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Rooftop Rainwater Harvesting as an Alternative Domestic Water Resource in Zambia

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Abstract

Within the last decade, substantial progress has been achieved in the management of centralized water reticulation in Zambia. Characterized by diversified fiscal resourcing, concurrent institutional restructuring and introduction of new players in water governance, the water sector is set to achieve improved reliability on sustainable grounds. However, the threat of underground water pollution resulting from increased urbanization besides the unreliable energy sector presents new challenges for the current urban water. In effect, urban areas are affected by chronic water rationing creating public stress and insecurity which impacts domestic development. While the course of development has meant investment in the extension and expansion of water infrastructure in Zambia, alternative urban water resources are being sought to address challenges of traditional water systems globally. This paper therefore attempts to make a case for the modernization of Rooftop Rainwater Harvesting (RRWH) as an augmenting water resource in the Zambian urban housing sector. Here—in, it is identified as a Low Impact Development technology within the Integrated Urban Water Management framework currently being forged by local water. Based on a desktop literature survey and online questionnaire survey, an argument to support the development of RRWH in Zambia was developed. While literature survey results revealed evidence of economic loss and a growing compromise to public health resulting from inconsistent water supply in the study area of Lusaka city, the online questionnaire survey depicted significant domestic stress due to erratic water supply. Results confirmed that at one time residents observed an average of eight hours of power blackouts which effectively induced water disruption forcing homeowners to engage in various water storage methods which in turn are costly on domestic time, health and finances. A retrospective discussion based on both survey results attempts to present benefits and opportunities of urban RRWH to water sector stakeholders providing recommendations towards the mainstreaming of the practice in Zambia.

Keywords

Low Impact Development, Integrated Urban Water Management, Rooftop Rainwater Harvesting, Urban Rainwater Harvesting

1. Introduction

Public water provision among other civil services like healthcare, housing or transport continues to present challenges for local authorities in many sub-Saharan countries today. Globally, a growing insecurity over water resources has been linked to overpopulation caused by urbanization and effects of climate change. In spite of the achievements of centralized services, the negative impact of high running costs and energy demand has provoked a search for new water resources. Recent contemporary discussions have therefore encouraged the identification of water resource alternatives which must attempt to meet a balance of economic flexibility, decentralization and environmental sensitivity to achieve sustainable water resourcing. The over-emphasis of infrastructure development to bring more water to the metropolitan area is neither sustainable, nor economically, environmentally or socially desirable as it represents a never ending vicious cycle where the quality of life improves for the rich while it worsens for the poor [1]. In response, urban water managers have forged Integrated Urban Water Management (IUWM), in which diversification and decentralization characterize water resourcing. Henceforth, it is through IUWM that Urban Rain Water Harvesting (URWH), among others, has been identified as a Low Impact Development (LID) technology to augment water resourcing in urban areas. Emerging urban water management acknowledges major transitions from a "hard path", to a "soft-path", in which centralized water systems are complemented by lower cost community-scale systems [2]. Alternative water systems might be considered in city centers with decaying water infrastructures and can be competitive in unstable contexts, where flexibility, resilience and adaptation are valuable; *i.e.* a context created by climate change in many places [3]. URWH fulfils basic fundamentals of IWRM which include the use of localized water supplies and their capacity for compatibility with centralized systems to create hybrid systems [4]. RWH is therefore a sustainable strategy to be included in urban water management presenting many benefits which may include the ability to reduce a city's external water demand, alleviate water stress on the area, reduce non-point source pollutant loads, reduce treatable urban runoff volume, prevent flooding and help to alleviate climate change [5].

Regarding development in modern rainwater harvesting technology, western countries are leading as the African realization which was still observed to be in its infancy with history limited to the late 1970's mainly in Kenya [6]. Extensive development of URW is not fully exploited in Africa compared to other regions like South East Asia as it may be hampered by such factors related to low information, misconceptions and low household income [7]. However, while various opportunities can be realized in URWH, a requirement for its development in the third world must represent a localized concept of IWRM to achieve compatibility. IWRM is defined in quite general terms and might be difficult to interpret for practical purposes because in many society's, social-cultural goals other than economic efficiency influence the choice of water management [8]. Therefore, mechanisms—to allow the contextualizing of IWRM are necessary as neoliberal oriented water policy prescriptions tend to ignore the cultural and political context, as well as the historical aspects within which these resources are embedded [9]. This paper therefore attempts to assess the potential of RWH technology as a factor in alternative water resourcing in the Zambian urban water sector, besides highlighting its reliability to local public water managers.

