Developing Retrofit Urban Sanitation Models for Enhanced Health and Resilience in Harare

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Abstract

This article explores the possibility of retrofitting Harare's urban neighbourhoods with water-sensitive urban design (WSUD) technologies for enhanced water and sanitation hygiene (WASH). It utilises the concepts of WSUD and water treatment technologies available today. From a desktop review of existing literature, it is clearly evident that there is a vast array of water harvesting, water storage and micro waste water treatment technologies. Coupling these technologies with the concepts of WASH and WSUD, there are distinct possibilities of creating healthier urban environments. Existing urban hydrological patterns and strategic urban land-uses that can be skilfully assimilated into WSUD and management are also focused on. Retrofit models are proposed for both formal and informal urban communities in order to improve sanitation health, resilience and sustainability.

Keywords: *water-sensitive urban design, sanitation, hygiene, integrated urban water cycle management, water technologies and innovations*

INTRODUCTION

On 28 July 2010, the United Nations General Assembly, declared that clean drinking water is "essential to the full enjoyment of life and all other human rights". The most recent General Assembly Resolution 7/169 of 2015 has been called a declaration of "The Human Rights to Safe Drinking Water and

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Sanitation (United Nations, 2015). Contemporary concepts of development also cite water as a key factor of quality of living; with the matrix of human needs developed by M. Max-Neef recognising it as essential to satisfy the need of subsistence (Max-Neef, 1991). According to the World Health Organisation (WHO), between 50 and 100 litres of water per person per day are needed to ensure that most basic needs are met and few health concerns arise (WHO, 2015). The global human population now exceeds seven billion, 54% of which currently live in cities (Young, Lieberknetch, 2019). The result of this urban expansion has led to leading global cities almost doubling their investment in water supply infrastructure (Statista, 2020), with countries like China and the United States of America leading in the water supply infrastructure investment drive. Zimbabwean city administrators must also critically consider investing more in conventional and unconventional innovative water supply and treatment strategies for improved resilience and future survivability.

Harare is Zimbabwe's capital, with an estimated population of 2,8 million and covering an approximately of 833km^2 (*Demographia*, 2020). Harare has been facing extensive water challenges, with the key driving factors being aging and dilapidated equipment. The water treatment infrastructure is now out-dated and this has had a negative impact on efficiency. Consequently, it has increased maintenance costs and reduced output capacity of 12 000m^3/day when the city requires a minimum of 18 000m^3/day. In addition to the aged infrastructure, the country has been subjected to electricity rationing measures of between 6-18 hours daily. That has also negatively impacted on water treatment and supply capabilities (Mangizvo and Kapungu, 2010). On the waste-water treatment side, the sewage treatment plants in Harare are overloaded with total design capacity of 219,500 m^3/day while current inflows average 287,000m^3/day (Muserere, Hoko and Nhapi, 2014). The magnitude of the current water supply and waste-water treatment challenge, coupled with poor rain seasons, clearly highlight the need for the adoption of new strategies to ensure guaranteed long-term WASH-based resilience Harare.

The purpose of this article is to practically demonstrate the potential of applying Water-sensitive Urban Design (WSUD) in Harare in order to significantly improve Water and Sanitation Hygiene (WASH) in both formal and informal communities. The strategies proposed herein will benefit existing urban communities in meeting short- and medium-term water needs and have the potential to influence future urban design approaches in the country.

LITERATURE REVIEW

Growing cities increasingly face challenges affecting provision of basic urban services. As a result, the 'business-as-usual' approach may be too costly and not resilient to changes in land-use, climate change and unexpected future shocks. Traditional engineering solutions are not likely to guarantee future urban water needs. Thus, new approaches to water supply are required (World Bank, 2012). Apart from looking beyond 'business as usual' approaches, it is also critical to understand that in developing solutions, the axiom that 'one size does not fit all' is also appropriate. A study carried out by the World Bank (2012) indicated three critical factors that determined how countries and regions developed solutions regarding their Integrated Urban Water Cycle Management (IUWCM) strategy. These are the role of water in national development (conversely, the impact of climate shift on water resources), the strength and coordination of national and local institutions in understanding the value of water as a key resource and the existing levels of urban services.

In the Netherlands, a location with abundant water due to its coastal siting, urban planning and water development intrinsically combine into their development paradigm and is reflected in their national policies. In a sense, the Netherlands may be described as a coastal water community that has developed specialised ways to live with water (Hooimeijer *et al*, 2005; Leenaers *et al*, 2010; Dolman *et al*, 2013). Similarly, in the UK, the spatial urban network has been created around watercourses and flood plains. The main urban development driver in these countries has been the need to prevent flood risk (moving water from land as fast as possible) and the economic pressure to strategically build around a complex hydrological system

(Dolman *et al*, 2013). This has logically led to water-sensitive design becoming a key component in the national development agenda. Adopting Integrated IUWCM, is assessing alternative infrastructure options, based on a cost benefit analysis (World Bank, 2012).

