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Going beyond basic access to improved water sources: Towards deriving a water accessibility index

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ABSTRACT

In this paper, we use a Water Accessibility Index (WAI) to determine differences in urban household water access in an inner-city community characterized by relatively high piped water coverage. The case study is based on field data collected in a low-income community called August Town, located in Jamaica's capital city of Kingston. A semi-formal survey was used to document how different socio-economic factors influenced household-level water accessibility within the study area. Data from the survey was later used to develop the WAI. The index revealed the importance of incorporating socio-economic and human-centered factors in the measurement of water accessibility, especially when access to improved drinking water sources is already gained. When used on its own, piped water coverage was found to be an inadequate indicator of water accessibility within the study area. In general, we regard the WAI as a useful management tool for tracking household-level and inter-community disparities, which could contribute greatly in facilitating improvements in water access where it is needed the most.

1. Introduction

As we continue to transition towards a post-2015 development agenda, the proper management and allocation of freshwater resources by all countries is critical in achieving universal and sustainable access to safe drinking water. Accurate collection and monitoring of data pertaining to the quality and type of drinking water sources used by populations around the globe will certainly form an essential part of this transition. In fact, monitoring programs dating back as early as the 1930s, have played a pivotal role over the years in (re)shaping international development policies and discourse around water and sanitation (Bartram et al., 2014). These monitoring programs are primarily intended to track progress towards achieving established global, regional and national development targets, as well as highlight gaps and opportunities for enhancing or accelerating efforts towards achieving these said targets and other related goals.

Since the 1960s, the international monitoring of drinking water has fallen under the UN system which has been based on a set number of global targets. The drinking water target under the recently concluded Millennium Development Goals (MDGs), called for halving the proportion of the global population without sustainable access to safe drinking water between 1990 and 2015. From all official accounts, this target was met from as early as 2010; which on the surface, signals a huge success for the international development community. Presently, according to official figures, the proportion of the world's population with access to improved drinking water sources stands at approximately 91 percent, compared to 76 percent in 1990 (WHO, 2017). This has resulted in an additional 2.6 billion people gaining access to an improved source of drinking water since 1990 (UNICEF/WHO, 2015). However, there are still wide disparities between countries and across regions. The drinking water coverage for both sub-Saharan Africa and Oceania is still below 70 percent for instance. There are also disparities between urban and rural water coverage, where approximately 96 percent of the global urban population had access to an improved drinking water source in 2015, as opposed to 84 percent of the rural population worldwide (WHO, 2017). As it pertains to piped water on premises, currently around 79 percent of urban dwellers globally have direct access to piped water on their premises, compared to only 33 percent in rural areas (UNICEF/WHO 2015).

There is a genuine concern however, that the situation may actually be worse than what is being reported. This is linked to a growing recognition of the inherent shortcomings in the data and other metrics conventionally used to measure countries' performance in achieving sustainable access to safe drinking water (see, for example, Bain et al., 2012; Bartlett, 2003; Clasen, 2012; Martinez-Santos, 2017; Smiley, 2017). As Satterthwaite (2016: 1) has pointed out in his recent review

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of progress made under the MDGs for urban water and sanitation provisions, UN statistics tend to overestimate who has sustainable access to safe drinking water due partly to deficiencies in available data globally, as well as how ‘sustainable access’ is both defined and measured. For example, the UN does not measure water quality directly, neither is there a clear set of methods to accurately capture quantity or sustainable access (also see, Clasen, 2012). Proxy indicators are used instead, based on the type of facility a household reports as its primary source of drinking water (WHO/UNICEF, 2012). Success is therefore evaluated based on the number of households recorded as having access to either an improved drinking water source (defined as water piped on premises) or other improved drinking water sources (which includes public taps, boreholes, rainwater harvesting or protected wells and springs). These contrasts sharply with unimproved drinking water sources that normally include informal vendor-provided water, unprotected wells and springs or surface water such as rivers, ponds and streams. However, these conventional measurements of improved water access say little as to whether the water is safe to drink (Dar & Khan, 2011; Smith, Lingas, & Rahman, 2000; Sultana, 2013); neither does it take other important parameters into account, such as the number of service hours available, distance to water source or if there is, in fact, an adequate, regular, affordable and reliable supply of potable water available (Martinez-Santos, 2017; Satterthwaite, 2016). No doubt these shortcomings in the data being used to measure people's sustainable access to water has serious policy implications, including masking underlying issues of social and material inequality, poverty and poor quality service provision. Furthermore, any limitation in the methods used to track and monitor progress in drinking water coverage could mislead future intervention and research programs aimed at extending and enhancing global water service provisions, or worse, result in the shifting of needed resources to other priority sectors.

Strongly tied to the aforementioned challenges, is a growing call for these metrics to be revised and reformulated to more accurately measure sustainable access to safe drinking water. These calls signal the need to go beyond measuring just access to ‘improved drinking water sources’, and to move instead towards an assessment of the quality and sustainability of public water provisions (Bain et al., 2012; Bartlett, 2003; Clasen, 2012; Martinez-Santos, 2017; Smiley, 2017). What has been noticeably missing from the debate so far however, is precisely how these methods and metrics can be improved given how difficult and costly it is to collect the required data at the global or national level; part of the reason the current international benchmarks were chosen in the first place – to provide the simplest and lowest common denominator all parties would be willing to accept and sign on to. For the most part, the focus has been on exploring more accurate ways of accounting for water quality due primarily to continued public health and human rights concerns in developing countries around water related illnesses (see, for example, Clasen, 2012; Dar & Khan, 2011; Sultana, 2013; Wang & Hunter, 2010). Findings from several recent studies have shown a clear disconnect between water infrastructure coverage and water quality (Clasen, 2012; Martinez-Santos, 2017; Sultana, 2013). Even a fairly recent study commissioned by the WHO/UNICEF Joint Monitoring Programme (JMP) on Water and Sanitation, which included field data from six countries, found that except for some centrally managed piped water systems, ‘improved sources’ were often microbiologically and chemically contaminated, with the level of faecal contamination being at its highest at the household level (WHO/UNICEF, 2010). Yet still, acceptable measurements of water quality remain elusive. A similar problem exists with regards to how best to treat the issue of sustainable access. This is largely due to the inherent difficulties in defining and measuring such a complex and cross-cutting concept as sustainability. From a practical standpoint, sustainability ‘comes down to ensuring permanent water supplies without compromising affordability or water quality’ (Martinez-Santos, 2017: 8). Therefore, the term does not apply to improved water sources unless the water provided is affordable and safe for domestic and personal consumption, and if the service is not subjected to regular interruptions or seasonal variability (Martinez-Santos, 2017). Again, these parameters are largely overlooked by current international benchmarks. There is therefore a genuine need for the international community to devise new methods that can better capture these and other important elements to provide a more accurate picture of the global situation.

In this paper, we seek to demonstrate an alternative approach to capturing inequalities in household water accessibility, while accounting for differences in reliability, affordability and adequacy of water supply. We utilize a Water Accessibility Index (WAI) to determine differences in urban household water access within an inner-city community characterized by relatively high piped water coverage. The case study is based on field data collected in a low-income community called August Town, located in Jamaica's capital city of Kingston. A semi-structured survey was used to document how different spatial and socio-economic factors influenced households' water access within the study area. Data from the survey was later used to develop the WAI. The index revealed the importance of incorporating socio-economic and human-centered issues in the measurement of water accessibility, especially when water is already piped on premises. When used on its own, piped water coverage was found to be an inadequate indicator of water accessibility within the study area. This contrasted with the WAI that was better able to capture critical household-level differences in water accessibility. In general, we regard the WAI as a useful management tool for tracking both intra- and inter-community disparities, which could contribute greatly in facilitating improvements in water access where it is needed the most. More importantly, the paper highlights the fact that continuous assessments and revision of indicators are needed to ensure that improvements in water supply and service provision benefits the most vulnerable and marginalized groups in society.

The remainder of the paper is organized into four broad sections. First, we discuss the context in which we situate the study, which includes a brief overview of Kingston's existing freshwater resources challenges. Second, we outline the steps taken in developing the WAI, and discuss its various components. This is then followed by a presentation of the main results of the study, paying particular attention to the socio-economic and spatial factors shaping household water accessibility in the August Town community. Finally, we conclude by discussing the strengths and policy implications of the proposed Water Accessibility Index relative to more conventional measurements of sustainable water access such as piped water coverage.

