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Investigation of Methods and Motives for Water Theft in A Suburb Township

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Abstract
Theft of water from water urban authorities is fast growing to a level of severe concern with the perpetrators moving several steps ahead of water utility companies. Consequently, counter-measures that are in tandem with the ever-changing business environment are greatly desired to empower water utility companies with effective methods to prevent the ever-growing water theft challenges. To ascertain the significance of the methods used to steal water, a study was undertaken in one of the suburbs of Blantyre in Malawi. A questionnaire survey was employed to elicit data on the methods used for stealing water and the motivations behind the thefts. The results indicated that the most prevalent method for stealing water was bursting pipes followed by vandalizing. Poor service was the most compelling reason behind water theft from the water utility company. The severity indices for the constructs used to steal water in this study can be used to design intervention frameworks for water utility companies. Additionally, iso-theft-index maps can be produced for suburb areas where water utility companies have water distribution networks to guide surveillance operations.
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1. Introduction

Water theft is not a new phenomenon but has existed as early as the aqueduct networks of Rome that supplied water to its cities where watermen responsible for installing and maintaining water supplies often perpetrated extensive water theft (Evans, 1997). However, in recent times, the level of sophistication in water theft has rapidly increased through techniques that make water theft harder to spot than before and even threaten the savviest water utility companies. Water theft is the illegal or unauthorized tapping of water from supply network systems of water utility companies. According to Kingdom *et al*. (2006), some forty-nine million cubic meters of drinkable water escape daily from official supply network systems, enough to provide water for two hundred million people. In developing countries, the water loss amounts to some thirty to fifty percent of all treated water (Puust *et al*. 2010). However, practices that shape the illicit abstraction of water are hardly confined to poor urban or underprivileged rural areas of the world (Khabusi & Jindal, 2020). Water theft has equally been reported in prime areas of the cities of the world, the majority being from developing countries. In most cities worldwide, there has been years of neglected maintenance to water storage, treatment, and distribution systems. In order for the urban and suburbs water cycle to function effectively, it needs to be supported by appropriate infrastructure in good working condition. Protecting the infrastructure used to treat and transport water (including sources, treatment plants, and distribution systems) is an important step in ensuring the safety and security of drinking water from theft. Poorly maintained water supply systems can generally be traced to insufficient financial resources and poor management. Such deterioration in the water infrastructure may also propagate water theft. Furthermore, as the climate crisis exacerbates water scarcity it is expected that water theft will only become more common in cities and suburbs of the world.

1.1 Impacts of Water Theft

Water theft can do a lot of damage to both water utility companies and its clients. When a utility company does not recoup the cost for producing the water, that cost is generally spread out across all the customers. The foregoing increases the water bills of customers as the utility company makes up for the losses incurred associated with producing the water. It might also lead to water rationing potentially leading to insufficient water availability. Secondly, the use of water that has not been paid for, often leads to under collection of revenue by the water utilities companies from their clients associated with water thefts (Gantala & Nalajala, 2017). This in turn, undermines repairs programs that a utility company could implement as well as failure to finance new water network schemes by water utility companies as means of coping with rising population migration in cities and suburbs (UNUS, 1999). Thus, the majority of water network schemes are still characterized with aging water infrastructure that often do not cope with the ever-changing business environment demanded today (Bakshi, 2017). Additionally, water utility companies require sufficient revenue generation in order to implement innovative technology water network and distribution systems and their associated upgrades for improved performance of water supply and the relations between the water utility company and its customers. Thirdly, water theft can lead to water contamination which often undermines its quality. Such water contamination can sometimes come as a result of water intrusion from water theft (Rodríguez, *et al*. 2011). Consequently, polluted drinking water can generate waterborne disease outbreaks and chemical poisoning. Therefore, pathogens and chemical intrusions from openings in the network associated with water theft can also degrades drinking water quality of water utility companies. Intrusion is often challenging particularly in areas where sanitation networks are heavily compromised. Fourthly, water theft can lead to social unrest. Additional costs, are always unpleasant to customers irrespective of their triggers whether from inefficiencies of utility water companies or the illicit water theft behavior of customers. The resulting increase of water prices has far-reaching consequences for a community. This is particularly true in low-income communities where individuals often do not have the disposable income to buy bottled water. In such communities, lack of water supply can have a devastating effect. Social unrest can be triggered as a result of rising water bills. Thus, public frustration with rising water bills may increase civil disorders. Increased water prices have catalyzed conflicts or social unrest (Unfried *et al*. 2022). Due to this, and against the backdrop of increasing environmental awareness, water scarcity now features predominantly within domestic politics. Thus, much of the world's focus right now is on water efficiency investments, which must achieve (at best) between 10-20% savings for water (Lock *et al*. 2020). But if much of the stolen water can be recovered by tackling water theft, with appropriate measures, then that would be good for the water supply companies. Returns from such water recovery would contribute to repair and expansion of water supply systems which would in turn contribute to water supply sustainability to clients in cities and suburbs.

