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CHALLENGES IN CIRCULAR URBAN WATER MANAGEMENT IN CONSTRUCTION INDUSTRY OF SRI LANKA

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Abstract: Construction industry can be known as one of the prominent natural resource consumers compared to all other industries. Among these natural resources, water can be identified as one of the major concerns worldwide at present. Especially in urban area water distribution for essential activities of human beings is also becoming a challenge in most of the countries. As the consumption of natural resource is considerably high in construction industry, moving towards sustainable construction has been recommended. The linear approach, which the construction industry has been practising for years related to all kinds of resources, has become a threat towards the sustainable construction. Construction sector accounts for about 30% of the world's freshwater consumption. In Sri Lankan construction industry, the focus on management of water is limited. Among the natural resources urban water holds a significant place. While highlighting the importance of urban water management, this paper aims to explore the key challenges in circular water management in Sri Lankan construction industry. 12 semi-structured interviews with industry practitioners and academic experts on circular economy were conducted and the data were analysed using manual content analysis. The findings revel that most of the challenges in implementing circular water management in the construction industry in Sri Lanka are due to lack of awareness, realisation, involvement, and commitment by both citizens and the government. Hence the paper has recommended 6R concept towards implementing circular urban water management within the Sri Lankan construction industry as the authors believe that managing urban water is one of the significant actions to be considered now before it becomes too late in achieving long term sustainability.

Keywords: *Circular Economy, Construction Industry, Urban Water Management, Sri Lanka*

1. Introduction

Human aggression against the Earth's system is reflected in climate change and changes in natural cycles such as water, carbon, nitrogen, resulting in land degradation and desertification (Tarrasón et al., 2016; Vu et al., 2014). Among the human aggressive activities, construction activities take a considerable rank, since these activities have an exponential impact on the environment, such as; particulate matter (PM), greenhouse gas (GHG) emissions, noise pollution, waste generation, water consumption and air pollution (Dräger & Letmathe, 2022). According to Purchase et al. (2021) the natural resource utilisation by the construction industry has been estimated as 32% approximately leading towards scarcity and over reliance. Among all the natural resources, water plays a pivotal role in human lives as well as the foundation of human survival and well-being, while playing an important role in many sectors of the economy (Voulvoulis, 2018). It has been identified that the construction sector accounts for about 30% of the world's freshwater consumption (Hong et al., 2019). Additionally, the world is expected to be half of the population water-stressed by 2025 (Hewavitharana et al., 2019) . Supplying water in urban areas has become one of the crucial obstacles due to the rapid urbanisation took place in last few decades (Giordano & Shah, 2014; Pearlmutter et al., 2021). As a result of urbanisation, the global water resources have faced grave challenges due to desertification of lands due to soil erosion including some European countries such as Spain, Portugal, Southern Italy (Angelo et al., 2001). Urban water can be identified as; natural surface water, ground water, drinking water, sewage, storm water, flood overflow water and recycled water in urban areas (Oral et al., 2020). Chan et al. (2018) stated that in global context, water scarcity, surface water flooding and pollution of fresh water are few of the recurrent concerns related to urban water management and out of all of these concerns, water scarcity has taken the prominence among water related issues. The primary reason towards the water scarcity is the linear approach of water consumption (LuoID et al., 2019), for instance when referred to the traditional way of extracting fresh water; extracting from natural resources and using potable water for human needs and disposing of it afterwards into natural water bodies as waste (Daigger, 2009). The implementation of circular management in the water sector is to stand against water scarcity and defeat current problems created due to the liner approach of water consumption (Voulvoulis, 2018). In

construction industry, a considerable amount of water is used for concrete mixing (nearly 500 L freshwater for every m3) (Ghrair et al., 2018). Besides, a substantial amount of fresh water will be used even during the process of concrete curing (Ghrair et al., 2018). The high usage of fresh water and improper practices of water management within the construction industry have negatively affected towards the natural water cycles (Varshney et al., 2021).