Documentation on urban rainwater harvesting in Zambia is seldom available, and when found, it is reserved to agricultural applications where NGO's drive RWH development for rural use. In Zambia activities were generally not coordinated systematically in the past due to lack of a Rainwater Harvesting Association [10]. Consequently, rainwater has been ignored and under-utilized as a resource in the urban area with very few RWH systems installed in schools using the simplest of methods [11]. This under-utilization of URWH results partly from a failure to value metropolitan rainwater where it is instead considered as a nuisance causing floods and vandalism [11]. Furthermore, a lack of acceptance and motivation has resulted from in availability of adequate hydrological data and information required for planning, design and implementation of RWH systems [12]. It is vital therefore that African cities begin to reclaim rainwater as a resource and value the importance of securing it as an "on-site" resource commodity [13].

Internationally, attention given to URWH is admirable with typical drivers, which include the need to diversify water resources backed by a growing environmental awareness aimed at achieving sustainable cities. Concurrently urban water managers have been supported by municipal and national policies with public interest propping such efforts. In the Australian experience, developments in URWH had been in response to the millennium drought that influenced a paradigm shift of water regulation in the water sector, which now identifies RWH as a component of IWRM [14]. In south Australia new homes were required to have a rainwater tank plumbed into the house for some domestic uses with intention to reduce demand on the mains water supply in the Adelaide region by an estimated 4000 mega liters a year by 2025 [14]. Since 2006, other initiatives have included local and state government rebate schemes aimed at encouraging rainwater tank installations in East Queens Australia which have been successful in reducing residential water demand and substituting mains water in laundry and toilets, irrespective of outdoor watering restrictions [15]. Such subsidy systems have been applied to counter the impact of post-world war urbanization in Japan where large scale rainwater systems are used for public buildings in Tokyo [16]. In India, it became mandatory to have a rainwater harvesting system for a building plan in order to secure approval from the New Delhi and Chennai local authority [17]. With support from USAID, in Jordan, a Mercy Corps' "Community Based Initiatives for Water Demand Management" project was successful in yielding 88,335 m^3 annually, leading to a 24% saving in potable water per year [18].

As development in RWH has been progressive, various authors have documented the economic, environmental, and health successes in URWH that result from a communal use of units. Various benefits include economies of scale for capital costs, such as centralized disinfection while providing flexibility in matching supply and demand for new housing development schemes [19]. Ecological benefits of large scale applications, suggest how RWH can significantly reduce rainfall to combined sewer systems [20] [21]. Other studies have shown how large scale use of 3KL rainwater tanks for toilet flushing, laundry and gardening could reduce nitrogen loads by 81%, thereby reducing the Biochemical Oxygen Demand (BOD) quantity of storm water deposed in rivers [22].

Likewise, the impact of rainwater use on public health has equally been documented widely presenting managers with the task of providing health guidelines and standards for URWH. For developing countries health concerns of RWH are justifiable, considering the challenging state of public health. According to the Australian department of Health and Ageing, the risks of contracting illness from rainwater supplied from well-maintained catchments and tanks is low as organisms that can be found in rainwater tanks do not represent a significant health risk, unless the person consuming the water is severely immune compromised [14]. However, there is a need to ignore assumptions that rainwater meets international guidelines for potable use as the relationship between potable rainwater and waterborne diseases raises concerns of HIV/AIDS and malaria in Southern Africa [23]. As a consequence of such ambiguity, regulation on RWH in Portugal supports outdoor uses like washing, irrigation, firefighting and nonfood-related industrial production, as a measure to safeguard public health [24].

