theory, focuses explicitly on biodiversity conservation as the objective of management, involves people who directly affect and are affected by conservation decisions in planning and stewardship, and strives to provide direct economic and social benefits to communities while increasing or maintaining biodiversity. CBNRM also incorporates 'co-management' which implies that decision-making authority is shared between the local people and local, regional or national government. Both community-based conservation and co-management approaches are argued to be associated with a couple of benefits. They lead to increased implementation of and compliance with management decisions, application of diverse knowledge sources to management including both local ecological knowledge and science, improved on-the-ground resource management, increased monitoring and adaptive management, decreased conflict over resources, increased trust and strengthened relationships (social capital) within the community,

improved livelihoods, greater community capacity, improved environmental conditions, and more resilient social-ecological systems [21]. These assertions lead to a suite of crucial research questions: Does CBNRM live up to its promise? How should 'success' be defined and who should define it? What factors influence the process and outcomes of CBNRM? Are the CBNRM outcomes really different or better than existing management regimes?

It is asserted that there has been growing interest in understanding the process and performance of contemporary, recently-established CBNRM, community-based conservation and co-management organizations [9]. It is claimed that, initially, much of the CBNRM and its sister organizations was positive and somewhat promotional in nature, featuring many success stories [7]. More recently, however, much of the scientific literature has been more critical of CBNRM and questioned whether the promise of these approaches can really be achieved [6]. A vital contribution of this work is the growing awareness of the importance of understanding the historical, cultural and socio-political contexts of specific CBNRM cases. Furthermore, it has been called into questions conventional definitions of 'community' as a territorially-defined social group bound by common values and norms. Such notions are argued to often obscure profound differences within communities in resource access and use, voice, and power along gender, age, ethnic, religious, class, or caste lines [1].

In the context of the proposed study, the natural resource which is the subject matter is water. The primary objective of the establishment of water supply schemes is to harness the water resources with a view of ensuring that the local community accesses clean and safe drinking water throughout. As it has been expounded by CBNRM, water supply schemes are community-based and as such the community should not only benefit from accessibility of water, but need also participate in the scheme's management. The study will further critically delve into the employability of the CBNRM theory in the water supply scheme under study.

6.2 Empirical Literature Review

In this section, empirical studies are reviewed in line with the study objectives and variables. The review is from a global perspective, regional perspective and ultimately, the Kenyan perspective.

6.2.1 Unaccounted for Water and Sustainability of Rural Water Supplies

Unaccounted-for-water (UFW) is said to be the water lost in the network of pipelines between the drinking water treatment plants and consumers as a result of leakage and other reason. It is further argued that UFW is usually caused by the lack of maintenance which causes the network to deteriorate over time. In Singapore, a comprehensive maintenance regime comes along with all built facilities and infrastructure. Pipelines are fixed and replaced on a regular basis. The system is also planned carefully and there is accurate metering at drinking water plants, before it is distributed, and in customers' premises. Furthermore, strict guidelines are put in place in order to stop water theft and

encourage the public to report water leakage in public premises. Over the years, Singapore has managed to lower UFW rate to about 5%. In many countries, however, UFW is argued to range between 10% and 30% [14].

The demand for both urban and rural water supplies is increasing rapidly as globalization accelerates economic development and brings improvements in living standards in countries such as India with the interactive effects of demographic growth and influx of migrants into cities due to push and pull factors. Provision of reliable and safe water to the human populace both in urban and rural habitats is asserted in a study [16], to be an essential input for overall economic and social advancement. In Raj's study on "sustainable urban habitats and urban water supply: accounting for unaccounted for water in Bangalore City, India", it is argued that urban water supply sector in India is facing a number of challenges and constraints in ensuring that supply of adequate potable water to half the number of people who are currently living without access to sustainable, safe drinking water sources by 2015. These are alleged to be occasioned by increasing water scarcity, low pricing, high subsidy, poor cost recovery, high transmission and distribution losses, poor maintenance, rising unaccounted-for and non-revenue water outgo.