2. Context

Water resources in the Caribbean are greatly influenced by a range of socio-ecological factors including prevailing weather and climate conditions, existing water management practices and population dynamics – especially the continued concentration of the region's population within urban centers (Bates, Kundzewicz, & Palutikof, 2008, pp. 1–210; Cashman, Nurse, & John, 2010; Gohar & Cashman, 2016; Nurse et al., 2014). Water availability within the region, while heavily dependent on seasonal rainfall patterns, is often affected by escalating water demand and poor water management practices which expose many Caribbean islands to periodic water stress. As urban centers throughout the Caribbean continue to expand, there will be an increased demand on existing freshwater resources which could in turn affect surface water levels and groundwater recharge due to over-abstraction (Lester, 2015). So, while the reliability of total natural renewable water supply plays an essential role in the ability of regional public water providers to meet annual water demand, proper water management strategies are equally important in safeguarding water security within the Caribbean (UNEP, 2012; Cashman et al., 2010). Integrated water resources management and a lack of adequate financial and technical resources are some of the major hindrances to many Caribbean Small Island Developing States (SIDS) delivering sustainable water services (Lester, 2015). Unequal distribution of water and inadequate and unreliable service provisions are common characteristics of many urban water supply systems throughout the region (Cashman et al., 2010); features which are typical of densely populated cities in developing countries with huge disparities in household income (Bakker, Kooy, Shofiani, & Martijn, 2008; Sultana & Loftus, 2012).

For Jamaica, an uneven distribution of water resources coupled with a disproportionately high concentration of the country's population in a few parishes and urban centers creates highly localized cases of water stress despite normally having sufficient water resources at the national level (Lester, 2015; Ministry of Water, 2004). According to a UNEP (2012) report, water resources in Jamaica are sufficient to meet the country's demand but are unevenly distributed in both time and space. The Caribbean basin shares a bimodal rainfall pattern – for Jamaica, the primary maximum rainfall season begins in October and the smaller secondary peak in May. Both seasons are separated by the mid-summer drought in July (Chen & Taylor, 2002). Both surface and groundwater resources provide a daily supply of piped water to residents across the island through the various supply systems operated by the National Water Commission (NWC) – which is a statutory body that was established in 1980 to serve as the primary provider of potable water and wastewater services in Jamaica. The island records a 30 year (1971–2000) mean rainfall of 1773 mm (Personal communication with Meteorological Service Jamaica, 2016), with north-eastern parishes like St. Mary and Portland receiving higher volumes than southern parishes like Kingston and Saint Andrew (Fig. 1). The spatial and temporal variations in the availability of water resources - the bulk of which is situated towards the north of the island, in relation to the concentration of population often leave southern parishes facing water shortages during the dry season and summer months. In recent years, increasing rainfall variability and recurring drought events have further exacerbated the problem (Lester, 2015).

In terms of spatial distribution, Jamaica's population can be described as highly uneven and geographically concentrated in a few parishes. Based on the latest census data, nearly one-half of the country's population resides in the three contiguous southern parishes of Kingston, Saint Andrew and Saint Catherine (Planning Institute of Jamaica, 2015). Added to this is a marked increase in the proportion of the country's population residing in urban areas over the last fifty years. While only 38 percent of Jamaicans were recorded as living in urban areas by the late 1960s, this figure has since increased to approximately 54 percent (Statistical Institute of Jamaica, 2011). Much of this growth has taken place in a few parish capitals, especially in and around the Kingston Metropolitan Area (KMA), and a few other established urban centers such as Spanish Town, Montego Bay, May Pen and Mandeville (Planning Institute of Jamaica, 2015).

Amidst current projections of an increasingly warmer and drier Caribbean climate (Gamble & Curtis, 2008; Taylor, Stephenson, Chen, & Stephenson, 2012), Kingston presents an interesting case study given the sheer size and density of its population relative to other urban centers in Jamaica – compounded by a highly fragile water supply management system (Lester, 2015). Since the 1950s, Kingston has experienced significant population growth. According to recent official estimates, the Kingston Metropolitan Area (an amalgamation of Kingston and urban Saint Andrew) currently has a population of approximately 584,627 - accounting for 88 percent of the population for the

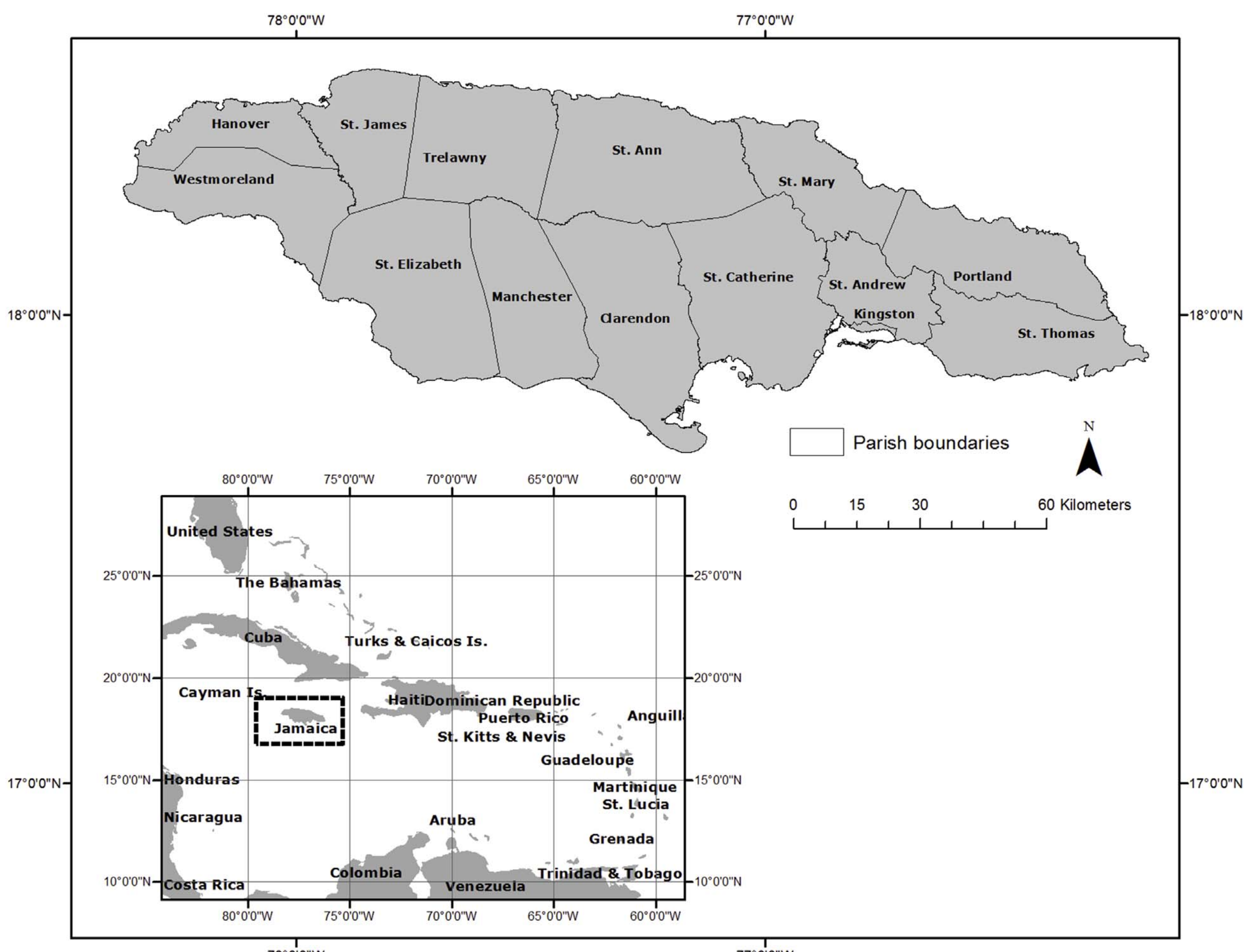

Fig. 1. Political map of Jamaica showing parish boundaries.

parishes of Kingston and St. Andrew, and a little over one-fifth of Jamaica's total population (The Statistical Institute of Jamaica, 2011). The majority of the city is located in a dry limestone basin known as the Liguanea Plains that normally receives less than 200 mm of rainfall annually. Over the years, the rapidly urbanizing city of Kingston has experienced significant reductions in the availability of freshwater resources for public provision due to increasing water demand and the pollution of groundwater sources attributed to sewage and saltwater contamination (see Lester, 2015). These problems are further compounded by the fact that nearly two-thirds of the total amount of potable water that is produced annually are lost through the water utility's distribution system, and to a lesser extent, from illegal connections to the NWC's pipe network (Lester, 2015).