In Sri Lanka (SL), Colombo which is the most urbanised city in the country, is currently facing a major water crisis due to the increasing demand and shrinkage of existing natural resources (Wickramasinghe, 2019). Parallel to this, in the Environmental Management and Monitoring Report, it has been clearly stated that in urban areas such as , Vauvniya and Mannar inadequate and poor water supply exists in major (Ocyana Consultants & Ltd, 2016). Further, in the study carried out by Waidyasekara et al. (2016) they have specifically highlighted the necessity of managing water, an already scarce resource, during the construction activities in Sri Lanka. In 2023, the Export Board of Sri Lanka also has declared that the water management practices in the construction industry is yet to be recognised in depth (Sri Lanka Export Development Board, 2023). Moreover, the World Bank in 2021 in one of their reports has stated that in the Sri Lanka's economic growth story water resource acts a major role and effective usage of existing water resources is an essential factor in Sri Lanka (The World Bank, 2021). Joshi et al. (2022) have highlighted that as the construction industry consist of different types of projects with different activities and technologies which has the requirement of water, the industry pollutes water in various methods. This confirms that the attention towards the water management within the construction industry is important. In Sri Lankan context specifically, there are only few research studies available in this area (Waidyasekara et al., 2016). Also, there is dearth of research that specifically focuses on circular urban water management related to construction industry within Sri Lanka. Hence, while establishing the need for circularly managing the urban water in the construction industry in Sri Lanka, this paper aims to explore the key challenges in circular water management in Sri Lankan construction industry.

2. Literature Review

Over the past few decades, global urbanisation has increased exponentially, coincided with the growth of the human population, and the use of material resources has increased (Purchase et al., 2022). The acceleration of global urbanisation is expected to reach 68% by 2050 (Nations, 2018). Due to urbanisation, the demand towards the construction sector has also increased. The relationship between urbanisation and demand for building materials is rigid (Augiseau & Barles, 2017). As the population increases, resource consumption also increases by defect, and by 2050 global material consumption is expected to reach about 90 billion tons (IRP, 2018).Construction uses a large percentage of natural resources (32%) (Yeheyis et al., 2013), and its water resource consumption is significant (Bardhan, 2011); for instance, it is about 50% of freshwater (Dixon, 2010). Further, it has been recognised that construction activities are one of the major contributors towards water pollution (Shen & Tam, 2002). In this study the main focus is on the "water" as it is one of the limited and most essential renewable natural resource.

Water is the most valuable natural resource, which plays a significant role in human well-being, socio-economic development, and sustainable ecosystem (United Nations Environment Programme, 2009). Also, it is an essential resource for all living beings (Nika et al., 2020). Undoubtedly, water is connected with the development of any country and it is the core of the production and conservation of many benefits and services for human beings and ecosystems (Colella et al., 2021). Issues related to Water Management (WM), such as water scarcity, surface water flooding, and freshwater pollution, are occurring more frequently worldwide (Chan et al., 2018). Most freshwater entering the city is used for consumption, while the rest is polluted, treated and emitted (Pradhan et al., 2019). To solve problems currently various technologies are being used in cities such as; improving water efficiency and water demand reduction technologies, water-sensitive urban design technologies, river flow, environmental water and the protection of natural wetlands, waterways and estuaries in urban landscapes(Bureau of Meteorology & Australian Government, 2020).