In a study of Adenta, Ghana [20], the study findings indicated that unaccounted-for water was as a result of leakage and theft, poor billing, bad meters, and revenue collection. Population growth and lack of capital investment for accelerated development were blamed for widening the gap between demand and supply of water. These factors culminated in the lack of access to potable water to a large number of people and the poor paying more money for their water. By year 2000, the unaccounted-for water in Adenta, Ghana was still over 50%. Another study established that water consumption in the Oromian Region of Ethiopia was far much less than anticipated [10]. This implied that there was surplus water from the sources that was not economically used, for instance in horticulture.

According to an assessment of Kenya's water and sanitation [12], one of the major challenges facing the water sector in the rural areas is unaccounted-for water. The study indicated that most water supply schemes in Kenya source water directly from rivers; and intake structures are constructed as source points with mains leading to treatment works or storage tanks or direct to distribution systems. Other water schemes source water from ground water which requires minimal treatment. These systems are either gravity or pumping systems; the latter having higher operational costs. Unaccounted-for water is noted to be a common challenge in the water supply systems. This has been estimated to be at an average of 60 per cent of water produced lost. Factors contributing to the high levels of unaccounted-for water include illegal connections, technical losses, unmetered connections (flat-rate billing), poor maintenance of the infrastructure, poor management of the systems especially inconsistent billing, and the extended life of intake and distribution infrastructure. Institute of Economic Affairs advises that urgent rehabilitation is required in almost all supply systems. The Kitale, Bungoma and Webuye water systems were identified to be in dire need of rehabilitation.

6.2.2 Sustainability of Rural Water Supplies

It is observed that, though conceptually very sound, a good number of community based projects in the water and sanitation sector fail to deliver benefits to society over the long term in developing countries [3]. It is argued that the genesis of this failure may be partly due to poor understanding of the sustainability issues. The sustainability of a water supply scheme can be argued to be the maintenance of an acceptable level of services throughout the design life of the water supply system. After the project completion, responsibility for management and ownership is granted to the community. Antonio further posits that it has been established that some projects become conspicuously unsuccessful, even without any technical failures, while others have achieved their targets without facing many bottlenecks. As such, identification of underscoring root-causes for the performance differences of community water supply projects would be, needless to say, crucial not only for sustainable management of existing projects, but also in establishing new development projects.

According to the results of a water sustainability assessment study of 20 water supply schemes in Sri Lanka 14 out of 20 schemes were found to be sustainable while the rest (6) were found to be unsustainable. At 71.8% the schemes under study were found to be performing relatively well in the technical, institutional and social aspects. The performance of financial management was established to be the best whereas, the performance of consumer satisfaction was found to be the poorest amongst the 20 schemes studied. The communities served under the schemes studied, were found to have real water demand and, as a result, they were highly motivated and worked towards a common goal during project implementation period. Well educated young individuals or retired government officers with high reputation possessing high capacity and good leadership character traits were the ones selected as members of the CBOs. A higher level of willingness to sustain the system was observed in these sustainable schemes, since they were found to be achieving many benefits with excellent management. The physical condition of the system was found to be good in sustainable schemes thus ensuring continuous service with minimum damage to the systems along with hardly any water contamination. The water supply scheme with the lowest sustainability score was characterized by weak CBO where office bearers were found to have neglected their responsibilities. It was further posited that the committee did not meet to discuss the problem of the affected water supply scheme.

It is noted that the water supply scheme in the Oromian Region of Ethiopia continued to function well [10]. Moreover, he observed that there existed a strong sense of social cohesion amongst the users, good financial discipline and reporting, and the tap-stands being kept clean and functioning. Given that the consumption of water in this region was less than half of the forecasted amounts, there was reduced revenue collected from the water connections and purchase. In the long-run the income generated from the water scheme's proceeds was feared to fail to cover major repair expenses as the systems become older and experience more serious breakdowns. This was seen to a potential threat to water supply scheme sustainability in this region.