These existing challenges coupled with a high and growing demand for potable water produces a highly vulnerable landscape for the more than half million urban dwellers currently residing in the KMA. In fact, Kingston's freshwater challenges have now taken center stage, as recent drought events have revealed how sensitive the city's water supply system is to inter-annual changes in the timing and length of the traditional wet and dry seasons; which have become more and more variable and intense in recent decades (Poore, Moulton, Gamble, Curtis, & Popke, 2016). Added to this, is the highly uneven nature of Kingston's urban development, which places low-income communities and households at a disproportionately higher risk of being severely affected during instances of water shortage. This has clear implications for development policy and planning – especially since the majority of at-risk communities are those that have developed outside the formal physical planning system, and therefore less likely to meet the required planning and building standards. Even though most households in Kingston are registered customers of the National Water Commission (NWC) many communities, particularly those of low and lower-middle income status undergo frequent service disruptions – which is referred to as 'water lock-offs' in this paper. Each year, the water supply system experiences a shortfall in meeting water demand. This leaves many of Kingston's urban poor vulnerable to water stress and a range of other related risks associated with insufficient and unsafe water access (see Lester, 2015).

In sum, rapid urban growth within the KMA has partly led to the emergence of highly vulnerable urban communities characterized by a combination of slums and informal settlements, typified by low income households, high levels of urban poverty, insecurity of tenure and limited access to basic urban services such as water and sanitation (see, for example, Gray, 2004; Clarke, 1966, 2006). The low-income community of August Town represents one such at-risk community that has been affected by chronic water shortages spanning more than two decades. The community is situated in the southeastern section of the KMA (Fig. 2), and receives its water supply from a nearby surface water treatment plant, which is supported during the dry season from groundwater extracted from a close-by limestone aquifer. The majority of the households in the community are registered customers of the National Water Commission (NWC). Those households who receive water are charged at either a flat or subsidized rate – which is typical of several other inner-city communities throughout the KMA where residents are deemed incapable to pay the full cost of water services. Ironically, the community is situated in one of the few service areas in the KMA where the amount of water produced annually normally exceeds demand (National Water Commission, 2011). Some of the surplus water produced is even used to serve communities outside the service area on a routine basis. Yet still, the August Town community has reportedly suffered from chronic water shortage problems that have worsened in recent years largely owing to growing population pressure and poor public water service provisions, alongside a spate of severe drought events that resulted in some of the lowest monthly rainfall averages in decades (Poore et al., 2016).

3. Developing the water accessibility index

The Water Accessibility Index (WAI) was created to identify variations in the water accessibility of individual households within the sample that had comparatively limited water access. This framework also allows for the application of a multi-scalar approach in which the level of water accessibility can be assessed not only at the level of the household, but also between communities and urban centers. In developing and analyzing the Water Accessibility Index (WAI), the following steps were undertaken:

1. Selecting the index components;
2. Calculating the WAI;
3. Correlating and comparing households' socio-economic characteristics using the WAI;

3.1. Selecting the index components

Going beyond defining water access as merely people having improved sources of water supply or water piped on premises, will form an important part in reframing and better contextualizing water accessibility in urban areas around the globe. For instance, high piped water coverage is typical of many urban areas in the developing world that suffer from chronic water shortages (Galaitsi et al., 2016; Martinez-Santos, 2017). Yet still, as aforementioned, most official measurements of water accessibility are based on this precise metric. The prevalence of piped water on premises has traditionally been used as an indicator to show which segments of a population have access to improved water supply (UNICEF/WHO 2015; Howard & Bartram, 2003). While water piped on premises is more likely to be treated and supplied by certified municipal providers, this measure by itself provides no clear indication of the reliability and extent of water received on a daily basis. In fact, it is quite common for urban pipe networks across the developing world to suffer from intermittent water supplies, which is often time linked to old and poorly maintained pipelines (Galaitsi et al., 2016; Kumpel & Nelson, 2016; Martinez-Santos, 2017). These traditional measurements also mask disparities and inequalities in the provision of water service, which has serious implications for development policy and planning, including the shifting of needed resources to other priority sectors. In other words, any limitation in the methods used to track and monitor progress in drinking water coverage could mislead future intervention programs aimed at extending and enhancing global water service provisions. Water accessibility is evidently rooted in poverty, power and inequality. The poor not only lack adequate water access but they also pay more for limited access and are increasingly exposed to health risk from poor water storage, unimproved sources and water collection. If disparities and inequalities are masked, it affects the basis upon which polices are made and the considerations of the vulnerable in water allocation, improvements and intervention programs. As such, this study takes a multidimensional approach in creating a water accessibility index which may capture critical intra-community or household-level differences in water accessibility within localities with high piped water coverage (Fig. 3).

3.2. Calculating the WAI

The Water Accessibility Index (WAI) measures comparatively limited access by examining seven (7) components recorded from the Household Water Security Survey.[1] The components selected were all identified as being important predictors of sustainable water access through our review of the literature (see for example, Satterthwaite, 2016; Schuster-Wallace, Kerr, & Shumba, 2016; WHO/UNICEF 2015;

[1] The Household Water Security Survey forms part of an ongoing independent doctoral research project.

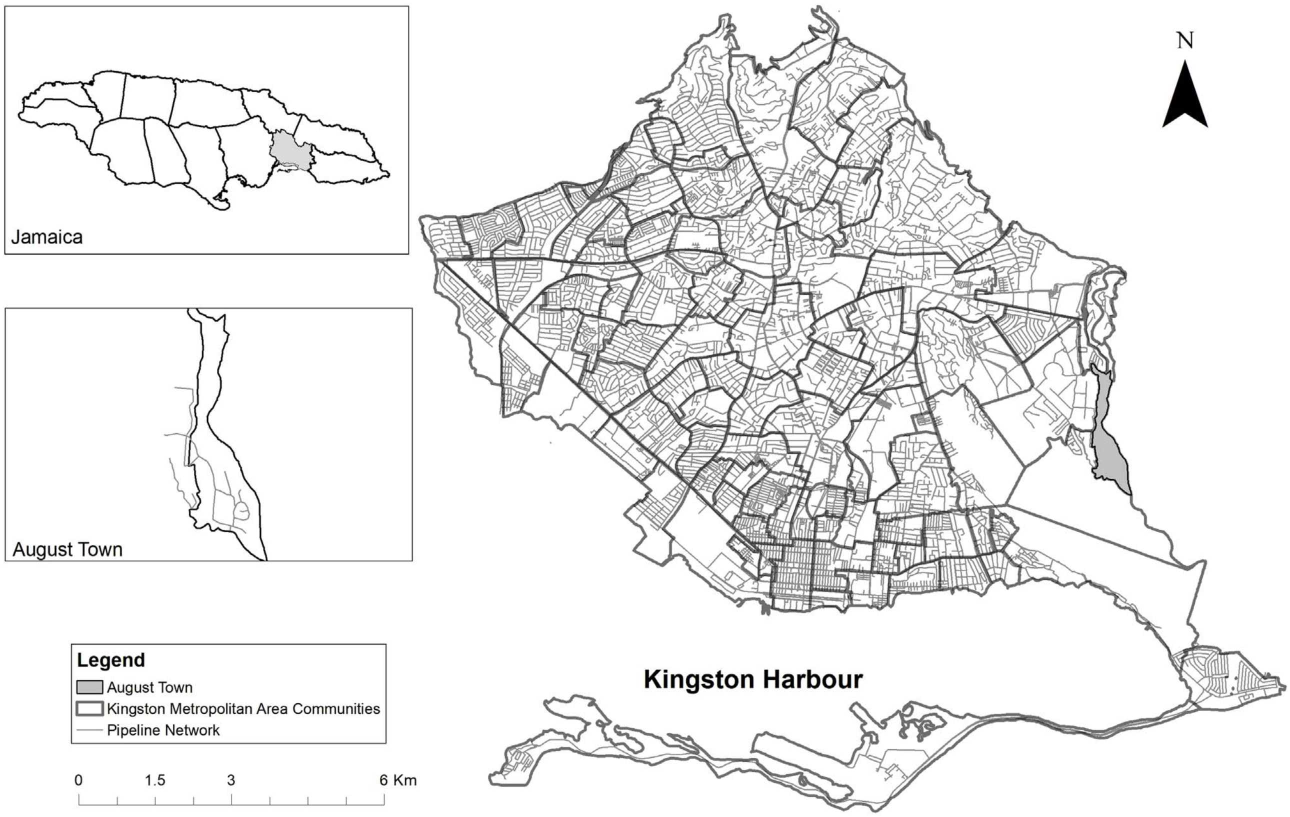

Fig. 2. Pipe water coverage in the Kingston Metropolitan area.