2.1. URBAN WATER MANAGEMENT (UWM)
Water supply, urban drainage, waste water treatment and wastewater management are the four central schemes in UWM. Additionally, UWM consists of planning, designing and operating infrastructure for the protection of drinking water and sanitation, control of stormwater infiltration and discharge, recreational parks and urban ecosystem maintenance (Larsen & Gujer, 1997). More than 80% of the world's wastewater is discharged without treatment; according to the 2017 World Water Development Report, wastewater continues to be an "unexploited resource" (Boretti & Rosa, 2019). Therefore, it is expected to practice more sustainable practices as a way forward towards Circular Economy (CE) in the waste water and water sectors. The Western Region has the most energy and water-intensive construction activity when considering the global conception due to its backward economy and outdated technology development (Hong et al., 2019). Concrete production consumes the highest percentage of water among all the other construction activities. The concrete production was responsible for 9% of industrial water withdrawals worldwide in 2012 and it has been pointed out that in 2050 75% of cement production's water demand will probably occur in regions predicted to be contaminated by water stress (Miller et al., 2018). Besides, a considerable amount of fresh water will also be used during the concrete curing process (Ghrair et al., 2018). Reducing water consumption and improving building water efficiency are essential in sustainable water management in Built Environment, but the Strategic Construction Forum emphasises that water use during construction is considered a low priority (Waylen et

al., 2011). As water management in the built environment is essential, some researchers have researched water efficiency in the construction phase of buildings, while others have studied various water efficiency measures in the construction phase (Carragher et al., 2012).

Although natural water flows around the world, human management of water is usually linear (Eric Poste Nancy Stoner, 2012). Hence, natural water flows are being polluted by unhealthy human activities. Without treating for the cause towards deteriorating water sources, wastewater has been treated for an extended period (Lofrano & Brown, 2010) which has mislead the relevant regulatory bodies relevant to environmental protection. CE approaches are aimed at eliminating waste and the concept of "end of life" through deliberate recycling and reuse of materials, products, systems and business models (Ellen MacArthury Foundation, 2013). Different studies have been conducted on the environmental management of other streams of waste such as waste water (Guerra-Rodríguez et al., 2020) and wastewater sludge (Gherghel et al., 2019) towards the concept of CE.

2.2 CIRCULAR CONCEPT TOWARDS WATER MANAGEMENT

The CE concept entails creating a regenerative system that keeps products and resources in a closed 'take-make-use' cycle, minimizing resource consumption, waste generation, emissions, and energy leakage. At the "end of life," scrapped items are used to create new materials (Geissdoerfer et al., 2017). The reduce, reuse, recycle, and recover waste management principles are the foundation of the CE theory (Hu et al., 2011; Winans et al., 2017). Waste is viewed as a resource under the CE paradigm, and there are potential to manage wastewater sustainably from a CE perspective. Waste water consist of different resources within it such as, water, energy and material which can be further used in different ways (Mo & Zhang, 2013). The water development report from the United Nations Educational Scientific Cultural Organization (Smakhtin et al., 2020) suggests that in the context of water scarcity and climate change, safe water reuse, or recovered water, is a dependable unconventional water resource. Reusing wastewater and its components can also cut down on greenhouse gas emissions. This emphasis has sparked discussion on the possibility of employing the developing CE concept to fulfill Sustainable Development Goal (SDG) 6's economic and environmental objectives by reusing water and recovering nutrients and energy from sludge. (Abu-Ghunmi et al., 2016; Mbavarira & Grimm, 2021). CE techniques frequently assist SDGs that increase waste recycling, decrease waste generation, and promote material circulation, as has been demonstrated in other industries (Schöggl et al., 2020).

