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STUDY ON THE APPLICABILITY OF SPONGE CITY CONCEPT TO FLOOD RESILIENT IN SRI LANKAN CITIES

BORALESGAMUWA AND SUB URBAN AREAS.

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Abstract: In the last few decades, climate change and urbanization have made natural disasters worse all over the world. This has increased the likelihood of flash flood disasters. The purpose of this research is to determine if the six key processes (retention, detention, infiltration, purification, storage, and drainage system) of the China sponge city concept have been accounted for in the projects carried out to construct flood-resilient towns in Sri Lanka, as well as the influence of flood mitigation. This research has identified projects that have adapted the concept's main processes by reviewing the report of the Weras Ganga Development Plan, conducting key informant interviews, and a field survey. As a result, flood height is reduced in Boralesgamuwa and sub-urban areas. But some stages are missed because the SCC is not applied as a concept to flash flood control projects in Sri Lanka.

Keywords: *flood resilience, key processes, magnitude, sponge city concept*

1. Introduction

Flash flooding is a type of flooding that occurs within a short period of time after a precipitation event, usually less than six hours. It is more likely in locations near rivers and lakes, but can also occur in areas with no surrounding water bodies. (Camp,2022b). It is more likely where waterways are small and steep, and impervious surfaces such as highways and concrete prevent water from draining into the earth. It is a major issue in Sri Lankan cities, but mitigation and adaptation can be done. (Met Office, n.d) Climate change and inadequate drainage systems are major causes of flash floods, and planners are trying to reduce the impact and create more positive effects. (Thu Thuy, Huu Hao, Wenshan , Xiaochang & Nanqi, 2017)

Water security planning has traditionally relied on "grey infrastructure" such as reservoirs, aqueducts, and treatment facilities. However, natural infrastructure, such as forests, wetlands, and rivers, ecosystems, can provide long-term, cost-effective solutions. Investment in nature within and outside cities can be a low-cost way to secure water supplies, minimize sediment and nutrient pollution, and manage flooding hazards. Sustainable green buildings, permeable pavements, urban parks, and safe flooding zones can help people see rainwater as a resource rather than a problem. Wetlands and lagoons can also play a cost-effective role in cleaning sewage before releasing it into rivers, streams, lakes, and aquifers. (Cross et al., n.d.). Nature-based climate change solutions are more cost-effective than constructed alternatives and provide 28% more value than grey infrastructure. China's "sponge city" concept has been successful in controlling flash floods, with 30 cities implementing it by 2030. (*How "sponge Cities" Can Help Protect Against Flooding*, 2022).

Flash flooding is becoming a common occurrence due to the shift in weather patterns since the 1970s, which has increased the risk of flooding in the Colombo Metro Area. (*Sri Lanka: Colombo's Wetlands Float to the Top of Flood Prevention Plan*, 2018). Sri Lanka has seen repeated floods over the past fifteen years, affecting almost all of the districts. Colombo has been affected by annual floods that affect more than 1.2 million people for the past 30 years due to illegal structures, waste being dumped in drainage canals, blackwater accumulation in the main canal system, irregular drainage system maintenance, and commercial development in wetland reserves. These floods caused serious property damage, costing Colombo millions of dollars in economic losses. (*Disaster Information Management System in Sri Lanka*, n.d.)

Sri Lanka is reducing its risk of flood disaster by following the Sendai framework (2015), and the National Disaster Risk Management Policy (2005), the National Emergency Operations Plan (2017). Institutional frameworks are made for early warning systems and a Post-Disaster Needs Analysis (PDNA) for big disasters. However, there is a problem with how well actions and approaches are put into practice.

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The Chinese People's Republic (PRC) has encouraged the creation of so-called sponge cities, which are designed to collect, clean, and use precipitation in a way that is environmentally sustainable and prevents harmful and polluted runoff. These cities are known to have permeable roads, roof gardens, constructed wetlands, rainwater collection, green areas, and blue areas like ponds and lakes. Harvesting rainfall during dry spells is an example of how green and gray measures should be linked to build resilience. (*Sponge Cities Mission in India to Cope with Urban Floods*, n.d.) (Asian Development Bank & Rau, 2022)

Table 1: Ranking of sponge cities

Country	Rank	Sponge rating	Reason
Auckland, New Zealand	01	35%	stormwater infrastructure, numerous golf courses, green parks, and vast private gardens.
Nairobi	02	34%	
New York , Mumbai , Singapore	03	30%	
Shanghai	04	28%	
London			high concrete percentage and poor soil absorption.

(*Sponge Cities Mission in India to Cope with Urban Floods*, n.d.)

According to Arup "nature-based climate change solutions are 50% more cost-effective than constructed alternatives and provide 28% more value than grey infrastructure". Countries like Australia, China, Japan, and India prioritize green infrastructure over grey infrastructure. (*"Nature-based Solutions": Using Digital Methods to Investigate Corporate Greenwashing*, n.d.) For instance, low-impact development was first presented by Barlow et al. in 1977 and is most often used in New Zealand and North America; water-sensitive urban design (WSUD) began in Australia; and the sustainable urban drainage system (SUDS) was developed in the 1990s and is widely used in the United Kingdom. Singapore's water body, the Public Utilities Board, launched the Active Beautiful Clean (ABC) Waters Programmed in April 2006. (Zongmin, Shuyan, Liming, n.d.) Although China introduced the sponge city concept to the world, countries like the USA, Australia, the UK, India, etc. have done research in this regard. About 60% of Sponge City research comes from the top four countries, which are the United States, China, England, and Australia. They also publish the most in this area. (Zongmin, Shuyan, and Liming, n.d.) Through the main processes (infiltration, storage, bio-retention, detention, purification, and drainage systems) in that concept, flash floods have been mitigated. The idea of lowering the flood risk in terms of grants is more valuable for a nation like Sri Lanka, which is experiencing a severe economic crisis and has a wealth of natural resources. The flash flood effect and other issues will be resolved by looking for solutions to these issues. The main objective of the study is to examine whether the implementation of the Sponge City concept has improved flood control with reference to Boralesgamuwa and its surroundings in Colombo, Sri Lanka. And the subobjectives are identifying the extent to which the processes of the sponge city have been applied to flood control projects in the Weras Ganga Basin of Sri Lanka and studying how far the flooding has been mitigated after implementation of the project.