1.2 Theories Underlying Water Theft

According to Lock *et al*. (2020) theories underlying water theft suggest that: (*i*) individuals depart from social norms due to a psychological predisposition towards rule breaking based on psychological theory of compliance or differences in personal moral development mimicking cognitive theory of compliance (Kohlberg, 1984); (*ii*) wanting moral behavior of individuals which is conditioned by interactions with their environment mirroring social learning theory (Akers,1973); (*iii*) individuals have divergent perceptions of the legitimacy and fairness of rules as in sociological normative theories (Tyler, 1990); (*iv*) individuals are likely to be non-compliant when the benefits outweigh the costs conforming with economic instrumental theory (Becker, 1968) and (*v*) individuals have proclivity to vandalize infrastructure due to susceptibility of assets matching the security theory (Wakefield, 2007). Interactions of such aforementioned theories within certain contexts of water utility customers are important for understanding why such customers and employees of water utility companies may engage in water theft activities.

While water theft does take place in richer nations, most of those stealing water are often poor and vulnerable people in developing countries. Combined with a lack of data, this has led to the issue being under-researched. Lock *et al*. (2020) has further lamented that research into water related challenges is underexplored in all disciplines. For example, while the literature is littered with pieces of information on the methods of water thefts from water utility companies, the severity and rakings of such water theft methods is not known and may differ from place to place. The foregoing underexplored knowledge, would empower water utility companies with informed mitigation measures so that their much-needed revenue is not unnecessarily lost. As a result, this paper reports part of a much larger research on the severity of the methods that were used in stealing water from the water utility companies including the motivation for doing so. Thus, understanding the severity of the methods used in water theft and addressing their likely drivers of water theft, utility companies will be better placed and equipped to prevent their irreversible harm.

3. Research model

Water utility clients from cities and suburbs who are compromised in one way or another by the preceding theories of illicit behavior may employ a variety of methods to get water without paying the bill for it. Such forms of water theft methods were grouped into categories as indicated in Fig. 1. The first category was one which is facilitated by the state or condition of the prevailing technology employed by the water utility companies which makes it easier and tempting for certain water users to steal water from the distribution network. According to Grigg (2017) most of the world water distribution infrastructure is very old which suffer from upgrades particularly in developing countries. Using innovative technology can improve the performance of water systems and the relations between the water utility and customer. As a result, the renewal and replacement of aging water and wastewater infrastructure is a top ranked agenda item that require urgent attention for the water industry (AWWA, 2018). If the water network relies on an aging technology it might be easier for customers of water utility companies to help themselves to the water without paying for it than the case would otherwise be if the state of the technology was in tandem with the business environment. Examples of the foregoing include: tampering of water meters in form of illegal connections in order to reduce readings of water consumption (Al-Radaideh & Al-Zoubi, 2018); meter bypasses in form of illegal connections that are usually done to draw water in a way that the water meters are bypassed (Gantala & Nalajala, 2017; deliberately reversing water meters in order to reduce readings of water consumption; direct tapping of pipeline or the unauthorized re-opening of closed/abandoned water service connections without consent or the unauthorized reopening of closed water service connections brought about by the non-payment of water bills; illegal dismounting of water meters by removing angle meter valves in order to draw water directly from the water service connections; illegal use of booster equipment inform of pumps that draw water directly from the water meters, thus, affecting the water pressure as well as the quality of water (Khole *et al*. 2015); pipe bursting by an induced action disguising it as if it was caused by high water pressure; vandalizing which takes several forms such as theft of valuable metal and plastic pipes and fittings such as meters, taps, valves, fire hydrants, stopcocks, and manhole covers.