A conventional flow of water and its exchange between various components is illustrated with the help of Figure 3.
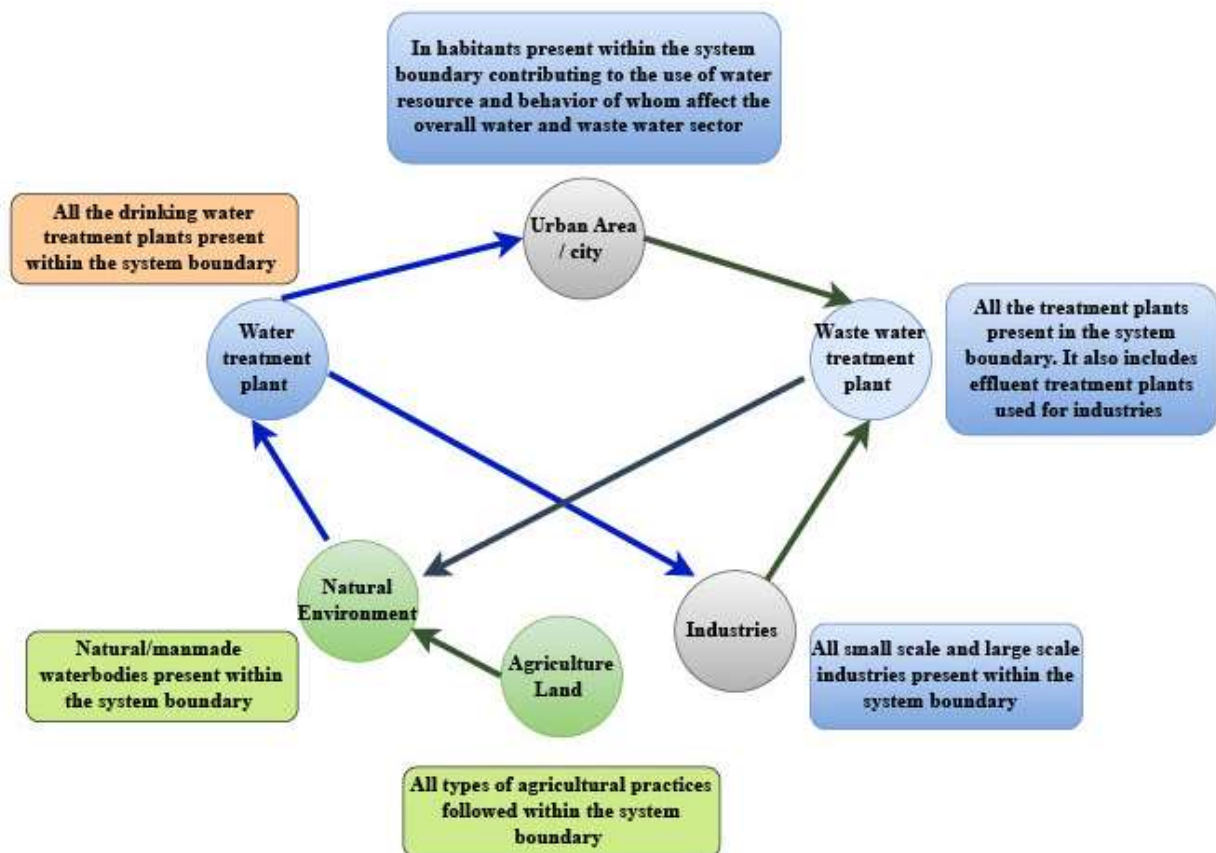

Figure 1 - Convectional Water Usage (source- Kakwani & Kalbar, (2020))

Due to different exchanges and interactions between the elements within the urban water management system, it has a complex nature and due to the liner management of water it has become more complex. As a result of this complexity, CE provides pathways to manage water resources in a sustainable manner. Extensive work has been

carried out (Kakwani & Kalbar, 2020) in a disaggregated form on wastewater 6Rs that refers to reduce, reuse, recycle, recover, remanufacture, and redesign. However, CE must take a multifaceted perspective in order to effectively integrate these tactics. Additionally, there is ambiguity in the terminology used to describe the 6Rs, such as reuse and recycling, across all industries, but it is particularly noticeable in the water sector (Blomsma & Tennant, 2020). Even though there are exiting literature on water management, only few literature has focused on challenges towards the CE implementation within the water sector in urban areas within the construction industry. Thus, to fill this gap, review of CE in the water sector in urban areas is primarily required to assess the potential of CE in the water management within the construction industry. Further, this paper focuses on 6R principle towards water management in urban areas related to the construction industry in Sri Lanka.