In contrast, although surrounded by water, countries such as Australia have inlands that are arid to semi-arid and have had to develop water strategies over time. WSUD has evolved from its early phases of storm water management to a broader framework that encapsulates sustainable urban water management (Wong, 2006). Australia's approach is similar to the Caribbean region where emphasis has been on conceptualising models for IUWCM and designing operational methodologies for cities wishing to develop IUWCM strategies (World Bank, 2012). Australia has instituted development guidelines for its local authorities with initiatives, such as the WSUD Guidelines (Melbourne Water, 2013). Such initiatives have allowed the country to move from mere theorisation to application of WSUD concepts in urban development.

South Africa is a country with nearly similar geo-ecological attributes to Zimbabwe. Within the region, South Africa has begun initiatives to develop a national framework for WSUD, with the National Water Commission funding research into its development, undertaken by the University of Cape Town. Amongst the issues highlighted in the research is the need to create more synchronised institutional structures, develop WSUD champions, ensure equity in service delivery, mitigate WASH-related risks and uncertainties and enhance understanding of ecosystem goods and services within the context of the general economy (Armitage *et al*, 2014). Further to this, sub-Saharan African countries, such as Kenya, Uganda and Cameroon, have begun to explore potential opportunities and new technologies in attempts to improve urban water supply (World Bank, 2012).

Water quality and sanitation are irrevocably intertwined. Poor sanitation leads to water contamination and in many parts of the world, the main source of water contamination is sewerage and solid human waste. Thus, the main objectives in urban sanitation health services are to ensure water quality in distribution systems, mitigate water scarcity and provision of safe ecological sanitation (Asano, 1998; Vinnerå *et al*, 2006; Khan *et al*, 2013). Although there are many country-specific barriers to progress in water and sanitation access, the universal challenges are identified. These are inadequate investment in water and sanitation infrastructure, lack of political will to tackle urban sanitation challenges, avoidance of new technological interventions, lack of community involvement and imposition of solutions inappropriate for the specific environment and community needs and, finally, failure to conduct evaluations of water and sanitation interventions to determine whether they are successful and sustainable or not.

Facing the challenge of water scarcity also requires research in three main areas: improving the efficiency of agricultural, industrial and domestic water use, the development of technology for implementing and monitoring safe water reuse and developing technologies and economic policies to promote effective water conservation (Moe and Rheingans, 2006)

To guarantee urban sanitation and public health, various strategies have been utilised globally. Countries such as China and America have largely opted to increase investment in water supply and sanitation infrastructure (Statista, 2020). In Brazil, engineers began experimenting in the early 1980s with a decentralised, low-cost approach to waste-water collection known as condominial sewers. These systems are less expensive than conventional sewers as drainage lines are installed below sidewalks or yards of homes, instead of under streets. Costs are lower because the drainage is made with cheaper material than is used in conventional sewers. Costs are again further reduced by having project beneficiaries participate in constructing and maintaining portions of the system, most commonly the household connections—sections of the sewer line running from the house to the clean-out box that is part of the condominial sewer system (Nance and Ortolano, 2007).

In the City of Outapi, Namibia, where water resources are scarce, strategies have been developed to reduce water conflicts by developing plans that separate grey-water from the main water reticulation system. This approach re-tasks grey waste-water mainly from informal settlement communal points as a new input for urban agricultural purposes, thus facilitating the re-use concept of urban waste-water. This assists in sanitation whilst addressing the need to supply agricultural produce that is in high demand in this region (Woltersdorf, Liehr, Scheidegger and Döll, 2015).

The review of literature explored the broad challenges and country specific solutions associated with WASH-WSUD strategies. In developing more concise solutions for Zimbabwe, a more detailed study of the socio-economic and institutional dynamics around the prevailing urban hygiene and sanitation health context will, however, be required.

RESEARCH METHODOLOGY

The data utilised included a desktop review of key global and local WASH statistics, online publications and existing local spatial development literature. First, a background of the global and local WASH models was given. This was followed by a literature review of key WASH concepts, the concept of WSUD and an overview of existing water treatment technologies available today. A conceptual framework is then presented that points to local opportunities for improving WASH-based resilience through urban design approaches that integrate WSUD principles. An approximate WASH-WSUD neighbourhood model that has the potential to enhance sanitation resilience is proposed. Finally, a discussion based on the strength, weakinesses, opportunities and threats (SWOT) approach concludes the exploration.