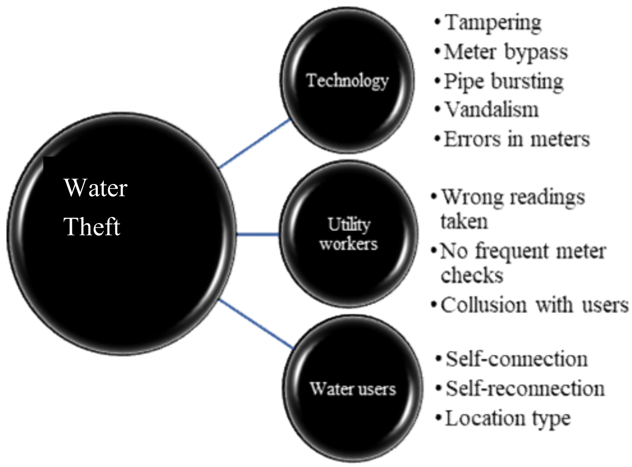

Fig. 1. Forms of Water Theft

The second category is facilitated by water utility employees or the insiders. An insider is a person with knowledge of the utility company who has access to the facilities or portions of the system as part of his or her daily work activities. Insiders may be disgruntled employees or contractors with employee-level access and may be armed. Insiders may also include personnel being manipulated by or working in collusion with criminals or saboteurs (ASCE/AWWA, 2009). Objectives of insiders may include compromising the effectiveness of the utility facilities and humiliating the utility's management, stealing records or other information. Thus, workers from water utility companies that are unprofessional and do not follow a utility code of ethics and values may generally perpetrate water theft because of unethical behavior. Therefore, customers of water utility companies whose morals are equally compromised will readily clasp hands with unprincipled employees of water utilities to undertake organized stealing of water syndicates to benefit the two parties (TI &WIN, 2008). The foregoing is one of the difficult practices to unearth and detect due to its form of operation from within the organization. Such practices, include inducing deliberate errors in the meter readings (Mutikanga *et al*. 2011), taking wrong readings deliberately by people within the syndicate, deliberately not frequently checking water meters for certain clients that are in the syndicate and deliberately tolerating water violations.

The third category is facilitated by illicit behavior of customers of water utility companies. Typical examples under this category include self-connections and reconnections including assimilated behavior as a result of the determinants of the location where the utility customer resides.

3.1 Research Methods

The research on water theft was undertaken in one of the townships in the commercial city of Blantyre in Malawi in 2021. Having established the variables of research through a literature review it followed that a quantitative approach was best suited to this investigation (Apuke, 2017). The study area was one of the townships located 3 km away from the center of Blantyre, the second largest city in Malawi. According to the AYIDO (2021) the township was growing by 3.5% each year due to natural growth and urbanization factors as there was a lot of rural urban migration due to socio-economic service opportunities. The unemployment rate in the township was at 57% and the illiteracy rate was at 27% for those without education while 82% were lacking formal skills. Poverty was pervasive in the township with 65% of the total households living below the poverty line and 46% of all households in the township earned less than $50 US per month and spent less than $1 US per day. The HIV/AIDS prevalence rate was at 17.3 % among young people aged 14-24 years. The focus of the study was on one particular sector of the township with 1,000 households. The foregoing characteristics presented themselves as a candidate for the study area.

A simple random sample of households was estimated by using Yamane's formula (1967) as:

$$\varphi = \upsilon(1+\upsilon e^{2})^{-1} \qquad (1)$$

where φ is the sample size, υ is the population. A confidence level of 90 percent was used with a margin of error of 0.1. Consequently, a sample size of 90 was required from population registered with water utility company.

After pre-testing, the questionnaire was sent to households that consented to the survey in Ndirande township to elicit data. Furthermore, five attributes were used to characterize the sample, namely: sex, age, level of education, period lived in the house and period the water utility was used. A total of 60 responses whose consent was given were obtained representing 61 per cent to the designed sample. Easterby-Smith *et al*. (1991) pointed out that the expected response rate from industry is of the order of 25–30%. The aforementioned response rate led to a corresponding confidence level of 87 per cent.