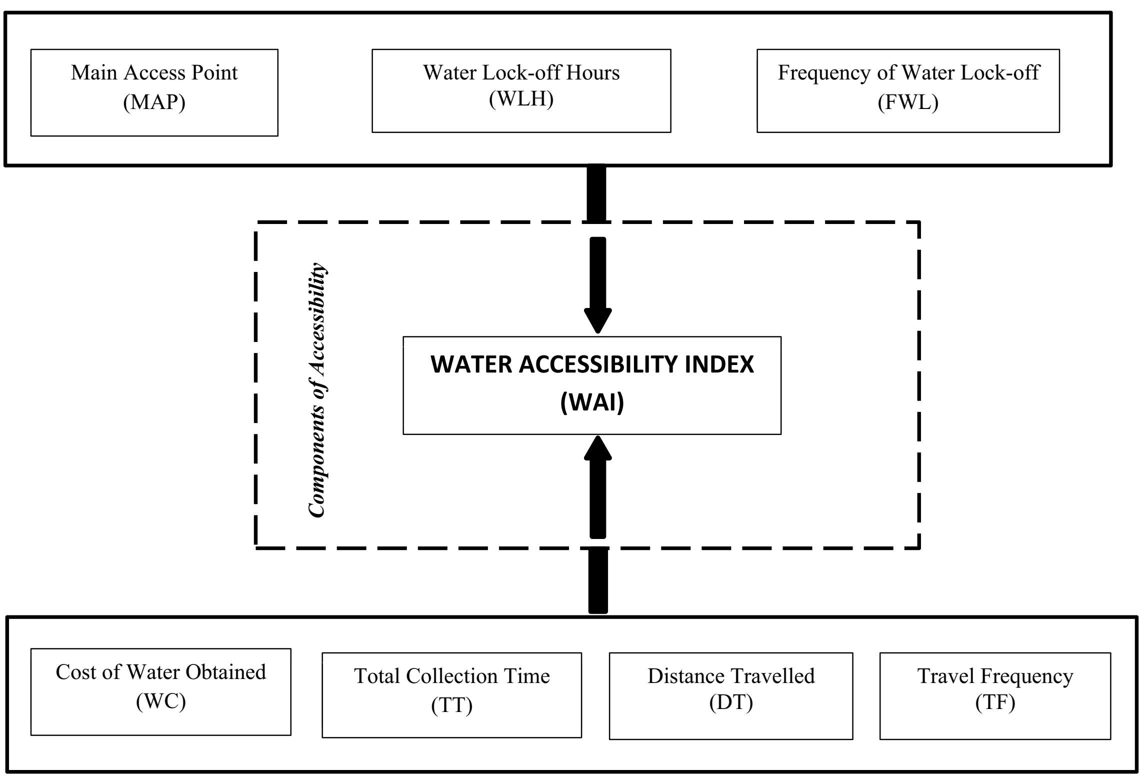

Fig. 3. An illustrative framework of the water accessibility index component.

Haller, Hutton, & Bartram, 2007) and the primary findings of the August Town household survey. *Sustainable access* is defined here as constituting sufficient, affordable, reliable and continuous supply of potable water at an adequate pressure on a daily basis. It also considers those cases where disrupted household water supply is restored before a refill of storage containers is needed, under normal weather conditions. The index is made up of seven different components, details of which are outlined in Table 1. Component 1 represents main access point for

Table 1
Components of the water accessibility index.

Index Components	Survey Question	Explanation of access	Rationale for Component
Main Access Point	What is your main access point for water?	Households whose main access point is a pipe on premises will have greater accessibility than those who access water away from their premises	Access at the household level results in greater time and cost saving benefits. Water piped on premises is an improved source of drinking water and is highly likely to be of good quality (WHO/UNICEF, 2015; Hutton, Haller, & Bartram, 2007)
Water Lock-off Hours	State the time period of water lock-off most frequently experienced on a given day (specify month/s of the year where applicable)?	Households with fewer hours of water lock-off on a given day will have greater accessibility	The total hours of water received daily plays an important role in the ability of households to sufficiently meet consumption and hygiene requirements as well as to carry out household activities (Howard & Bartram, 2003; Schuster-Wallace et al., 2016)
Frequency of Water Lock-off	How often do you experience a disruption in water supply?	Households with a lower frequency in the disruption of water supply will have greater accessibility	Reliable and continued water supply is a key feature of urban water access. (Satterthwaite, 2016; Howe et al., 1994)
Cost of Water Obtained (i.e. transportation cost and/or price of water)	What is the estimated cost (i.e. transportation &/or price of water) of obtaining water from named alternative source?	Households with no cost for obtaining water from alternative sources or lower cost will have greater accessibility	Acquiring water supply at alternative sources presents an added cost which some households may not be able to afford, while for other households, this may result in water cost being greater than household income (Hutton, 2012; Haller et al., 2007; United Nations Committee on Economic, Social and Cultural Rights, 2003)
Total Collection Time	What is the total duration of a roundtrip for water collection (i.e. travel and filling containers)?	Households with shorter durations spent collecting water will have greater accessibility	Time lost in travelling and collecting water has economic and social implications. It affects participation in productive work, educational and recreational activities (Boone, Glick, & Sahn, 2011; Whittington, Mu, & Roche, 1990)
Distance Travelled	How far do you have to travel for water?	Households with a shorter distance of travel will have greater accessibility	Water sources closer to households allow for the collection of greater volumes of water and more frequent visits within a safer physical reach (Howard & Bartram, 2003; Lester, 2015)
Travel Frequency	How often do you have to travel to sources or request delivery?	Households that travel to sources less will have greater accessibility	Frequency of travel is directly related to duration of water-lock, water storage capacities, demand- side strategies and household water use. It is reduced with larger storage capacities, the practice of demand- side strategies and smaller households (Lester, 2015)

Notes: The formatting of this table has been adapted from (Baptiste and Kinlocke, 2015; Hahn et al., 2009; Shah, Dulal, Johnson, & Baptiste, 2013).

water (MAP), which serves as a proxy for current mainstream measures of improved water sources. Households which had access to a pipe on their premises would therefore record a greater MAP score compared to those households that were accessing water away from their premises (which included a combination of alternative and unimproved water sources). The remaining components representing water lock-off hours (WLH), frequency of water lock-off (FWL), cost of water obtained (WC), total collection time (TT), distance travelled (DT), and travel frequency (TF) were incorporated to take account of other important parameters of sustainable water access at the household level.

Each component was measured on a different scale, therefore each of the variables had to be standardized before calculating the WAI, which is a composite index. A dichotomous method, where 0 indicates lesser accessibility and 1 indicates greater accessibility, was used in recoding each of the standardized components – which were then summed and the mean calculated using the following equation:

$$WAI = \frac{\sum_{\mathrm{i}=1}^{\mathrm{n}} WA_{components}}{\mathrm{n}}$$

where

WAI is the overall Water Accessibility Index, WA components represent a combination of each component of sustainable access, and *n* is the number of components. Equal weighting was given to each component as developing a method which assigns a particular numerical quantity to the weighting of different components would have been too subjective, thus increasing the likelihood of bias within the study (compare with, Baptiste & Kinlocke, 2016). Though equal weighting assumes that each variable has an equal impact on the outcome, we find this less problematic compared to the inherent subjectivities involved in assigning individual weights to variables when values for weighting cannot be precisely determined. This inherent bias of weighting variables also cast a shadow on the extent to which inequalities excavated from patterns in the dataset may be adequate representations of actual patterns in the data. Equal weighting, we believe, allows variables to speak for themselves and therefore lessens the inherent biases involved in the data transformation process.

As an illustrative example, the WAI was calculated based on the mean of the seven (7) WA components using the following equation:

$$WA = \frac{\sum_{\mathrm{i}=1}^{7} MAP + WLH + FWL + WC + TT + DT + TF}{7}$$

The data collected for each component was defined and broken down into distinct classes, hence all values incorporated in the WAI had a defined range. Statistical techniques were then used to represent each variable on a scale ranging from 0 to 1. These scores were assigned relative to the mean of the variable. For example, for a categorical variable with 5 classes, each class was ranked from 0 to 4 and individual households were assigned values based on where they fell among the respective ranks. The scale was then expressed in using values ranging from 0 to 1. This was necessary for a standardization of the scale. The following formula $\frac{\mathrm{n}}{(\max - \min)}$ was used for standardization. This method represents an adaptation of the Hahn, Riederer, and Foster (2009) technique.