ANALYSIS AND RESULTS

Harare utilises a centralised/monopolised water treatment model that supplies water to the entire city through its single water treatment plant, Morton Jaffrays, whilst waste-water is also centrally treated through the use of two sewerage treatment plants, Crowborough and Firle Sewerage Treatment Works. However, as illustrated in Figure 1, the existing water supply and treatment infrastructure is inadequate to meet the needs of the city inhabitants, posing significant sanitation health risks to the city's population.

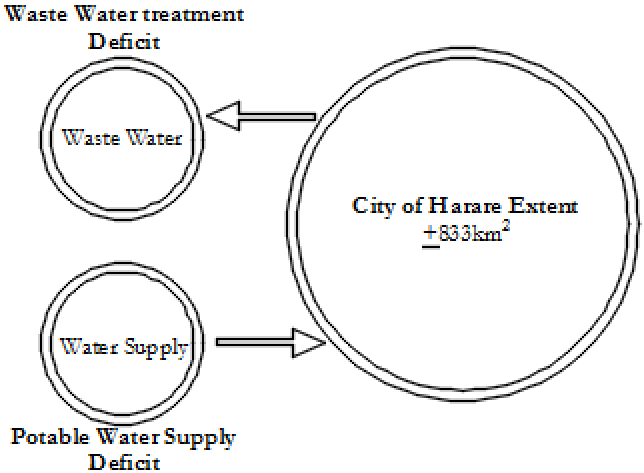

Figure 1: Overview of Harare water supply and waste water treatment scenario (Author, 2020)

The City of Harare is naturally located within region 2 of Zimbabwe and, as such, its pre-climatic shift characteristics feature above average rainfall patterns, ecological diversity coupled with land patterns permeated by perennial and seasonal water courses (Natural Regions Map, Agritex Zimbabwe, Harare Wetlands Map, Environmental Management Agency Zimbabwe). The natural endowments and hydrological properties afford the city significant opportunities to strategically invest in WSUD that will ensure WASH-resilience for its urban communities. Figure 2 illustrates a typical neighbourhood in Harare with watercourse and wetland buffers.

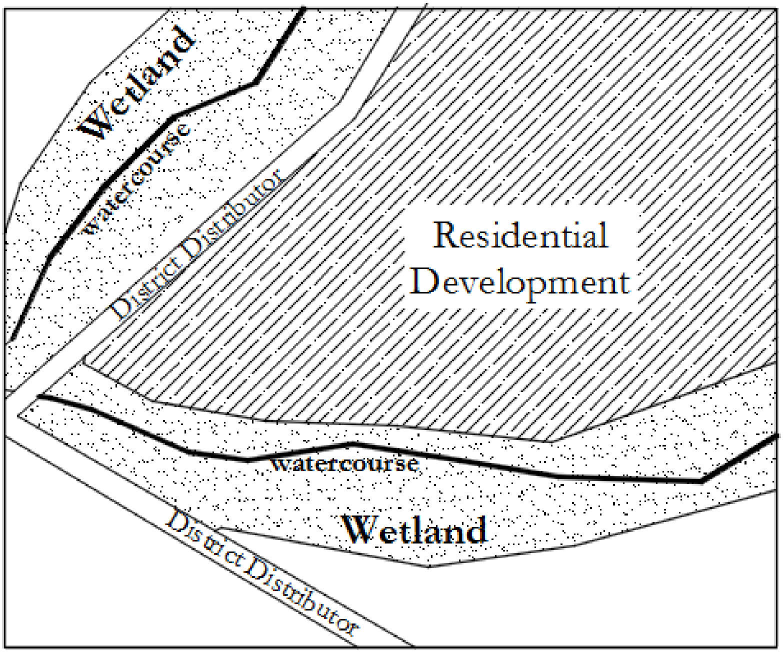

Figure 2: Typical hydrological-urban development intersections (Adapted by Author from Environmental Management Agency Harare Wetlands Map).

The current urban design strategies deployed in Zimbabwe primarily focus on sale revenue generated by residential, commercial and industrial land-uses and have not considered the need to incorporate WASH and WSUD strategies into the design at the local level for improved medium-to long-term resilience (Rose 1999; Howe *et al*, 2011; Bell, 2015). In developing WASH-enhanced resilience for Harare, the critical platform for the adoption of new strategies is the urban spatial platform. Land-use planning in Zimbabwe is governed at macro level by the Regional, Town and Country Planning Act 29:12 and at the micro level by the Layout Design Manual (Department of Physical Planning, Ministry of Local Government). From an environmental protection perspective, the layout design manual designates buffers for watercourses and mandatorily requires a set percentage of land developed to be set aside for passive and active recreation space (approximately 5%). These mandatory buffers, passive and active recreational spaces are key potentials in deploying WSUD retrofitting for Harare's urban areas.