3.2 Analysis of Results

The main statistics used in data analysis were mean scores, Spearman correlation coefficient and non-parametric one-way analysis of variance. The weighted mean was an average in which each variable to be averaged was assigned a weight as an ordinal value in the questionnaire. These weightings determined the relative importance of each variable on average. Therefore, the common practice of water theft methods by the surveyed households was calculated by the following equation:

$$\xi = \frac{\sum_{i=1}^{w} \lambda_i(x_i)}{\sum_{i=1}^{p} (x_i)} \qquad (2)$$

where x_i is the observation, λ_i is the weight of the observation w is the 5-point likert-scale, p is the number of respondents and i is integer numbers.

The weighted mean score values were further interpreted to reflect the responding rating of strongly agree, agree, not sure, disagree and strongly disagree, According to Meddis (1984) such a procedure helps conversion of a continuous index i.e. weighted mean score into discrete categories. In this case, the categories of the weighted mean scores (ξ_j, for j is 1 to 5) were classified as:

Level 5. $4.50 < \xi_1 \leq 5.00$
Level 4. $3.50 < \xi_2 \leq 4{:}50$
Level 3. $2{:}50 < \xi_3 \leq 3{:}50$
Level 2. $1{:}50 < \xi_4 \leq 2{:}50$
Level 1. $1{:}00 \leq \xi_5 \leq 1{:}50$

An analysis of variance was used to detect any difference in rating by their groupings designated (k). The surveyed respondents had the following grouping: sex (k = 2), age (k = 5), level of education (k = 3), period lived in the house (k = 4) and period the water utility was used (k = 4). The test is appropriate for detecting variation within a sample (Ostertagová, 2014; Siegel and Castellan, 1988). Such tests were important for purposes of ensuring if calculations were to be approached by groupings or as a consolidated set data despite the groupings (Ghasemi and Zahediasl, 2012). The test statistic H is denoted as:

$$H = \frac{12}{\cdots} \left[\frac{\sum_{i=1}^{k} T_i^{\cdots}}{\cdots} \right. \qquad (3)$$

Where N is the total number, n_i is the number in the i-th group, and T_i is the total sum of ranks in the i-th group when the data does not contain ties. If the data contains ties, the equation δ was used, where G was the number of groups of tied ranks and t_i is the number of tied values within the i^{th} group for the denominator.

$$\delta = \frac{= \frac{12}{\cdots} \left[\frac{\sum_{i=1}^{k} T_i^{\cdots}}{\cdots} \right.}{\cdots}$$

ction can be

$$(4)$$

The evaluation of the degree of association between attributes of surveyed sample and the variables of methods of stealing water was achieved by the application of Spearman's correlation coefficient (ρ). Rank correlation is one of the means that is suggested to evaluate the associations where ordinal scales are used as shown where $D_i = R_{1i} - R_{2i}$, R_{1i} = rank of i in the first set of data, R_{2i} = rank of i in the second set of data and n = number of pairs of observations.

$$\rho = 1 - \frac{6\sum_{i=1}^{n} I\cdots}{\cdots(\cdots^{2}} \qquad (5)$$

These monotonic relationships were further unraveled to correspond to the following ranges or levels of relationships (ρ_j, for j is 1 to 5) classified as:

$\pm 0.00 \le \rho_1 \le \pm 0.19$	very weak relationship on positive or negative range
$\pm 0.20 \le \rho_2 \le \pm 0.39$	weak relationship on positive or negative range
$\pm 0.40 \le \rho_3 \le \pm 0.59$	moderate relationship on positive or negative range
$\pm 0.60 \le \rho_4 \le \pm 0.79$	strong relationship positive or negative range
$\pm 0.80 \le \rho_5 \le \pm 1.00$	very strong relationship on positive or negative range

4. Results and Discussion

Fig. 2 characterizes the distribution of sample that was surveyed on gender, age, highest level of education and length of stay in the house using water from the water utility company. The distributions are dichotomy, bi-modal, positively and negatively skewed respectively.