Ideally, many discussions on healthy rainwater are based on various ways the yield can be contaminated, as it is, weather conditions, quality of materials used, animal activity and user behavior may influence contamination along the flow path, [25]. Bacteria, viruses and protozoa may originate from fecal pollution by birds, mammals and reptiles that have access to roof tops or rainwater storage tanks and while bacteria conglomerate in a micro-layer on the water surface, many of the heavy metals and other contaminants precipitate settle at the bottom of the tank [25] [26]. Contamination of harvested water can also be dependent on the quality of the rainwater itself from regional anthropogenic activities affecting the water cycle. Atmospheric pollutants including particles, microorganisms, heavy metals and organic substances, accumulate on the catchment areas as dry deposition as they are washed out from the atmosphere during rainfall events [27]. Such deposition may result from heavy pesticide farming, mining effluents, vehicular traffic, construction etc. Likewise, high concentrations of polycyclic aromatic hydrocarbons (PAHs), nitrate and sulfate can be attributed to fossil fuel combustion for heating, traffic exhausts and industrial activity, while high electrical conductivity, alkalinity caused by sulfate, sodium and potassium were attributed to urban development [21]. Therefore preliminary surveys are advised so as to establish regional anthropogenic activities that may compromise atmospheric quality. Evidently, hygiene and good user practices are equally important to uphold health standards as misuse and vandalism can jeopardize water-quality while careless consumption may risk the user's health. Furthermore, it is necessary to advocate for simple, inexpensive testing measures to allow RWH system owners to more frequently and accurately monitor quality of their yield [28].

The review here-in, establishes that RWH is a re-emerging traditional method in constant development within objectives of IWRM. While various scholars have raised health concerns, much research has shown positive impacts of RWH on social-economic and ecological fronts. Given the viability of generic factors that support harvesting like seasonal rainfall or technical soundness, the role of government or municipal support systems is recognized as fundamental in developing the practice for urban use. It becomes imperative that public stakeholders in the water industry prioritize localized research to foster an enabling environment towards the development of URWH as an alternative water resource in Zambia.

2. Methodology

The methodology used herein is characterized from a desktop study anchored on a literature survey alongside an online questionnaire survey undertaken in the study area of Lusaka city. The use of publicized government reports gives an insight into the state of the Zambian water sector while articles sourced form journals help to establish the state of URWH as a resurfacing global practice. The online questionnaire survey was undertaken to: 1) establish the current experiences of locals with mains water supply, and 2) to assess public knowledge on RWH with reference to its technical economic or social parameters. By using various social media applications to acquire a random sample, invitations were broadcast in online chat rooms requesting members to forward email addresses so as to receive web links to the questionnaire administered through *survey-monkey.com*. Other specific methods included sharing of the web-link on social media through Twitter™, Facebook™, WeChat™ and LinkedIn™. Over a three month period and after weekly reminders, a total of 320 homeowners from within and around the city of Lusaka participated in the survey detailed in part 3.2.

3. Results

3.1. State of Water Supply in Lusaka city

Lusaka city is currently supplied by groundwater sources of about 130,000 m^3/day through the Iolanda plant at the Kafue River and two smaller water stations at Chong we and Luangwa with production capacities of 7200 m^3/day and 700 m^3/day respectively. As a supplement, the Lusaka Water and Sewerage Company operates 92 boreholes spread out within Lusaka city providing about 60% of the total daily production through a distribution network of approximately 1500 km [29]. Unfortunately, at any one time about 20% of the borehole supply capacity is lost due to electricity outages or repair rehabilitation and frequent pipe bursts as most of the pipelines are over forty years old [29]. Currently water demand exceeds Lusaka's average yield of approximately 260,000 m^3/day as no major water supply development has occurred in the past 30 years, despite increasing demand, with old and poorly maintained infrastructure and poor administrative and management systems leading to 47% of water supply being unaccounted for as Non-Revenue Water (NRW) [30].

To compensate for the unreliable water supply residents and industry in Lusaka city have in time resorted to installation of private boreholes across the city and a daily practice of household water collection. While these boreholes provide an alternative, the future of groundwater supply is undermined by drying and contamination from pit latrines in informal settlements and the uncontrolled increase in decentralized soak-aways constructed to compensate for an unmatched development in centralized sewerage services [31]. In 2013, the Lusaka City Council revealed that over 80% of boreholes in developing neighborhoods to the south-east of the city were contaminated as a result of an interaction between underground water and septic tank effluent [30]. This pattern of housing development where newly build houses are complimented with a borehole and septic tank is common across many developing districts in the city. While borehole use may provide some benefit of water supply, they are costly at installation and into the long-term as well as being highly susceptible to power blackouts. As a result the bulk of households depending on borehole water supply are faced with long hours of water absence due to power outages from the electric grid. Furthermore, borehole use has proved to be financially selective across social lines, while carrying the risk of drying and contamination.