SANITATION AND URBAN DISEASE PREVALENCE

The last cholera outbreak in Zimbabwe was in 2018 and lasted from 4 September to 3 October, with an estimated 8 535 cases and a 0,6% fatality rate. Of the 8 535 cases reported, 98% were in the densely populated capital of Harare, with the most affected suburbs being Glen View and Budiriro. Contaminated water sources, including wells and boreholes, were suspected as the sources of the outbreak (WHO, 2020).

A CONCEPTUAL FRAMEWORK FOR RESILIENCE-BASED LOCALISED NEIGHBOURHOOD WASH-WSUD MODEL

To clearly outline the current WASH-water supply urban strategy being employed in Harare and demonstrate the opportunity gap, a set of conceptual frameworks will be utilised. The frameworks will progressively move from a macro to micro level of analysis.

Framework 1: Existing Urban WASH Model

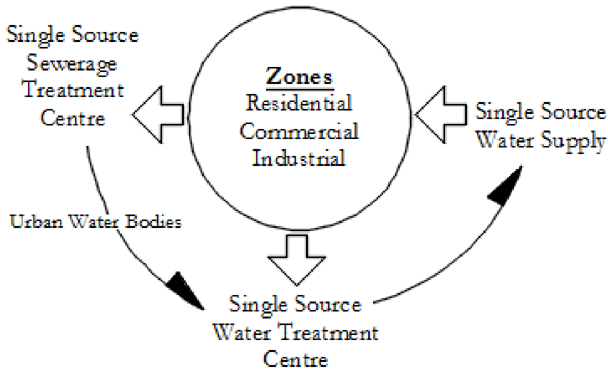

Figure 3: Framework 1: Existing urban WASH Model (Author, 2020)

The current model for urban WASH strategies is single and monopolistic in nature. It is based on centralised and monopolised water sources that supply water to urban zones which comprise primarily residential, commercial and industrial areas. The water utilised in these urban zones is then funnelled through a single unselective sewerage system to a centralised sewerage treatment plant. On arrival at the sewerage treatment plant, this urban discharge is treated and the effluent is discharged into existing urban water bodies where it finds its way to centralised urban water treatment plants. From this point, the water is recycled back into use.

Framework 2: Potential threats to existing water supply model

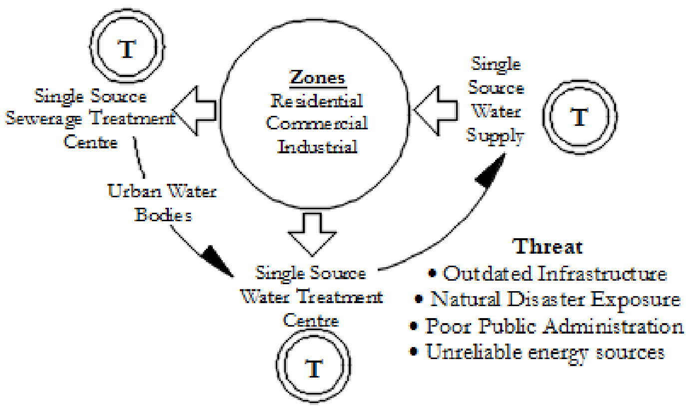

Figure 4: Framework 2: Potential Threats to Existing Water Supply System (Author, 2020)

The major deficiency of the centralised model is that any threats on key urban WASH-water supply infrastructure can cause the whole system to collapse. The threats currently being experienced in Harare are the dilapidation of key water supply infrastructure, rapid urban expansion and electricity supply shortages (Chidakwa and Mundawarara, 2020). These focal threats are a clear testament to the weaknesses of the existing urban amalgamated model. Figure

4 above illustrates these key threats to the existing urban water supply and treatment system.

FRAMEWORK 3: MONOCHROMATIC UTILITY OF ANNUAL WATER CYCLE

The existing urban WASH water supply model is disadvantageously monotone in its utility of the natural water cycle (rainfall patterns). The strategy is primarily based on surface water catchment and retention, with the assumption that this strategy will be adequate to supply water for urban needs during the whole year.