Water quality is not accounted for in the WAI, because the index was designed to specifically explore an alternative way of measuring sustainable access by taking account of other important parameters such as the reliability, affordability, adequacy and level of service provision. That said, the WAI is not intended to provide any direct insight on water quality. Instead, we envision an index that can provide a more robust indication of differences in water access across a variety of scales. And while we believe a focus on water quality is critical in advancing the human right to water and the sustainable development agenda, the complexity of the issues involved in determining what constitutes safe drinking water, does not make it suitable to translate in one or two dimensions in the WAI. Developing a metric for measuring water quality at the household or community level requires several considerations due to the complexities and mix of factors which affects water quality. Studies have shown, for instance, that water quality changes from the main access point to the point of use, with noticeable reductions in microbiological quality (see for example, Rufener, Mausezahl, Mosler, & Weingartner, 2010; Wright, Gundry, & Conroy, 2004). Changes in water quality may occur during water collection, transportation and storage – attributable to contamination introduced at a particular point from the source or the main access point to the actual point of use (see also, Lester, 2015; Jensen et al., 2002; Carincross, Blumenthal, Kolsky, Moraes, & Tayeh, 1996). For example, rust and leaking pipes may lead to the contamination of treated water piped on premises, while contamination of water accessed away from premises may occur during collection, transportation and storage. Measuring water quality therefore necessitates the development of an independent index, that can take full account of the wide and dynamic range of issues involved in guaranteeing access to safe drinking water.

4. Results

4.1. Findings from the household survey

For the field study, a total of 320 households were surveyed from the community, out of a total of 1902 units (STATIN, 2011). The sample was based on a 95% confidence level and a ± 5% level of precision, which ensured that approximately 95 percent of the sample values were within two standard deviations of the true population value. For the purposes of this study, only heads of households were included in the survey. Data collection was conducted between January and February 2014. The primary tool of data collection was a questionnaire which was divided into several major sections addressing socio-demographics, water accessibility issues and a case study of households' responses to the 2010 drought event. The surveys were purposively administered within the community. Because the sample was purposively selected, the results are intended to reflect patterns within the sample and should be cautiously extrapolated to represent the experiences of the general population. While claims of quantitative representativeness based on probabilistic criteria cannot be asserted based on the sampling technique, variations in the population were addressed using qualitative techniques. In this regard, the community was spatially disaggregated into three distinct sections to account for geographic and social variations in the characteristics of residents and the conditions of the community. Heads of households were selected from each section to capture diversity within the sample as an alternative to random sampling techniques. Ultimately, a hybrid approach was taken which involved a probabilistic determination of the sample size combined with a non-probability technique that was conditioned by qualitative observations. It is believed that this combination of techniques essentially strengthened the overall design of the study. This methodological approach also proved useful because of the complex layout of the study area. In general, houses in the community did not follow a linear pattern, and many dwellings were not individually metered. In a few instances, clusters of houses were found sharing the same water meter.

At first glance, analysis of the field data indicates that the majority of households have access to either piped water on premises, other forms of improved water sources or both (Fig. 4). For example, approximately 83 percent of households reported that they had water piped on premises, compared to only 3 percent that mainly accessed water from unimproved sources such as nearby streams or informal private water suppliers. Once water connection is obtained from the municipal provider (NWC), households may erect several pipes in their yards or pipe water into their house. Thirty-seven percent (37%) of households surveyed reported having at least three pipes erected on their premises for accessing drinking water. In which case, based on conventional measurements, it could easily be assumed that the daily required water consumption and hygiene of residents are being met, as

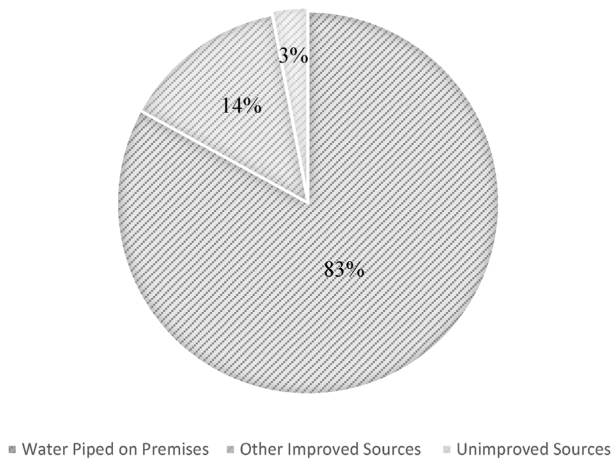

Fig. 4. Main access point reported by Households.

a drinking water piped on one's premises is seen as the highest level of access an individual can possess (Howard & Bartram, 2003; UNICEF/WHO, 2015).

However, further analysis revealed that adequate and sustained water consumption are compromised because of unreliable and insufficient water supply – despite the dense pipe network observed in the area. In fact, many households reported experiencing water-related problems such as frequent water lock-offs and low water pressure (for many, dating back for more than two decades). Some 36 percent of residents indicated that they experience frequent disruptions in water supply, often without any form of notification. A few respondents also reported experiencing extended periods of water lock-off, sometimes lasting for several days. Daily rationing and water disruptions sometimes lasting several days were reported by 38 percent of respondents, while 20 percent indicated that continuous disruptions over months coupled with low pressure, made it rather difficult for residents to utilize bathroom showers, high taps and regular flush toilets. For the majority of these households, these problems were being experienced on a routine basis, and were exacerbated during the traditional dry season and periods of severe drought.

These results reveal a clear disconnect with conventional measures such as pipe water coverage or water piped on premises from more qualitative and contextual understandings of water accessibility and other relational concepts such as 'sustainable' access. These conventional measurements therefore fail to fully capture the "realities experienced by local people in local contexts" (Mason & Calow, 2012, p. 8). In the case of the August Town community, having access to piped water services on premises, in and of itself, not only says very little about households' actual access to drinking water, but could in fact, place low-income households in a worse off situation if they are still expected to pay for an unreliable service. In the next section, we report on the findings of the WAI, which is intended to provide a rough measure of intra-community differences in water accessibility, even within localities such as August Town that possess high piped water coverage.

4.2. *Socio-economic determinants of household water accessibility*

The Water Accessibility Index measures relative household water access by examining seven (7) components taken primarily from the Household Water Security Survey. The WAI ranges from 0 to 1, with scores closer to 0 indicating limited access, and scores closer to 1 indicating greater household water access. Statistical procedures were used to evaluate how the socio-economic variables selected correlated with household water accessibility in the study area. The aggregate scores representing the seven key components of the WAI in relation to household socio-demographic characteristics are compared in Table 2.

Based on the results obtained, male-headed households were revealed to have a slightly higher water accessibility score than female-headed households. In the case of employment status, there was no difference in the water accessibility score between the employed and unemployed. With regards to tenure, households that either owned or rented their property displayed a higher water accessibility score compared to households whose dwellings were rent free or who resided in an informal settlement. The results also revealed that smaller

Table 2
Community socio-demographic profile in association with the Water Accessibility Index.

Socio-demographics	Components Value							WAI
	Main Access Point	Water Lock-off Hours	Frequency of Water Lock-off	Cost of Water Obtained	Total Collection Time	Distance Travelled	Travel Frequency	
Gender of Household Head	**.808**	**0.472**	**.310**	**.821**	**.683**	**.774**	**.428**	**.613**
Male	.831	.448	.307	.804	.676	.776	.410	.607
Female	.786	.496	.314	.839	.690	.772	.446	.620
Employment Status	**.811**	**.470**	**.311**	**.825**	**.683**	**.774**	**.426**	**.615**
Employed	.789	.488	.311	.816	.686	.770	.443	615
Unemployed	.833	.453	.312	.835	.681	.779	.410	615
Tenure	**.753**	**.450**	**.293**	**.84**	**.677**	**.762**	**.392**	**.595**
Owned	.855	.497	.321	.775	.718	.788	.514	.638
Leased	.771	.425	.314	.880	.692	.785	.392	.608
Rented	.808	.504	.322	.893	.590	.750	.313	.597
Rent free	.764	.403	.294	.752	.779	.794	.352	.591
Informal settlements	.571	.424	.218	.900	.607	.696	.392	.544
Household Size	**.794**	**.476**	**.303**	**.824**	**.690**	**.775**	**.428**	**.613**
Small *(3 or less)*	.741	.483	.265	.828	.720	.782	.417	.605
Large (more than 3)	.848	.469	.341	.821	.661	.768	.439	.621
Public Water Utility Customer Status	**.693**	**.437**	**.272**	**.845**	**.687**	**.773**	**.423**	**.590**
Yes	.978	.528	.350	.802	.676	.782	.457	.653
No	.478	.375	.242	.860	.699	.757	.376	.541
Disconnected	.625	.410	.225	.875	.687	.781	.437	.577
Total Water Storage Capacity	**.805**	**.475**	**.311**	**.823**	**.686**	**.774**	**.432**	**.615**
Number of Water Conservation Methods Practiced	**.805**	**.473**	**.311**	**.823**	**.684**	**.774**	**.430**	**.614**

Note: Informal settlements are those which are not planned by the local authorities and the land has been obtained illegally. These settlements often lack adequate infrastructure.

households (comprising 3 members or less) had greater water accessibility than larger households. Despite these observations, there were no statistically significant association revealed between these variables and water accessibility.