Unavailability of reliable water supply has its bearing on both social-cultural and social-economic structures, and where it becomes erratic and unreliable it tends to frustrate domestic progress. The sustenance of good public health, sanitation and economic functions relies significantly on water reliability and are negatively impacted by erratic water supply. Currently, Zambia loses $194 million (equivalent to 1.3 percent of GDP) every year due to poor sanitation caused by deaths due to diarrhea ($167 million), loss of productivity while sick ($1 million), healthcare ($10.6 million) and time ($16 million) [32]. Bringing water and sanitation closer to its user's would yield significant time savings, especially for women and girls, releasing time for educational and productive opportunities. Given that water is a necessary prerequisite for many businesses, the increased availability of this resource also drives the start-up or expansion of small enterprise and thus increases both disposable household and national incomes [32].

Comparative review of key reports depicting government's water development strategy shows no formal recognition or specific development plan for URWH. As of 2014, a national health survey recorded 0.0% to 0.1% use of rainwater harvested for urban and rural water resourcing respectively while revealing that an average of 24.4% and 46.2% of urban and rural households respectively had no water for sanitation facilities or basic hand-washing hygiene [33]. It is possible therefore that rainwater harvesting can be used to meet the difference and supplement existing sources in a bid to alleviate poor sanitation. In spite the government's commitment to adopt IWRM as a framework for sustainable water management, there is little to no indication that URWH is being pursued as an alternative water resource method.

3.2. Questionnaire Survey

According to results of the survey administered to 320 homeowners scattered around Lusaka city, preliminary information of respondents established a typical distribution of housing type similar to the 2010 census showing stand-alone housing accounted for 3 quarters of formal housing [34]. The questionnaires thus showed that 58.33% of the respondents lived in stand-alone housing with 16.67% to 25% living in semidetached and multi-family apartments respectively. An income distribution of respondents can be estimated using the formal housing "cost" criteria of the Lusaka city council which revealed that 57.58% lived in medium cost housing, while 30.30% and 12.12% lived in high and low cost housing respectively. This result may not be representative of the overall income distribution attached to housing in the city as the informal settlement is recognized as housing the largest percentage of city dwellers. In an attempt to determine the water rationing or water shortage experienced by these households, the results, as shown in **Figure 1**, established that up to 27% of households experienced rationing between 6 to 10 hours every day while 24% to the most 5 hours of rationing. However, while another 16% would equally have no water for up to 24 hours at a time, about 33 % of respondents connected to mains service did not experience any water rationing whatsoever. Presumably this unaffected

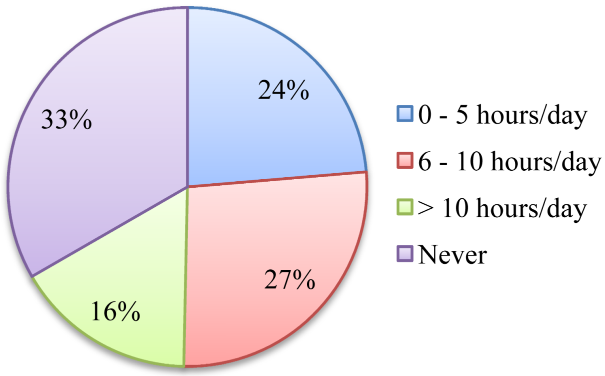

Figure 1. Period of water rationing.

group of respondents catering for the medium and high cost housing were likely to reside in effluent inner city neighborhoods accustomed to well-maintained public service conditions or around satellite water stations of the water network.