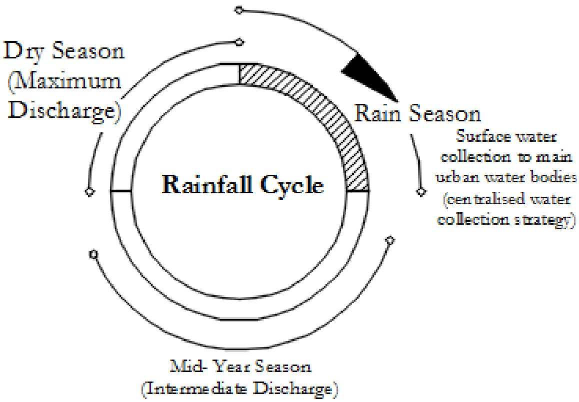

Figure 5: Current urban water collection and Storage strategy (Author, 2020)

This last decade has seen some unprecedented threats exposing the frailty of the existing urban model, especially within the context of urban sanitation and health. The global climate shift phenomenon has exposed the weakness of centralised urban water service supply as weather patterns and, subsequently, natural water supply, has dwindled in the last few years. The COVID-19 pandemic that has swept the world is one of the current threats that again have exposed the frailty of the existing urban water supply model. Climate shift and the COVID-19 pandemic have a direct bearing on the inadequacy of the existing centralised Urban WASH strategy for Harare. However, current urban water-based technologies and innovations can provide unprecedented solutions to the existing water supply challenges faced by Harare (Webb *et al*, 1998; Pauli, 2010; Hardoy *et al*, 2013; Banana *et al*, 2015). By incorporating these technologies into concepts of WSUD, practical solutions that will realise enhanced urban water resilience strategies, especially if viewed from a modular perspective of solving water challenges at household and neighbourhood level can begin to be explored. Figure 6 illustrates potential opportunities for implementing a modular-based WSUD-WASH approach at neighbourhood level.

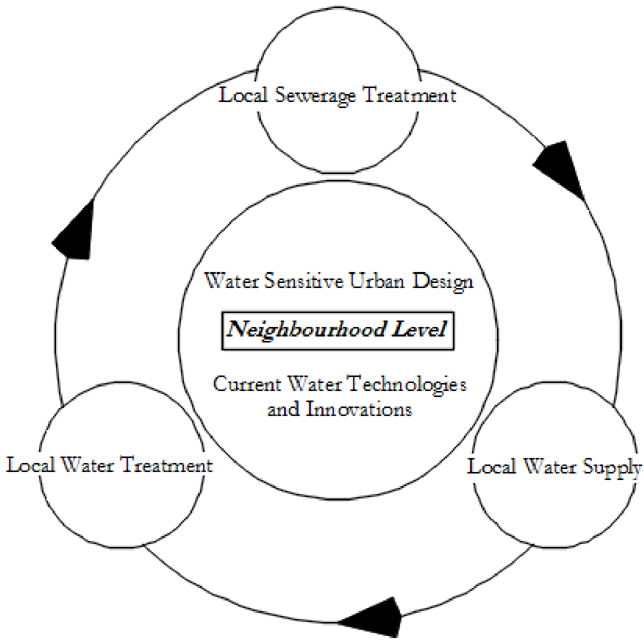

Figure 6: Opportunities for Localised (Neighbourhood) WASH-WSUD Strategies (Author, 2020)

This conceptual framework is thus predicated on the idea of developing a localised urban water recycling model for residential areas to create independent and potentially interdependent residential modules that can capture, utilise and recycle local water resources to improve resilience through the use of appropriate water technologies in concert with WSUD initiatives.

MODELLING A RESILIENCE-BASED LOCALISED NEIGHBOURHOOD WASH-WSUD MODEL

A smart-city is described as an evolutionary transformation in urban infrastructure and its management (Young and Lieberknecht, 2019). The operational platform of the smart-city is leveraged by the widespread adoption of technologies that encompass the smart home amongst other attributes (*Digital Journal*, 2015). If one of the critical components of a smart-city is smart homes, through extrapolation, the smart-city must also naturally encompass 'smart neighbourhoods'. The ideal of the smart-city is that it is sustainable, relying more on renewable energy and integration of green spaces with an emphasis on minimising waste by increasing energy efficiency and reducing water consumption (Athrady, 2015). The first step towards developing a localised WASH-WSUD neighbourhood is identifying the key technological innovations that will be its key components. For the model presented here, black and grey-water recycling systems will be utilised in conjunction with Free Water Surface Constructed Wetlands (FWS-CWs).

High efficiency modular aerobic black water digesters, such as the Biorock™, could be utilised to treat polluted water at household or neighbourhood level. The Biorock aerobic digester is a two-tank system that comprises a primary sedimentation tank and a bio-reactor and is capable of treating domestic waste water (Jakubaszek and Stadnik, 2018). The advantage of its modular design is that it can be used in isolation at household level or upgraded to cater for neighbourhood black water treatment. Grey-water systems, such as the Flotender™, are designed to capture domestic grey-water and filter it so that it can be used for irrigation or re-used for non-consumptive domestic purposes, such as toilet flushing systems (Harju, 2010).