Kenya has a strong culture of self-help, which has been harnessed for many development activities, especially in rural areas. Out of the 8 million Kenyans who had access to improved water in rural areas, 30% were being served by community-managed water supply schemes. Most of these schemes were developed by self-help groups. Many of them were constructed during 1970s and 1980s and are still working [17]. The water supply schemes in Kenya were found to be generally successful [11]. It is argued that there has been cohesion within the members of the scheme, consumers pay their bills, and they also receive good service. However, the schemes were alleged not to serve the needs of the whole population equitably. They are in effect an intermediate stage between community-managed public water suppliers and non-profit enterprises. Conditions set for gaining membership into a scheme often restrict membership to about 30% – 40% of the households within a water supply area. Non-members, on the other hand, can be served through public tap-stands, but these only work reliably in a system with strong financial management.

7. Research Methodology

The study adopted descriptive research design which attempts to answer the “what?” question [14] as is the case with the current study. The rationale of employing descriptive studies stems from the fact that such studies illustrate relationship between variables. The researcher conducted a survey across the subordinate staff, technical staff, finance officers and management staff of Kangui water supply scheme. Survey method was deemed appropriate since it is argued, provided an efficient and precise avenue of assessing information about the target population [19]. The target population comprised of the 62 staff of Kangui water supply scheme. A census survey was employed in the study. Therefore, the sample and the target population were one and the same thing. Census survey method eliminated both the sampling error and sampling bias since all members of the target population took part in the study.

A structured questionnaire containing closed ended questions which were on a 5-point Likert scale was used to collect data. A pilot testing involving 7 respondents extracted from the target population but excluded from the main study was conducted. This was in order to determine both the reliability and validity of the research instrument prior to administering them in the ultimate study. The Cronbach alpha was used to test reliability while the Principle Axis Factoring (PAF) method was used to determine the construct validity of the questionnaire.

7.1 Data Processing and Analysis

The study used the Statistical Package for Social Sciences (SPSS) tool to process and analyze the collected data. Data was analyzed using both descriptive and inferential analysis. The former constituted mean and standard deviation while the latter was in form of Pearson's correlation. The study findings were presented in form of tables that reflected summary statistics (both descriptive and inferential).

7.2 Research Finding

The main study involved 55 respondents given that 7 respondents who took part in the pilot study were excluded from the final study. 54 out of 55 questionnaires issued were filled competently and collected by the researcher. As such, the response rate was almost absolute (98.2%).

7.2.1 Descriptive Findings for Unaccounted for Water

The researcher sought the views of respondents regarding unaccounted for water. The findings of pertinent analysis are as shown in Table 1.

Table 1: Descriptive Findings for Unaccounted for Water

	N	Min	Max	Mean	Std. Dev.
Inefficient line patrolling	54	1	5	1.85	1.123
Poor recoding of demand verse supply	54	1	4	1.57	.903
Leakages not well attended	54	1	3	1.70	.662
There are a lot of illegal connections	54	1	4	2.33	1.116
Svstem parts are obsolete	54	1	5	2.52	1.424
Meters are defective	54	1	5	1.96	1.081

7.2.2 Descriptive Findings for Sustainability of Kangui Water Supply Scheme

The study further investigated the views of the respondents regarding water supply sustainability and the study findings are as indicated in Table 2. Respondents on average disagreed (mean \approx 2.00) income level of consumers impact negatively on project sustainability; and that quality of water supplied impact negatively on scheme sustainability. On the other hand, they agreed (mean \approx 4.00) that supplying of sufficient quantities of water enhances sustainability; pipes and fittings need renewal; and that proper follow-up of water supplied is very vital. It was previously [10] observed that sufficiency of water does not necessarily enhance water supply scheme's sustainability which contradicts the findings of the current study. However, the respondents were indifferent (mean \approx 3.00) that unaccounted for water makes the project unsustainable; and that local sources such as springs and wells are cheaper.