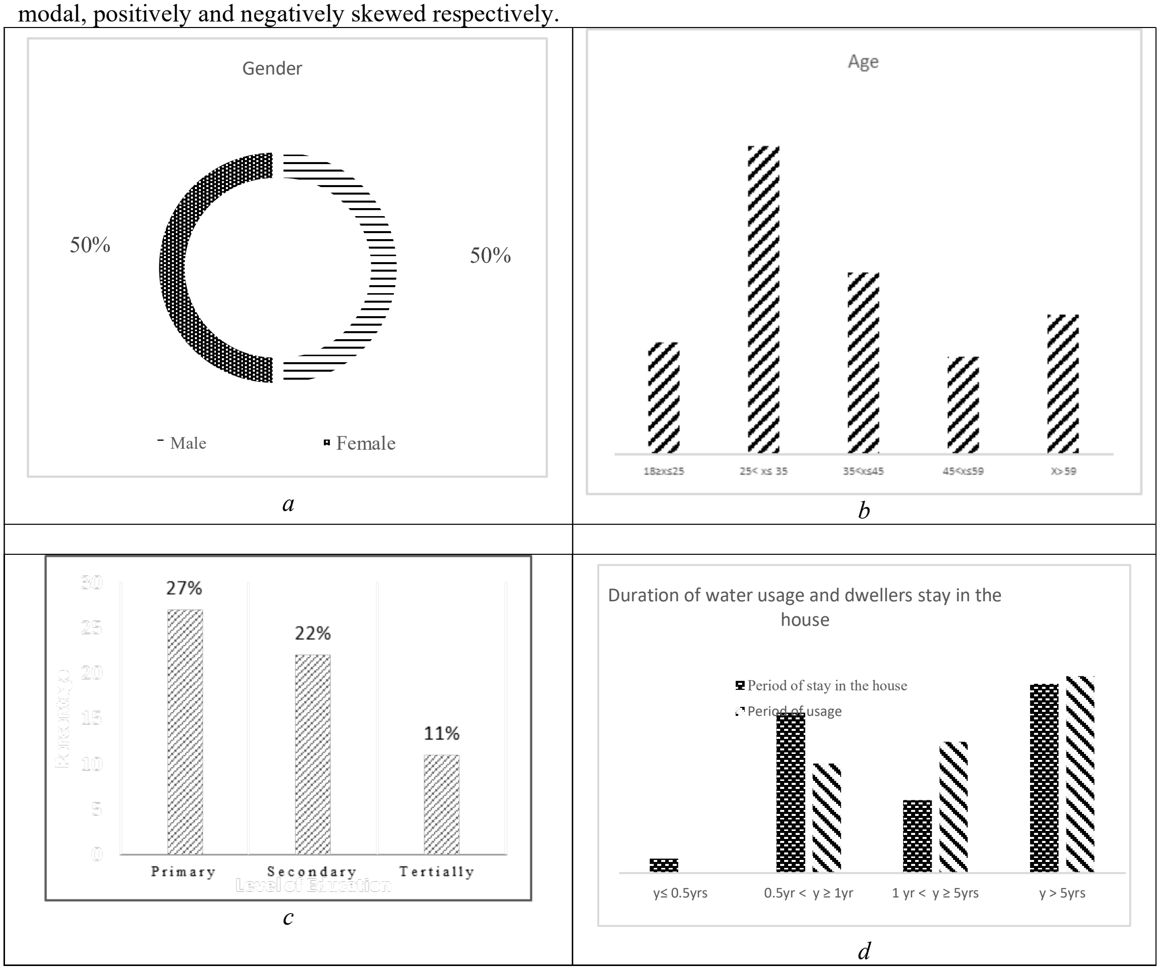

Fig. 2. Sample Characterization

As a result of the characteristics of the sample in Fig. 2, it was necessary to check if the respondents rated the questionnaire according to their group-segmentations or not. Therefore, analysis by variance using nonparametric test was conducted for ordinal data (Krustal & Wallis (1952). Table 1 shows analysis of variance for the various methods of water theft by attributes of the sample. It can be shown that there were no significant differences in the ratings of the questionnaire by the various groupings of the respondents at $p < 0.05$. This result prompted further analyses for weighted mean scores and correlation to be approached without recourse to analyzing the data set by groupings of the sample since no significant differences were detected in their ratings of the variables for methods of water theft.