The filtered product from the grey-water recycling system could potentially be re utilised in the neighbourhood within the context of enhancing water resilience strategies. FWS-CWs comprise shallow channels or basins, with a sealed bottom (e.g. geotextile or clay) to prevent water seepage to the underlying aquifer. Water flows nearly horizontally at a low velocity above the soil layer along with the system. The water flows through the wetland bed and comes into contact with the soil grains and plant parts, thus enabling a series of physical, biological and chemical processes to take place, that contribute to the degradation and removal of various pollutants (Stefanakis, Tsihrintzis, Akratos, 2014). These artificial wetlands are designed using the regulated flow of effluent. Within the context of WASH-resilience, this effluent can be stored locally, then treated and recycled into the neighbourhood.

The overflow from these constructed wetlands can then be further discharged into rivers and streams, thereby augmenting the local hydrological patterns and providing neighbourhoods downstream with a regular raw water supply. Localised water treatment strategies can be realised through potable water treatment plants. These potable solar or electric driven plants treat raw water through the process of distillation and are ideal for use at local levels. An example of such a water treatment system is the Rainmaker™ (Charan, 2017).

Table 1: Technological components of the WASH-WSUD Neighbourhood Model (Author, 2020)

Water treatment Aspect	**Water Treatment Technology**
Black water Treatment	Aerobic Digesters
Grey-water Treatment	Grey-water Treatment Systems
Localised Water Purification	Potable Water Distillation Plants
Local water storage and release	Free Water Surface-Constructed Wetlands (FWS-CW)

Figure 7 shows the connectivity between the black water treatment plant, grey-water treatment plant, the Potable water distillation plant and the FWS-CWs.

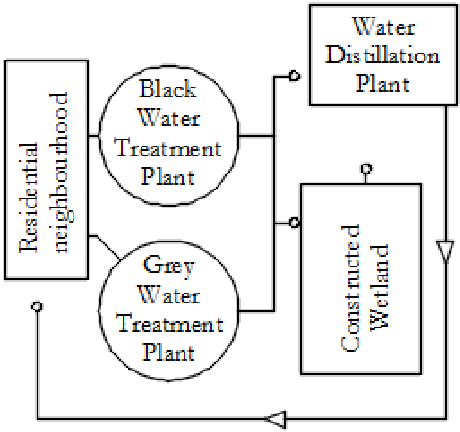

Figure 7: Connectivity of smart-city components of the WASH-WSUD Neighbourhood Model (Author, 2020)

Ecological-wise design is described as the simultaneous achievement of social and ecological sustainability through evidence-based planning interventions requiring minimal input and maintenance (Patten, 2014). These interventions leverage ecological and cultural systems to create real and permanent good for generations (Carnegie ,1889; Xaing, 2014). Ecological-wise design is based on three critical elements. The first is the recognition of nature as a subjective factor in project development and outputs. Secondly, ecological design relies on the inputs of a broad trans-disciplinary community and, finally, it values perceptions and knowledge from previous generations (Young and Lieberknecht, 2019).

To facilitate enhanced water resilience at local level, the model proposed here will use WSUD-modified open spaces. These spaces will comprise of recreational parks and buffers that will be included in with surface reservoirs, sub-surface reservoirs and FWS-CWs. These components of the model will be used to synergise with the natural hydrological patterns (rainfall patterns and natural surface water systems). This aspect of the model will require input from a multi-disciplinary team that includes ecologists, urban planners, engineers and architects, amongst other specialists.

Table 2: Ecological-wise components of the WASH-WSUD Neighbourhood Model (Author, 2020)

Ecological Design Aspect	**Functional Aspect**
Surface Reservoirs	Rainfall collection and storage
Sub Surface reservoirs	Rainfall collection and storage
Water Retention Zones (for underground water recharging)	Rainfall collection, storage and charging of underground water reserves
Free Water Surface Constructed wetlands (FWS-CW) and natural wetlands	• Collection and storage of treated neighbourhood water discharge, storage and charging of underground water reserves • Supply of treated water to adjacent neighbourhoods in the model network • Preservation and conservation of ecological systems along with urban water ways.

Figure 8 Illustrates the Ecological wisdom components of the WASH-WSUD Neighbourhood Model.