Table 2: Descriptive Findings for Sustainability of Kangui Water Supply Scheme

	N	Min	Max	Mean	Std. Dev
Unaccounted for water make the project unsustainable	54	2	5	3.17	1.077
Income level of consumers impact negatively on project sustainability	54	1	4	2.26	1.169
Supplying of sufficient quantities of water enhances sustainability	54	2	5	4.44	.965
Pipes & fittings need renewal	54	1	5	3.85	1.188
Proper follow up of water supplied is very vital	54	1	5	4.37	1.263
Local sources e.g. springs & wells are cheaper	54	2	5	3.44	1.127
Quality of water supplied impact negatively on scheme sustainability	54	1	4	1.87	.825

7.2.3 Relationship between Unaccounted for Water and Water Supply Scheme Sustainability

The researcher sought to determine the relationship between unaccounted for water and sustainability of Kangui Water Supply Scheme Table 4.13 shows the findings.

Table 4.13: Relationship between Unaccounted for Water and Sustainability

		Sustainability
Unaccounted for Water	Pearson Correlation	-.656**
	Sig. (2-tailed)	.000
	N	54

** Correlation is significant at the 0.01 level (2-tailed).

The findings indicated that there exists a strong but negative relationship ($r = -0.656$; $p < 0.01$) between unaccounted for water and sustainability of the water supply scheme. When the amounts of unaccounted for water are increased, the sustainability of water supply schemes is reduced. On the other hand, when unaccounted for water is minimized, the sustainability is enhanced. Where the water system is in order, that is, unaccounted for water is minimized the sustainability of the water supply scheme is enhanced.

8. Summary, Conclusions and Recommendations

The section provides a summary of key study findings both descriptive and inferential. The conclusions are then drawn from the findings before pertinent recommendations are suggested. The summary, conclusions and recommendations are in tandem with the study objectives.

8.1 Summary

The study findings showed that respondents disagreed that there is inefficient line patrolling; poor recoding of demand versus supply; leakages are not well attended; there are a lot of illegal water connections; water system parts are obsolete; and that water meters are defective. This was in tandem with previous findings [12] that factors contributing to the high levels of unaccounted-for water include illegal connections, technical losses, and unmetered connections, among others. The inferential analysis findings indicated that there exists a strong but negative correlation ($r = -0.656$; $p < 0.01$) between unaccounted for water and sustainability of the water supply scheme.

Respondents on average established to disagree that income level of consumers impact negatively on project sustainability; and that quality of water supplied impact negatively on scheme sustainability. On the other hand, they were found to agree that supplying of sufficient quantities of water enhances sustainability; pipes and fittings need renewal; and that proper follow-up of water supplied is very vital. In a past study [10], it is observed that sufficiency of water does not necessarily enhance water supply scheme's sustainability which contradicts the findings of the current study. However, the respondents were indifferent that unaccounted for water makes the project unsustainable; and that local sources such as springs and wells are cheaper.

8.2 Conclusions

The researcher concluded that in the case of Kangui Water Supply Scheme, there is efficient line patrolling, water demand and supply are appropriately recorded, leakages are well attended, illegal water connections are not many, water system parts including meters are operational. Furthermore, it was inferred that unaccounted for water strongly affect sustainability of water supply schemes.

8.3 Recommendations

It is recommended that, the water supply scheme must completely get rid of illegal water connections, ensure that leakages are repaired in time and that the water supply system including the meters are fully and always functional.