2. Methods and materials

2.1 THEORITICAL FRAMEWORK

This study aimed to investigate how the sponge city concept may be used to make Sri Lankan cities more flood-resistant. This study finds out if the six main processes of the sponge city concept have been taken into account in projects to build flood-resistant towns in Sri Lanka, as well as what effect flood mitigation has had. The idea of Sponge City has not been implemented in Sri Lanka. However, the six application processes will be the main emphasis. It is planned for the initiative's influence to be felt in the area where it has been implemented, and a main study being conducted in Sri Lanka will ascertain whether those protocols have been followed. Flood resilience is a term that means damage from flooding is kept to a minimum, there is enough space for flooding and river changes, cleaning up after a flood may cost less, and the water resource is not hurt and can recover on its own. It helps people and communities deal with flooding and plan for it.

Table 2: Key processes' definition and practices of sponge city concept

Key processes	Definition	Practices	Sources
Infiltration	stormwater runoff enters and pass through the soil's subsurface.	Ponds, Improve Green spaces, Pervious surfaces	("Measures to Promote Stormwater Infiltration," 1997) (Zhang & Chui, 2019)
Retention	A bioretention system, which includes several layers of filter material, greenery, an overflowing weir, and an additional underdrain, is a landscaping depression that collects runoff from upgradient impermeable surfaces. The catchment areas that	Rain Gardens. Retention Ponds Green areas	(Liu et al., 2014) (Post Construction Stormwater Management in New Development and Redevelopment, 2021)

	bioretention cells normally handle are fewer than 2 hectares in size.		
Detention	Stormwater runoff is temporarily stored in a detention basin or pond. By retaining stormwater runoff and discharging it gradually until it has completely drained, the basin is intended to manage it.	Detention pond	(*Detention Vs Retention Basin | Manheim Township, PA - Official Website*, n.d.)
Storage	Large pipes must be made, which is a time-consuming and expensive process.	Lakes, ponds, reservoirs underground rainfall storage tank	(Kim & Han, 2008) (Nguyen et al., 2019)
Drainage system	Stormwater is transported to ponds, lakes, streams, and rivers by a network of buildings, channels, and underground pipelines.	Rain Garden Water-Absorbing Plants. Grassy Swale. Paving Materials. Drainage pipes Infrastructure	(Rio, 2021) (*CHAPTER 6 - DRAINAGE*, n.d.)
Purification	Water must be free of impurities such as suspended solids, gases, harmful compounds, and biological contaminants to be safe for human consumption.	Green areas	(“Water Purification,” 2017)