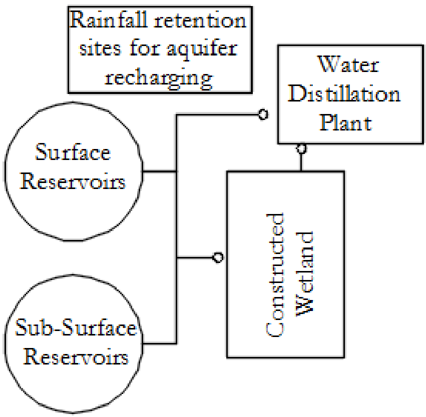

Figure 8 Ecological wisdom components of the WASH-WSUD Neighbourhood Model (Author, 2020)

THE PROPOSED WASH-WSUD NEIGHBOURHOOD MODEL

The concepts of smart-city and ecological wisdom are new to local cities but are timely, considering the current challenges that these urban areas are facing. This exploration will not look at the entire city model in its attempt to offer a solution but will, however, focus on technology and ecological interventions that can be incorporated at household and neighbourhood levels. The model is based on the two pillars of technology (smart-city concepts) and ecology (ecological wisdom concepts).

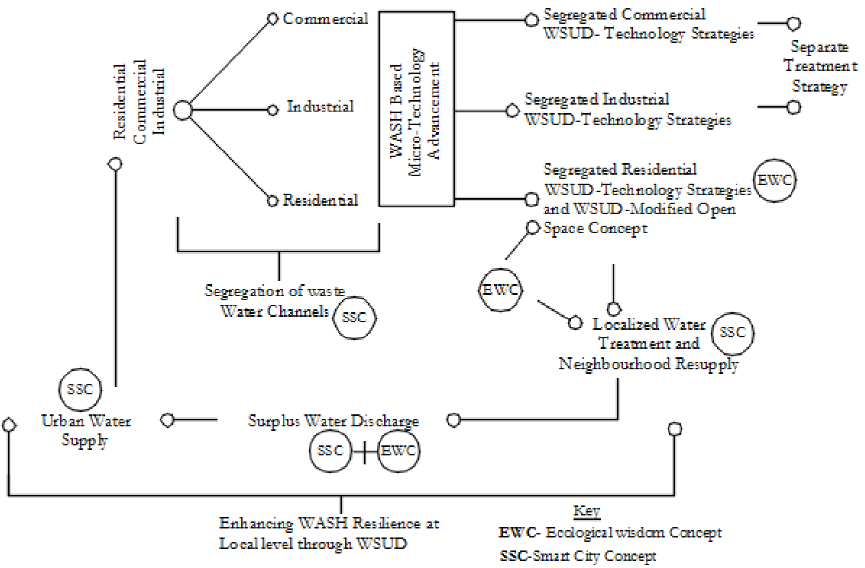

Figure 9: Theoretical Framework for Resilience-based Localised Neighbourhood WASH-WSUD Model (Author, 2020)

In positing the development of WASH-enhanced resilient urban settlements, it is critical to use a modular approach that focuses on the individual neighbourhood as a key component of the urban settlement. This allows the development of solutions for both formal and informal neighbourhoods.

Formal/Serviced Neighbourhoods

The take-off point is to segregate waste-water from urban land-uses. This entails the segregation of residential, commercial and industrial waste-water channels. At neighbourhood level, this is easier to facilitate as all waste water is household derived. Household waste-water is treated using black water treatment technologies, such as aerobic digesters and grey-water recycling systems. The discharge is collected and treated using local water distillation plants. The locally treated water is then stored (retained) using neighbourhood ground and underground reservoirs and re-supplied to the neighbourhood. A surplus is then channelled into SFW-CWs. These wetlands double as surface water retention systems and aquifer recharging sources. Excess water is discharged into urban hydrological systems for potential use by downstream neighbourhoods. The conventional centralised water supply system can continue to function with a new enhanced role of acting as an intermittent recharge system for the closed loop neighbourhood WASH-WSUD water recycling system. This is illustrated in Figure 10.

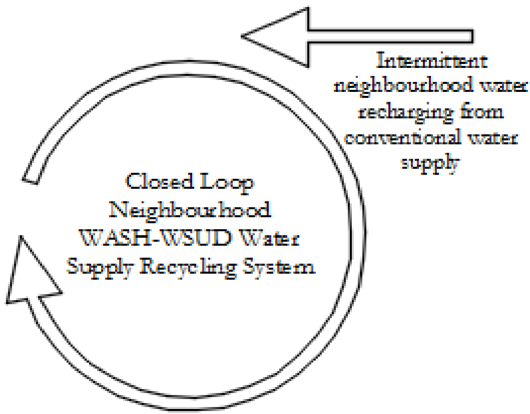

Figure 10: New role of conventional water supply system (Author, 2020)