Table 1. Kruskal Wallis Analysis of Variance on Water Theft Method by Attributes

	Sex, n = 60, df =1		Age, n = 60, df = 4		Level of education n = 60, df = 2		Period lived in the house n = 60, df =3		Period water utility used n =60, df =3	
	χ^2	ρ	χ^2	ρ	χ^2	ρ	χ^2	ρ	χ^2	ρ
Collusion	1.583	0.208	3.772	0.438	1.827	0.401	0.430	0.806	6.830	0.078
Data not collected	0.021	0.885	4.658	0.324	0.635	0.728	1.678	0.432	4.178	0.243
Tampering	0.791	0.374	2.418	0.659	0.372	0.830	0.107	0.948	3.990	0.263
Pipe busted	0.345	0.557	8.187	0.085	0.484	0.785	3.795	0.150	1.021	0.796
By passing meter	1.401	0.237	7.218	0.125	1.104	0.576	5.485	0.064	1.150	0.765
Vandalism	0.692	0.405	8.051	0.090	2.583	0.275	0.489	0.783	2.152	0.541
Self-connection	0.591	0.442	7.801	0.099	0.747	0.688	3.004	0.223	2.453	0.484
Self-reconnection	2.344	0.126	2.241	0.692	2.137	0.343	4.151	0.125	1.268	0.737

ρ = Spearman correlation coefficient, *$p \leq 0.05$ is significant for a 2-tailed test

A further analysis of variance for the various motives on water theft methods was checked to ascertain if the ratings of the questionnaire by the various groupings of the surveyed respondents was the same or not. Table 2 shows that apart from level of education of respondents which was significant at $p < 0.05$ ($\chi^2 = 6.108$, $p = 0.047$) the rest of the various water theft methods were not significant at $p < 0.05$. In other words, three per cent (one out of thirty) of the data combinations was significant. Consequently, the foregoing was not large enough to influence the results data analysis by group segregation.

Table 2. Kruskal Wallis Analysis of Variance on Motives by Attributes

	Sex, n = 60, df = 1		Age, n = 60, df = 4		Level of education n = 60, df = 2		Period lived in the house n = 60, df = 3		Period water utility used n = 60, df = 3	
	χ^2	p	χ^2	p	χ^2	p	χ^2	p	χ^2	p
Expensive	0.208	0.649	2.133	0.711	1.928	0.381	0.490	0.783	1.884	2.390
Poor service	0.013	0.908	5.900	0.207	0.155	0.925	1.023	0.600	0.446	2.800
Intermittent water supply	1.429	0.232	5.591	0.232	4.355	0.113	0.336	0.845	1.675	2.433
Unbilled consumption	0.090	0.764	3.078	0.545	0.420	0.810	4.524	0.104	4.690	2.096
Meter not checked	3.380	0.066	1.071	0.899	6.108	0.047*	0.559	0.756	0.246	2.884
Poor Technology	0.162	0.687	3.248	0.517	0.163	0.922	1.272	0.529	2.506	2.286

*$p \leq 0.05$ is significant for a 2-tailed test

The results of Tables 1 and 2 guided the evaluation of the consensus by weighted average of the respondents' ratings on the various methods used for stealing water without segmenting the groupings. Table 3 shows the rankings of the variables as severity indices. It can be shown that for the surveyed sample, bursting and vandalism were the prioritized methods for getting water without paying for it. Such behavior was expected because there are generally no culprits isolated when enforcement agencies visit the scene. Therefore, residents seemed to be corruptly benefiting from the fact that the real culprits might eventually not be pinpointed and as such they prioritized such methods. Table 3 shows that by-passing meters and self-connecting to mains were least used. Equally, this result was expected because it is a calculated and reasoned approach by the customers. Once the person is caught, it is easy to link the culprit to the crime. Therefore, most of the residents may have been afraid to use such methods because of the direct linkage and traceability of the individuals to the crime. The foregoing agrees with (Wood, 2015) why people may prefer to commit crimes in a group to avoid detection as a result of social cognitive effects that the group membership is likely to elicit.

Table 3. Severity Indices on Water Theft Methods

Variable	*Severity index*	*Rank*
Bursting	4.90	1
Vandalism	4.50	2
Tampering	3.50	3
Collusion	3.10	4
Data not collected	3.00	5
Self-reconnecting	3.00	5
Bypassing	2.90	6
Self-connecting	2.80	7

The severity indices can become handy and a cost-effective or a low-cost tool for surveillance of areas of a water distribution network. For example, the iso-severity-index is a line or curve on a map joining points representing states of equal severity indices. The foregoing can be used as a map for water theft in a location equivalent to isobars that map areas of equal pressure on a map or equivalent to contour lines that map places of equal attitude. As such, the iso-severity-index can provide valuable information about the nature of location for water theft status.