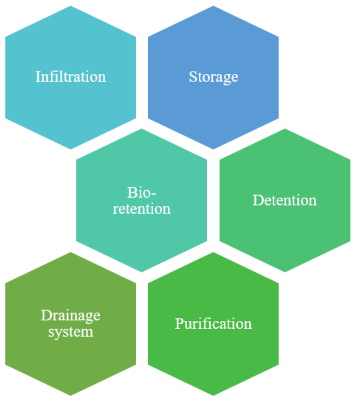


Figure 1: six key processes of SCC

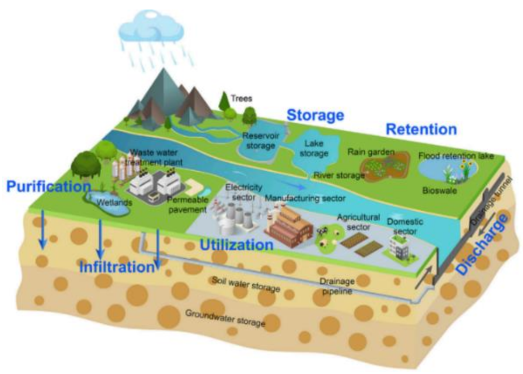


Figure 2: Ground level process of six key processes of SCC

2.2 METHOD OF STUDY

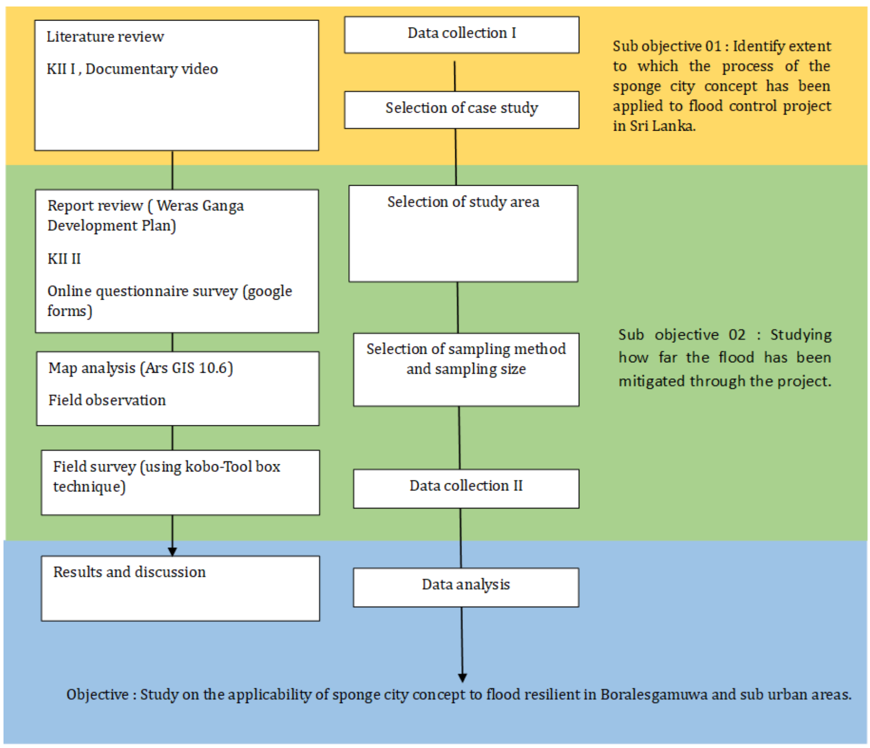


Chart 1: Methodology

2.3. SELECTION OF CASE STUDY AREA AND STUDY AREA

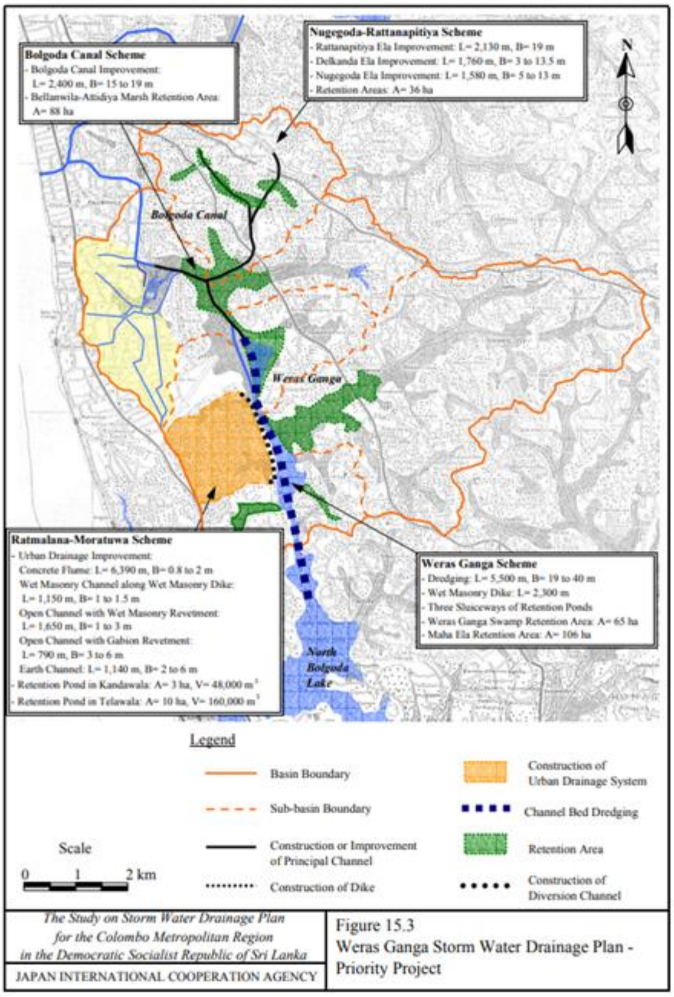
2.3.1 Data collection I and KII I

Opinion of respondent 1 :Environmental scientist of SLLDC	Opinion of respondent 2: Senior lecturer of department of Town and Country Planning , University of Moratuwa

Selecting the most appropriate case study to investigate the six main processes of Sponge City Concept used in flood mitigation and adaptation projects in Sri Lanka based on Key In formant Interview I (KII I) and literature review.

Conclusion of KII I: The Weras Ganga Development Plan, a major project under the Storm Water Drainage Plan for the Colombo Metropolitan Area, was selected.

Documentary review and Key Informant Interview II:
Based on the documentary review : The Sri Lankan Urbanization process has resulted in more uncontrolled land filling and waterway encroachment. During the rainy season, large flooding in Nugegoda, Rattanapitiya, Piliyandala, Boralesgamuwa and Werahera is an appropriate example. In 2003, the SLLDC has created a detailed Master Drainage Plan (Colombo Metropolitan)Region with the assistance of a team from the JICA. Following that research, the ***Weras Ganga Storm Water Drainage and Environmental Improvement Project*** was initiated in 2011.



Map 1: Weras Ganga Storm Water Drainage Plan

The following table shows projects of Weras Ganga Development Plan

Table 3: sub projects of Weras Ganga Development Plan:

1) Weras Ganga Sub-basin

Component Scheme	Measures
(1) Weras Ganga	• Weras Ganga Dredging (L=5.5 km, B=19-40 m) • Flood Protection Dike on Right Bank (L=2.3 km) • Weras Ganga Swamp Retention Area (65 ha) • Maha Ela Marsh and Lowland Retention Area (106 ha)
(2) Nugegoda-Rattanapitiya Scheme	• Channel Improvement of Nugegoda-Ela (L=1.58 km, B=5-13 m) • Channel Improvement of Delkanda Ela (L=1.76 km, B=3-13.5 m) • Channel Improvement of Rattanapitiya Ela (L=2.13 km, B=19 m) • Retention Areas(36 ha in total)
(3) Bolgoda Canal Scheme	• Channel Improvement of Bolgoda Canal (L=2.4 km, B=17-19 m) • Bellanwila-Attidiya Marsh Retention Area (88 ha)
(4) Boralesgamuwa North Scheme	• Channel Improvement of Depawa Ela (L=3.09km, B=6 m)
(5) Boralesgamuwa South Scheme	• Channel Improvement of Werahara Tributary (L=0.98 km, B=15m)
(6) Maha Ela Scheme	• Channel Improvement of Maha Ela (L=2.7 km, B=32 m) • Channel Improvement of Maha Ela Tributary (L=1.76 km, B=15 m)
(7) Ratmalana-Moratuwa Scheme	• Urban Drainage Improvement (L=11.12 km, B=0.8-6 m) • Kandawala Retention Pond (3 ha) • Telewala Retention Pond (10 ha) • Channel Improvement of Katubedda Tributary (L=1.25 km, B=8 m)

Based on the key Informant Interview II

Based on the thematic analysis, infiltration, retention, and flood mitigation can be identified as common themes that each key informant has discussed, respectively.