References

- [1] Agrawal, A. & Gibson, C (2001). *Communities and the environment: ethnicity, gender, and the state in community-based conservation*. New Brunswick, NJ: Rutgers University Press.
- [2] Aleobua, B., Schroten, E.H.J., Hamza, A., Karani, P. Sifuma, J., Njui, P., Owur, P., & Mend, A. (2009). Small towns and rural water supply and sanitation project. Project Appraisal Report.
- [3] Antonio, G.F. (2005). The European response to the challenges of water and sanitation in developing countries.
- [4] Berkes, F., Colding, J. & Folke, C. (2003). *Navigating social-ecological systems: Building resilience for complexity and change*. Cambridge, UK: Cambridge University Press.
- [5] Brian, B. (2005). Sustainability and intergenerational justice. *Theoria*, 45, 43–65.
- [6] Brosius, P.J., Tsing, A.L. & Zerner, C. (2005). *Communities and conservation: Histories and politics of community-based natural resource management*. Walnut Creek, CA: AltaMira Press.
- [7] Child, B. & Lyman, M.W. (2005). *Natural resources and community assets, lessons from two continents*. Madison, WI and Washington, D.C.: Sand County Foundation and the Aspen Institute.
- [8] Ediriweera, I.V.W. (2005). Strategies adopted for sustained water supply and sanitation through community participation in Sri Lanka. 31st WEDC International Conference. Kampala, Uganda.
- [9] Fernadez-Gimenez, M.E. (2008, June 16 – 20). Community-based natural resource management: State of the science – Global perspective. Paper presented at the research planning meeting “Does community-based rangeland ecosystem management increase resilience to climate change in Mongolia, Ulaanbaatar, Mongolia.
- [10] Gary, C. (2002). Gravity-fed water supply in Ethiopia: Community management and financial sustainability. *Water and Sanitation Program Field Note*.
- [11] Gichuri, W. (1999, November 28 – December 2). Case study on the Kabuku Water Project in Kenya. Paper presented at a regional workshop on Financing Community Water Supply and Sanitation, Mpumalanga, Republic of South Africa.
- [12] Institute of Economic Affairs (2007). *A rapid assessment of Kenya's water, sanitation and sewerage framework*. Nairobi, Kenya: IEA.
- [13] Julian, A. (2005). *Sustainable communities and the challenge of environmental justice*. New York: New York University Press.
- [14] Kothari, C.R. (2004). *Research methodology – Methods and techniques*. New Delhi, India: New Age International Publishers.
- [15] Mimrose, D.M.C.S., Gunawardena, E.R.N. & Nayakakorala, H.B. (2011). Assessment of sustainability of community water supply projects in Kandy District. *Tropical Agricultural Research*, 23(1), 51-60.
- [16] Neo, M. (2011, August 21 – 27). *Sustainable water for Singapore – Past, present & moving forward*. Paper presented at the 2011 World Water Week in Stockholm.
- [17] Pretty, J. & Ward, H. (2001). Social capital and the environment. *World Development* 29, 209-227.
- [18] Raj, K. (2013) Sustainable Urban Habitats and Urban Water Supply: Accounting for Unaccounted for Water in Bangalore City, India. *Current Urban Studies*, 1, 156-165
- [19] Salim, A.S. (2002). Rural piped water supplies in Ethiopia, Malawi and Kenya: Community management and sustainability. *Water and Sanitation Program*.
- [20] Taylor, B. (2009). *Addressing the sustainability crisis: Lessons from research on managing rural water projects*. Dar es Salaam: WaterAid Tanzania.
- [21] Thomas, J., Harden, A., Oakley, A. et al. (2004). Integrating qualitative research with trials in systematic reviews. *British Medical Journal* 328, 1010-2.
- [22] Uusitalo, K. (2002). *An evaluation of urban water systems using environmental sustainability indicators: A case study in Adenta, Ghana*. Goteborg: Chalmers University of Technology.
- [23] Walker, B. & Salt, D. (2006). *Resilience thinking: Sustaining ecosystems and people in a changing world*. Washington, D.C.: Island Press.
- [24] Willis, J. (2008). Global ethics, Christian theology, and sustainability. *Worldviews: Global Religions, Culture, and Ecology*, 12, 197–217.
- [25] World Health Organization. (2010). Millennium Development Goals (MDGs). Western, D. & Wright, R.M. (1994). *Natural connections*. Washington, D.C.: Island Press.

Author Profile



Kibuika F. Mwangi has done MSc in Project Management (Jomo Kenyatta University of Agriculture and Technology, Kenya); Higher Diploma in Water & Irrigation Engineering (Technical University, Kenya); and Bachelor of Technology in Civil Engineering (Egerton University, Kenya). He is a vastly experienced water engineer and is a member of Engineers Registration Board of Kenya. Currently, he is Nyandarua North Sub-County Water Engineer.