A statistical significant relationship only existed between the WAI and three of the seven variables shown in Table 2: public water utility customer status (df = 2; F = 2.218; p = .000), total water storage capacity (r = .150; p = .027) and the number of water conservation methods practiced (r = .147; p = .037). This statistically significant relationship between public water utility customer status and water accessibility, showed that households which were customers of the NWC generally had a greater level of water accessibility than those households that were not customers or whose services were disconnected at the time of the study. Non-customers (including disconnected customers) predominantly fell within the level of low water accessibility, while the scores for active customers ranged from medium to high water accessibility. It is important to note however, that the scores for frequency of water lock-offs (FWL), water lock-off hours (WLH) and travel frequency (TF) were the lowest recorded across all three groups. Whilst it is expected that households with water piped on their premises, most of which are customers of the public water utility company, are likely to have a relatively high main access point (MAP) score (equal or closer to 1); the components of water lock-off hours (WLH) and frequency of water lock-off (FWL), revealed the importance of reliable and continuous water supply in measuring sustainable access. These two components i.e. water lock-off hours and frequency of water lock-off, were found to be particularly useful in explaining differences in sustained water access at the household level. The results suggest that all households in the study area are subjected to regular disruptions in their water supply irrespective of their customer status and source of water. This is an indication that in addition to having water piped on premises, factors of reliability and continuity of service – which in this case is marked by total water lock-off hours (WLH) and the frequency of water lock-off (FWL) – have a significant influence on the disparities and vulnerability in water accessibility across all households in the August Town community.

Bivariate correlation between total water storage capacity and the number of water conservation methods practiced, both produced a statistically positive correlation in association with water accessibility. In other words, the results revealed that households with larger storage capacities tended to have greater water access. Water accessibility was also found to increase with the number of water conservation methods practiced within a given household. The storage of water and the water conservation methods practiced are examples of household-level adaptation strategies employed overtime to cope with unreliable water supply. Our study found that the effectiveness of water storage as an adaptation strategy was greatly influenced by household size and the size of storage containers. Generally, storage capacities were between 51 and 250 gallons which lasted between 3 and 7 days depending on household size and domestic activities. However, these sources deplete quickly in the dry season or due to frequent and extended periods of water lock-offs.

Finally, the WAI was divided into terciles, categorized as low (0-.573), medium (.5731 - .679) and high (.6791–1), to represent what constitutes low, medium and high water accessibility relative to the distribution of the values in the dataset. A standard statistical procedure which divides the data into three equal groups was used. The cut-off points or thresholds used are relative to the distribution of the data collected. This means that these class boundaries are likely to vary if applied to another community. The technique is therefore meant for purposes of understanding variations of accessibility within the specific area of study. Any classification of values into these categories will remain subjective until repeated applications of the WAI technique is done on different datasets. This work, therefore, provides a baseline for further exploration into the application of this technique. Subsequent, research or application will facilitate the acquisition of additional datasets which can then be used to develop standardized classifications. The data indicated that the mean water accessibility score for all the households surveyed was within the medium range (M = .615; S.D. = .1289; N = 217) as measured on the 0–1 scale, where 0 = lesser/lower water accessibility and 1 = greater water accessibility. Water accessibility within the sample was evenly distributed amongst the three categories, where 34% (n = 74) of households were classified as having a low level of water accessibility, 32% (n = 69) of households' water accessibility scores were classified within the medium range and another 34% were classified as having a high level of water accessibility. Fig. 5 illustrates this classification amongst the components of the index.

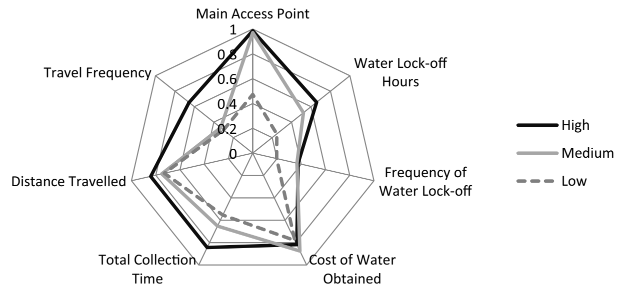

Fig. 5. Classification of water accessibility scores.

When compared across all the components of the WAI, households classified as having a low level of water accessibility, scored lower across all the components of the WAI. Households with water piped on their premises were likely to record a medium or high level of accessibility and had similar scores relating to their main access point for water (i.e. water piped into their yard and/or house) and the frequency of water lock-off (service disruption) experienced. However, the frequency of water lock-off seemed to be the greatest impediment for households' attaining a high level of water accessibility. In the case of distance travelled and total water collection time, households that recorded a high level of water accessibility tended to travel relatively shorter distances and took less time to make a round trip for water collection compared to households with medium to low levels of water accessibility scores. The travel frequency of households with a high level of water accessibility was also significantly less than those with medium to low levels of water accessibility. The cost of obtaining water was relatively the same for all households, with those having a medium level of water accessibility having a slightly lower cost for obtaining water in comparison to the other categories.

In sum, these results illustrate a highly uneven urban water landscape. Households that had active accounts with the water utility company, had relatively larger storage capacities and employed a larger number of conservation methods, tended to display higher water access scores. The analysis also reveals that water lock-off hours and frequency of water lock-offs displayed a strong influence on sustained water access at the household-level. Most importantly, the results demonstrate that the main access point in which households in the study area sourced water – an indicator akin to mainstream measures of improved water sources – by itself, did not provide an adequate measure of sustainable access. Instead, household-level water access was shaped by a combination of factors that related more to service quality and delivery, as well as the broader spectrum of socioeconomic conditions that characterize the August Town community.

Though variables such as gender, employment status, tenure and household size offered no statistically significant relationship with the WAI in this case study, they are still considered important elements of water accessibility as they often underlie disparities and influence the social conditions of access. The connection between gender and water accessibility is important as gender is often associated with unequal power and access to choices and resources (Mejía, Hubner, Sánchez, & Doria, 2012). Whilst there is an effort to mainstream gender issues into water accessibility, access-related inequalities still persist due to different conditions of access. In support of this development agenda, the progress towards equal accessibility between men and women must continuously be explored. Employment and tenure may also pose barriers to accessing piped water services. Whether piped on premises or accessed away from premises, a household's ability to pay for water services plays a pivotal role in access, as difficulties in operationalizing and striking the balance between the rights-based approach and the market-based approach to water accessibility lingers (see, for example, Bakker, 2007; Miranda, Hordijk, & Molina, 2011; Sultana & Loftus, 2012). In the case of tenure, municipal laws that restrict water provision to persons who reside on land informally or who are unable to provide proof of ownership (such as land titles) oftentimes place already marginalized households in highly precarious positions with regards to accessing safe drinking water.

5. Discussion and concluding remarks

The primary purpose of this paper is to illustrate an alternative approach to capturing inequalities in household water accessibility while accounting for differences in the reliability, affordability, and adequacy of water service provision. The Water Accessibility Index (WAI) provides an alternative approach to identifying households with comparatively limited water access. We situate the study within the inner-city community of August Town, located in Kingston, Jamaica – a low-income community characterized by relatively high piped water coverage. The findings indicate that the majority of households in the study area can be found in the medium range of water accessibility. The contribution of this paper to the literature and the post-2015 sustainable development agenda, particularly, the global goal for water which seeks to secure sustainable water for all, is of great significance. It provides a targeted approach in addressing the challenges of inequalities in water access and disparities in water distribution within cities. The current measure of access to safe drinking water used by the Joint Monitoring Programme (JMP) of the UNICEF and WHO produces estimates of access based on the following categories: water piped on premises, other improved sources and unimproved sources. Generally, a pipe water connection located on a user's premises signals a high level of access. The use of this measure as a true determinant of water accessibility has proved limited however. The Main Access Point for water (MAP) was the component of the WAI which captured whether or not households had water piped on their premises. This component was revealed to generate the highest water access score for most households, which generally trended towards greater water accessibility. This indicates that the vast majority of households within this low-income urban community do have drinking water piped on their premises and suggests the existence of a relatively high and equitable service coverage. Further analysis revealed however, that this did not equate to sustainable access or proper service provision and intervention in the majority of cases. As this study has shown, households in the August Town community are not guaranteed reliable and continuous water supply in adequate quantities to meet their daily water requirements, even under normal conditions; nor can they rely upon proper water intervention methods (e.g. water delivery, lock-off notifications and schedule water lock-offs) from municipal providers – interventions which could limit the use of alternative or unimproved water sources during water disruptions or in the dry season.