Code	Highlighted word
1	a soft surface
2	Two retention ponds
2	Papiliana Marshland
1	wetlands
1	absorption
1	the absorbed water is slowly released to the ground
2	paddy fields
2	one side of the canal
2	cultivations on both sides.
1	, the water that falls directly into the groundwater table is stored in the lake without any delay.
2	wetlands
3	reduce the effect of floods
1	the Verus river
1	Conservation of existing wetlands
3	has more green and blue areas
3	to natural base solutions."

Theme	Code	Number of time the code was applied
Infiltration	1	7
Retention	2	6
flood mitigation	3	3

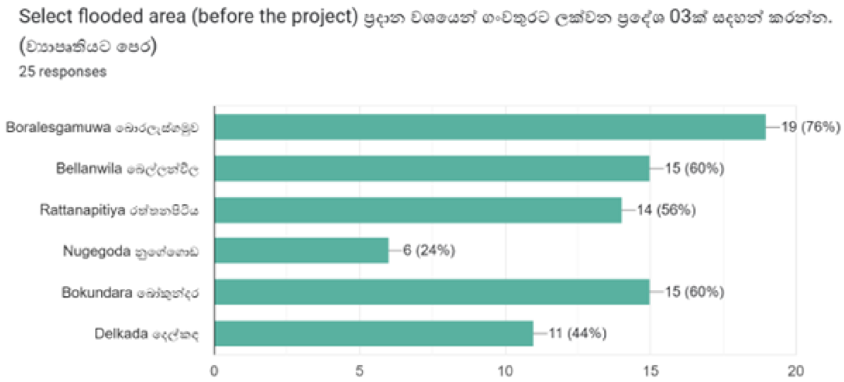
2. 3.2 Data collection II

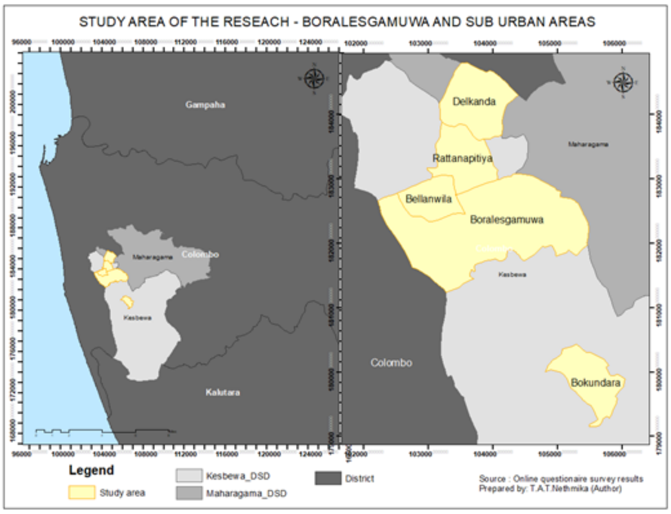
Selection of study area

A online questionnaire survey was conducted to find the appropriate study area by using google forms and analyze results through it. The snowball technique was chosen as the sampling method in this case. Selected Sample size is 25.

Based on the results have selected Boralesgamuwa, Rattanapitiya, Bellanwila, Delkanda and Bokundara as locations of study area.

Table 4: online questionnaire survey





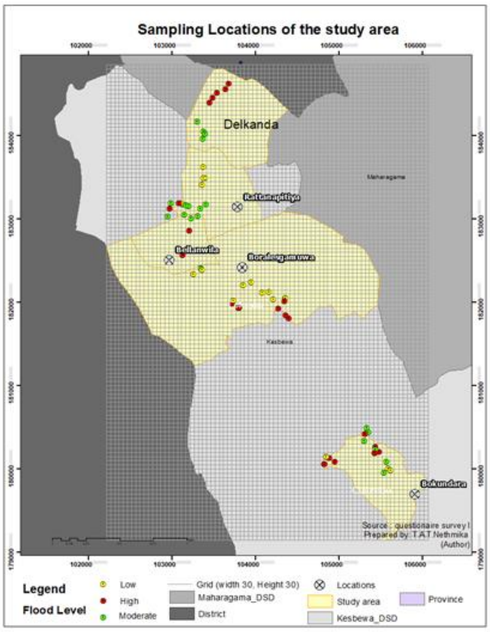
Map 2: Study area

2.4. SELECTION OF SAMPLING SIZE AND SAMPLING METHOD

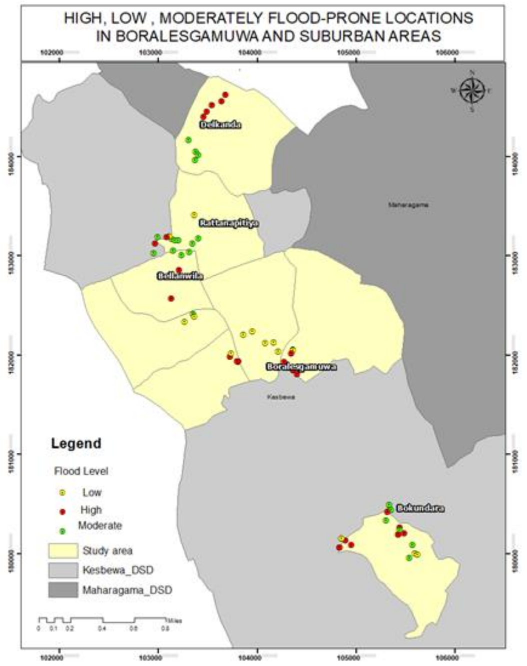
The survey of Weras ganga basin involves surveying one in five houses, ending with the house not affected by the flood. A square grid is created and the house in one box is surveyed. Basically this study follow systematic sampling method for the questionnaire survey.

Based on the survey results , have identified high, low and moderate flood prone areas.