INFORMAL-UN-SERVICED SETTLEMENTS

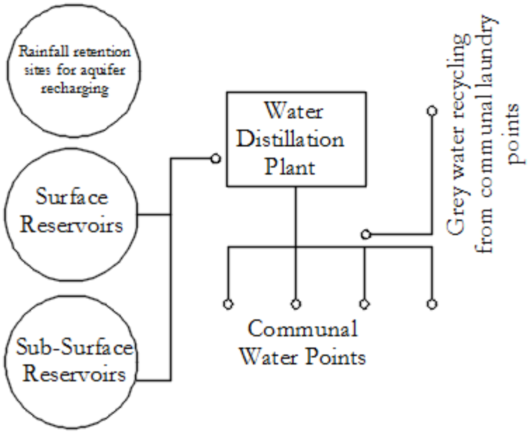

Figure 11: Informal settlement WASH-WSUD Model (Author, 2020)

In the case of informal un-serviced neighbourhoods, the WASH-WSUD strategy is varied marginally but can be equally effective in supplying short to medium-term water requirements for the year. Rainfall water is harvested using basic rain-water collection infrastructure and stored in surface and sub-surface reservoirs. Where dry solid waste treatment techniques are used, such as the Ecosan toilet system, surface water retention sites may be deployed for aquifer recharging. Water collected in reservoirs is then treated using potable water treatment technologies, such as the Rainmaker™ and distributed to communal water points. Grey water, from communal washing points, can be collected and treated using grey-water treatment technologies and re-used locally.

DISCUSSION

The outbreak of the novel Coronavirus has ushered in a new world order in that water, sanitation and hygiene have to be put into context for informing policy and practice of urban resilience (Amin and Ofori-Asenso, 2020). The COVID-19 pandemic is a wake-up call for urban planners and municipal bureaucrats to integrate WSUD and water smart cities into their policies and practices and this includes peri-urban informal settlements (Neal, 2020:2).

The existing model for water supply and treatment in the case of Harare is now clearly inadequate as a centralised distribution and treatment approach can be easily disrupted by single occurrence natural disasters, such as earthquakes, infrastructure damage, accumulated contamination and mismanagement. This water supply and treatment model is also prone to on-going events, such as climate shift. A new approach is required and the COVID-19 pandemic can be a key catalyst in driving new models in water sanitation and hygiene in urban areas. Extreme events that impact humanity, such as the world wars and HIV & AIDS have had the intrinsic ability to bring divergent groupings of society together to develop solutions. The COVID-19 pandemic is not dissimilar. This pandemic has affected all sectors of society and can be the 'glue' to bring together previously polarised and unlinked sectors of society to develop new collaborative pathways.

In terms of facilitation and implementation, key actors already exist in the current country structures. Research and Development (R&D) institutions, namely universities and polytechnics, have been doing research in WASH-related urban challenges. Global organisations, such as the United Nations, have been facilitating WASH implementation and relief strategies through their various sub organisations such as UNDP, UNICEF and UN-HABITAT. Local authorities in Zimbabwe have, over the last few years, been facing challenges with water supply and treatment for their ever-growing urban environs. The COVID-19 is a new challenge and, as such, requires new solutions and enhanced collaborations between the various urban spatial planning actors. With the technological innovations of the fourth industrial revolution (World Economic Forum, 2020), it is now possible to develop new urban water and sanitation hygiene models that will be centred around decentralised WSUD and cater for both formal and informal settlements.

The strategy for deploying the innovative WASH-WSUD model proposed in this article can be predicated on the theory of Diffusion of Innovations (Rogers, 2012). Despite the socio-economic challenges that Harare is currently facing, the city has nodes that demonstrate peculiarly unique and interesting confluences of social cohesion and collaboration. Two examples come to mind, namely the suburban community surrounding the Monavale wetland area and the Homeless Peoples Federation Dzivarasekwa housing project. These urban communities have the distinct characteristic of coming together to devise solutions to the challenges they face. Such examples of "innovator" communities, with their open-mindedness, could be utilised as case studies for the implementation of the WASH-WSUD model. Once it is demonstrated that social cohesion and livelihood improvement determinism, coupled with innovative WASH technologies can guarantee improved resilience, educational and public awareness programmes could be launched to propagate the model to other communities in Harare. With the support and facilitation of the local authority, R&D institutions and development facilitators, such as the World Bank and United Nations, these innovator communities could practically demonstrate the viability of new WASH models as tools towards the realisation of short and medium term urban sustainability and resilience.

CONCLUSION

This article sought to demonstrate the practical application of existing WSUD concepts in conjunction with available market technologies to create enhanced hygiene resilience at neighbourhood level. It has been established that there are possibilities for being innovative in developing solutions that will ensure guaranteed water supply to the residential environs of Harare. The urban planning challenges that the world is experiencing today require not an only financial investment, but most importantly innovative intellectual investment that focuses on viewing challenges from new perspectives and developing pathways towards new unprecedented solutions.

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