In reviewing the Millennium Development Goals (MDGs), it is evident that the poor and marginalized make up the vast majority of those without access to improved sources of drinking water worldwide. Though the MDGs have played a pivotal role in driving the provision of water services globally; issues of inequality, changing climate and poor water management practices, indicate the need to go beyond tracking just access to improved drinking water sources. As we continue to transition towards a post-2015 development agenda, there is indeed a need to begin to seriously consider shifting towards an assessment of reliability, continuity and quality of the service provision of public water supply at the micro-scale. Challenges of inequalities and poor water governance, fuels the persistence of poor service provision, as well as inter- and intra-community disparities in water distribution. As while many urban households may be in a better position today to access water supply from municipal providers, challenges in the reliability and consistency of water supply are still barriers to sustained water access (see also, Martinez-Santos, 2017; Satterthwaite, 2016; Bartlett, 2003).

Often, arguments of urban bias in pipe water provision and reducing gaps between urban and rural areas dominate discussions on the progress of access to drinking water (see also, UNDP, 2016; Jones & Corbridge, 2010; Crow & Sultana, 2002). However, the emphasis placed by the SDGs on improving sustainability and water governance whilst reducing inequalities highlights the need for setting the standards of water accessibility higher, once access to improved water sources is achieved. This goal necessitates an exploration of the conditions of access, and not just the type of water sources being used. The conditions of access speak to the relationship between water and the human system – the social dimensions of access such as distribution through time and space, service level and different socio-economic challenges embody the conditions of access. The ability to identify household-level differences in water accessibility can better highlight spatial variations in accessibility within cities with high pipe water coverage, thus creating an avenue to reduce inequality as marginalized and vulnerable groups are exposed. The WAI feature this ability; a tool such as this provides a metric which can potentially influence policy implementation which allows developmental and water intervention resources to be directed to low-income households and communities, even when improved access is achieved. At the same time, we caution that the WAI is not an end in and of itself, and should certainly be viewed as just one method that offers an alternative to traditional approaches that could potentially provide a stepping stone to the next level of achieving more accurate measurements of the progress being made in achieving universal sustainable water access. Additionally, equal consideration has to be given to issues concerning water quality and good governance in order to secure truly sustainable water access for all.

Achieving universal water access in a sustainable and equitable environment requires a more robust and targeted approach which can identify the most vulnerable to water inaccessibility at the local scale. The WAI provides one such approach. While there are still ways to refine the WAI and continuous assessments of indicators are still needed; this management tool could potentially allow for the monitoring and evaluation of progress in addressing inequalities and furthering the commitment to acknowledge people's sustainable access to safe drinking water as a basic human right. It enhances the availability of data at the community level which allows for informed decision making in the provision of water supply and water improvements. Additionally, the WAI can facilitate comparison and assessment of water accessibility either at the level of households, communities or cities. The WAI is basically a technique, hence the components and indicators used for measuring water accessibility are easily adaptable. The simplicity of the index allows for that flexibility of upscaling and downscaling. This means that if the technique was to be used at the town or city level, then the range of classes within individual components could be adjusted accordingly. However, a standardized metric for the index could be created to allow for some degree of consistency in measurement regardless of scale. This is unlike most other measurements that are designed at more aggregated scales. Over the last two decades, indices of water availability have been useful in the assessment of water resource vulnerability. However, proxies such as the Flakenmark indicator (Falkenmark & Lundqvist, 1998; Falkenmark, Lundqvist, & Widstrand, 1989), Social Water Stress Index (Ohlsson, 1998), Water Poverty Index (Sullivan, 2002; Sullivan, Meigh, & Giacomello, 2003) and even the household water security index (Asian Development Bank, 2016) utilized by the Asian and Pacific Region have predominantly measured water availability and/or accessibility at the national level. However, in order to excavate differences and provide interventions needed to reduce vulnerability within a particular context, simple and cost effective measures such as the WAI are useful. This multi-scalarity, could help in better identifying the most effective measures and interventions needed to reduce vulnerability to water stress within localized settings, without losing sight of broader developmental and planning goals or targets – thus contributing to the achievement of universal and sustainable water access. In general, we regard the WAI as a useful management tool for tracking household-level and inter-community disparities, which could contribute greatly in facilitating improvements in water access where it is needed the most.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.habitatint.2018.02.001.

References

Asian Development Bank (2016). *Asian water development outlook 2016: Strengthening water security in Asia and the Pacific.* Mandaluyong City: Asian Development Bank.

Bain, R. E., Gundry, S. W., Wright, J. A., Yang, H., Pedley, S., & Bartram, J. (2012). Accounting for water quality in monitoring access to safe drinking-water as part of the Millennium Development Goals: Lessons from five countries. *Bulletin of the World Health Organization, 90*, 228–235.

Bakker, K. (2007). The "Commons" versus the "Commodity": Alter-globalization, anti-privatization and the human right to water in the Global South. *Antipode, 39*(3), 430–455.

Bakker, K., Kooy, M., Shofiani, N., & Martijn, E. (2008). Governance Failure: Rethinking the institutional dimensions of urban water supply to poor households. *World Development, 36*(10), 1891–1915.

Baptiste, A., & Kinlocke, R. (2016). We are not all the same!: Comparative climate change vulnerabilities among Fishers in Old Harbour Bay, Jamaica. *Geoforum, 73*, 47–59.

Bartlett, S. (2003). Water, sanitation and urban children: The need to go beyond "improved" provision. *Environment and Urbanization, 15*, 57–70.

Bartram, J., Brocklehurst, C., Fisher, M., Luyendijk, R., Hossain, R., Wardlaw, T., et al. (2014). Global monitoring of water supply and Sanitation: History, methods and future challenges. *International Journal of Environmental Research and Public Health, 11*(8), 8137–8165.

Bates, B., Kundzewicz, Z., & Palutikof, J. (2008). *Climate change and water.* Technical Paper of the Intergovernmental Panel on Climate Change Geneva: IPCC Secretariat. Available at: https://www.ipcc.ch/pdf/technical-papers/climate-change-water-en.pdf, Accessed date: 12 February 2017.

Boone, C., Glick, P., & Sahn, D. (2011). Household water supply choice and time allocated to water collection: Evidence from Madagascar. *Journal of Development Studies, 47*(12), 1826–1850.

Carincross, S., Blumenthal, U., Kolsky, P., Moraes, L., & Tayeh, A. T. (1996). The Public and Domestic domains in the transmission of disease. *Tropical Medicine and International Health, 1*(1), 27–34.

Cashman, A., Nurse, L., & John, C. (2010). Climate change in the Caribbean: The water management implications. *The Journal of Environment & Development, 19*(1), 42–67.

Chen, A. A., & Taylor, M. A. (2002). Investigating the link between early season Caribbean rainfall and the El Nino + 1 year. *International Journal of Climatology, 22*, 87–106.

Clarke, C. G. (1966). Population pressure in Kingston, Jamaica: A study of unemployment and overcrowding. *Transactions of the Institute of British Geographers, 38*(1), 165–182.

Clarke, C. G. (2006). *Decolonizing the colonial City: Urbanization and stratification in Kingston, Jamaica.* Oxford, UK: Oxford University Press.

Clasen, T. K. (2012). Millennium Development Goals water target claim exaggerates achievement. *Tropical Medicine and International Health, 17*(10), 1178–1180.

Crow, B., & Sultana, F. (2002). Gender, class, and access to Water: Three cases in a poor and crowded delta. *Society & Natural Resources, 15*(8), 709–724.

Dar, O., & Khan, M. (2011). Millennium development goals and the water target: Details, definitions and debate. *Tropical Medicine and International Health, 16*, 540–544.

Falkenmark, M., & Lundqvist, J. (1998). Towards water security: Political determination and human adaptation crucial. *Natural Resources Forum, 22*(1), 37–51.

Falkenmark, M., Lundqvist, J., & Widstrand, C. (1989). Macro-scale water scarcity requires micro-scale approaches. *Natural Resources Forum, 13*(4), 258–267.

Galaitsi, S. E., Russell, R., Bishara, A., Durant, J. L., Bogle, J., & Huber-Lee, A. (2016). Intermittent domestic water supply: A critical review and analysis of causal-consequential pathways. *Water, 8*, 274. http://dx.doi.org/10.3390/w8070274.

Gamble, D., & Curtis, S. (2008). Caribbean precipitation: Review, model and prospect. *Progress in Physical Geography, 32*(3), 265–276.

Gohar, A. A., & Cashman, A. (2016). A methodology to assess the impact of climate variability and change on water resources, food security and economic welfare. *Agricultural Systems, 147*, 51–64.

Gray, O. (2004). *Demeaned but Empowered: The social power of the urban poor in Jamaica.* Kingston, Jamaica: University of the West Indies Press.