Sample size of locations



Map 3: Sampling locations of the study area



Map 4: High, Low , Moderate flood prone areas

Table 5: Sample sizes from each locations

Flood level	Boralesgamuwa	Bokundara	Rattanapitiya	Bellanwila	Delkanda	Total
High	7	9	3	2	4	25
Low	0	7	1	2	4	14
Moderate	9	2	11	1	5	28
	Sample size					**67**

2.5 DATA ANALYSIS :

Data analysis was done by using Google Forms, Kobo Toolbox, Excel, ArcGIS 10.6, NVIVO, and Google Earth software. Google form results were used to identify study area locations. Kobo Tool Box was used to conduct a questionnaire survey and obtain the locations of houses, flood height, lag time, and exposure of the flood. Excel was used to analyze the flood magnitude. Google Earth was used to identify the locations. By using ArcGIS 10.6 and creating flood height and lag time maps. NVIVO software was used to analyse the KII results.

3. Results and Discussion

In this research, the researcher has reviewed and found out the SCC key processes that have been applied to the projects by using the Weras Ganga Development Plan. Secondly,this research focuses on the effectiveness of those key processes. Based on the three factors (flood height (flood level), duration (lag time), and exposure), the effectiveness of the SCC was determined. The following are the results of all the research analyses.

3.1 EFFECTIVENESS OF APPLYING SPONGE CITY CONCEPT IN BORALESGAMUWA AND SURROUNDING AREA

3.2.1 *Identified the key processes of SCC by reviewing the Weras Ganga Development plan and conducting the KII II.*

Table 6: Sub-basins' area of Weras Ganga basin

Sub-basin	Area (km^2)
Nugegoda-Rattanapiya	8.2
Bolgoda Canal	7.7
Boralesgamuwa North	4.9
Boralesgamuwa South	4.0
Maha Ela	20.4
Ratmalana-Moratuwa	8.1
Thumbowila	2.2
Total	55.5

Source: Weras Ganga Development Plan , Report

Basic information of Weras Ganga Basin : The Weras River basin storm-water drainage project aims to preserve the lowlands, which serve as a storm water *retention region*. In order to avoid major storm water drainage issues, the development must come before the drainage of storm water projects.

The construction of the Weras Ganga Basin Drainage of Storm Water Project can help reduce poverty by improving the living circumstances of those it will benefit, most of whom fall into the low-income category. The lowlands will be preserved as a result, and the ecosystem will benefit. The river basin is 55.5 km2 in total.

The green in the checklist indicates that the key processes in the SCC have been applied.

Table 7: Applied key processes of SCC of Weras Ganga Development Plan

sub-projects in the Weras Ganga Development Plan's six primary basins.	Sponge city key processes					
	Retention	Detention	Infiltration	Purification	Storage	Drainage system
01.Weras Ganga scheme						
1.1 Construction of Flood Protection Dike along Right Bank						■
1.3Swamp Retention Area (Weras Ganga)	■					
1.4 Maha Ela Marsh, Lowland Retention Area	■		■	■		
02.Nugegoda-Rattanapitiya Scheme.						
2.1 Rattanapitiya Ela Channel Improvement	■		■			■
2.2 Delkanda Ela Channel Improvement	■					■
2.3 Nugegoda Ela Channel Improvement	■					■
2.4 Retention Areas in Urbanized Area	■					
03.Bolgoda Canal Scheme						
3.1 Channel Improvement of Bolgoda Canal	■					■
3.2 Bellanwila-Attidiya Marsh Retention Area	■		■			
04.Boralesgamuwa North Scheme						
4.1 Channel improvement	■					■
05 Boralesgamuwa South Scheme						
5.1 Channel Improvement Stretch	■					■
05.Maha Ela Scheme						
6.1Channel Improvement	■					■
6.2Channel Improvement- Tributary	■					■
06.Ratmalana-Moratuwa Scheme						
7.1 Urban Drainage						■
7.2 Retention Pond Kandawala	■					
7.3 Retention Pond Telawala	■					
7.4 Channel Improvement Minor Tributary of Weras Ganga	■					■

Questionnaire survey I and KII I :

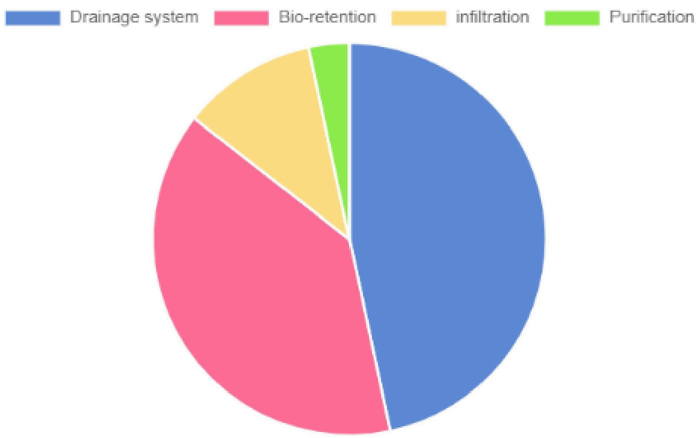
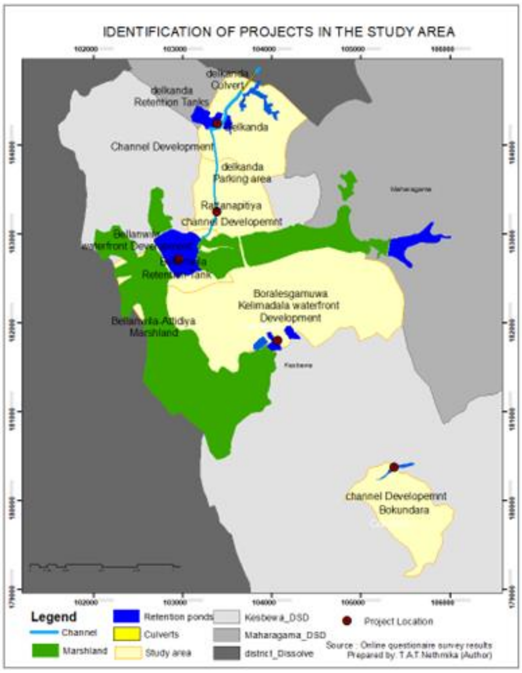


Chart 2: identified key processes of SCC of the stuy area

Based on the questionnaire survey I , identified projects which were implemented in the study area. (Chart 1)
Based on the field observation and key informant interview II, the above areas (map 07) identified as project implemented locations in Weras Ganga Basin.