Table 4 shows that poor service and high-water rates were rated highest as the reasons why the customers of the water utility company stole the water. Access to water, sanitation and hygiene are basic human rights and yet some people are still unable to adequately access such services in low income areas due to social status and inability to afford the water bills. Furthermore, response to water and other utility challenges that are experienced in marginal areas occupied by low income communities may take too long to be responded to or addressed (Deichmann & Lall, 2007). Additionally, urbanization is growing which is creating a huge demand and strain on the already scarce and fragile water sources challenging provision of water quality from utility companies (Rashid *et al*. 2018).

Table 4. Severity Indices on Motives Water Theft

Variable	*Severity index*	*Rank*
Poor services	3.42	1
Expensive	3.37	2
Meter not checked	3.12	3
Poor technology	2.92	4
Intermittent water supply	2.80	5
Unbilled Consumption	2.80	5

Unbilled water and intermittent water supply were the least motivators for the surveyed sample to steal the water. Communities whose income is low would generally not bother if water utilities bill them very late. In most cases, communities would welcome late water billing. Sometimes residents might be acclimatized to some challenges such as intermittent water supply or long periods of drought or flooding that can pollute clean water sources and cause disease outbreaks as a result of climate change and unpredictable and extreme weather which are becoming the norm (Kusangaya *et al*. 2013).

Table 5 shows the examination of the relationships between methods of stealing water and characteristics of the sample. The correlation-based Spearman's rank coefficient as a nonparametric measured the strength and direction of the association between variables of methods of water theft on one hand and level of education, number of people living in the house, period lived in the house and period water utility was used on the other hand.

Table 5 shows that out of the forty pairs of the variables, only three pairs had significant relationships at $p < 0.05$. Such variables are pipe bursting with age (ϱ =0.28, p = 0.026) number of people living in the house and tampering (ϱ = - 0.32, p = - 0.013) and self-connection with age (ϱ = - 0.31, p = 0.018). It seems the order and aged residents' preference of water bursting are consolidated with the findings of Table 4 knowing that once offences are committed culprits are hardly pinpointed or traceable. Whereas the young aged group were venturing in offices of water theft where culprits may easily be found. The foregoing could be a result of inexperience as to the norm from the old and aged communities.

Table 5. Spearman's Correlations with Water Theft Methods

Variable	Statistic value	Age	Level of education	Number of people living in the house	Period lived in the house	Period water utility has been used
Collusion	ϱ	0.064	0.036	-0.183	0.085	-0.029
	p	0.630	0.785	0.163	0.517	0.827
Data not collected	ϱ	-0.215	-0.103	0.041	-0.167	-0.218
	p	0.099	0.434	0.753	0.202	0.094
Tampering	ϱ	-0.068	-0.069	-0.319*	0.021	-0.050
	p	0.604	0.599	0.013*	0.872	0.706
Pipe busted	ϱ	0.288	-0.076	0.090	-0.235	-0.081
	p	0.026*	0.561	0.496	0.071	0.540
By passing meter	ϱ	0.011	0.092	-0.099	0.203	-0.095
	p	0.935	0.487	0.450	0.119	0.470
Vandalism	ϱ	-0.114	0.012	0.013	0.088	0.187
	p	0.386	0.930	0.919	0.506	0.152
Self-connection	ϱ	-0.305*	-0.067	-0.111	-0.013	-0.173
	p	0.018*	0.612	0.398	0.919	0.186

Variable	Statistic value	Age	Level of education	Number of people living in the house	Period lived in the house	Period water utility has been used
Self-reconnection	ϱ	-0.052	0.130	0.025	0.192	-0.052
	p	0.693	0.322	0.853	0.141	0.693

ϱ = Spearman correlation coefficient, * is 2-tail test at $p \leq 0.05$

Table 6 shows relationships between characteristics of the sample and the motives that prompted the surveyed sample of the customers of the water utility as to how they employed various methods for stealing water from the water utility's distribution network. The relationships are non-significant at $p < 0.05$. Furthermore, the relationships can be described as weak ($\pm 0.20 \leq \rho \leq \pm 0.39$) to very weak ($\pm 0.00 \leq \rho \leq \pm 0.19$).