3. Methodology

A qualitative approach has been adopted by this study. As stated by Yin (2011) a qualitative research methodology offers researchers the chance to fully comprehend unique and emerging themes in comparison to other research methodologies. The background study discovered that Sri Lanka's construction sector only has rudimentary expertise of using CE for water management. Due to this, it was more difficult to compile a significant sample of responders for the data collecting operation. In this situation a qualitative research approach was chosen based on literature suggestions as the existing knowledge about the study area is minimal and little opportunity to gather a large sample. In a qualitative study the sample size can be expressed through the concept of "diminishing returns" (Ritchie et al., 2013) or "saturation" where obtaining new information from collecting more data is not always the case (Mason, 2010). In qualitative investigations, it suffices to identify a single piece of data or code for it to be added to the analysis framework (Mason, 2010) unlike in quantitative studies, where the frequency with which a data point appears indicates its significance for the study.

In this study, as the most suitable data collection method semi-structured interviews were selected in accordance with the qualitative research approach used and based on the research problem. Semi-structured interviews allowed the researcher to simultaneously collect any additional information provided by respondents during the data collecting process and collect particular information for comparisons. Saunders et al. (2009) interviews can be described as a focused conversation between two or more people that enables the development of insightful and in-depth knowledge about a certain field of study. Through in-depth discussions with experts it offers the chance to getting the perspective of subject-matter and experience (Dawson, 2007). Etikan (2016) also mentioned that experts in a particular field are the subjects of purposive sampling. Accordingly, industry practitioners who could demonstrate sufficient knowledge and understanding on urban water management and circular economy principles in the context of construction industry were recruited using purposive sampling method. The profile of the respondents is shown in Table 1. Manual content analysis was carried out to analyse the primary data gathered through the semi-structured interviews.

Table.1 - Respondent's Profile

Respondent	Experience	Occupation	Background
R01	24 years	Project Manager	Contracting and consultant background
R02	5 years	Project Manager	Contractor
R03	23 years	Architect	Design and Consultant
R04	14 years	Architect	Consultant
R05	12 years	Site Engineer	Contractor & Green rating procedures
R06	13 years	Environmental Engineer	Contractor
R07	10 years	Site Engineer	Consultant
R08	20 years	Quantity Surveyor	Contractor
R09	8 years	Quantity Surveyor	Contractor
R10	15 years	Project Coordinator	Consultant
R11	25 years	Project Director	Service provider
R12	9 years	Managing Director	Service provider

The number of interviewees was limited to 12 since the study reached data saturation by the 10th interviewee and to justify the saturation point, two more interviews were carried out. According to O'Reilly & Parker (2013) data saturation is achieved when enough information is available to reproduce the study.

The semi-structured interviews mainly captured, the significant activities of water consumption within the construction industry, the current practices followed to manage urban water in construction and the challenges of effectively managing circular water in the construction industry of Sri Lanka.

As the "member checking" is a key component of quality research validation (Koelsch, 2013) the analysed qualitative data were finally validated with all the 12 interview respondents.