Conclusion **:** According to the project engineer of SLLDC, protected marshes, retention tanks, culverts, parks, channels, waterfront developments, etc., that are part of the Weras Ganga Development Projects are marked above map . Through them, retention tanks, waterfront developments, parking areas, and channels were easy to spot through field observations.



Map 5: SCC key processes applied projects in the study area

According to the table 7 , the retention system has been implemented in all six major schemes under the Weras Ganga Development Plan. Also, drainage system development (one key process of the SCC) has been done in the first project under the Ratmalana-Moratuwa scheme. The infiltration has mainly occurred in the Bellanwila - Attidiya Marshland. This marshland has been allowed to absorb rainwater into the ground as clean water (purification) so that it naturally absorbs water quickly into the ground and the water becomes clean naturally. Small development interventions have been applied mainly to allow water to drain naturally. Therefore, based on the project manager's information, field observations, and the Weras Ganga development plan report, it is clear that the drainage system and the retention methods were implemented as main mechanisms, followed by infiltration and purification.

Accordingly, it is clear that although the SCC is not implemented as a concept, many of the key processes contained in that concept have been implemented in the Weras Ganga Development Plan.

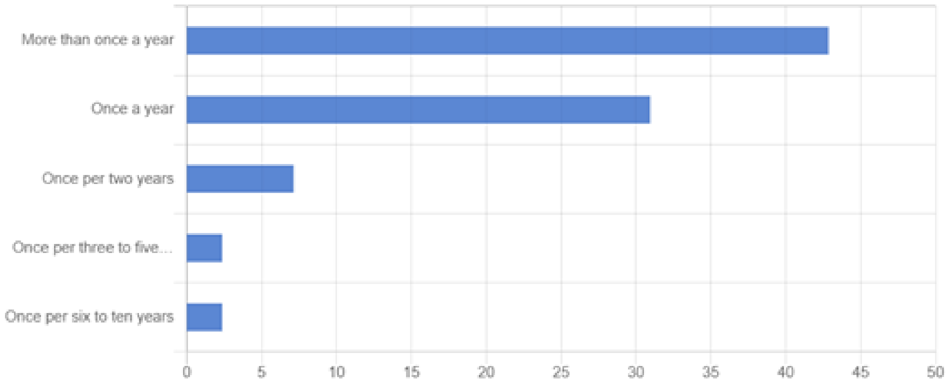


Chart 3: Frequency of precipitation

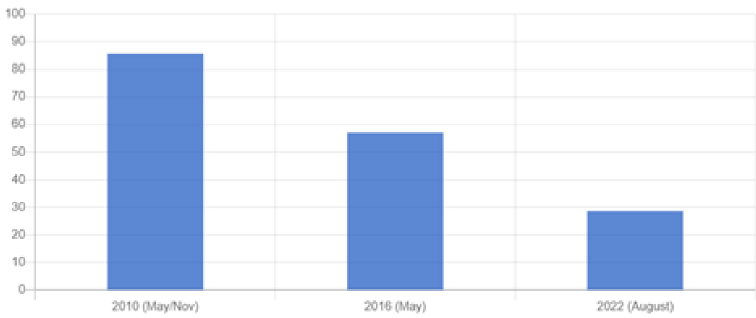


Chart 4: Flood level of , 2010,2016 & 2022

3.2 ANALYSIS AND DISCUSSION II – STUDYING HOW FAR THE FLOODING HAS BEEN MITIGATED AFTER IMPLEMENTATION OF THE PROJECT.

The area selected for the research in the Weras Ganga basin, the projects from the plan that have been developed and implemented, and the results of a real-ground investigation to see how much the magnitude of floods in the area has decreased because of these projects.

Type of flash flood **:** The irrigation department has reported out in three ways how likely it is to flood: Critical (50 years), major (10 years) and minor (01 year) floods. (Weerakoon & Dharmapriya , 2021)The most common thing here, according to the field survey, is the annual flood. So, it became clear that minor floods happened once, twice, or three times a year. Flooding has affected the identified study areas for 2010, 2016, and 2020, according to the questionnaire survey.

3.2.1 Effectiveness of Sponge City Concept - Magnitude of the Flash Flood

The first analysis and discussion, the key processes of the China SCC in the Weras Ganga Development Plan were identified. The extent of efforts to minimize the flood in Boralesgamuwa and its surrounding areas (Bellanwila, Rattanapitiya, Bokundara, and Delkanda) selected through the online survey in that basin is discussed below. Before and after the implementation of the project, attention has been focused on the under

1. flood level
2. Duration
3. Exposure

Thus, it is essential to consider whether the sponge city's main processes have actually reduced flood lev-els. It was done as follows:

Chart 5: Flood level of , 2010,2016 &

3.2.2 Flood level

The flood level is classified as follows based on the questionnaire survey

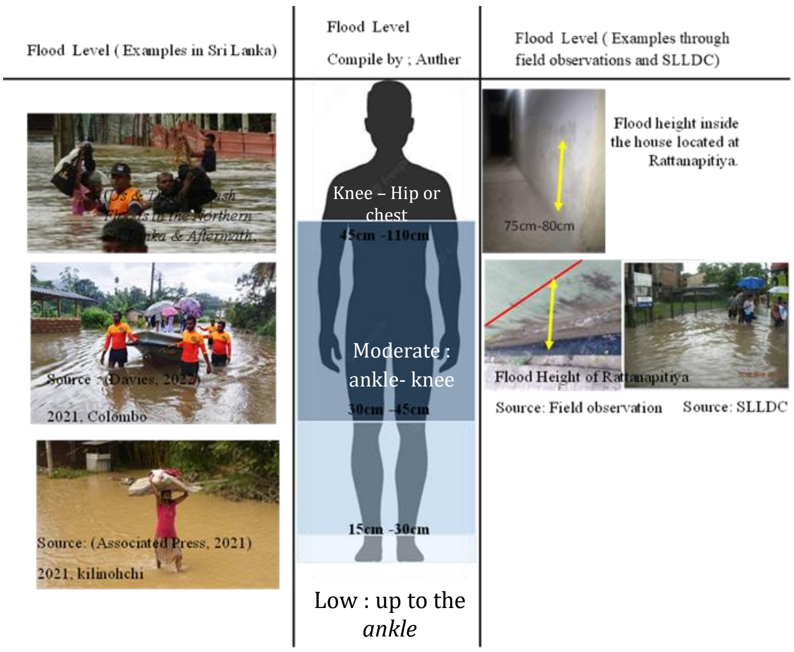
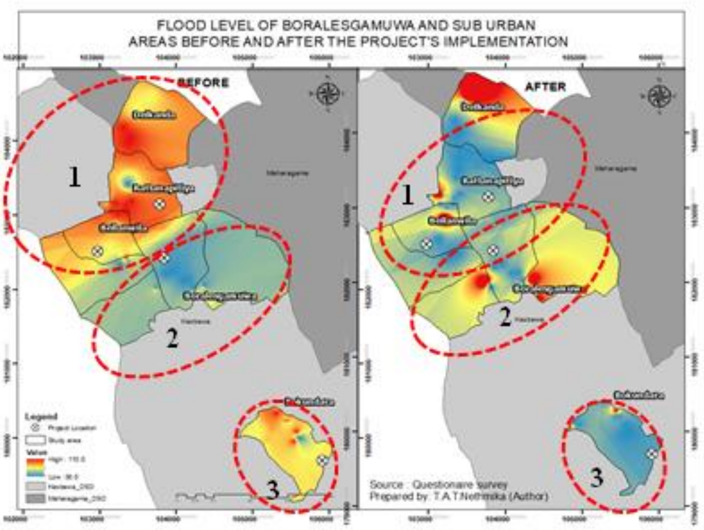


Figure 4: Main flood level

1,2 and 3 areas analysis : Based on the *map 9*, the highest flood level is 45 cm to 110 cm, which is above the knee, above the waist, and close to the chest. The moderately affected flood level is 15 cm to 45 cm, which is from the top of the ankle to the knee, and the lowest flood level is 15 cm to 30 cm, which is to the ankle.High flood levels can be seen in the *1st* area (Rattanapitiya, Delkanda, Bellanwila, and Boralesgamuwa). A blue patch stands out among them, and it's clear that Rattanapitiya has places with low water levels. Among them, the flood levels in yellow, which are medium scale, are more or less represented in the towns of Delkanda, Rattganapitiya, and Bellanwila.In the area mentioned as *number 2*, there was a minimum flood level before the project, but after the implementation of the project, it has increased to a medium and high flood level. This is a specialty that can be seen in Boralesgamuwa town and nearby areas. In area *number 3*, there are mostly high and moderate flood levels. But it is clear that the flood level has reduced after the implementation of the projects. Areas with slightly higher and medium water levels remain, but the impact is less than before.

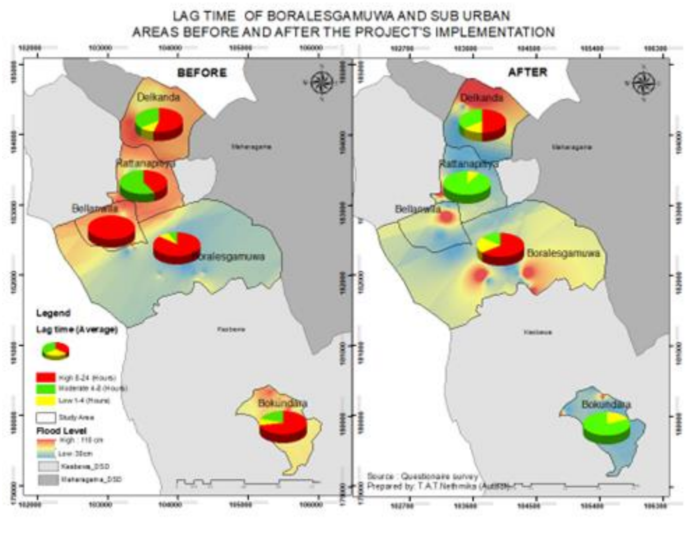


Map 6: Flood level map- before and after projects implementation

Conclusion : Comparing the two overall maps, the flood level in the study area has decreased after the implementation of projects. But some areas with a minimum water level have been transformed into medium- and high-water-level areas after the project. It is notable that the flood level has decreased near the project site.

In here specially noted that, Floods have occurred in several places that have never been flooded before. The main reason for this is that the parallel drains were not cleaned during the implementation of the project, so they were blocked. Also, since there is no more sub-drainage improvement in the Weras Ganga Development Plan, the various projects that took place there have been adversely affected. It was evident in the field observations and when questioning the people. But drain improvement is a key process in the SCC. But that process has not been fully implemented through these projects. Accordingly, it is clear that, in the implementation of Sponge City, attention should be paid to the six key processes. Otherwise, such cases will emerge.

3.2.3 Magnitude of the flash flood – Lag time



Map 7: Flood level map- before and after projects implementation

Analysis : The average time taken for the flood level to decrease in the study area is stated in hours. Before the projects' implementation, the flood level in the Delkanda area had been there for a long time, and it has reduced after the projects' implementation. Earlier in Rattanapitiya, the number of hours it took for the flood level to reduce had increased. It used to take longer, but now there is a moderate to low level of lag. Although Bellanwila used to have a flood level for a long time, the flood has been eliminated from the area with the project. Before the projects, it took more hours to reduce the flood level in Boralesgamuwa, and later, the hours have decreased. Although it took between 8 and 24 hours before the flood subsided in Bokundara, now it takes a maximum of 8 hours.