To deal with the erratic water servicing, it is common practice for homes to store water using household containers like PVC bottles, jerry cans, dishes and buckets. Accordingly, **Figure 2** shows in liters the amounts of water the respondents stored per day including the 33% using borehole serviced storage even though it did not rely on the mains supply. However, some households used other large storage amounts in the form of 5000 liter PVC reserve tanks filled by a "booster" pump attached to the mains service line and stored outside of the house within the premises. While the survey did not capture the relative costs of storing the water, an obvious assumption is that the cheapest method was the use of household containers as opposed to reserve tanks which relied on electricity and other complimentary equipment, e.g. pipping, storage tanks, water pumps etc. Whether or not containers were filled everyday was neither determined by the survey, it was clear however that rationing was daily, and thus the assumption that storage was also an everyday practice.

When asked to estimate how the respondent used water they collected, it was evident use was divided between potable and non-potable applications. As shown in **Figure 3**, about 16% of respondents used all the water for bathing, while in some cases about 58% used only 1 quarter (25%) for bathing. For potable applications only 16.67% used at least half (50%) for cooking, while 75% of respondents used only 25% for cooking. This chart shows various permutations of respondents and how much water they applied to each use. What is important to note is that each the water was meant for various in-house and outdoor applications, which in effect depicts a large amount of extra house hold work. However, in the case of potable uses, one assumption raises the influence of alternative food sources in a sense that respondents who used less water for cooking had the option of purchasing food from restaurants to compensate for the inability to cook at home. Expectedly, this situation causes some sort of pressure on household incomes.

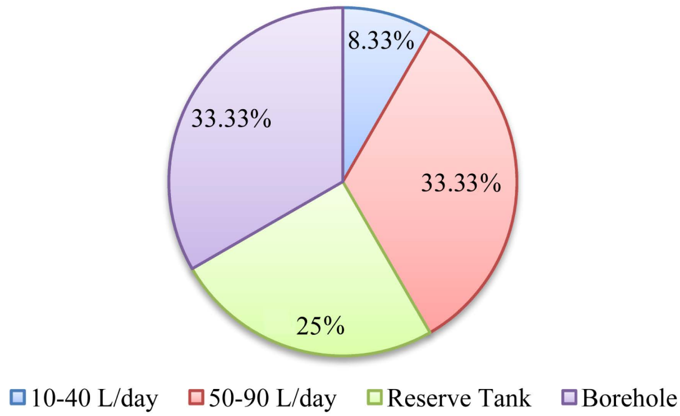

Figure 2. Amount of water storage in liters.

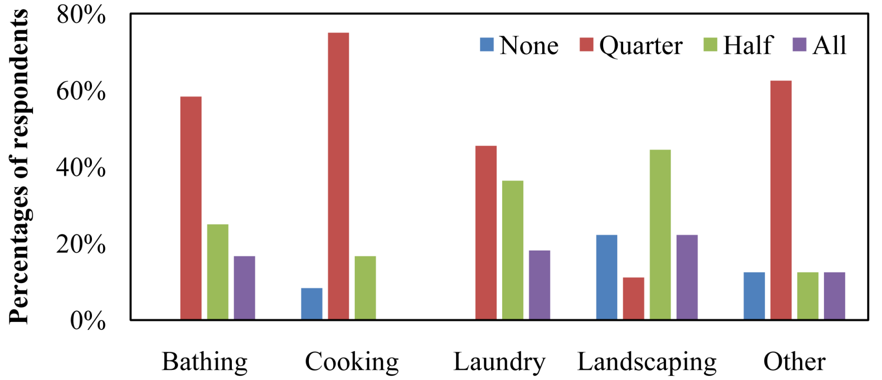

Figure 3. Application and amount of water used.

In further questioning, when respondents were asked to rate their level of know-how on RWH, only 8.33% had a positive "good" idea while a slightly larger 16.67% elected to have "moderate" knowledge of the practice of RWH. Comparatively, a larger sense of ignorance was shown when 33.33% had elected to have "no idea" with 41.67% rating their understanding as "very low". Because this high level of ignorance on the topic was expected, the questionnaire was also structured to present the various sub-topics of RWH as a form of awareness. In this regard respondents were requested to grade their interest in the significance of the various technical, economic or social cultural aspects considered in RWH. Therefore, Figure 4 presented the technical issues in which at least 66.67% of participants considering the aesthetic value as "significant" against 25% who viewed aesthetics as "unimportant". Through this result, it was interesting to note that respondents were concerned about the impact of rainwater tanks on the appearance or spatial layouts of houses as the role of aesthetics and usability of property is important in today's real estate markets.