4. Research Findings and Discussion

The main activities with regard to the water consumption in the construction industry are presented in Figure 2.
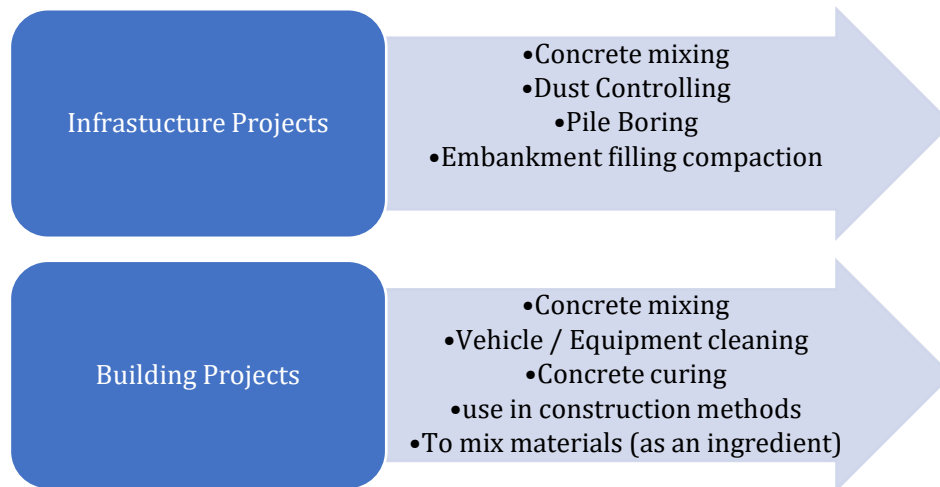

Figure 2 - Activities of water consumption in construction projects in Sri Lanka

Figure 1 shows the key activities that consume water in both building and infrastructure projects. In comparison to the building projects, infrastructure projects such as roads, bridges, and culverts consume a considerably higher amount of water. The major activity which consumes the highest amount of water in both building and infrastructure projects is concrete mixing. In addition, dust controlling and embankment compaction in infrastructure projects, consume a considerable amount of water.

4.1 SIGNIFICANCE OF URBAN WATER MANAGEMENT IN THE SRI LANKAN CONSTRUCTION INDUSTRY
The respondents mentioned that for infrastructure projects such as roads, bridges, highways and airports, natural water resources like rivers, lakes and canals are used to access water for construction whereas for building projects in urban areas, water is provided by NWSDB (National Water Supply and Drainage Board). Further, respondents stated that in urban areas, due to various reasons such as cost and high demand, contractors tend to extract water from the nearest natural water reservoir.

The experts acknowledge that the water management is not considered significant by most of the construction practitioners in Sri Lanka, as they haven't seen the threat with water scarcity yet. Hence the construction industry in Sri Lanka has not paid adequate attention towards the management of water throughout the construction process. However, R06 stated that *"even though the water consumption is not currently a concern in Sri Lanka, due to the environmental unfriendly activities done by the man kind all over the world, in near future Sri Lanka also will face water scarcity as environment doesn't have boundaries"*. All the respondents agreed the fact that water in construction has to be managed properly specifically in large scale projects. Currently, majority of the water requirements for the construction are provided through natural water reservoirs and the used water is disposed back to water reservoirs without any purification. These actions have directly caused damages in natural water cycles and water pollution. Respondents highlighted that the purification methods or water management are not much of a concern of the construction stakeholders and authorities, unfortunately.

Releasing polluted water to the natural water reservoirs has become one of the major issues in some areas in Sri Lanka as some of the citizens directly obtain water for their day-today activities such as domestic food production, from natural reservoirs. Further, respondents stated that the method of supplying water for the construction project is based on the clients' requirements. In some major projects obtaining water in an organised manner will cost high. Therefore, if the client is not willing to spend money on obtaining water in an organised manner the contractor will have to supply water for the project in an unorganised manner. In a scenario like this, obtaining water from the natural resources for construction activities is considered as the most economical method. Few respondents emphasised that the methods of using water resource change according to the location of the construction project, type of construction and sometimes on the client's preference if they want a particular type of water resource.

All respondents indicated as the water resource is essential for all kinds of construction works in Sri Lanka, there is a necessity of managing water resources in the Sri Lankan construction industry, especially in urban areas due to the high demand in urban areas. The experts quoted '*there is high demand in urban areas of Sri Lanka. The construction progress get severely affected during the time there are water cuts*' (R03,R06,R07). R08 further added "*if Sri Lanka did not receive rainwater for a considerable period of say 2-3 months, water and electricity supply would be interrupted in*

urban areas". Thus, the respondents agreed that supplying water for large-scale projects without any interruptions has been an issue in an urban area. Specifically in Colombo, providing water for construction works has been difficult and costly.