Conclusion: There is a clear difference, especially in the Rattanapitiya and Bokundara areas. Before the project, the flood level took a maximum of 24 hours to go down, but after the project, it fluctuated in a period of 1 hour and 8 hours.

3.2.4 Magnitude of flash flood - Exposure

This section explains the degree to which people are exposed, depending on the height of the flood. When asked about it in the first questionnaire survey, respondents classified exposure into four stages. That is, severely exposed, limited exposure, observing others exposed, and not exposed.

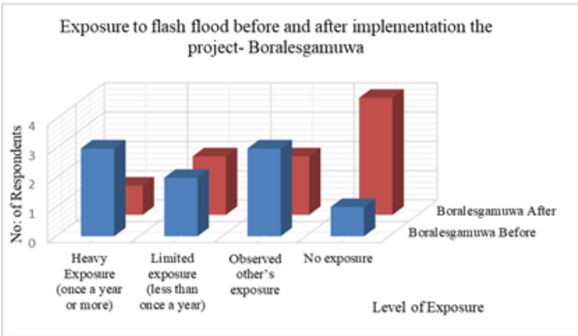


Chart 6: Exposure level-before and after projects implementation - Boralesgamuwa

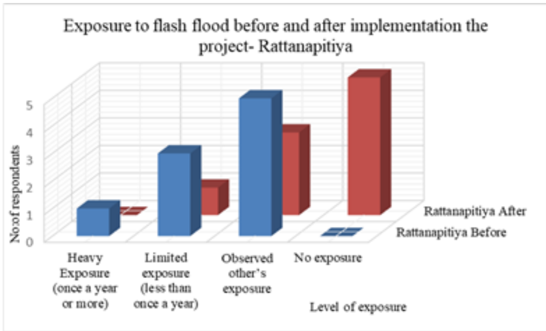


Chart 7: Exposure level-before and after projects implementation - Rattanapitiya

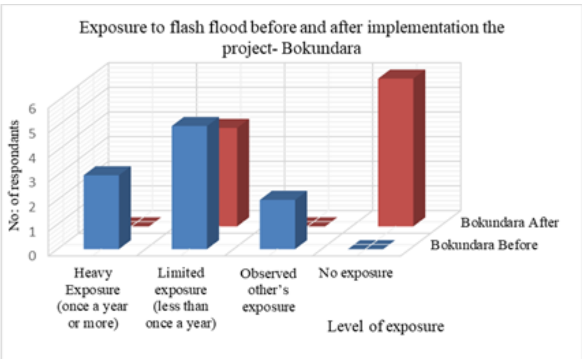


Chart 8: Exposure level- before and after projects implementation- Bokundara

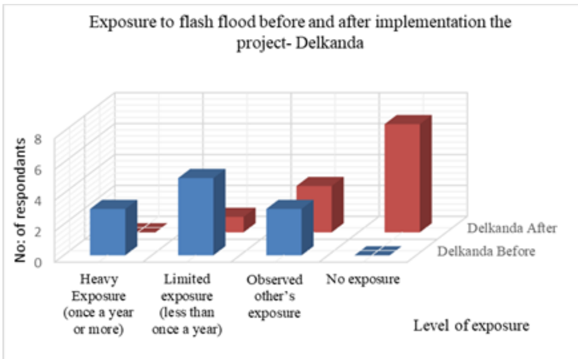


Chart 9: Exposure level- before and after projects implementation-Delkanda

As a whole, the areas that were heavily flooded before the implementation of the projects in the study area have limited flood impact after the implementation of the projects. Limited, i.e., less flood-prone areas, have no flood impact at present. But in some areas, neighboring houses are affected. At the same time, areas with little or no flood impact have also been created after the implementation of the projects.

4. Conclusion

There is no project that directly applies the SCC in Sri Lanka. However, it is clear that Weras Ganga Development projects have adapted the concept's main processes. Retention, infiltration, purification and drainage systems have been implemented as a result of those main processes. Through this projects, the main principles of the SCC—protection, restoration, and low-impact development—have been implemented. For simple instances, point out the protection of the existing marshland, the carrying out of agriculture in the developed areas, as well as the strengthening of the canal network by connecting the water canals and further expanding the existing canals.(Source: Assistant General Manager, Research and Design unit in SLLDC) Even though the flood height is reduced and the lag time is only a few feet, the flood effect persists in some areas. Even areas that were not particularly affected before are now affected. And also, spring water emerges from houses. The main reason for this is that the process of infiltration is being slowed down by the construction over the paddy fields and other wetlands. The drains around the houses are not properly maintained, and only focus on drainage system which was developed through the main projects in Weras Ganga. But both the drainage system and infiltration are the main functions of SCC. Some stages are missed because the SCC is not applied as a concept to flah flood mitigation projects in Sri Lanka. This causes the aforementioned problems.

5. Scope and limitations

- Only key processes of the sponge city concept are considered in this study. Using only Weras Ganga Development Projects to test applicability in Sponge City concept. It should be tested by several more projects or plans.
- selecting only five flood-prone areas of the Weras River Basin to practically investigate the magnitude of floods after implementing projects. For that, all the flood-prone areas in the Weras Ganga basin should be examined. Then using the systematic sampling method (one in five houses) for the sampling method, in some cases the sixth or seventh house has to be surveyed. That is, people not willing to answer, there is no one in those houses, etc. can be cited as the reason.

5.1 RECOMMENDATION FOR FUTURE STUDIES

- Investigate the difficulties in implementing the SCC in Sri Lanka.
- Analyzing the cost and benefits of implementing the SCC in Sri Lanka.
- Investigating whether applying a concept from another country to Sri Lanka is successful in the current economic crisis using the SCC.
- examining how well agencies that plan and carry out flood control and prevention projects know about the Sponge City idea.
- Investigate the economic, environmental, and social efficiency of the SCC.

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