Regarding water quality, up to 91.67% of respondents rated the issue of contamination as a "highly" important factor, which in-turn suggests a prioritization on household health. Equally, the important role of financial costs emerges

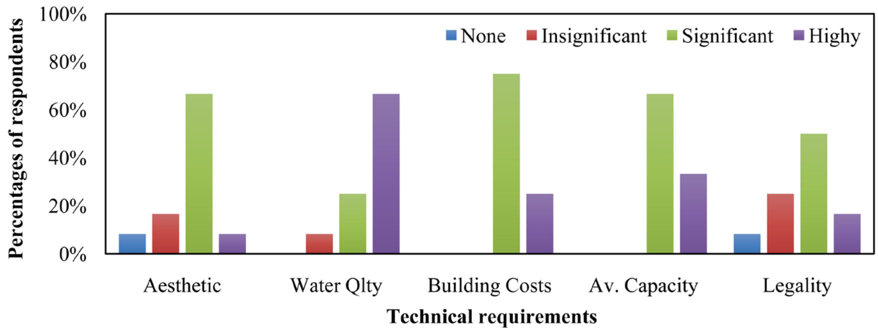

Figure 4. Technical requirements upon which to consider URWH.

when up to 75% respondents marked as "significant" the issues relating to cost implications of constructing and maintaining rainwater harvesters. Furthermore, interest on the potential quantity of rainwater available for harvesting attracted attention of all respondents tallying at 100% which in itself indicates some suspicions on the functionality and practicality of the RWH system. Interestingly, this is representative of common misconceptions that RWH is intended to ultimately replace or compete with mains supply when in fact it can only be used as an augmenting resource. On issues to do with legality to practice RWH, at least 50% of respondents were "favorably" willing to follow local authority regulations on the use of rain-harvesters, with the rest equally rendering it in significance or unnecessary. In retrospect this result must be considered both a challenge and encouragement considering the many cases of illegal water connections that lead to vandalism or tend to increases Non Revenue Water (NRW) in Lusaka.

In presenting the non-technical, social-*cultural* attributes inherent in RWH, as a form of awareness and promotion of the practice, respondents were asked to gauge their interest in the practice as a means to achieve *food security*, *attain more water rights, household convenience*, *charity* among others as shown in Figure 5. When asked as to how important respondents viewed their right to access rainwater as a consequence of their property, 41.67% of respondents seemed uninterested as they graded this attribute as "low", while 50% graded it between "moderately" to "highly" important. In retrospect, this attribute depicts the split value respondents placed on rainwater, thus raising questions as to what extents one can lay claim or take responsibility over rainwater. On another hand only about 50% were "highly" interested in the ability of RWH to add value to their property which shows in itself the leverages that water resource security presents in real estate markets. As an opportunity for household vegetable gardening, an average of 81% of respondents was interested in the capacity of RWH to supplement food security. Also, when the respondents were asked if they would support government effort of water service provision by adopting RWH to relieve demand pressure, only an average of 29.16% showed an interest to do so, showing that most respondents believed it was government responsible

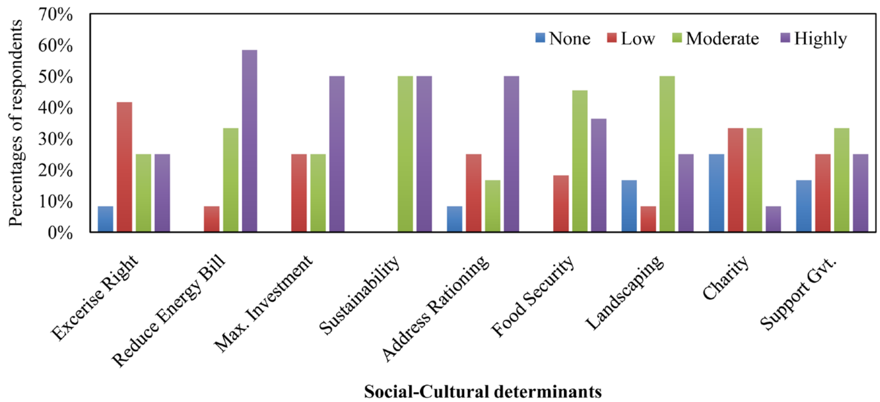

Figure 5. Non-technical parameters upon which to consider URWH.

to provide adequate water services.