While agreeing to the fact that there is no proper water management strategy implemented at the construction sites in Sri Lanka, all respondents emphasised that, it is necessary to manage urban water efficiently to ensure long term sustainability in the construction industry. When the circularity concept in managing urban water was explained, the experts responded that the construction industry shall face several challenges in effectively managing circular urban water consumption and disposal due to the lack of awareness on this concept. The explored challenges are discussed in the following section.

4.2 CHALLENGES TOWARDS CIRCULAR WATER MANAGEMENT IN SRI LANKA CONSTRUCTION INDUSTRY

Sri Lanka is in a primitive stage of water management and circular water management is a whole new concept for the construction stakeholders. Therefore, Sri Lankan construction industry will face several challenges in implementing circular water management. Figure 2 shows various challenges towards implementing circular water management in the Sri Lankan construction industry gathered from the semi-structured interviews.
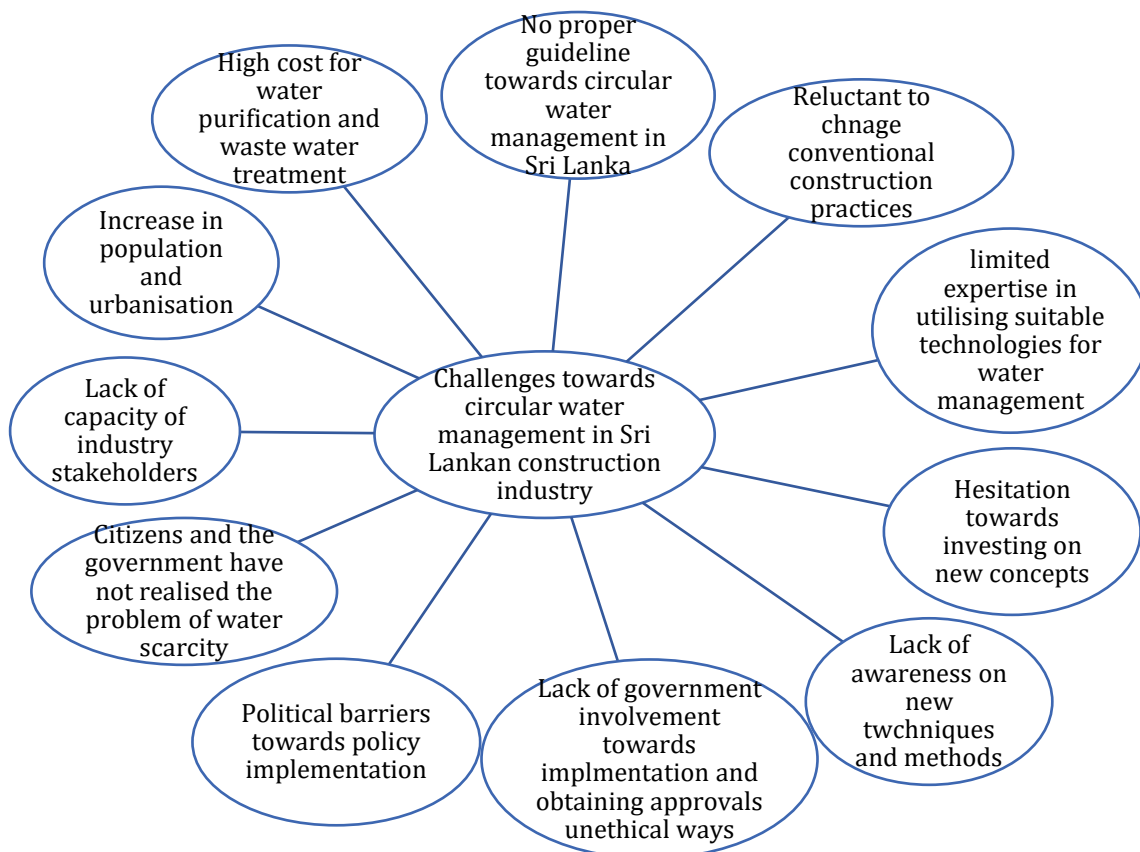
Figure 3 - Challenges towards circular urban water management in Sri Lanka