Hahn, M., Riederer, A., & Foster, S. (2009). The livelihood vulnerability index: A pragmatic approach to assessing risks from climate variability and change—a case study in Mozambique. *Global Environmental Change, 19*(1), 74–88.

Haller, L., Hutton, G., & Bartram, J. (2007). Estimating the costs and health benefits of water and sanitation improvements at global level. *Journal of Water and Health, 5*(4), 467.

Howard, G., & Bartram, J. (2003). *Domestic water quantity, service level and health.* Switzerland: World Health Organization (WHO).

Howe, C. W., Smith, M. G., Bennett, L., Brendecke, C. M., Flack, J. E., Hamm, R. M., et al. (1994). The value of water supply reliability in urban water systems. *Journal of Environmental Economics and Management, 26*(1), 19–30.

Hutton, G. (2012). *Monitoring "Affordability" of water and sanitation services after 2015: Review of global indicator options.* Working paper . Available at: http://www.wssinfo.org/fileadmin/user_upload/resources/end-wash-affordability-review.pdf, Accessed date: 4 February 2017.

Hutton, G., Haller, L., & Bartram, J. (2007). Global cost-benefit analysis of water supply and sanitation interventions. *Journal of Water and Health, 5*(4), 481.

Jensen, P., Ensink, J., Jayasinghe, G., Hoek, W., Cairncross, S., & Dalsgaard, A. (2002). Domestic transmission routes of pathogens: The problem of in-house contamination of drinking water during storage in developing countries. *Tropical Medicine and International Health, 7*(7), 604–609.

Jones, G., & Corbridge, S. (2010). The continuing debate about urban bias. *Progress in Development Studies, 10*(1), 1–18.

Kumpel, E., & Nelson, K. L. (2016). Intermittent water supply: Prevalence, practice, and microbial water quality. *Environmental Science and Technology, 50*, 542–553. http://dx.doi.org/10.1021/acs.est.5b03973.

Lester, S. (2015). Assessing urban household vulnerability at the climate-water-health nexus in Jamaica: A case study of the August town community. *Caribbean Geography, 20*, 74–90. Available at: https://www.researchgate.net/publication/305800351_Assessing_urban_household_vulnerability_at_the_climate-water-health_nexus_in_Jamaica_A_case_study_of_the_August_Town_community.

Martinez-Santos, P. (2017). Does 91% of the world's population really have 'sustainable access to safe drinking water'. *International Journal of Water Resources Development, 33*(2014), 1–20.

Mason, N., & Calow, R. (2012). *Water security: From abstract concept to meaningful metrics. An initial overview of options.* Working Paper 357London: ODI.

Mejía, A., Hubner, M., Sánchez, E., & Doria, M. (2012). Side Publication Series*The United Nations world development report - N°4 - water and sustainability (A review of targets, tools, and regional cases), Vol. 3*, United Nation Children's Fund and World Health Organization23.

Ministry of Water and Housing (2004). *Jamaica water sector Policy: Strategies and action plans* (Jamaica).

Miranda, L., Hordijk, M., & Molina, R. (July 2011). *Water governance key Approaches: An analytical framework – literature review. No.4. Chance 2 sustain*.

National Water Commission (2011). *Kingston and St Andrew water supply plans; draft document.* Kingston, Jamacia: NWC.

Nurse, L., McLean, R., Agard, J., Briguglio, L., Duvat-Magnan, V., Pelesikoti, N., et al. (2014). Small islands. In V. Barros,, C. Field,, D. Dokken,, M. Mastrandrea,, K. Mach,, & T. Bilir, (Eds.). *Climate change 2014: Impacts, adaptation, and vulnerability. Part B: Regional aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change* (pp. 1613–1654). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Ohlsson, L. (1998). *Water and social resource scarcity.* Rome: Food and Agriculture Organization.

Planning Institute of Jamaica (2015). *Economic and social survey of Jamaica 2014.* Kingston: Jamaica: Planning Institute of Jamaica [PIOJ].

Poore, S., Moulton, A. A., Gamble, D. W., Curtis, S., & Popke, J. (2016). The 2014 Jamaican drought: Climate change or interannual climate variability? In D. Barker, D. McGregor, K. Rhiney, & T. Edwards (Eds.). *Global change and the Caribbean: Adaptation and resilience* (pp. 43–51). Kingston, Jamaica: The University of the West Indies Press.

Rufener, S., Mausezahl, D., Mosler, H., & Weingartner, R. (2010). Quality of drinking-water at source and point-of-consumption-drinking cup as a high potential recontamination risk:a field study in Bolivia. *Journal of Health, Population and Nutrition, 28*(1), 34–41.

Satterthwaite, D. (2016). Missing the Millennium Development Goal targets for water and sanitation in urban areas. *Environment and Urbanization, 28*(1), 99–118.

Schuster-Wallace, C., Kerr, R., & Shumba, L. (2016). The water-health nexus. In I. Luginaah, & R. Kerr (Eds.). *Geographies of health and development* (pp. 225). (1st ed.). New York: Routledge.

Shah, K., Dulal, H., Johnson, C., & Baptiste, A. (2013). Understanding livelihood vulnerability to climate change: Applying the livelihood vulnerability index in Trinidad and Tobago. *Geoforum, 47*, 125–137.

Smiley, S. L. (2017). Defining and measuring water access: Lessons from Tanzania for moving forward in the post Millennium Development Goal era. *Africa Geographical Review, 36*(2), 168–182.

Smith, A. H., Lingas, E. O., & Rahman, M. (2000). Contamination of drinking-water by arsenic in Bangladesh: A public health emergency. *Bulletin of the World Health Organization, 78*, 1093–1103.

Statistical Institute of Jamaica, Jamaica (2011). *General report, census 2011: Revised copy*Kingston, Jamaica: STATIN.

Sullivan, C. (2002). Calculating a water poverty index. *World Development, 30*(7), 1195–1210.

Sullivan, C., Meigh, J., & Giacomello, A. (2003). The water poverty Index: Development and application at the community scale. *Natural Resources Forum, 27*(3), 189–199.

Sultana, F. (2013). Water, technology and development: Transformations of development technonatures in changing waterscapes. *Environment and Planning D: Society and Space, 31*(2), 337–353.

Sultana, F., & Loftus, A. (2012). *The right to water.* London: Routledge.

Taylor, M., Stephenson, T., Chen, A., & Stephenson, K. (2012). Climate change and the Caribbean: Review and response. *Caribbean Studies, 40*(2), 169–200.

United Nation Children's Fund, & World Health Organization (2015). *Progress on sanitation and drinking water: 2015 update and MDG assessment.* Geneva: World Health Organization. Available at: http://filres.unicef.org/publications/files/Progress_on_Sanitation_and_Drinking_Water_2015_Update_.pdf, Accessed date: 3 February 2017.

United Nations Committee on Economic, Social and Cultural Rights (2003). *Substantive issues arising in the implementation of the international covenant on economic, social and cultural rights. General comment No. 15.* Geneva: United Nations. Available at: http://www2.ohchr.org/english/issues/water/docs/CESCR_GC_15.pdf, Accessed date: 3 February 2017.

United Nations Development Programme (2016). *Human development report 2016: Human development for everyone*New York: United Nations Development Programme. Available at: http://hdr.undp.org/sites/default/files/2016_human_development_report.pdf.

United Nations Environmental Programme (2012). *Integrated water resources management planning approach for Small island developing States.* UNEP. Available at: http://staging.unep.org/NairobiConvention/docs/Integrated_Water_Resources_Management.pdf, Accessed date: 4 February 2017.

Wang, X., & Hunter, P. R. (2010). A systematic review and meta-analysis of the association between self-reported diarrheal disease and distance from home to water source. *American Journal of Tropical Medicine and Hygiene, 83*, 582–584.

Whittington, D., Mu, X., & Roche, R. (1990). Calculating the value of time spent collecting water: Some estimates for Ukunda, Kenya. *World Development, 18*(2), 269–280.

WHO/UNICEF (2010). *Rapid assessment of drinking water quality*. Stockholm, Sweden: Presentation at World Water Week. 5–11 September 2010 http://www.worldwaterweek.org/.../3-RADWQ_presentation_at_SWWW20.

WHO/UNICEF (2012). *Progress on drinking water and sanitation: 2012 update.* New York: World Health Organization, Geneva and United Nations Children's Fund.

World Health Organization (2017). *Global health observatory Data: Use of improved drinking water sources.* Website: http://www.who.int/gho/mdg/environmental_sustainability/water_text/en/.

Wright, J., Gundry, S., & Conroy, R. (2004). Household drinking water in developing countries: A systematic review of microbiological contamination between source and point of use. *Tropical Medicine and International Health, l9*(1), 106–117.