While these results illustrate findings based on a small part of the city population they imply a significant amount of ignorance as to the practice of RWH. As a reference point for further studies, the survey herein provides a reliable scope of expectations and priority areas of interest needed to convince the general public on advantages inherent in RWH.

4. Discussion: The Case for Urban Rainwater Harvesting

The emphasis of this paper is to highlight the potential of RRWH as a viable means to achieve household water security as well as promote the development of sustainable solutions to the impending water crisis in Lusaka city. Essentially, it must be noted that rainwater harvesters will not be sufficient to meet the total household water demand and thus priorities of use must be set to reliable scheduling. Overlooking the need for prioritization leads to misinformation about the possibilities in harvesting and sets the tone for undermining the potential of RWH.

The survey in part 3.2 has depicted a level of public ignorance of RWH as an alternative urban water resource. While it is difficult to point out particular reasons as to why this is so, some assumptions can be raised which may include: 1) The lack of promotion by government as a deliberate measure to promote water security; 2) Insufficient promotion by the education system to spearhead the development of URWH; 3) the emphasis of residential borehole drilling as the ultimate alternative to mains supply; 4) The general tendency of residents to attaching luxury to water which has led to generally poor household water management. Among many other possible assumptions, these reasons have led to a system which values quantity over efficiency thereby undermining the potential of Low Impact Development (LDC's) strategies in water resourcing. As a consequence, public frustration and insecurity have become a reality as opportunities in LID's continue to be overlooked while residents accrue more financial costs and increased health risks from contaminated boreholes or water collection. The impending threat of drying boreholes also presents an environmental risk as underground water reserves are over-used. For supplementary purposes therefore, rainwater systems become admirable as they bring water directly to households, thus relieving the burden of water-carrying, particularly for women and children [35].

In realizing the viability of RWH in the Zambia water sector, concerted efforts from various government agencies must be harmonized to assess the technical, political and social paradigm relating to RWH. This is necessary to understand and respect the value society places on water so as to achieve adequate representation. While the country may be considered as a developing country lacking in some expertise, appreciating the milestones achieved so far in the water sector would boost morale of stakeholders. As it is, the development of mainstream URWH will be dependent on the climatic, economic, and technical paradigms in the Zambia water sector. These conditions must be realized simultaneously and practically feasible in all urban centers in each of the countries geological subregions beyond the study area of part 3. Besides making adjustments to existing administrative structures, there will be need to introduce specialized departments which identify with URWH as a decentralized system. While such arrangements may seem challenging for already resource strapped local authority, the overall benefits of URWH must instead be viewed as opportunities towards sustainable water resourcing.

Currently in Zambia, an Integrated Water Resources Management/Water efficiency Implementation plan developed in 2007 meant to facilitate integration of climate change issues in national planning has contributed to the country's climate change adaptive potential [36]. As a result, various national water development programs undertaken since provide reliable experience to enhance URWH. In lieu of the impacts of climate change, RWH tends to "by-pass" many technical complexities which lie at the mercy of climate change thereby stressing centralized water systems. Furthermore, while the energy required for water reticulation has proved to be erratic due to drought and infrastructural mismanagement, the recent rainfall patterns around the country are feasible for URWH. In this regard, the common rhetoric around climate change, coupled with the ambiguity of climate change predictions to provide intricate foresight, must not dispel proposal for RWH development. Instead the threat of climate change must be an incentive to redefine water management institutionally and technically.

To allow for the diversity of various income groups, rain harvesters must assume characteristics of sustainability including technical diversity that allows early build ability and improvements overtime. While they can be built from simple materials to complex units imploring mechanical components, users must not be constrained by design complexities that influence high costs. Equally, technical prowess must suffice to ensure reliability of mainstream URWH. In Zambia here has been a steady development of basic building trades such as plumbing, carpentry, metal smith skills, etc. over the past decade due to a boom in the construction industry of the 2000's. Accounting for 12% - 15% of GDP growth between 2007 and 2013, the construction industry remains one of the fastest-growing sectors in Zambia which continues to create employment opportunities for more water related professionals [37]. The resulting experience, expertise and skills development, as well as improvement of local manufacturing industries stand as opportunities for URWH to develop technically.