Most of the challenges shown in Figure 3 indicates that there is a considerable level of lack of knowledge, awareness and commitments among the citizens and government in achieving sustainability through circular water management. Besides, there is always a reluctance in changing the conventional practices and adopting new concepts. This has resulted in the absence of guidelines or policies to implement circular water management. The respondents believe that all of these challenges are due to the fact that the water scarcity in construction has not been realised by the construction stakeholders and by the government, in the current context. As a results, the government or the construction stakeholders think that there is no need to take any measures to manage urban water, by completely missing the point that we are not very far from getting affected by scarcity of water.

As stressed by the experts, educating citizens and other government authorities about the necessity of water management is therefore important. In addition, the experts highlighted that we, as one of the as developing countries, shall face technical and financial barriers such as increase in population and urbanisation, high cost for water purification and waste water treatment, and limited expertise in utilising suitable technologies for water management.

4.3 WAY FORWARD IN MANAGING CIRCULAR WATER IN SRI LANKA CONSTRUCTION INDUSTRY

The main concern of the interview participants was that the perspectives of construction stakeholders towards circular water management. According to the interviewees, the circular water management in Sri Lanka has to be implemented systematically. Specifically in urban areas in Sri Lanka, when the demand is high (peak hours), water

supply has become a greater problem even to manage essential day-to-day activities. Hence, providing water for construction activities in urban areas is solely based on natural water reservoirs. Nevertheless, several challenges towards implementing circular urban water management in the Sri Lankan construction industry have been identified. It was highlighted that the regulatory bodies should identify the necessity towards management of urban water used for construction industry and develop necessary regulatory policies and guidelines to be followed in the industry. A common thought highlighted by all the respondents was that, as a developing country mere development of policies and regulations are not sufficient, but strict implementation of such policies and monitoring mechanisms are essentially followed. They further added that we shall impose restrictions when the construction projects do not have a proper water management plan. However, the respondents mentioned that circular water management in the industry will be limited to the activities other than the ones where the water is used as a material such as concreate mixings. Further they emphasized, when considering the cost and structural features of these items using an alternative other than water might not be practical.

Respondents with the industrial experience recommended 6Rs strategies in the water sector to achieve circularity of water and wastewater resources. Collaborating all the industries (refer Figure 1) in terms water, will allow the industry to practice 6R principle of CE. Although considerable research (Kakwani & Kalbar, 2020) has performed in the field of water under different topics such as; water conservation, wastewater reduce, reuse, recycle, reclamation, recovery, and restoration, contextualizing these topics from CE perspective is needed in an urban environment. Thus, 6Rs relevant to the water sector to achieve CE implementation can positively effect on the water management within the construction industry.

5. Conclusions

Sri Lanka, as a developing country is in a need of developing the socio-economic factors of the nation. Hence the development of the construction industry is significant. On the other hand, the environment pollution caused by the construction industry has also increased significantly. Construction industry has been recognised as one of the highest resource consumers compared to other industries. This is mainly due to the linear traditional construction practices in the industry. This paper has discussed urban water management in the construction industry. Managing the water in a circular manner would help to sustain the water as water is considered as a scarce resource in global context. However, this fact has not been realised by many of the construction stakeholders, and the government, since water scarcity is not considered as a threat in Sri Lanka in the present context. The purpose of the paper is to highlight the significance of managing urban water in the construction, explore the challenges in managing urban water in Sri Lankan construction, and to stress the importance of considering circularity in water management in Sri Lanka using 6R principles.

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