Table 6. Spearman's Correlations Motives for Water Theft Methods

Variable	Statistic value	Age	Level of education	Number of people living in the house	Period lived in the house	Period water utility used
Expensive	ϱ	0.033	0.181	0.028	0.049	0.043
	p	0.802	0.167	0.830	0.709	0.743
Poor service	ϱ	-0.204	0.051	-0.005	-0.072	0.113
	p	0.118	0.699	0.969	0.583	0.388
Intermittent water supply	ϱ	-0.069	0.217	0.109	0.041	0.071
	p	0.602	0.096	0.408	0.757	0.589
Unbilled consumption	ϱ	-0.101	0.031	0.051	-0.001	-0.066
	p	0.441	0.815	0.700	0.996	0.619
Meter not checked	ϱ	-0.007	-0.113	-0.068	-0.096	-0.013
	p	0.955	0.390	0.607	0.466	0.924
Poor Technology	ϱ	-0.132	0.012	0.021	0.018	-0.015
	p	0.314	0.930	0.871	0.891	0.908

ϱ = Spearman correlation coefficient, * is 2-tail test at $p \leq 0.05$

Fig. 3 shows seven mitigation measures that were explored to combat water theft. The most rated method was rewarding people that report the malpractice at 19%. In more recent times, rewards are less about bounty hunting and more about persuading people to provide information that can help solve a crime. It is an attempt to use money to overcome fear and apathy and sometimes that can be difficult. The study location being a poverty-stricken area corresponds well with what the surveyed respondents' consensus need for money. This finding is important particularly to water utility companies who may sometimes use one shoe fits all policy as a measure to address water theft problems. The least mitigation measure was review of policies at 8%. While in essence you would expect policies to drive effective measures particularly where they are abreast of the times, the surveyed respondents seemed to prefer measures that would benefit them financially. The foregoing, corresponds well to the social characteristic of the community where poverty was pervasive in the township with 65% of the total households living below the poverty line and 46% of all households in the township earned less than $50 US per month and spent less than $1 US per day (AYIDO, 2021).

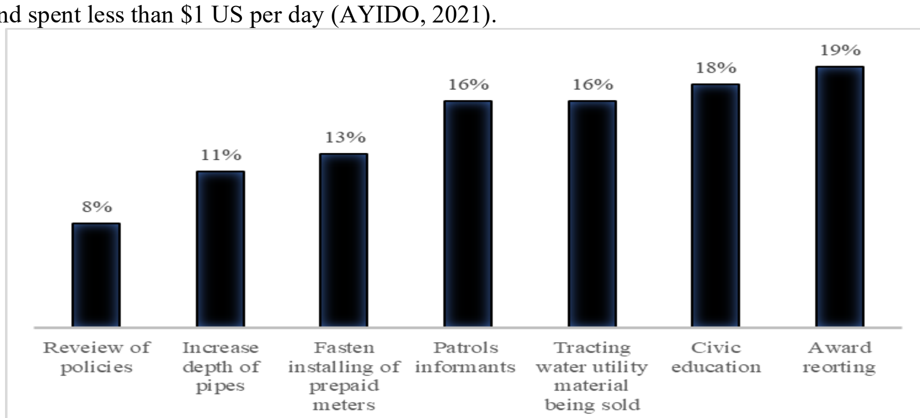

Fig. 3. Mitigation Measures for Water Theft

5. Conclusion

This paper has presented the rakings through severity indices of the methods that were employed to get water without paying for it. The severity indices have established by consensus of the surveyed respondents that bursting pipes followed by vandalizing water distribution network were preferred methods of stealing water which also corresponded well to the demographic characteristics of the area that was studied. It further established that poor service by the water utility company was the most compelling reason behind the water theft. The severity indices if used as an iso-severity-index theft map, has potential to become a tool for surveillance of locations of a water distribution network. Consequently, mapping locations with iso-severity-indices particularly for developing countries for water utility companies has the potential to influence cost-effective or a low-cost mitigation measures against water theft. The results in this study may be used to assist water managers of water utility companies in adjusting to a business environment that demands measuring business processes to form a basis for continuous improvement. The study also forms the basis for further research, water theft methods continue to evolve and preferences for particular methods for stealing water may differ from one region, location and demographic characteristic to the other. Recommendations for further study include increasing the size of the sample of the data set to address the limitation in this study.

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