As shown in the survey of part 3.2, URWH usually raises financial concerns for institutions and individuals who tend to weigh the returns on investment. Determining the financial advantage of RWH systems is a complex issue that factors in many financial variables, including a cost comparison of alternatives. Previous studies, have found RWH systems to be financially unrewarding under the current water price regime where water is supplied to urban residents at a subsidized rate [38]. Based on this context, adoption of rain harvesters has more success as a form of backup. Where the alternative source to rainwater harvesting is treated piped water, rainwater is mostly used for secondary purposes like laundry and cleaning which is quite the opposite of rural RWH practice [5]. However, the initial capital costs of rainwater harvesting may be high, but it yields benefits whose value may exceed the cost of the system and can be suitable for an incremental approach [6] [39]. Considering the financial outlook of large scale RWH, the small unit size of decentralized system allows closer matching of capacity to actual growth in demand, and can be built house-by-house, or cluster-by-cluster, in a "just-in-time" fashion moving capital costs of capacity to the future. This means that a community needs to incur less debt, compared to the borrowing requirements of a large up-front capital investment in capacity which can reduce the financing costs for that community [21]. One other potential economic value inherent in RWH is the labelling of real estate as "green" or "sustainable", as this can be advantageous for the property market. As the "Green" labelling continues to gain ground in the region, Zambia and other southern African countries may stand to win when URWH presents new financial incentives or opportunities to achieve sustainability and water security in the real estate market. Theoretically, the development of domestic RWH can offset industrial harvesting, which can promote the commercializing of a new sub-industry leading to various economic outcomes.

The ultimate success of rainwater utilization in Zambia will depend on the ability of users and systems alike to acknowledge safety standards, which must be drawn from research and represent the interest all stakeholders. These standards must satisfy both potable and outdoor applications so as to enhance the versatility of rainwater use. Particular guidance should be specific towards detailing of the installation and materials, treatment methods, maintenance processes etc., and should be categorized to cater for various income groups of the population. However, while lower income groups might find treating of collected rainwater expensive, the option to use yields for cultivation in domestic fruit or vegetable gardens must be encouraged as it serves to relieve the pressures of off-site water collection. Promoting such flexibility will be essential in achieving a broad adoption of the practice across social lines, and thus reflecting a real sustainable development agenda for RWH.

5. Conclusions and Recommendations

The paper has shown that current water resource development plans, have done little to recognize and spearhead LID's like URWH even though Zambia has adopted IWRM in water governance. In-spite the benefits achieved by traditional centralized water systems and borehole usage, todays water insecurity threatens public health and both household and national development. To achieve the opportunities inherent in URWH, the following strategies to achieve a specialized networking between stakeholders can be formulated to make rainwater utilization a part of the water sector: 1) A systematic approach which incorporates URWH utilization into municipal ordinances intended to observe localized standards which guide on unit design and usage; 2) Promote pilot projects across the country as an initiative to exhibit prototypes used to convince the general public and various utility companies; 3) Encourage technological development and training through monetary incentives in the form of funding, subsidies or rebates and consultation with experts. To achieve strategic advantage, it's recommended that a specific department within government must be formulated to facilitate a national program and coordinate stakeholders. Additionally, a vital role of the department must be to promote empirical studies into the financial feasibilities around URWH and those correlating safewater standards required for both potable and domestic uses. The impact of such a role would respond to the resulting intensification of RWH, thereby encouraging its use in multiple domestic applications including outdoor garden use besides potable use. Promoting outdoor uses is essential especially were homesteads would face challenges in meeting treatment costs required for potable use. Furthermore, in the event of a successful RWH campaign, the foreseeable challenge of monitoring individual units can be resolved through the inclusion of the private sector. It is possible that small businesses specialized in rainwater services can support local authority to facilitate water quality control while creating a sub economy within the water sector.

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